



Dir WHC  
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C/Nº 2015-39 - APP

Monowar Islam, ndc  
Secretary  
Power Division  
Ministry of Power, Energy & Mineral Resources  
Government of the People's Republic of Bangladesh

Memo No: 27.00.000.071.014.51.14-483

Dated: 1 January, 2015

Subject: State of Conservation of the Sunderbans, Bangladesh.

Dear Sir,

The Power Division, Ministry of Power, Energy and Mineral Resources, the Government of Bangladesh (GoB) presents its compliments to the World Heritage Center (WHC), United Nations Educational, Scientific and Cultural Organization (UNESCO) and has the honour to express its commitment to uphold the decision (38 COM 7B.64) of WHC adopted at 38<sup>th</sup> session in Doha, 2014 on the captioned subject.

2. You are aware that energy security is one of the preconditions of sustainable development. Bangladesh is working hard to ensure energy security for its people. The present power generation capacity of Bangladesh is around 11,000 MW whereas the country needs 24,000 MW power by 2021 and 40,000 MW by 2030. At present, little over 60% people have access to electricity and per capita consumption is less than 400 Kwh. The government has planned electricity for all by 2021 and to make Bangladesh a middle income country by the same time. Electricity, besides its benefit as a private goods, also contributes to the health of children and mother, facilities empowerment of women, promotes spread of education and reduces income poverty.

3. In the past, the country resorted to generate power based on natural gas (87%). Since the supply of gas and the known assets are inadequate in relation to the existing demand, not to speak of the growing needs of the economy (there is acute shortage of gas leading to closure of gas fired power plants and fertilizer factories), the Government of Bangladesh (GoB) decided to go ahead with coal based power plants to meet its development goals as per the Power System Master Plan- 2010. Given the small size of Bangladesh ( 1,47,570 sq km) with a population of about 160 million and limited navigation choices, there are a few options for sighting coal based power plants in this highly densely populated country.

4. Against this backdrop, the Government of Bangladesh has selected after careful considerations, Rampal, Bagerhat to construct 1320 MW coal based power plant after details feasibility study and Environmental Impact Assessment which has been approved by Department of Environment on 5 August, 2013. The report has been hosted to the website of Bangladesh





Monowar Islam, ndc  
Secretary  
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Ministry of Power, Energy & Mineral Resources  
Government of the People's Republic of Bangladesh

-2-

Power Development Board (BPDB) and Bangladesh India Friendship Power Company Ltd (BIFPCL) ( [www.bpdb.gov.bd](http://www.bpdb.gov.bd) & [www.bifpcl.com](http://www.bifpcl.com) ). It may be mentioned here that Bangladesh has hardly any carbon footprint. The per capita emission is less than 0.25 ton annually.

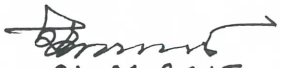
5. For your kind information, the Power Division along with Bangladesh Power Development Board (BPDB) and Bangladesh India Friendship Power Company Ltd (BIFPCL) have taken all measures to assess and mitigate the impacts of 1320 MW Maitree Super Thermal Power Project on the environment and ecosystem. A short report on “The issues related to Environment in respect of the proposed 1320 MW Maitree Super Thermal Power Project at Rampal, Bagerhat, Bangladesh” is enclosed for your kind perusal. It is assumed that a lot of misinterpretation and communication gaps have been arisen around the proposed power plant - for which a close understanding between the Power Division & WHC, UNESCO is desirable.

6. It may be mentioned that the plant is located 14 km away from the northern most tip of Sunderbans and 97 km away from UNESCO World Heritage site. Let me assure you that the GoB is highly committed to protect its environment and ecosystem specially Sunderbans.

7. In view of the position stated above, I would request you to kindly invite a delegation from Bangladesh to UNESCO HQs to discuss the environmental issues and mitigation measures taken by GoB on the proposed 1320 MW Maitree Super Thermal Power plant. Please do not hesitate to ask us any further clarification on the subject.

Please accept our highest consideration always.

Sincerely Yours

  
01.01.2015  
(Monowar Islam)

Mr. Kishor Rao  
Director,  
World Heritage Center (WHC)  
United Nations Educational, Scientific and Cultural Organization (UNESCO)  
7, Place de Fontenoy  
75352 Paris 07 SP, France.

Enclosed: Report

## Report

on

### **The issues related to Environment in respect of the proposed 1320 MW Maitree Super Thermal Power Project at Rampal, Bagerhat, Bangladesh.**

The Project is being developed by Bangladesh-India Friendship Power Company (Pvt) Ltd (BIFPCL), a 50:50 Joint Venture between Bangladesh Power Development Board (BPDB) of Bangladesh and National Thermal Power Company (Pvt) Ltd (NTPC) of India.

**Salient features:** Highlights of the environmental issues and protection/risk mitigation measures being adopted by BIFPCL for this Project are as follows:

**1. Location:** The plant is located 14 km away from the northern most tip of Sunderbans and 97 km away from UNESCO World Heritage Site.

**2. Advanced Technology:** Very advanced and proven Technology, with higher steam and pressure parameters has been adopted. This will result in much higher efficiency as compared to the conventional Subcritical coal fired Technology. This will mean much lower consumption of coal and reduction in dust as well as green house gas emission.

**3. Water pollution:** Only makeup water will be drawn from river Possur which is a tidal river. There is no Thermal pollution due to hot water discharge as Closed Circuit Cooling Water systems with Induced Draft Cooling Tower will be used. The cooled water is then further re-circulated and used for process purpose within the plant. No effluents from the plant will be discharged into the river without treatment. Effluent Treatment Plant and Sewage Treatment Plants are provided. Hence, no damage to flora & fauna in the water bodies is envisaged.


**4. Air pollution / fugitive emission:**

**a. Particular matter:** High efficiency (99.9%) Electrostatic precipitators will be provided which will capture ash from the flue gas and will control the emission of particulate matters to  $75.0\mu\text{g}/\text{NM}^3$  as per stipulation.

**b. Flue Gas Desulphurization unit (FGD):** Imported Coal with low sulfur content ( $<0.6\%$ ) will be used which, as such, will keep the  $\text{SO}_x$  level very low. However, as an additional air pollution control measure, FGD will be provided which will virtually nullify the effect of sulfur in the exit flue gas and always keep the  $\text{SO}_x$  level / pollution level in the flue gas on the lower side of the World Bank specified range of such pollutants. Hence, there is no possibility of acid rain etc.

**c. Very High Chimney:** 275 M high chimney is provided to further disperse the effluents to a wider range to further control and reduce the ground concentration of dust etc and keep the same below the statutory limit.

**d. Green belt development:** 100 meter wide green belt is envisaged to be developed in and around the plant area through plantation of over 200 thousand trees initially. This will not only bring down the pollution levels further, but will also improve the overall environment / ambience making it more friendly for birds / migratory birds etc.





e. **Air flow:** The location of the proposed project is Northern side of Sundarbans. During November to February, maximum prevailing wind flows from north and north-west to south and southeast direction and for rest of the period it flows from south. During March to April wind mostly flows from south and southeast to north and northeast and from May to October it flows from south and southeast to north and northwest direction. So it is evident that the negligible impact of the power plant will never affect Sunderbans any way.

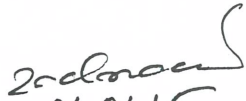
**5. Utilization of ash generated in the Project:** Imported coal with low ash content will be used for the Project. This will as such produce very low quantum of ash. BIFPCL is making arrangement to use 100% of fly ash to be generated in the Project. Utilization of bottom ash is also being planned. This will largely obviate the need for ash pond and help develop fly ash based industries in the region.

**6. Coal Transportation:** Coal for the Project will be imported using the existing maritime route of Bangladesh for reaching the Mongla Port, which is 12 KM downstream of the Project site. However, to look into the most optimum coal transportation system, without affecting the environment adversely, BIFPCL has appointed PwC (an international coal transportation and logistics consultant) to advise on the coal logistics. The terms of reference of PwC includes EIA for coal transport in the Possur river. Appropriate arrangement for coal transportation shall be made for the Project based on the report of PwC.

**7. Regular Monitoring of the Environment:** Further, as per the stipulations of the Dept. of Environment, Govt. of Bangladesh, a reputed agency name Center for Environmental and Geographic information Service (CEGIS) has been appointed to monitor the environment during the pre-construction and construction period of the Project. The Terms of Reference of the Monitoring Agency, in-ert-alia, includes the following:

- Physical Environment Monitoring Plan;
- Water resources Monitoring Plan;
- Transportation Monitoring Plan;
- Land and Agriculture Monitoring Plan;
- Fisheries Monitoring Plan;
- Ecosystem Monitoring Plan;
- Socio-Economic Environment Monitoring Plan;

From the aforesaid it is evident that the Project will be developed with advanced technology and with utmost care for the environment. Hence there will be no adverse impact on the Sunderbans or the nearby Possur river are foreseen.

  
01.01.15  
**Md. Zillur Rahman**  
Senior Assistant Secretary  
Power Division  
Ministry of Power, Energy & Mineral Resources  
Government of the People's Republic of Bangladesh

Government of Peoples' Republic of Bangladesh  
Ministry of Power, Energy and Mineral Resources  
Power Division  
[www.powerdivision.gov.bd](http://www.powerdivision.gov.bd)

No: 27.00.000.071.014.51.14.477

Date: 30.12. 2014

Sub: State of Conservation of the Sundarbans, Bangladesh.

Ref:(a)World Heritage Center Memo No-CLT/HER/WHC/APA/14/134 date:11.07.14  
(b) Bangladesh Embassy in Paris Memo No-BDP/UNESCO, Gen.com/13 date: 18.07.14  
(c) Bangladesh UNESCO National Commission Memo No-37.18.0000.005.24.049.06.572 date-9.08.14  
(d) পবম/(বঃশাঃ- ১)/০৬/২০১১(অঃশঃ- ১)/৩৭৬ তারিখঃ ০৩.১২.১৪খ্রিস্টাব্দ

The undersigned is directed to refer your letter dated 03.12.2014 on the captioned subject. I have the pleasure to furnish below the steps taken by Power Division, Ministry of Power, Energy and Mineral Resources regarding the World Heritage Committee(WHC) decision no 38 COM 7B.64:

| Information required by WHC   | Steps taken by the BPDB & Power Division   |
|---|--|
| 1. To ensure that the Environmental Impact Assessment (EIA) for the dredging activities include a specific assessment of potential impacts on Outstanding Universal Value (OUV).  | All the dredging activities for the area concerned will be executed by Mongla Port Authority under the Ministry of Shipping. Mongla Port Authority has already completed EIA for dredging activities including a specific assessment of potential impacts on OUV (Annexure-1).   |
| 2. To undertake a comprehensive Strategic Environmental Assessment (SEA) to ensure that cumulative impacts of developments in the Sundarbans are adequately assessed, including in relation to the OUV of the property. | EIA study for coal based power project was completed according to the approved Terms of Reference (ToR) given by Department of Environment (DoE). SEA for cumulative impacts of developments in the Sundarbans including in relation to the OUV of the property may be conducted by Ministry of Environment & forests. |
| 3. To urgently submit the results of the ecology monitoring programme to the World Heritage Centre for review by IUCN.  | Bangladesh India Friendship Power Company Ltd (BIFPCL) has engaged the Centre for Environmental and Geographic Information Services (CEGIS) for ecological monitoring work. The latest monitoring report and its executive summary for the period September-November, 2014 (Annexure-2) is enclosed.                   |
| 4. To submit an international assistance request to further support the ongoing restoration of infrastructure and the procurement of management resources.  | Ministry of Environment & Forests may take necessary action if necessary. The Power Division will provide all support relating to power plants.  |

2. It may be mentioned here EIA and ecological monitoring reports of third quarter for the first year have been hosted at the web site of Bangladesh Power Development Board (BPDB) and Bangladesh-India Friendship Power Company Ltd (BIFPCL) ([www.bpdb.gov.bd](http://www.bpdb.gov.bd) & [www.bifpcl.com](http://www.bifpcl.com))



3. It will be highly appreciated if Ministry of Environment & Forests takes necessary initiative to send a Bangladesh delegation to WHC, UNESCO in order to review the progress of the measures that have been taken by the Power Division, Ministry of Power, Energy and Mineral Resources and identify future course of actions for the State of Conservation of the Sundarbans, Bangladesh.

29/09/2018  
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Copy for information;

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109, avenue Henri Martin, 75016 Paris.
2. Chairman, Bangladesh Power Development Board.
3. Director, WHC, UNESCO, 7 place de Fontenoy, 75352 Paris 07 SP, France.
4. Country Representative, IUCN, Dhaka.
5. Managing Director, BIFPCL.
6. Secretary, Bangladesh National Commission for UNESCO, 1 Sonargaon road, Palashi- Nilkhat, Dhaka
7. PS to Advisor to the Hon'ble Prime Minister, Power & Energy Affairs.
8. PS to Hon'ble State Minister, Ministry of Power, Energy & Mineral Resources.





## Monitoring Report of Third Quarter, First Year

Monitoring of environment parameters and implementation of Environmental Management Plan during pre-construction and construction period along with Engineering Activities for site development of Khulna 1320 MW Coal based Thermal Power Plant

November 2014.



Monitoring Report of Third Quarter, First year  
Monitoring Period: September 2014 – October 2014

**Bangladesh – India Friendship Power Company  
(Pvt.) Limited**

*(A Joint Venture of NTPC Ltd and BPDB)*



SUBMITTED BY

**C&GIS**

Center for Environmental and Geographic Information Services  
House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh. Tel: 8817648-52, Fax: 880-2-8823128





# Bangladesh India Friendship Power Company (Pvt.) Limited

(A Joint Venture of NTPC and BPDB)

*Monitoring of environment parameters and implementation of  
Environmental Management Plan during pre-construction and  
construction period along with Engineering Activities for site  
development of Khulna 1320 MW Coal based Thermal Power  
Plant*

**Monitoring Report of Third Quarter  
(September – November), First Year (2014)**

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**(Monitoring Period: September 2014 – October 2014)**

November, 2014



Center for Environmental and Geographic Information Services  
House 6, Road 23/C, Gulshan-1, Dhaka-1212, Bangladesh. Tel: 8817648-52, Fax: 880-2-8823128

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## Acknowledgement

The Center for Environmental and Geographic Information Services (CEGIS), a Public Trust under the Ministry of Water Resources, is indebted to Bangladesh India Friendship Power Company (Pvt) Limited (BIFPCL) for awarding the contract of "***Monitoring of environment parameters and implementation of Environmental Management Plan during pre-construction and construction period along with Engineering Activities for site development of Khulna 1320 MW Coal based Thermal Power Plant***" to CEGIS.

CEGIS is grateful to Mr. Monowar Islam ndc, Secretary, Ministry of Power, Energy and Mineral Resources (MoPEMR) and Chairman, BIFPCL for his exceptional leadership. CEGIS expresses its gratitude to Mr. Md Abduhu Ruhullah, Chairman, Bangladesh Power Development Board (BPDB) for his continuous inspiration and support in all respect. CEGIS is also thankful to Mr. V.S. Tamrakar, Managing Director, Bangladesh India Friendship Power Company (Pvt) Limited (BIFPCL) for his direction and guidance. CEGIS appreciates the support and instruction of Mr. Atanu Kumar Mitra, Deputy General Manager, BIFPCL, Mr. Anindya Majumder, Chief Technical Officer, BIFPCL and Engr. Dinesh Chandra Mistry, Executive Engineer, BIFPCL.

CEGIS is indebted to Mr Md. Alamgir Hossain, Junior Supervisor (Mech), BIFPCL for accompanying the team during carrying out monitoring in the Sundarbans.

CEGIS is also grateful for the contribution of the field officials of different Government and Non-Government organizations for sharing their ideas and views on the attitudes of the local people towards the Project and existing problems of the study area as well as their suggestions in solving the problems.

Last but not the least, the study team appreciates and acknowledges the concerns and perceptions of local people regarding the Project and their active participations during field visits.





## Executive Summary

With the aim of complying with the given condition of Department of Environment and the environmental and social safeguarding rules of Bangladesh, the Bangladesh-India Friendship Power Company Pvt. Ltd. (BIFPCL) has initiated a study on monitoring environmental and social parameters and implementation of environmental management plans during pre-construction and construction phases. Center for Environmental and Geographic Information Services (CEGIS) has been entrusted for carrying out the study. The study covers quarterly monitoring of different environmental and social parameters, and implementation of EMP during pre-construction and construction phases. The results of the monitoring are quarterly reported to BIFPCL through Monitoring Report of each quarter. Accordingly, the report on first quarter monitoring was submitted in April 2014 and the second quarter monitoring was submitted in August 2014. Following the monitoring schedule, the third quarter monitoring activities were carried out in the field in two phases, first in 20 September to 3rd October and second from 15 October 2014 to 29 October 2014. The third quarter monitoring activities involved:

- Monitoring Implementation of EMP and Environmental Compliance
- Monitoring of ambient air quality
- Monitoring of ambient noise
- Monitoring of ambient water quality
- Monitoring of ambient transportation condition
- Monitoring of soil quality
- Monitoring of fisheries resources covering fish habitats, biodiversity, migration and production
- Monitoring of ecosystem and biodiversity
- Monitoring of Sundarbans Forest Health
- Monitoring of Socio-economic Condition, Community Health, Safety and Security, and Labor and Working Conditions.

A brief summary of the aforementioned activities are provided in the following paragraphs.

### ***Monitoring of EMP during Pre-construction Activities***

At present, the following pre-construction activities are in progress at project site:

- Land development of the remaining 580 acre of land
- Construction of Embankment around the Project site
- Construction of Boundary wall
- Construction of 2 x 200 KV Transformers
- Construction of pre-fabricated site office
- Installation of Drinking Water supply Facilities, etc.

The monitoring study also includes, monitoring of environmental compliance of these pre-construction activities and monitoring of implementation of Environmental Management Plan as suggested in the EIA report and later vetted by DoE. In general, the environmental due diligence covered the following components:

- Environmental and Social Management System and Action Plan
- Labour and Working Condition
- Community Health, Safety and Security
- Biodiversity and Sustainable Management of Living Natural Resources



The monitoring study found the pre-construction activities partially complied with the EMP.

### ***Air Quality Monitoring***

Similar to the earlier quarter monitoring, ambient air quality has been monitored at the same 11 locations. Prevailing wind direction was same, South-East, as of first quarter monitoring. During third quarter monitoring weather was sunny in daytime and fog was observed in morning. In this quarter concentration of SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub> and SPM were found within the standard in most of the locations. Only in Pankhali and at Khan Jahan Ali Bridge, SMP concentration was found above the standard.

### ***Noise Monitoring***

Ambient noise was monitored at the same 11 locations as of first quarter monitoring. Similar to the earlier noise monitoring results, this time noise level was found above the standard in Sundarbans. Wind action on trees, river wave, bird's chirping, ship and fishing boats, etc are the source of noise observed in Sundarbans.

### ***Water Quality Monitoring***

Same water quality parameters as tested in the earlier quarter were also considered for this quarter monitoring at the same sampling locations as of first quarter monitoring. In total two locations in Maidara rivers, 12 locations in Passur river and one location in Sibsha river were pre-selected. There are four hand pump tubewell selected for monitoring water quality at each quarter.

The insitu testing result shows that there are seasonal variation in salinity, pH, DO and BOD. Collected water samples are being analyzed in the DPHE's laboratory. The laboratory analysis includes measurement of COD, As, Hg, Pb, Hardness, NO<sub>3</sub>, PO<sub>4</sub>, SO<sub>4</sub>, TS, Turbidity, Na, K, Ca, Mg, Si, Fe, HCO<sub>3</sub>, CO<sub>3</sub>, Cl, EC, and oil & grease concentration. Once the laboratory analysis report of this quarter is available, it will be submitted BIFPCL. However, the earlier laboratory reports were provided in chapter 5.

### ***Transportation Monitoring***

Transportation monitoring included monitoring of traffic volume in Khulna-Mongla high way and access road to Project site at the same five locations as of earlier quarter monitoring. This time traffic volume was found higher than earlier in morning and afternoon.

### ***Land Resources Monitoring***

In this quarter, the composite soil samples were collected from five agricultural lands located within 10km radius of the Project site. Samples have been submitted to SRDI, Dhaka laboratory for analysis. Once the reports are available, those will be attached in the next monitoring report.

### ***Agricultural Resources Monitoring***

The existing cropping pattern was found during monitoring as Fallow – HYV Aman/Local Aman-Fallow in three monitoring plots out of five. No crop damage was found in agricultural resources monitoring.

### ***Fisheries Monitoring***

Fisheries resources have been monitored at the same locations as of first and second quarter monitoring. The following are the key finding of the third quarter monitoring:

- Seasonal variation in classification of habitats



- As per Jaccard similarity index the length frequency of different fish species were more homogenously distributed among the sampling sites in case of third quarter monitoring phase in the month of October than that of first and second quarter monitoring
- Evenness in fish diversity (as defined by Shannon-Weiner Index) is almost homogenous from down stream to up stream. River condition, food availability and spawning migration are the possible reasons for this.
- Fish species richness (FSR) varies at different locations. Poma, Phessa, Bele, Banshpata, Tapsi, Hilsa, Golda and different prawn are dominating species in upstream of Sundarbans. And Tapsi, Bele, Chewa, Loitta, Chela, Chanda Chela and Motka chingri are dominating species in the Sundarbans.
- Among migratory fish species Poma, Lal Chewa and Gang Tengra are dominating migratory species. Among the migratory species, Hilsa, Poma and Banshpata migrate long range for their spawning and feeding behaviour.
- As found in the second quarter monitoring phase, the highest productivity has been found in Sheola Khal at Chandpai of Passur River System. But lowest productivity has been found in Akram point of Passure River. Moreover, as expected higher productivity was observed in the third monitoring phase as compared to that of the second monitoring.
- In case of shrimp/fish farm, the highest production comes from the shrimp farm of Chunkuri-2 and lowest from that of Bhekatkhali. Moreover, the production from all the sampling Ghers is higher in third monitoring phase as compared to the first two consecutive monitoring phases.

### ***Ecosystem and Biodiversity Monitoring***

Plant health, plant canopy cover, lichen cover, bird habitat and dolphin occurrence have been monitored for this monitoring season. Homestead plants were followed improved in terms of overall health situation. Nevertheless, coconut and date palm has sighted unhealthy of all at Rajnagar and Chalkghona village. Canopy status of the sample homestead vegetation remains unchanged except Chalkghona. Lichen coverage showed in decreasing for most of the plant barks. No bird nest was found at examined homesteads.

A total of 28 butterfly species have been recorded from the study area. Rice Swift, Common Crow, Grass-yellow, Common Emigrant, Blue Tiger are the common butterflies of the study area frequently found in the study area.

Dolphin occurrences follow an increasing trend at Passur river along Project site. A total of 13 individuals of Ganges River dolphin has sighted during transect survey and river confluence point shows highest occurrence. This aquatic mammal was also found at Maidara River and other monitoring locations of Passur River near Karamjal and Harbaria.

### ***Sundarbans Forest Health Monitoring***

Forest health was monitored at four locations – Karamjal, Harbaria, Akrampoint, Hiron point and Sutarkhali. Forest health monitoring covered assessment of species diversity, richness, regeneration, recruitment, seedling survival, canopy cover diameter, biomass, and disease and damage. In this quarter, tree tagging done in earlier quarter was rechecked. Forest regeneration was monitored



In this quarter, no significant difference in two subsequent monitoring was found in canopy cover and pneumatophores density in most of the monitoring plots. Only in Karamjal, pneumatophores density was found higher than the earlier monitoring.

### ***Socio-economic monitoring***

#### ***Compensation***

Compensation to the affected landowners was almost finished by the DC office Bagerhat. Few landowners are yet to get compensation due to inadequacy of land ownership documents. However, local people made statement in other way. 56% of the surveyed HHs stated they received full compensation which was 47% in earlier monitoring and 44% claimed they did not receive full compensation money.

#### ***Rehabilitation and Resettlement***

In general, local peoples are not satisfied with rehabilitation and resettlement process. DC office gives priority to the evicted HHs from the acquired area in Government's shelters (gucchhogram).

#### ***Health***

During survey, local peoples ranked Influenza/fever as highest occurring disease. In general, Fever, Cough/cold, hypertension, Gastric, etc are common diseases. Skin disease and Asthma were ranked as lowest occurring diseases.

#### ***Labor and working condition***

Labor and working condition was not found complied with the EMP. Sanitation facilities for labor and workers are poor. Open Pit toilets were found at project site constructed for labor. Drinking water facilities have not been installed yet. Labors manage their own water. Safety was not found mandatory.

#### ***Community Health, Safety and Security***

BIFPCL runs weekly health camps for locals. Construction of safety wall around the Project site is in progress. An Ansar Camp has also been established in the Project site for ensuring security.

#### ***Livelihood and occupation***

In this quarter, more peoples were found engaged in agriculture, fishery and service than earlier.

#### ***Income***

Average Households income was found little bit higher in this quarter.

#### ***Migration***

In this quarter, 2% In-migration was found in the project nearby areas. Employment opportunity in BIFPCL's project influences people to in-migrate.

#### ***Corporate Social Responsibility***

BIFPCL runs free weekly health camp for local people. The health camp offers free health consultation and limited medicine.

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## Abbreviations and Acronyms

|           |   |
|-----------|---|
| AECL      | Adroit Environment Consultants Ltd  |
| AAS       | Atomic Absorption Spectrophotometer   |
| BIFPCL    | Bangladesh India Friendship Power Plant Company Ltd   |
| BOD       | Biochemical Oxygen Demand   |
| BPDB      | Bangladesh Power Development Board  |
| BCSIR     | Bangladesh Council of Scientific and Industrial Research  |
| BUET-BRTC | Bangladesh University of Engineering and Technology- Bureau of Research, Testing and Consultation |
| CEGIS     | Center for Environmental and Geographic Information Services                                      |
| COD       | Chemical Oxygen Demand  |
| CPUE      | Catch per Unit Effort   |
| DO        | Dissolved Oxygen  |
| DoE       | Department of Environment   |
| DPHE      | Department of Public Health Engineering   |
| dBH       | Diameter at Breast Height   |
| EC        | Electric Conductivity   |
| ECR       | Environment Conservation Rules  |
| EIA       | Environmental Impact Assessment   |
| EMP       | Environmental Management Plan   |
| FGD       | Focus Group Discussion  |
| GoB       | Government of Bangladesh  |
| GIS       | Geographic Information System   |
| GPS       | Global Positioning System   |
| HS        | Household Survey  |
| IUCN      | International Union for Conservation of Nature  |
| IFC       | International Finance Corporation   |
| Kg        | Kilogram  |
| KII       | Key Informants Interview  |
| MoPEMR    | Ministry of Power, Energy and Mineral Resources   |
| MW        | Mega Watt   |
| NTPC      | National Thermal Power Corporation  |
| PCU       | Passenger Car Unit  |
| PGCB      | Power Grid Company of Bangladesh Ltd  |



|      |                                      |
|------|--------------------------------------|
| PMU  | Project Management Unit              |
| PRA  | Participatory Rural Appraisal        |
| PMU  | Project Management Unit              |
| PWD  | Public Works Datum                   |
| QMR  | Quarterly Monitoring Report          |
| RRA  | Rapid Rural Appraisal                |
| RS   | Remote Sensing                       |
| SRDI | Soil Resources Development Institute |
| SRF  | Sundarbans Reserve Forest            |
| ToR  | Terms of References                  |
| TDS  | Total Dissolved Solid                |
| TS   | Total Solid                          |

# 1 Introduction

## 1.1 Study Background

1. The Project proponent (BIFPCL) has entrusted CEGIS with the responsibility for conducting the environmental and social monitoring relevant to the pre-construction and construction activities of Khulna 1320 MW Coal Based Thermal Power Plant under the caption "Monitoring of environment parameters and implementation of Environmental Management Plan during pre-construction and construction period along with Engineering Activities for site development of Khulna 1320 MW Coal based Thermal Power Plant".

2. Accordingly, the monitoring during first and second quarter was carried out during the period in March 2014 - April 2014 and June 2014 – July 2014. The Monitoring Reports were submitted in May 2014 (First Quarter) and August 2014 (Second Quarter). Followed by the second quarter monitoring, the third quarter monitoring period was September 2014 – October 2014. The field monitoring activities have been carried out from 28<sup>th</sup> September to 2<sup>nd</sup> October 2014 and 15 October to 29 October 2014.

## 1.2 Objectives of third Quarter Monitoring

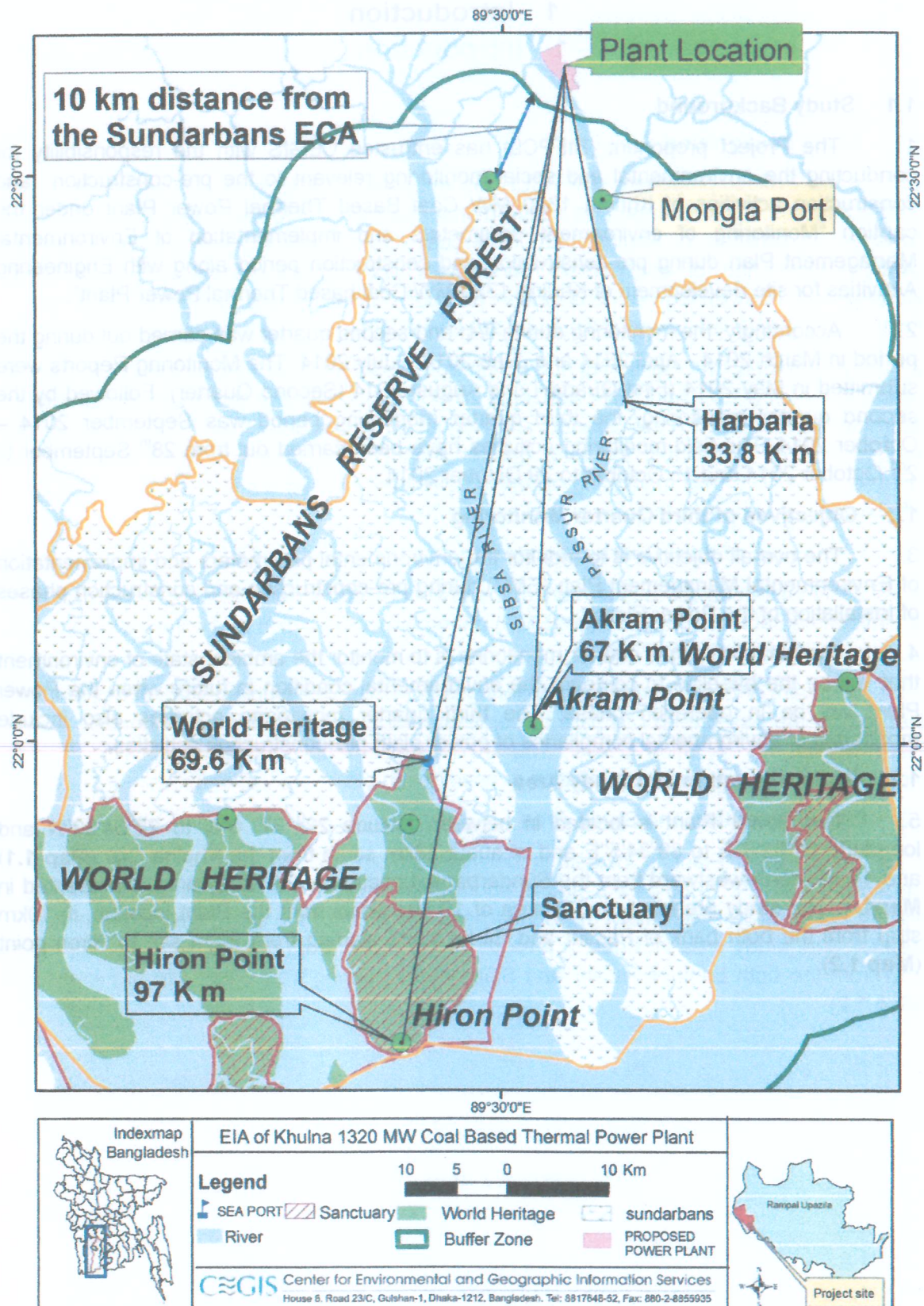
3. The overall objective is to monitor the environmental parameters and implementation of Environmental Management Plan (EMP) during pre-construction and construction phases of installation of the Power Plant.

4. The aim of this third quarter monitoring is to monitor the ambient state of environment that will be the baseline to compare the environmental condition in future when the Power Plant will be in operation phase. The third quarter monitoring activities also include monitoring of environmental compliance of power plant pre-construction activities.

## 1.3 Project Location and Study Area

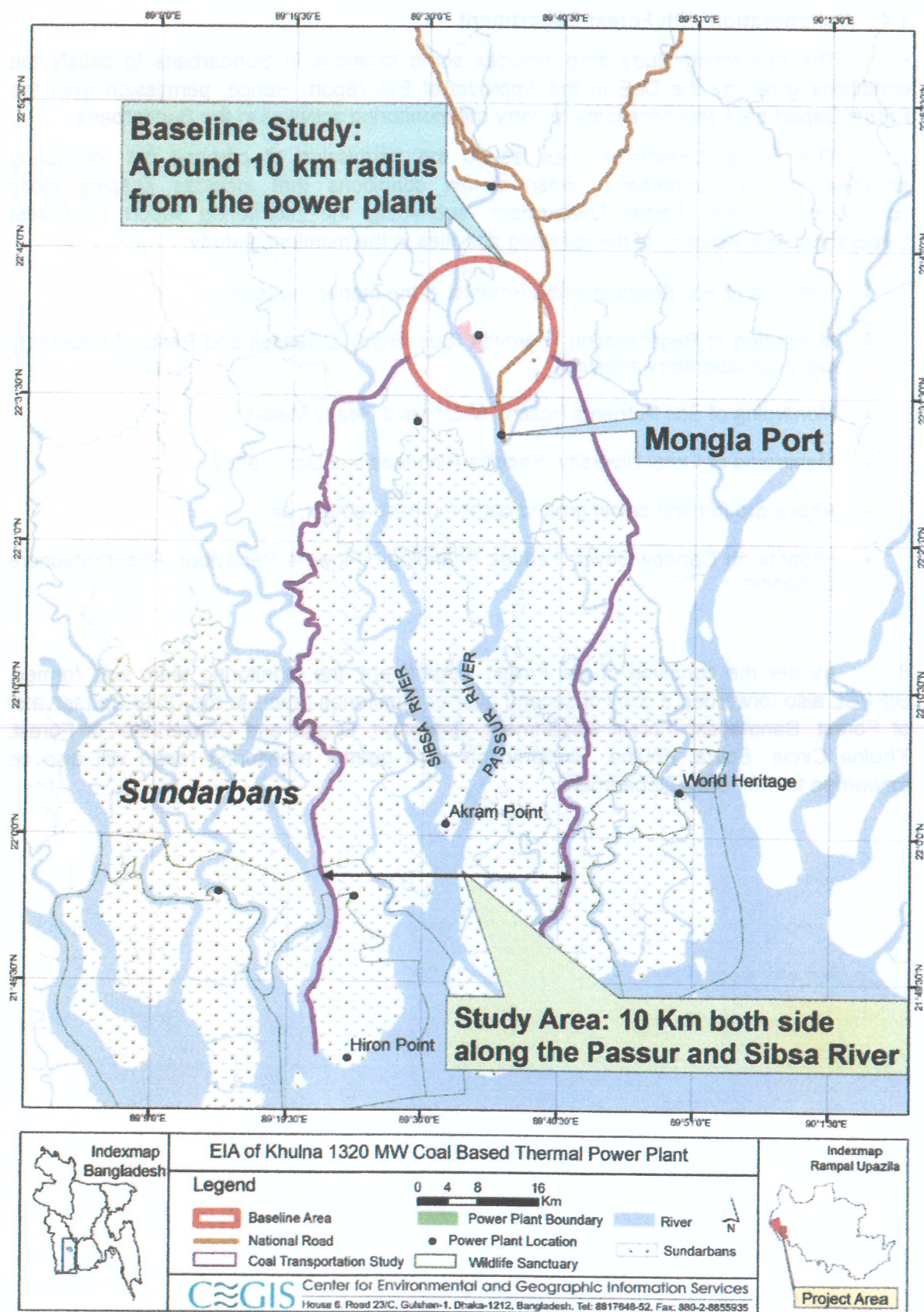
5. The Power Plant is located in between latitude 22° 37' 0"N to 22°34'30"N and longitude 89°32'0"E to 89°34'5"E and at about 23km south from the Khulna City (**Map 1.1**) and 14 km north-westward from the Sundarbans. Location of the study area is presented in **Map1.1**. The study area includes: i) area of 10 km radius from the Plant location, ii) 10km strip from the both bank of Passur and Sibsa rivers starting from Plant site to Hiron point (**Map 1.2**).





Map 1.1: Location Map of the Coal Based Thermal Power Plant





Map1.2: Area under the Interest of Environmental and Socio-economic Monitoring



#### 1.4 Collaboration with Forest Department

6. The monitoring study area includes some locations in Sundarbans to satisfy the conditions given by the DoE in the Approval of EIA report. Hence, permission from the Forest Department was necessary to carry out monitoring activities in the Sundarbans.

7. The Forest Department has issued the permission of carrying out monitoring activities in the Sundarbans under certain conditions that includes keeping close communication with Forest Department, submitting the monitoring report to Forest Department and inclusion of the following activities in the monitoring study:

- Inclusion of Soil Scientist and a Botanist in the monitoring team,
- Monitoring of Regeneration, Ingrowth (Seedlings), Diseases and Pests (if necessary carry out laboratory analysis),
- Monitoring of Soil Nutrients (macro, Micro) and Heavy Metals,
- Monitoring of Floral Diversity, Species Richness and Dominancy,
- Above ground and below ground carbon measurement, and
- Impacts on Canopy Cover, Leaves Phenology, Flowers Behaviour, Pneumatophore Condition

8. As per the condition of the Forest Department, the monitoring team was formed. BIFPCL also forwarded a copy of second quarter monitoring report to the Chief Conservator of Forest, Bangladesh Forest Department, Agargaon, Dhaka and Conservator of Forest, Khulna Circle, Boyra, Khulna. Similarly this third quarter monitoring report will also be forwarded to the Forest Department.

## **2 Monitoring of Environmental Compliance during Pre-construction Activities**

### **2.1 Background**

9. Land development in 426 acres area, construction of a pontoon, construction of overhead transmission line, temporary site office, heli pad, pontoon to site office road and some other activities were completed before engagement of CEGIS as environmental monitoring consultant.

10. At present the following activities are in progress:

- Land development of the remaining 580 acre of land
- Construction of Embankment around the Project site
- Construction of Boundary wall
- Construction of 2 x 200 KV Transformers
- Construction of pre-fabricated site office
- Drinking Water supply, etc.

### **2.2 Monitoring of Environmental Compliance**

11. The environmental compliance monitoring that includes monitoring of EMP implementation was based on physical observation and assessment. A comprehensive diligence checklist was developed to monitor the environmental compliance to different components e.g.:

- Environmental and Social Management System and Action Plan
- Labour and Working Condition
- Community Health, Safety and Security
- Biodiversity and Sustainable Management of Living Natural Resources

12. The aim of the checklists is to check the diligence of measures and effectiveness of the measures. The checklists produce a Compliance Data Sheet that would contain both quantitative and qualitative data. The details of the compliance data sheet are attached in Annex I. The details of the monitoring results of Community Health, Safety and Security, Living and Livelihood Condition and Labor and Working Condition are discussed in Chapter 12. Here, **Table 2.1, 2.2, 2.3 and 2.4** presents summary of the findings of the environmental compliance monitoring:



Table 2.1: Monitoring Environmental and Social Management System Action Plan Implementation

| SI No | Impacts  | Mitigation Measures   | Remarks on Due Dilligence  |
|-------|--|---|--|
| 1     | <p>Generation of Dust from</p> <ul style="list-style-type: none"> <li>land filled area</li> <li>the area under land development process, and</li> </ul>  | <ul style="list-style-type: none"> <li>Installation of water spraying system to control dusts</li> <li>Conducting dust monitoring and visual inspection around the site boundary</li> <li>Fencing the construction site by drum sheet or Tarjja of any other fencing</li> </ul> | <ul style="list-style-type: none"> <li>No measures taken so far to control dust</li> <li>Construction of boundary wall is in progress</li> </ul>   |
| 2     | <p>Generation of Noise (moderate) from</p> <ul style="list-style-type: none"> <li>Dredgers and sand carrying vessels involved in land filling activities</li> <li>Excavator and other machineries involved in land leveling and site development</li> <li>Other machineries e.g. brick crashing, piling, etc</li> <li>Generator</li> </ul> | <ul style="list-style-type: none"> <li>Use efficient machineries fitted with noise control devices</li> <li>Switching off/throttled downing of machines/equipments/generators which are not in use</li> </ul>   | <ul style="list-style-type: none"> <li>Partially complied by Switching off/throttled downing of machines/equipments/generators which are not in use</li> <li>Excavators used in land leveling and site development activities produce minimum noise</li> <li>However, the conventional dredgers used in land filling activities are producing huge noise at project site.</li> </ul> |
| 3     | <p>Generation of Greenhouse gases, SOx, NOx from Generators, dredgers, sand carrying vessels</p>   | <ul style="list-style-type: none"> <li>Use of efficient engines, machineries, generator in the construction activities</li> <li>Regular maintenance of vehicles, generator and machinery in accordance with manufacturer's specifications</li> </ul>                            | <ul style="list-style-type: none"> <li>Partially complied by Switching off/throttled downing of machines/equipments/generators which are not in use</li> <li>Black smoke was noticed visually from the sand carrying vessels</li> </ul>  |

*Monitoring of Environmental Management Plan during Pre-construction Activities*

|   |   |  |  |
|---|---|--|--|
|   |   | <ul style="list-style-type: none"> <li>Switching off and throttling of machines/equipments/generators which are not in use</li> </ul>  | <ul style="list-style-type: none"> <li>Lack of regular maintenance of vehicles, generator and machinery in accordance with manufacturer's specifications</li> </ul>  |
| 4 | No water pollution from construction activities | <ul style="list-style-type: none"> <li>Arrangement of runoff drainage for reducing any water logging</li> <li>Location of backfilling stockpile in safe area and protected from wind and rain action</li> <li>No storing of backfilling materials/spoil stored on river bank/slope</li> <li>No disposal of waste and untreated waste water into the river</li> </ul> | <ul style="list-style-type: none"> <li>Complied</li> <li>Construction of runoff drainage system in the land filled site is in progress</li> <li>All the stockpiles are protected from wind and rain actions</li> <li>No storage of backfilling materials/construction materials on river slope</li> <li>No disposal of waste into the river</li> </ul>   |
| 5 | Waste generation                                | <ul style="list-style-type: none"> <li>Provision of onsite waste management system</li> <li>No disposal of waste and untreated waste water into the river</li> <li>Proper management of sanitary waste</li> </ul>  | <ul style="list-style-type: none"> <li>conventional practice of managing domestic waste on site</li> <li>Labors use open toilets</li> <li>spilling from toilet pit was noticed</li> </ul>  |
| 6 | Improvement of Living and livelihood condition  | <ul style="list-style-type: none"> <li>Development of Access Road for Project</li> <li>Operation of Corporate Social Responsibilities</li> <li>Prohibiting any activities which are subversive to society</li> <li>Offer Employment opportunity to local people</li> </ul>   | <ul style="list-style-type: none"> <li>LGED will construct an access road for this project that might take time. Meanwhile, LGED will develop the existing rural road for communication.</li> <li>BIFPCL is running a weekly health camp at site with an aim of extending it to nearby union parishad offices under the CSR program</li> <li>Local peoples are getting opportunity to work in construction related activities. BIFPCL is hiring labor through third party. The third party is instructed to give priority to locals</li> </ul> |



Table 2.2: Monitoring Labor and Working Condition

| Sl No | Issue  | Measures   | Remarks on Due Dilligence   |
|-------|--|--|---|
| 1     | Providing Safe Working Place and Working Condition | <ul style="list-style-type: none"> <li>• Safe and Appropriate Sanitation and Water Supply System at Site</li> <li>• Installation/Construction of Safety Fence around the project area</li> <li>• Use of Personnel Protective Equipments (i.e. safety suit, safety goggles, ear plug, safety shoes, gloves, dust mask, etc.)</li> <li>• Safety trainings for workers (i.e. fire control, working at height, working in heat, first aid etc.)</li> <li>• Practice of Tool box meeting, safety talks,</li> <li>• Safe Storage of Hazardous Chemicals (e.g. fuel, flammable chemical, toxic chemicals, etc.)</li> <li>• Provision of Health care facilities such as doctor, hospital etc available at/nearby the Plant construction site</li> <li>• Preparation and Follow of Emergency Response Plan</li> <li>• adequate fire precautions in place (for example, fire extinguishers, escape routes)</li> <li>• documentation and reporting of occupational accidents, diseases, and incidents</li> <li>• policies and procedures for managing and monitoring the performance of third party employers in relation to OHS</li> </ul> | <ul style="list-style-type: none"> <li>• Overall Sanitation and Safety system was found unsatisfactory</li> <li>• The sanitation system was found very poor. Temporary toilets at remote construction site were found in adequate, unhygienic (open pit) and causing pollution to nearby water bodies.</li> <li>• Drinking water supply was found limited</li> <li>• Safety procedure was not found mandatory</li> <li>• Limited use of PPE by workers</li> <li>• Workers have access to weekly Health Camp running by the project authority</li> </ul> |

|   |                    |  |  |
|---|--------------------|--|--|
| 2 | Workers Well Being | <ul style="list-style-type: none"> <li>• Establishment Grievance Mechanisms</li> <li>• Ensuring fair treatment, non discrimination and equal opportunity</li> <li>• Compliance of project's labor policy with the national labor law</li> <li>• No Child Labor</li> <li>• No incident of forced labor</li> <li>• Provision of Welfare facilities for Worker/Labor</li> </ul> | <ul style="list-style-type: none"> <li>• Labors have been engaged by third party</li> <li>• No complain about unfair treatment, discrimination were found</li> <li>• Involvement of public representative in selecting labor for the third party has two fold impacts. Their involvement ensures that the labor to be recruited is local. But some locals were blaming them for political biasness</li> <li>• No child labors and forced labor were found</li> </ul> |
|---|--------------------|--|--|

Table 2.3: Monitoring Community Health, Safety and Security

| SI No | Community Issue               | Mitigation Measures  | Remarks on Due Diligence   |
|-------|-------------------------------|--|--|
|       | Community Safety and Security | <ul style="list-style-type: none"> <li>• Practicing Risk Assessment and Evaluation Process</li> <li>• Practicing safe management for hazardous materials which may pose threat to the community</li> <li>• Availability and operation of Emergency Response Plan</li> <li>• Maintaining open communication channel with the local community</li> <li>• training and instruction to the security personnel about their behavior and communication with the local people</li> <li>• Aware the security personnel about the right of the community people</li> <li>• Establishing a grievance mechanism for the community dwellers</li> </ul> | <ul style="list-style-type: none"> <li>• Partially complied. The project construction is at very initial stage. The grievance mechanism, training of security personnel, safe management of hazardous materials, etc are not yet implemented. However, an open communication channel with the local community is maintained. The project authority has recruited mobilized a social worker to maintain liason with local community and to deal different social issues.</li> </ul> |
|       | Community Health              | <ul style="list-style-type: none"> <li>• Provision of providing health service facilities</li> </ul>   | <ul style="list-style-type: none"> <li>• Complied. The BIFPCL has initiated weekly</li> </ul>  |



|  |  |   |  |
|--|--|---|--|
|  |  | to community if the project poses any health risk like sexually transmitted disease, communicable disease, vector-related   | health camp. Each time roughly 150 plus people come to get health service. BIFPCL has plan to extend this service by organizing similar health camp at each nearby unions  |
| Youth Empowerment                                |  | <ul style="list-style-type: none"><li>• Providing training program for the local youth potential to get involved in the project related activities, (If yes, please write down the number of the people received training in the remarks section)</li></ul> | <ul style="list-style-type: none"><li>• No such training has been initiated. However, the project authority is encouraging the locals through different meetings, community visit, etc to admit the youth in different technical training, vocational training program.</li></ul>  |
| Public Communication, Consultation and Awareness |  | <ul style="list-style-type: none"><li>• Arranging public communication/consultation meeting held</li><li>• Sharing of project information shared with local people</li><li>• Organizing environmental and social awareness programs/meetings</li></ul>      | <ul style="list-style-type: none"><li>• Complied</li><li>• The project authority has installed different sign board, bill board, information display board at site.</li><li>• The social worker of the project authority conduct regular community visit and discussion meeting in the nearby communities and villages</li><li>• CEGIS which is engaged for environmental and social monitoring also conducts FGD, KII and informal discussion with the local people to disseminate project information and aware local about different environmental and social issues.</li><li>• The public communication is also maintained through organizing regular health camp at site.</li></ul> |

Table 2.4: Monitoring Biodiversity and Sustainable Management of Living Natural Resources

| SI No | Impacts                      | Mitigation Measures   | Remarks on Due Dilligence   |
|-------|------------------------------|---|---|
| 1     | Impacts on Fisheries         | <ul style="list-style-type: none"> <li>• Use of sediment fences, traps and basins for trapping the sediment, if required</li> <li>• Installation of proper run on/runoff drains</li> <li>• Availability of dispersants for controlling accidental oil spillage</li> <li>• Avoiding fish breeding season (June – August) for sand extraction from river bed</li> </ul> | <p>Partially complied as:</p> <ul style="list-style-type: none"> <li>• Construction of boundary wall is in progress</li> <li>• Construction/installation of proper run on-run off drains are in progress</li> <li>• No dispersants are available at site office to mitigate oil spillage (if happen)</li> </ul> |
| 2     | Impacts on Ecosystem Habitat | <ul style="list-style-type: none"> <li>• No cutting/ felling of trees existing along the river bed</li> <li>• No anchrochment of inter-tidal flood plain area</li> <li>• No disturbance to Dolphin community</li> <li>• Monitoring of Ecosystem Health and Monitoring of Sundarbans Forest Health</li> </ul>  | <ul style="list-style-type: none"> <li>• Complied</li> <li>• Engagement of CEGIS for monitoring ecosystem health and Sundarbans Forest Health ensure the compliance to DoE's condition</li> </ul>   |



**Photo Album of Environmental Compliance Monitoring Activities**



DGM E&C&I briefing Project Information exhibited in the display board to the Monitoring Team



Monitoring Team having discussion with BIFPCL Personnel in site office



Open Pit Toilet installed at construction site, contaminating nearby water bodies



No/Limited use of PPE by the construction workers





**No/Limited use of PPE by the construction workers**



**Temporary shed for labor at project site to take rest during day time**



**Temporary Labor Shed for Night Stay**



**Running of Health Camp at Project site office under CSR Program**

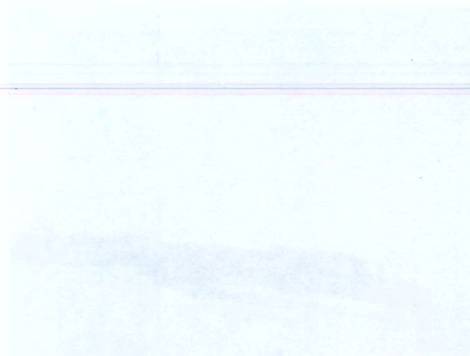
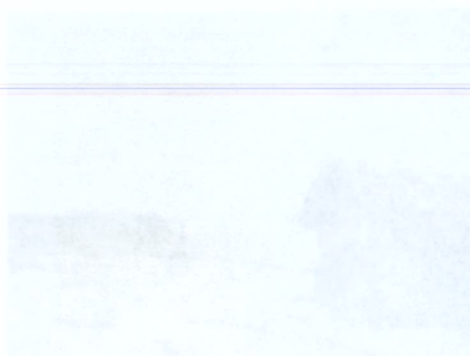




Donnating in different religious and social programm under CSR program



Construction of alternative Access Road by LGED



## 3 Air Quality Monitoring

### 3.1 Methodology

13. With the aim of monitoring the impact of the emission of particulate matter and gaseous pollutants from the Power Plant related activities,  $PM_{2.5}$ ,  $PM_{10}$ ,  $SO_x$ , and  $NO_x$  concentration in the ambient air, have been considered as parameter of monitoring. With relation to the Project related activities, model generated emission dispersion scenario and Environmental Monitoring Plan provided in the Environmental Impact Assessment report (CEGIS, 2013), eleven locations have been identified where concentrations of the aforementioned parameters have been monitored.

#### 3.1.1 Method of Sampling and Laboratory Testing

14. Respirable Dust Sampler (Model-Envirotech India APM-460BL) and Fine Particulate Sampler (Model-Envirotech India APM-550) have been used to collect the air sample. The  $PM_{2.5}$ ,  $PM_{10}$ , and SPM have been tested by gravimetric method. The  $SO_2$  has been absorbed and tested by West-Gaeke method. The  $NO_2$  has been absorbed and tested by Jacob and Hochheiser method.

#### 3.1.2 Locations of air quality monitoring

15. Ambient air quality has been monitored during this third quarter monitoring phase in the same locations as monitored in earlier quarter. The locations of the air quality monitoring points have been shown in **Map 3.1**.





### 3.2 Results of air quality monitoring

#### 3.2.1 PM<sub>2.5</sub>, PM<sub>10</sub> and SPM

16. PM<sub>2.5</sub> and PM<sub>10</sub> were found within the standard limit at each location. SPM was found exceeding the standard level at the Khan Jahan Ali Bridge. High traffic might be the source of SPM there. In Mongla, SPM was found very close to the standard. Industries especially Cement Industries, road traffic and on going dredging operation of Mongla Port Authority in Passur river might be the sources of SPM there. All the monitoring data of ambient air quality are given in Table 3.1.

#### 3.2.2 SO<sub>2</sub>

17. Concentration of Sulfur di oxide in the ambient air was found within the standard. In the Sundarbans reserve forest area, the SO<sub>2</sub> concentration is very low and ranged from 12 to 14 µg/m<sup>3</sup>. In other areas, SO<sub>2</sub> varies in between 19 µg/m<sup>3</sup> to 28 µg/m<sup>3</sup>. All the monitoring data of ambient air quality are given in Table 3.1.

#### 3.2.3 NO<sub>2</sub>

18. Similar to SO<sub>2</sub>, NO<sub>2</sub> concentration in the ambient air of Sundarbans was found very low, varyin from 19 - 27 µg/m<sup>3</sup>. In Project site and its adjoining areas, NO<sub>2</sub> concentrations were found a little bit higher than that of Sundarbans but still within the standard limit. Among the 11 locations, NO<sub>2</sub> concentration was highest, 41 µg/m<sup>3</sup>, at Khan Jahan Ali Bridge. The monitoring results are shown in Table 3.1.

#### 3.2.4 CO and O<sub>3</sub>

19. CO and O<sub>3</sub> concentrations are also very low. CO concentration ranges from 110 µg/m<sup>3</sup> to 330 µg/m<sup>3</sup> in Project area and its adjoining areas, while in Sundarbans the concentration ranges 50 µg/m<sup>3</sup> to 70 µg/m<sup>3</sup>.

**Table 3.1: Ambient Air Quality Monitoring Results**

| Locations of Monitoring  | Pollutants        | 1st QM, April 2014                      | 2nd QM, July 2014 | 3rd QM, October 2014 | 4th QM, January 2015 | 5th QM, April 2015 | 6th QM, July 2015 | 7th QM, October 2015 | 8 QM, January 2016 | 9th QM, April 2016 | 10th QM, July 2016 | 11th QM, October 2016 | 12th QM, January 2017 | Bangladesh (DoE) Standard for ambient Air ( ECR 2005) | IFC/WB Standard |
|--------------------------|-------------------|---|-------------------|----------------------|----------------------|--------------------|-------------------|----------------------|--------------------|--------------------|--------------------|-----------------------|-----------------------|---|-----------------|
| Weather                  |                   | Sunny                                   | Rainy/ Cloudy     | Sunny                |                      |                    |                   |                      |                    |                    |                    |                       |                       |   |                 |
| Wind Direction           |                   | SE                                      | SE                | SE                   |                      |                    |                   |                      |                    |                    |                    |                       |                       |   |                 |
|                          |                   | Concentrations are in µg/m <sup>3</sup> |                   |                      |                      |                    |                   |                      |                    |                    |                    |                       |                       |   |                 |
| SW Corner of the PP area | PM <sub>2.5</sub> | 33                                      | 37                | 25                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65  | 75              |
|                          | PM <sub>10</sub>  | 78                                      | 77                | 53                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150   | 150             |
|                          | SPM               | 207                                     | 239               | 190                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200   | NF              |



| Locations of Monitoring                        | Pollutants        | 1st QM, April 2014 | 2nd QM, July 2014 | 3rd QM, October 2014 | 4th QM, January 2015 | 5th QM, April 2015 | 6th QM, July 2015 | 7th QM, October 2015 | 8 QM, January 2016 | 9th QM, April 2016 | 10th QM, July 2016 | 11th QM, October 2016 | 12th QM, January 2017 | Bangladesh (DoE) Standard for ambient Air (ECR 2005) | IF WB Standard |
|--|-------------------|--------------------|-------------------|----------------------|----------------------|--------------------|-------------------|----------------------|--------------------|--------------------|--------------------|-----------------------|-----------------------|--|----------------|
| Weather  |                   | Sunny              | Rainy/ Cloudy     | Sunny                |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                |
| Wind Direction                                 |                   | SE                 | SE                | SE                   |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                |
| Concentrations are in $\mu\text{g}/\text{m}^3$ |                   |                    |                   |                      |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                |
|  | SO <sub>2</sub>   | 21                 | 24                | 19                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125            |
|  | NO <sub>x</sub>   | 26                 | 29                | 27                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200            |
|  | CO                | 120                | 188               | 140                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF             |
|  | O <sub>3</sub>    | 27                 | 26                | 19                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160            |
| Proposed Township area of the PP               | PM <sub>2.5</sub> | 39                 | 48                | 48                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75             |
|  | PM <sub>10</sub>  | 89                 | 90                | 74                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150            |
|  | SPM               | 217                | 263               | 217                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF             |
|  | SO <sub>2</sub>   | 19                 | 28                | 22                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125            |
|  | NO <sub>x</sub>   | 29                 | 39                | 27                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200            |
|  | CO                | 165                | 210               | 230                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF             |
|  | O <sub>3</sub>    | 33                 | 26                | 26                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160            |
| NW Corner of the PP area                       | PM <sub>2.5</sub> | 37                 | 44                | 19                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75             |
|  | PM <sub>10</sub>  | 67                 | 78                | 56                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150            |
|  | SPM               | 234                | 217               | 157                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF             |
|  | SO <sub>2</sub>   | 19                 | 22                | 18                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125            |
|  | NO <sub>x</sub>   | 23                 | 28                | 22                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200            |
|  | CO                | 110                | 178               | 110                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF             |
|  | O <sub>3</sub>    | 25                 | 19                | 17                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160            |
| Barni, Gauramba                                | PM <sub>2.5</sub> | 39                 | 47                | 57                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75             |
|  | PM <sub>10</sub>  | 103                | 122               | 67                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150            |
|  | SPM               | 233                | 244               | 183                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF             |
|  | SO <sub>2</sub>   | 21                 | 23                | 17                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125            |
|  | NO <sub>x</sub>   | 25                 | 28                | 22                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200            |
|  | CO                | 175                | 210               | 190                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF             |
|  | O <sub>3</sub>    | 26                 | 29                | 22                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160            |



| Locations of Monitoring                        | Pollutants        | 1st QM, April 2014 | 2nd QM, July 2014 | 3rd QM, October 2014 | 4th QM, January 2015 | 5th QM, April 2015 | 6th QM, July 2015 | 7th QM, October 2015 | 8 QM, January 2016 | 9th QM, April 2016 | 10th QM, July 2016 | 11th QM, October 2016 | 12th QM, January 2017 | Bangladesh (DoE) Standard for ambient Air (ECR 2005) | IFC/WB Standard |
|--|-------------------|--------------------|-------------------|----------------------|----------------------|--------------------|-------------------|----------------------|--------------------|--------------------|--------------------|-----------------------|-----------------------|--|-----------------|
| Weather  |                   | Sunny              | Rainy/ Cloudy     | Sunny                |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                 |
| Wind Direction                                 |                   | SE                 | SE                | SE                   |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                 |
| Concentrations are in $\mu\text{g}/\text{m}^3$ |                   |                    |                   |                      |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                 |
| Chunkuri-2, Dacope                             | PM <sub>2.5</sub> | 35                 | 39                | 46                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 77                 | 86                | 69                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 117                | 113               | 162                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 19                 | 24                | 21                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |
|  | NO <sub>x</sub>   | 23                 | 26                | 27                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 190                | 205               | 170                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 27                 | 24                | 18                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |
| Pankhali, Dacope                               | PM <sub>2.5</sub> | 47                 | 49                | 57                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 119                | 127               | 139                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 297                | 266               | 254                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 28                 | 31                | 31                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |
|  | NO <sub>x</sub>   | 41                 | 39                | 36                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 230                | 217               | 250                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 49                 | 38                | 36                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |
| Mongla Port area                               | PM <sub>2.5</sub> | 47                 | 55                | 39                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 139                | 174               | 77                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 288                | 303               | 197                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 27                 | 28                | 26                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |
|  | NO <sub>x</sub>   | 44                 | 39                | 33                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 230                | 320               | 220                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 57                 | 52                | 37                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |
| Harbaria, Sundarbans                           | PM <sub>2.5</sub> | 19                 | 22                | 33                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 41                 | 39                | 59                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 111                | 117               | 129                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 9                  | 10                | 14                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |



| Locations of Monitoring                        | Pollutants        | 1st QM, April 2014 | 2nd QM, July 2014 | 3rd QM, October 2014 | 4th QM, January 2015 | 5th QM, April 2015 | 6th QM, July 2015 | 7th QM, October 2015 | 8 QM, January 2016 | 9th QM, April 2016 | 10th QM, July 2016 | 11th QM, October 2016 | 12th QM, January 2017 | Bangladesh (DoE) Standard for ambient Air (ECR 2005) | IF /WB Standard |
|--|-------------------|--------------------|-------------------|----------------------|----------------------|--------------------|-------------------|----------------------|--------------------|--------------------|--------------------|-----------------------|-----------------------|--|-----------------|
| Weather  |                   | Sunny              | Rainy/ Cloudy     | Sunny                |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                 |
| Wind Direction                                 |                   | SE                 | SE                | SE                   |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                 |
| Concentrations are in $\mu\text{g}/\text{m}^3$ |                   |                    |                   |                      |                      |                    |                   |                      |                    |                    |                    |                       |                       |  |                 |
|  | NO <sub>x</sub>   | 19                 | 22                | 27                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 65                 | 58                | 70                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 13                 | 12                | 13                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |
| Akram Point Sundarbans                         | PM <sub>2.5</sub> | 17                 | 19                | 23                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 39                 | 44                | 32                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 114                | 133               | 97                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 7                  | 9                 | 12                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |
|  | NO <sub>x</sub>   | 17                 | 19                | 22                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 49                 | 60                | 50                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 11                 | 14                | 9                    |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |
| Hiron Point Sundarbans                         | PM <sub>2.5</sub> | 15                 | 23                | 19                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 44                 | 38                | 34                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 101                | 119               | 107                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 8                  | 7                 | 13                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |
|  | NO <sub>x</sub>   | 18                 | 18                | 19                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 52                 | 62                | 65                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 14                 | 13                | 11                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |
| Khulna City, near Khanjahan Ali Bridge         | PM <sub>2.5</sub> | 54                 | 39                | 52                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 65   | 75              |
|  | PM <sub>10</sub>  | 139                | 117               | 91                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 150  | 150             |
|  | SPM               | 301                | 287               | 239                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 200  | NF              |
|  | SO <sub>2</sub>   | 33                 | 29                | 33                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 365  | 125             |
|  | NO <sub>x</sub>   | 49                 | 41                | 39                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 100  | 200             |
|  | CO                | 330                | 370               | 330                  |                      |                    |                   |                      |                    |                    |                    |                       |                       | 40000*   | NF              |
|  | O <sub>3</sub>    | 59                 | 67                | 57                   |                      |                    |                   |                      |                    |                    |                    |                       |                       | 160*   | 160             |

Note:

- Concentrations are in  $\mu\text{g}/\text{m}^3$  DoE- Department of Environment, NF – Not found
- Fine Particulate Matter ( $\text{PM}_{2.5}$ ), Respirable Dust Content ( $\text{PM}_{10}$ ), Suspended Particulate Matter (SPM), Oxides of Nitrogen ( $\text{NO}_x$ ), Sulphur Di-Oxide ( $\text{SO}_2$ ), Carbone Mono-Oxide (CO), & Ozone ( $\text{O}_3$ ).
- All standards are for 24hr average except CO and  $\text{O}_3$ , standards for CO and  $\text{O}_3$  are for 1 hr average.
- This monitoring was carried out by - Respirable Dust Sampler (Model-Envirotech India APM-460BL) and Fine Particulate Sampler (Model-Envirotech India APM-550).

### **3.3 Pollution Sources**

#### **3.3.1 Pollution sources at Project area**

20. A number of cement industries and petroleum industries are currently operating along the Passur River at different locations in between the Project site and Mongla Port area.

#### **3.3.2 Pollution sources in the Sundarbans**

21. Mostly river traffics of Mongla Port area traveling across the Sundarbans are the sources of Suspended Particulate Matter (SPM), Oxides of Sulfur ( $\text{SO}_x$ ), Oxides of Nitrogen ( $\text{NO}_x$ ) and Green House Gas (GHG) in the Sundarbans. An inventory of the current emission sources in the study area with the types of emissions have been provided in **Table 3.2**.



### Table 3.2: Baseline Emission Inventory

[illegible]



[illegible]



|  |      |   |                 |   |                    |   |             |   |              |   |                            |   |                           |   |                              |   |                |   |                 |   |                           |   |                   |   |                       |   |                               |   |                                   |   |                            |   |  |   |                      |   |                     |   |                     |   |                           |   |                  |   |                               |   |                     |   |
|--|------|---|-----------------|---|--------------------|---|-------------|---|--------------|---|----------------------------|---|---------------------------|---|------------------------------|---|----------------|---|-----------------|---|---------------------------|---|-------------------|---|-----------------------|---|-------------------------------|---|-----------------------------------|---|----------------------------|---|--|---|----------------------|---|---------------------|---|---------------------|---|---------------------------|---|------------------|---|-------------------------------|---|---------------------|---|
|  | GHGs | X | Cement Industry | X | Petroleum Industry | ✓ | Brick Field | ✓ | Road Traffic | ✓ | Small vessels, engine boat | ✓ | Inland Water Cargo vessel | X | Sea going Mother Vessel (MV) | ✓ | Flyash Carrier | ✓ | Klinker Carrier | ✓ | Clinker, Fly Ash Handling | X | Coal Carrier (MV) | X | Coal Ash Carrier (MV) | X | Coal Carrier (Lighter Vessel) | X | Coal Ash Carrier (Lighter Vessel) | X | Coal Loading and Unloading | X | Coal Handling (Stock Yard, Conveyor belt, etc) | X | BIF Power Plant (PP) | X | Other Coal Based PP | X | Other Fuel Based PP | X | Dredging and Land Filling | X | Earth excavation | X | Other Construction Activities | X | Residential sources | ✓ |
|--|------|---|-----------------|---|--------------------|---|-------------|---|--------------|---|----------------------------|---|---------------------------|---|------------------------------|---|----------------|---|-----------------|---|---------------------------|---|-------------------|---|-----------------------|---|-------------------------------|---|-----------------------------------|---|----------------------------|---|--|---|----------------------|---|---------------------|---|---------------------|---|---------------------------|---|------------------|---|-------------------------------|---|---------------------|---|

Legend X Absence of source or no emission, ✓ Presence of source, emission of pollutant

## **4 Noise Monitoring**

### **4.1 Methodology**

22. Noise levels were measured for thrice in a day (morning, afternoon and evening) in each of the 11 locations selected for noise monitoring. Each time noise level was recorded for a five minutes time span with a 30 second intervals by using portable noise level meter. Depending on the site condition and acoustic environment, the noise meter was set up and calibrated each time following the manufacturer's instruction manual.



**Photo 4.1: Specialists calibrating and setting up noise meter at site before use**

### **4.2 Locations of Noise Monitoring**

23. There are eleven locations for noise level monitoring. Three locations are inside the Sundarbans, six locations are in and around the Project site, one is at Khanjahan Ali Bridge and one is at Mongla Port (Map 4.1).





### 4.3 Results of Noise Monitoring

#### 4.3.1 Noise at Dacope Upazila Parishad

24. The monitoring location was at Chalna Upazila Market which falls under commercial area. According to Environmental Conservation Rules (ECR), 1997, noise level standard for commercial area is 70dB(A). The monitoring data shows that noise level of third quarter monitoring are higher than the noise level of second quarter but still are within the standard (Table 4.1).

25. There, the significant noise sources were road traffic and people's crowd. The road traffics were mostly from locally made engine van (locally called as Nosimon), motor bike, easy bike (battery operated tri-cycle), etc. Traffic load was comparatively lower than that of first quarter monitoring due to rain fall that eventually resulted the less noise.

#### 4.3.2 Noise at North West Corner of the Project Area

26. The North West (NW) corner of the Project area falls in Kaigar daskati mouza of Gauramba union. The monitoring location was nearby Gucchagram (a cluster village built by the Government for the landless and homeless people). This area can be categorized as residential area where standard maximum ambient noise level is 50dB(A) at day time (ECR, 1997). This time due to rough weather the noise level could not be monitored during the field visit.

#### 4.3.3 Noise at Chunkuri-2, Bajua

27. This area is classified as residential where the standard maximum ambient noise level is 50dB (A) at day time (ECR, 1997). Similar to first quarter monitoring, noise levels during the second quarter monitoring were also found exceeding the standard limit (Table 4.1). The significant noise sources are road traffic and people's crowd. The road traffics were mostly locally made engine van (called as Nosimon), motorcycle, bicycle, van, etc which are very frequent here.

#### 4.3.4 Noise at South West corner of the Project area

28. The South West corner of the Project area falls in Sapmari Katakhal mouza of Rajnagar union. The area also falls under residential class. ECR, 1997, defines 50dB(A) as the standard maximum ambient noise level for this class at day time. Similar to the earlier monitoring, noise levels in this quarter monitoring were within standard limit (Table 4.1).

#### 4.3.5 Noise at proposed township area of the Project

29. The proposed township area of the Power Plant is located at the middle of the eastern portion of the Project area. The area falls under residential or rural class of the noise standard where the standard of the maximum ambient day time noise is 50dB(A). Similar to the first quarter monitoring, noise levels were within standard limit in this quarter monitoring also (Table 4.1).

#### 4.3.6 Noise at Barni, Gaurambha

30. This area also falls under residential class where the standard maximum ambient noise level is 50 dB(A) at day time. The noise levels were found a little bit higher than the



standard noise level during morning and day, however, the average noise level was found within the standard level. Though this area falls under rural classification, the commercial activities like bazaar, local traffic, crowd etc are increasing.

#### **4.3.7 Noise at Khan Jahan Ali Bridge, Khulna**

31. The monitoring location is near the toll booth of the Khan Jahan Ali bridge, Khulna. This area falls under commercial class where the standard maximum ambient noise level is 70 dB(A) at day time. During the noise levels were found within the standard limit. Here the road traffic is the main source of noise. In the day of monitoring, Noise was found higher during morning and evening where traffic load was also higher. In morning, the noise was found above the standard. It is expected, this road will be busier in coming days due to increase of port activities.

#### **4.3.8 Noise at Mongla Port area**

32. The monitoring location was at Khulna-Mongla highway, 200m northward from the main entrance of the Mongla Port area. The area is completely industrial. The ECR 1997 defines ambient maximum noise level for this class as 75dB(A). During the 3<sup>rd</sup> quarter monitoring noise levels were found within the standard level.

33. The sources of noise were mostly road traffic (heavy vehicles, light vehicles, Nosimon, etc) and noise from Mongla Port activities (crane, ships, etc).

#### **4.3.9 Noise at Harbaria, Sundarbans**

34. Harbaria area of the Sundarbans is very critical in terms of biodiversity consideration. The area is also important for sea going vessels of Mongla Port Area. Most of the sea going vessel of the Port anchor here for lighterage operation. The area falls under silent class of noise standard and the ambient day time noise standard is 45dB(A) (ECR, 1997). Here, noise was recorded at about 100m inside the forest from right bank of the Passur River to avoid noise from wave breaking. The ambient noise levels were found above the standard. Ships movement, Ship Salvage operation, engines of anchored ships, wind, birds, wave, and wick action on tree leaves were the main sources of noise in this location.

#### **4.3.10 Noise at Akrampoint, Sundarbans**

35. Akram Point area of the Sundarbans is another biodiversity hot spot in Sundarbans. This area has been selected for anchorage area of coal carrying mother vessel for the Power Plant. This area also falls under the silent zone where the ambient day time noise standard is 45dB(A). The monitoring location is at the left bank of the Sibsa river. Noise was recorded at about 100m inside the forest from the river bank to avoid noise from wave breaking. The ambient noise level was found above the standard limit. Birds, stormy wind, wave and tree leaves are the main sources of noise here.

#### **4.3.11 Noise at Hiron Point, Sundarbans**

36. Hiron point falls under wildlife sanctuary zone of Sundarbans. As per the Noise Control Rules, 2006, the appropriate standard for this zone would be 45dB(A). Noise level was recorded during morning only. The ambient noise level was found above the standard limit. Birds, stormy wind, wave breaking on the sandy shore and tree leaves are the main sources of noise here.

37. The recorded noise was above the standard level. High wave breaking on the shore was the main source of noise.



Table 4.1: Summary of the ambient noise monitoring

| Sl. No | Location                             | QM1 (Noise Level in dB (A)) |                   |                 |              | QM2 (Noise Level in dB (A)) |                   |                 |              | QM3 (Noise Level in dB (A)) |                   |                 |              | Std*         |              |
|--------|--------------------------------------|-----------------------------|-------------------|-----------------|--------------|-----------------------------|-------------------|-----------------|--------------|-----------------------------|-------------------|-----------------|--------------|--------------|--------------|
|        |                                      | Morning (9:00)              | Afternoon (13:00) | Evening (18:00) | Day time AVG | Morning (9:00)              | Afternoon (13:00) | Evening (18:00) | Day time AVG | Morning (9:00)              | Afternoon (13:00) | Evening (18:00) | Day time AVG | Day time AVG | Day time AVG |
| 1      | Chalna, Dacope                       | 80.32                       | 60.86             | 63.22           | 68.13        | 52.71                       | 55.62             | 50.27           | 52.87        | 53.37                       | 53.52             | 57.00           | 54.63        | 70.00        |              |
| 2      | NW Corner of the Project area        | 55.23                       | 53.00             | 47.43           | 51.89        | NM                          | NM                | NM              | NM           | 42.67                       | 41.73             | 41.37           | 41.92        | 50.00        |              |
| 3      | Chunkun-2, Bajua                     | 62.69                       | 57.19             | 53.39           | 57.76        | 54.61                       | 51.14             | 51.90           | 52.55        | 52.26                       | 51.14             | 50.76           | 51.39        | 50.00        |              |
| 4      | SW corner of the project area        | 49.20                       | NM                | NM              | 49.20        | 44.55                       | 48.94             | 49.33           | 47.60        | 45.56                       | 45.10             | 47.18           | 45.95        | 50.00        |              |
| 5      | Proposed Township area, project site | 47.80                       | 49.70             | NM              | 48.75        | 46.15                       | 47.21             | NM              | 46.68        | 42.67                       | 41.73             | 41.37           | 41.92        | 50.00        |              |
| 6      | Barni, Gauramba                      | 64.95                       | 50.93             | 60.65           | 58.84        | 48.73                       | 50.37             | 50.75           | 49.95        | 50.18                       | 50.89             | 48.27           | 49.78        | 50.00        |              |
| 7      | Khan Jahan Ali Bridge, Khulna        | 76.12                       | 66.72             | 72.25           | 71.70        | 55.97                       | 64.68             | 61.75           | 60.80        | 72.24                       | 58.30             | 68.30           | 66.28        | 70.00        |              |
| 8      | Mongla Port area                     | 69.38                       | 54.55             | 59.79           | 61.24        | 54.75                       | 54.20             | 52.58           | 53.84        | 66.80                       | 55.20             | 59.50           | 60.50        | 75.00        |              |
| 9      | Harbaria, Sundarbans                 | 39.24                       | NM                | 42.51           | 40.88        | 59.25                       | 60.52             | 48.62           | 56.13        | 54.08                       | 56.51             | NM              | 55.30        | 45.00        |              |
| 10     | Akram Point, Sundarbans              | 40.95                       | 41.98             | 39.90           | 40.94        | 48.95                       | 46.86             | NM              | 47.90        | 45.27                       | 42.69             | NM              | 43.98        | 45.00        |              |
| 11     | Hiron Point, Sundarbans              | 35.99                       | 40.75             | 39.16           | 38.63        | 51.29                       | NM                | NM              | 51.29        | 47.98                       | 39.42             | NM              | 47.98        | 45.00        |              |

Note: NM – Not Measure, \*Std- Standard as defined in National Noise Control Rules 2006

## **5 Water Quality Monitoring**

### **5.1 Methodology**

38. Monitoring of water quality directly depends on selection of water quality parameters, sampling points, sampling frequency, evaluation criteria etc. Standard practices have been followed for monitoring of water quality of Passur Sibsha River System (RS). This study is measuring both surface and ground water quality parameters to reveal the present water quality status in the surroundings of Rampal Power Plant and the Sundarbans. Monitoring will be carried out at every three months interval (quarterly) and first, second and third monitoring was performed in April, July and October 2014 respectively. As a part of entire monitoring activities, sample collection for third monitoring schedule was started from 19<sup>th</sup> to 27<sup>th</sup> October this year. In future, the same parameters in the same area will be monitored as per the monitoring schedule to observe the changes (if any). In order to establish a strong baseline, the water quality monitoring results are not only been presented but also have been compared with the national and international standards.

### **5.2 Sampling Location**

39. Similar to the first and second quarter monitoring, water samples were collected from pre-selected 15 points for surface water and 4 points for groundwater (**Map 5.1 and 5.2**). These sampling points were preliminary selected at inception stage and finalized during first quarter monitoring. In future, samples will be collected from the same location as well.





### 5.3 Sampling Procedure

40. Sampling of surface and groundwater has been conducted following the standard methodologies and practices. The study area is highly influenced by tidal variation. Hence, temporal and spatial variations of tides have been considered significantly in sampling procedure. The standard sampling procedure maintained in pragmatic manner will reduce the error as well as increase the level of confidence of the results.

41. Each sample was tagged at the time of sampling. Maximum surface water samples were collected during the low tides or relatively slag period after the low tide. Samples were taken 50m away from the riverbank. Samples were collected from a depth of 6 cm below the river surface and only for oil and grease sampling samples were collected from the river surface.

42. Ground water samples were collected from hand pump tube wells after 5-7 minute water extraction. Samples were collected in four kinds of different bottles. Every sampling bottle was rinsed before sampling. Acidified sampling bottles were used for heavy metal (As, Hg, Pb) sampling and wrinkle bottles were used for BOD<sub>5</sub> sampling. Samples were preserved as per standard practices.

43. A number of water quality parameters have been tested on the spot as in-situ measurement. Temperature, pH, DO and Salinity have been tested on the spot while the rest of the samples have been collected, preserved and analyzed in the laboratory.

#### 5.3.1 Surface water quality

44. The selected parameters for water quality monitoring includes Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Heavy Metals (As, Hg, Pb), pH, Salinity, Hardness, Nitrate (NO<sub>3</sub>), Total Dissolve Solids (TDS), Total Hardness (TH), Turbidity, Temperature, Oil and Grease. Selected water quality parameters and their collected locations and frequency of sampling at each of the locations have been presented in Table 5.1.

**Table 5.1: Surface Water Quality Monitoring Parameter and Location**

| Parameters  | Locations of Sampling  |
|---|--|
| DO, BOD, COD, Heavy Metals (As, Hg, Pb), pH, Salinity, Hardness, NO <sub>3</sub> , PO <sub>4</sub> , SO <sub>4</sub> , TDS, Temperature, Oil and Grease | 1. Right Bank of Passur River at 100m u/s of North West corner from the Project boundary |
|   | 2. Middle of the Passur River at 100m u/s of North West corner from the Project boundary |
|   | 3. Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  |
|   | 4. Right Bank of Passur River at the Jetty location of the Project boundary              |
|   | 5. Middle of the Passur River at the Jetty location of the Project boundary              |
|   | 6. Left Bank of Passur River at the Jetty location of the Project boundary               |



| Parameters | Locations of Sampling  |
|------------|--|
|            | 7. Right Bank of Passur River at South West corner from the Project boundary<br>8. Middle of the Passur River at South West corner from the Project boundary<br>9. Left Bank of Passur River at South West corner from the Project boundary<br>10. Maidara river at the township area of the Project<br>11. Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence<br>12. Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence<br>13. Passur river at Harbaria point<br>14. Sibsha river at Akram point<br>15. Passur river at Hiron point |

### 5.3.2 Ground water quality

45. Four points have been selected for monitoring the ground water quality of the study area. Among them, one well is in the Project area near the proposed townships area and other three tube wells are located in the monitoring study area. Samples have been collected from the selected handpump tubewells. Collected samples have been tested in the laboratories of Department of Public Health and Engineering (DPHE). The selected parameters are presented in Table 5.2.

**Table 5.2: Ground Water Quality Monitoring Parameter and Location**

| Parameter   | Location of Sampling   |
|---|--|
| DO, COD, Heavy metals (As, Pb, Hg), pH, salinity, TH, NO <sub>3</sub> , TDS | 1. Deep tube well near the township<br>2. Deep tube well at Rajnagar<br>3. Shallow tube well at Kalikerber<br>4. Deep tube well at Kapashdanga |

### 5.3.3 Water quality analysis procedure

46. Water quality parameters have been selected on the basis of potential impacts during pre-construction, construction and operation phases of the Power Plant Project. The collected samples have been analyzed as per the procedure of APHA standard.



Table 5.3: Testing of Water Quality Parameter

| Parameters                             | Unit | Methods   |
|--|------|---|
| Temperature                            | °C   | TDS meter   |
| pH                                     |      | Microprocessor pH meter   |
| TDS                                    | ppm  | TDS meter   |
| TSS                                    | ppm  | Drying and Filtration   |
| Salinity                               | ppt  | Salinity Refractometer (Master- S/Millim Cal. No. 2493, ATAGO)                                |
| DO                                     | ppm  | Dissolved Oxygen meter DO-5509  |
| BOD                                    | ppm  | 5-Day BOD Test at 20°C  |
| COD                                    | ppm  | Closed Reflux Method  |
| Total Hardness                         | ppm  | Titrimetric   |
| Ortho-Phosphate ( $\text{PO}_4^{3-}$ ) | ppm  | UV-VIS Spectrophotometers   |
| Nitrate ( $\text{NO}_3^-$ )            | ppm  | UV-VIS Spectrophotometers   |
| $\text{SO}_4^{2-}$                     | ppm  | UV-VIS Spectrophotometers   |
| Oil and Grease                         | ppm  | Liquid-liquid extraction with hexane, treatment with silica gel and gravimetric determination |
| As                                     | ppm  | Atomic Absorption Spectrophotometers – Hydride Vapor Generating (AAS-HVG)                     |
| Hg                                     | ppm  | Mercury Analyzer  |
| Pb                                     | ppm  | Atomic Absorption Spectrophotometers – Graphite Furnace (AAS-GF)                              |

47. In case of surface water quality monitoring, the main parameters which have been monitored are grouped into four categories:

- (i) Physical and aggregate properties i.e. pH, Temperature, Salinity, Hardness, TDS, TS, Turbidity, Oil & Grease
- (ii) Inorganic non-metallic constituents i.e. DO,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$  and  $\text{SO}_4^{2-}$
- (iii) Aggregate organic constituents i.e. BOD, COD and
- (iv) Heavy Metals i.e. As, Hg and Pb.

#### 5.4 Results of surface water quality monitoring

##### 5.4.1 On-site tested parameters

###### (a) pH

48. In October (post monsoon season), pH values in the Passur-Sibsha River System varied from 7.0 to 8.2 that are within the standard limit (6.5 – 8.5) of ECR'97 for inland surface. Highest (8.2) pH value was found at Right Bank of Passur River at Project site-Jetty and Middle of Passur River at 100 meter North-West corner of the project boundary. In rest of the places, it varies from 7.0 to 8.1 where second highest pH value (8.1) was found at most of the sampling points in this third quarterly monitoring.

49. The monitoring results show that there is a seasonal variation in pH of the river water. This time (October, 2014), the pH values were found to be higher than the first and



second quarter monitoring which were conducted in April (Pre-monsoon season) and July (Monsoon season), 2014 respectively. During post monsoon, (October-November) river water level normally goes down because of low rainfall and less upstream flow of Passur-Sibsha River system and which was the main reason behind observed high pH values during third quarter monitoring interest.

50. After all, compare to first and second quarter monitoring results, the pH value found in the third quarter monitoring has been increased slightly in the river system. The measured pH values of selected monitoring locations during first, second and third quarterly monitoring of Passur-Sibsha River System (RS) are presented in **Table 5.4**.

**Table 5.4: pH Values of Passur River Water**

| S<br>I | Sampling Locations  | pH Values |         |         |                |
|--------|---|-----------|---------|---------|----------------|
|        |   | 1Q<br>M   | 2Q<br>M | 3Q<br>M | BD<br>Standard |
| 1      | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 7.2       | 7.0     | 8.1     | 6.5 – 8.5      |
| 2      | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 7.2       | 7.0     | 8.2     |                |
| 3      | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 7.2       | 6.9     | 8.0     |                |
| 4      | Left Bank of Passur River at Project site-Jetty                                       | 7.9       | 7.1     | 8.1     |                |
| 5      | Middle Passur River at Project site-Jetty   | 7.1       | 6.9     | 8.1     |                |
| 6      | Right Bank of Passur River at Project site-Jetty                                      | 7.1       | 6.9     | 8.2     |                |
| 7      | Left Bank of Passur River at South West corner from the Project boundary              | 7.4       | 7.0     | 8.1     |                |
| 8      | Middle of Passur River at South West corner from the Project boundary                 | 7.4       | 6.9     | 8.0     |                |
| 9      | Right Bank of Passur River at South West corner from the Project boundary             | 7.3       | 6.8     | 8.0     |                |
| 10     | Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence  | 7.4       | 6.9     | 8.1     |                |
| 11     | Maidara river near proposed township area   | 7.4       | 6.8     | 8.1     |                |
| 12     | Passur river at Passur-Mongla confluence  | 7.3       | 6.8     | 7.4     |                |
| 13     | Passur river at Harbaria of Sundarbans  | 7.9       | 6.9     | 8.0     |                |
| 14     | Passur river at Akram of Sundarbans   | 7.2       | 6.9     | 7.9     |                |
| 15     | Passur river at Hiron point of Sundarbans   | 7.2       | 7.0     | 7.0     |                |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014)

#### (b) Temperature

51. The surface water temperature observed during third quarterly monitoring varies from 27°C to 32°C, which is very common in coastal region. The standard temperature for sustaining aquatic life is 20°C -30°C as per the Environment Conservation Rules 1997 of Bangladesh. The surface water temperature largely depends on daily weather condition. The normal river temperatures were measured in third quarter monitoring and found little bit lower than the second was as October is cooler period than July according to the seasonal weather condition of Bangladesh. The measured temperature values of selected monitoring locations during first, second and third quarterly monitoring of Passur-Sibsha RS are presented in **Table 5.5**.



**Table 5.5: Surface Water Temperature in Passur River**

| S<br>I | Sampling Locations  | Temperature (°C) |     |         |                |
|--------|---|------------------|-----|---------|----------------|
|        |   | 1Q<br>M          | 2QM | 3Q<br>M | BD<br>Standard |
| 1      | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 31               | 33  | 31      | 20 – 30 °C     |
| 2      | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 31               | 33  | 31      |                |
| 3      | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 31               | 33  | 30      |                |
| 4      | Left Bank of Passur River at Project site-Jetty                                       | 31               | 33  | 31      |                |
| 5      | Middle Passur River at Project site-Jetty   | 30               | 32  | 31      |                |
| 6      | Right Left Bank of Passur River at Project site-Jetty                                 | 30               | 32  | 31      |                |
| 7      | Left Bank of Passur River at South West corner from the Project boundary              | 31               | 32  | 30      |                |
| 8      | Middle of Passur River at South West corner from the Project boundary                 | 31               | 31  | 29      |                |
| 9      | Right Bank of Passur River at South West corner from the Project boundary             | 31               | 31  | 29      |                |
| 10     | Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence  | 30               | 31  | 28      |                |
| 11     | Maidara river near proposed township area   | 30               | 32  | 27      |                |
| 12     | Passur river at Passur-Mongla confluence  | 29               | 30  | 32      |                |
| 13     | Passur river at Harbaria of Sundarbans  | 30               | 30  | 27      |                |
| 14     | Passur river at Akram of Sundarbans   | 29               | 29  | 30      |                |
| 15     | Passur river at Hiron point of Sundarbans   | 29               | 30  | 29      |                |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014)

### (c) Salinity

52. Water salinity at the selected sampling stations of Passur-Sibsha RS of consecutive three seasons is presented in **Table 5.6**. In this quarter (October), no salinity was found in the river water from project site to Harbaria. Low salinity was observed in the river section from Akram point to further downstream.

53. In October, freshwater flow from the upstream sources is still significant that confronts the salinity intrusion from the sea. Freshwater influence was dominating in the upstream of Akram point area whereas seawater influence was dominating further downstream of Akram Point.

**Table 5.6: Salinity (ppt) in Passur River**

| SI | Sampling Locations  | Salinity (ppt) |         |         |
|----|---|----------------|---------|---------|
|    |   | 1<br>QM        | 2<br>QM | 3<br>QM |
| 1  | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 11.5           | 2.5     | 0.0     |
| 2  | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 11.5           | 0.3     | 0.0     |
| 3  | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 11.5           | 0.2     | 0.0     |
| 4  | Left Bank of Passur River at Project site-Jetty                                       | 12.0           | 2.2     | 0.0     |



| Sl | Sampling Locations   | Salinity (ppt) |      |      |
|----|--|----------------|------|------|
|    |  | 1 QM           | 2 QM | 3 QM |
| 5  | Middle Passur River at Project site-Jetty  | 12.0           | 0.3  | 0.0  |
| 6  | Right Bank of Passur River at Project site-Jetty                                     | 12.0           | 0.5  | 0.0  |
| 7  | Left Bank of Passur River at South West corner from the Project boundary             | 9.5            | 4.0  | 0.0  |
| 8  | Middle of Passur River at South West corner from the Project boundary                | 9.0            | 0.0  | 0.0  |
| 9  | Right Bank of Passur River at South West corner from the Project boundary            | 10.0           | 2.5  | 0.0  |
| 10 | Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence | 10.0           | 0.5  | 0.0  |
| 11 | Maidara river near proposed township area  | 9.0            | 4.5  | 0.0  |
| 12 | Passur river at Passur-Mongla confluence   | 10.0           | 9.5  | 0.0  |
| 13 | Passur river at Harbaria of Sundarbans   | 12.0           | 10.0 | 0.0  |
| 14 | Passur river at Akram of Sundarbans  | 19.0           | 15.0 | 1.0  |
| 15 | Passur river at Hiron point of Sundarbans  | 23.0           | 19.5 | 2.0  |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014)

#### (d) Dissolved Oxygen

54. Passur-Sibsha RS indicated the concentration to be between 4.9 to 7.9 mg/L at pre-monsoon period whereas during monsoon, DO level fluctuated from 5.9 to 7.3 mg/L. Post monsoon observation at the measuring stations recorded DO level to be between 5.6 to 8.0 mg/L. Maximum and minimum concentration of DO was measured in post monsoon and pre-monsoon periods respectively.

55. The higher values of DO in the upstream stations may be due to DO enriched inland freshwater input through the river. In addition, the oxygen saturation concentration depends on temperature and salinity (Weiss 1970). High temperature and salinity cause the oxygen to be relatively low (Badran 2001): the higher the temperature, the lower the solubility of oxygen in seawater. Monitoring results found relatively low DO level through the river directed from upstream to downstream of the Passur-Sibsha RS as salinity is decreasing from downstream to upstream of the same RS.

56. The measured DO values at different locations during first, second and third quarterly monitoring of Passur-Sibsha RS are presented in Table 5.7.

Table 5.7: Dissolve Oxygen in Passur River

| SL | Sampling Locations  | Dissolve Oxygen (mg/L) |      |      |   |
|----|---|------------------------|------|------|---|
|    |   | 1Q M                   | 2Q M | 3Q M | BD Standard                                   |
| 1  | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 5.9                    | 6.1  | 5.6  | 5 or more (standard for sustaining fisheries) |
| 2  | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 4.9                    | 6.8  | 7.7  |   |
| 3  | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 5.2                    | 6.7  | 7.7  |   |
| 4  | Left Bank of Passur River at Project site-Jetty                                       | 5.7                    | 6.8  | 7.6  |   |
| 5  | Middle Passur River at Project site-Jetty   | 5.9                    | 6.9  | 7.2  |   |
| 6  | Right Bank of Passur River at Project site-Jetty                                      | 5.8                    | 6.6  | 8.0  |   |



| SL | Sampling Locations   | Dissolve Oxygen (mg/L) |         |         |                |
|----|--|------------------------|---------|---------|----------------|
|    |  | 1Q<br>M                | 2Q<br>M | 3Q<br>M | BD<br>Standard |
| 7  | Left Bank of Passur River at South West corner from the Project boundary             | 6.6                    | 7.3     | 5.6     |                |
| 8  | Middle of Passur River at South West corner from the Project boundary                | 6.5                    | 7.1     | 5.6     |                |
| 9  | Right Bank of Passur River at South West corner from the Project boundary            | 6.5                    | 7.2     | 5.8     |                |
| 10 | Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence | 6.0                    | 6.5     | 8.0     |                |
| 11 | Maidara river near proposed township area  | 6.7                    | 6.8     | 8.0     |                |
| 12 | Passur river at Passur-Mongla confluence   | 5.3                    | 6.2     | 7.0     |                |
| 13 | Passur river at Harbaria of Sundarbans   | 5.4                    | 5.9     | 7.0     |                |
| 14 | Passur river at Akram of Sundarbans  | 7.9                    | 6.4     | 7.7     |                |
| 15 | Passur river at Hiron point of Sundarbans  | 7.5                    | 6.5     | 7.8     |                |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014)

#### (e) Biochemical Oxygen Demand

57. During third quarterly monitoring, BOD<sub>5</sub> values varied from 1.7 mg/L to 5.5 mg/L. The highest BOD<sub>5</sub> was found at Ichamoti-Maidara confluence (5.5 mg/L) while lowest BOD<sub>5</sub> observed at Passur-Mongla confluence of Passur River. Beside Ichamoti-Maidara confluence, in some points BOD<sub>5</sub> was little bit high-compared to other locations which are Middle Passur River at 100m upstream of North West corner from the project boundary (4.1 mg/L), Left Bank of Passur River at project site-Jetty (4.0 mg/L) and Maidara river near proposed township area (4.0 mg/L). BOD<sub>5</sub> of post monsoon season of the Passur-Sibsha RS fully complies with the BD standard (6 or less for sustaining fisheries).

58. The measured BOD<sub>5</sub> values at different monitoring locations during first, second and third quarterly monitoring of Passur-Sibsha RS are presented in Table 5.8.

**Table 5.8: BOD<sub>5</sub> of Passur River Water**

| S<br>L | Sampling Locations  | Biochemical Oxygen Demand (mg/L) |     |         |   |
|--------|---|----------------------------------|-----|---------|---|
|        |   | 1QM                              | 2QM | 3Q<br>M | BD<br>Standard                                |
| 1      | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 3.4                              | 2.2 | 1.9     | 6 or less<br>(for<br>sustaining<br>fisheries) |
| 2      | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 4.9                              | 3.3 | 4.1     |   |
| 3      | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 2.2                              | 2.8 | 3.4     |   |
| 4      | Left Bank of Passur River at Project site-Jetty                                       | 3.2                              | 3.1 | 4.0     |   |
| 5      | Middle Passur River at Project site-Jetty   | 3.0                              | 2.5 | 3.5     |   |
| 6      | Right Left Bank of Passur River at Project site-Jetty                                 | 5.8                              | 3.5 | 3.6     |   |
| 7      | Left Bank of Passur River at South West corner from the Project boundary              | 3.9                              | 2.8 | 2.6     |   |
| 8      | Middle of Passur River at South West corner from the Project boundary                 | 3.8                              | 3.3 | 2.8     |   |
| 9      | Right Bank of Passur River at South West corner from the Project boundary             | 6.5                              | 3.8 | 2.9     |   |
| 10     | Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence  | 3.2                              | 3.3 | 5.5     |   |



| S<br>L | Sampling Locations                        | Biochemical Oxygen Demand (mg/L) |     |     |             |
|--------|---|----------------------------------|-----|-----|-------------|
|        |   | 1QM                              | 2QM | 3QM | BD Standard |
| 1      | Maidara river near proposed township area | 4.1                              | 3.7 | 4.0 |             |
| 2      | Passur river at Passur-Mongla confluence  | 2.3                              | 2.2 | 1.7 |             |
| 3      | Passur river at Harbaria of Sundarbans    | 2.2                              | 2.5 | 2.6 |             |
| 4      | Passur river at Akram of Sundarbans       | 5.0                              | 2.9 | 3.7 |             |
| 5      | Passur river at Hiron point of Sundarbans | 4.3                              | 2.7 | 3.9 |             |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014)

#### 5.4.2 Laboratory tested parameters

##### (a) Total Dissolved Solids, Total Hardness and Total Suspended Solids

59. Similar to other coastal rivers in South-western region, sediment load in Passur is also high. Within the monitoring reach the TDS values vary from 12,400 mg/L to 21,500 mg/L in pre-monsoon season. In contrary, during monsoon season it reduces a lot and ranging 251 mg/L - 15,960 mg/L. These results confirmed that the TDS concentrations of the Passur river are comparatively higher than the recommended level of TDS in Bangladesh and in WHO (1000 mg/L) (WHO, 1993 & 2007). Monitoring results also suggest that TDS are low in monsoon and very high in pre-monsoon season in Passur and Sibsha rivers. In monsoon period the Passur-Sibsha river system receives large volume of fresh water compare to pre-monsoon period and hence the river water TDS reduces drastically by mixing up with upstream freshwater (rainfall and surface runoff).

60. During pre-monsoon and monsoon period, the TDS was observed low in upstream and very high in downstream of the said river system. Significant spatial variation was found, because of seawater and the area might be influenced by the erosion-accretion nature of the river. Moreover, rivers those are inter-connected directly to Bay of Bengal, receives huge amount of saline water and hence increase the ions ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Sr}^{2+}$  etc) of the water more than the upstream monitoring points.

61. During the pre-monsoon period, the water hardness in the sampling stations of Passur River was found to be ranged 2,500 mg/L - 13,060 mg/L, whereas it remarkably decreased to 251 mg/L (ranged 251 – 13,625 mg/L) in monsoon season. Availability of large volume of fresh water from upstream of the river mainly influenced to reduce the hardness of the water. Similar to TDS, TH has the same increasing trend of hardness from upstream to downstream in both pre-monsoon and monsoon season of the Passur-Sibsha RS.

62. Total Suspended Solid (TSS) includes solid materials of organic and inorganic origins that are suspended in the water. There are many suspended matters in the water of the Passur-Sibsha RS. The particles may be sand, clay, silt and loam. TSS obtained from this monitoring study was 7 - 598 mg/L during the pre-monsoon season whereas in monsoon it ranged 24 - 310 mg/L. Except at Passur-Mongla confluence (310 mg/L) and Left bank of Passur river at 100 meter upstream of the North West corner from the project boundary (598



mg/L), TSS were found within the standard value (150 mg/L) suggested for Bangladesh (DOE, 1991) during both pre-monsoon and monsoon seasons of this year of monitoring.

63. The TDS, TH and TSS of pre-monsoon and monsoon seasons at different monitoring locations are presented in **Table 5.9**

**Table 5.9: TDS, TH and TSS of Passur River System**

| SL | Sampling Locations  | TDS (mg/L) |       | TH (mg/L) |      | TSS (mg/L) |     |
|----|---|------------|-------|-----------|------|------------|-----|
|    |   | 1QM        | 2QM   | 1QM       | 2QM  | 1QM        | 2QM |
| 1  | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 13060      | 251   | 2900      | 250  | 598        | 126 |
| 2  | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 12630      | 246   | 2500      | 180  | 45         | 92  |
| 3  | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 12900      | 383   | 2650      | 170  | 53         | 112 |
| 4  | Left Bank of Passur River at Project site-Jetty                                       | 13190      | 445   | 2550      | 175  | 54         | 99  |
| 5  | Middle Passur River at Project site-Jetty   | 13330      | 353   | 2600      | 275  | 60         | 100 |
| 6  | Right Bank of Passur River at Project site-Jetty                                      | 13380      | 402   | 2625      | 350  | 55         | 105 |
| 7  | Left Bank of Passur River at South West corner from the Project boundary              | 13180      | 655   | 2550      | 325  | 24         | 116 |
| 8  | Middle of Passur River at South West corner from the Project boundary                 | 13390      | 587   | 2800      | 350  | 27         | 112 |
| 9  | Right Bank of Passur River at South West corner from the Project boundary             | 13240      | 916   | 2500      | 475  | 67         | 37  |
| 10 | Maidara river of the South East corner of the project at Ichamoti-Maidara confluence  | 12480      | 455   | 2500      | 450  | 7          | 65  |
| 11 | Maidara river near proposed township area   | 10970      | 2510  | 2400      | 725  | 9          | 24  |
| 12 | Passur river at Passur - Mongla confluence  | 12800      | 6410  | 3150      | 1400 | 50         | 310 |
| 13 | Passur river at Harbaria of Sundarbans  | 12280      | 9360  | 2625      | 2150 | 65         | 90  |
| 14 | Passur river at Akram of Sundarbans   | 21500      | 15960 | 4500      | 3625 | 115        | 99  |
| 15 | Passur river at Hiron point of Sundarbans   | 21500      | 14050 | 4850      | 3050 | 91         | 72  |

Source: Field Survey- April and July 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

#### (b) Chemical Oxygen Demand

64. In general COD was found higher in Passur-Sibsha River system. The river contain high load of Organic Content. Total Organic Content, 6.25 mg/L -7.91 mg/L found near project site, which is very high and it might be much higher in the Sundarbans region. This high organic content causes high COD. Moreover, a large scale industrial activity is taking place along the left bank of Passur river from Chalna to Harbaria, which may also contribute to the high COD.

65. The COD concentration of pre-monsoon and monsoon seasons at different monitoring locations are presented in **Table 5.10**. In Monsoon (July), COD was found lower than the pre-monsoon (April). In July, higher discharge dilutes the COD load in the river



**Table 5.10: COD of Passur River System**

| Sl | Sampling Locations  | COD (mg/L) |     |
|----|---|------------|-----|
|    |   | 1QM        | 2QM |
| 1  | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 288        | 24  |
| 2  | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 284        | 20  |
| 3  | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 328        | 56  |
| 4  | Left Bank of Passur River at Project site-Jetty                                       | 376        | 28  |
| 5  | Middle Passur River at Project site-Jetty   | 400        | 60  |
| 6  | Right Bank of Passur River at Project site-Jetty                                      | 364        | 496 |
| 7  | Left Bank of Passur River at South West corner from the Project boundary              | 364        | 108 |
| 8  | Middle of Passur River at South West corner from the Project boundary                 | 400        | 40  |
| 9  | Right Bank of Passur River at South West corner from the Project boundary             | 408        | 120 |
| 10 | Maidara river of the South East corner of the project at Ichamoti-Maidara confluence  | 276        | 32  |
| 11 | Maidara river near proposed township area   | 284        | 96  |
| 12 | Passur river at Passur - Mongla confluence  | 408        | 172 |
| 13 | Passur river at Harbaria of Sundarbans  | 372        | 216 |
| 14 | Passur river at Akram of Sundarbans   | 536        | 520 |
| 15 | Passur river at Hiron point of Sundarbans   | 540        | 416 |

Source: Field Survey- April and July 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

### (c) Nitrate, Sulphate and Phosphate

66. Nitrate concentrations as  $\text{NO}_3\text{-N}$  in the Passur-Sibsha RS were generally low and varied from 0.10 to 2.70 mg/L in pre-monsoon season. During monsoon season, nitrate was ranged 0.76 - 3.32 mg/L. Nitrate concentration in monsoon season is comparatively little bit higher than the season pre-monsoon in each of the monitored locations except left bank of Passur River at project site jetty (pre-monsoon, 1.30 mg/L and monsoon, 0.76 mg/L).

67. Generally, over the whole river system the nitrate is showing low concentration and irregular spatial variation in both pre-monsoon and monsoon season.

68. Naturally Sulphate is higher in sea water and river water in coastal region. From the observed dataset, it is seen that generally Sulphate concentration increases from upstream to downstream.

69. The highest  $\text{SO}_4^{2-}$  concentration was observed in pre-monsoon (ranged 1120 - 2600 mg/L) season whereas it is lower in monsoon (ranged 20 - 1400 mg/L) due to dilution effect.

70. The monitoring result shows concentration of phosphate as  $\text{PO}_4\text{-P}$  ranges from 0.50 to 7.51 mg/L in pre-monsoon season. During monsoon, phosphate concentration becomes low due to dilution effect and varies from 0.29 to 2.42 mg/L.

71. The observed  $\text{NO}_3^{2-}$ ,  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentration at different locations during pre-monsoon and monsoon seasons are presented in **Table 5.11**.



**Table 5.11:  $\text{NO}_3^{2-}$ ,  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentration of Passur River System**

| S<br>I. | Sampling Locations  | $\text{NO}_3^{2-}$ (mg/L) |      | $\text{SO}_4^{2-}$ (mg/L) |      | $\text{PO}_4^{2-}$ (mg/L) |      |
|---------|---|---------------------------|------|---------------------------|------|---------------------------|------|
|         |   | 1QM                       | 2QM  | 1QM                       | 2QM  | 1QM                       | 2QM  |
| 1       | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 0.90                      | 2.89 | 1840                      | 20   | 0.52                      | 2.23 |
| 2       | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 0.70                      | 2.40 | 1320                      | 23   | 0.50                      | 1.99 |
| 3       | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 0.10                      | 3.20 | 1280                      | 36   | 1.10                      | 2.55 |
| 4       | Left Bank of Passur River at Project site-Jetty                                       | 1.30                      | 0.76 | 1360                      | 45   | 2.10                      | 0.45 |
| 5       | Middle Passur River at Project site-Jetty   | 1.40                      | 2.69 | 1040                      | 32   | 2.20                      | 2.13 |
| 6       | Right Bank of Passur River at Project site-Jetty                                      | 1.10                      | 2.98 | 1320                      | 20   | 2.00                      | 2.42 |
| 7       | Left Bank of Passur River at South West corner from the Project boundary              | 0.75                      | 2.13 | 1640                      | 60   | 0.57                      | 1.25 |
| 8       | Middle of Passur River at South West corner from the Project boundary                 | 1.10                      | 2.43 | 1520                      | 40   | 1.20                      | 1.51 |
| 9       | Right Bank of Passur River at South West corner from the Project boundary             | 1.20                      | 2.05 | 1280                      | 80   | 1.50                      | 1.10 |
| 10      | Maidara river of the South East corner of the project at Ichamoti-Maidara confluence  | 0.30                      | 2.18 | 1120                      | 20   | 0.55                      | 2.10 |
| 11      | Maidara river near proposed township area   | 0.50                      | 0.88 | 1320                      | 210  | 1.10                      | 0.53 |
| 12      | Passur river at Passur - Mongla confluence  | 0.60                      | 1.52 | 1360                      | 620  | 1.30                      | 0.35 |
| 13      | Passur river at Harbaria of Sundarbans  | 1.40                      | 1.75 | 1560                      | 860  | 1.10                      | 0.56 |
| 14      | Passur river at Akram of Sundarbans   | 2.70                      | 3.32 | 2600                      | 1400 | 1.30                      | 0.29 |
| 15      | Passur river at Hiron point of Sundarbans   | 0.80                      | 2.84 | 2080                      | 1160 | 7.51                      | 0.29 |

Source: Field Survey- April and July 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

#### (d) Heavy Metals

72. As, Pb and Hg concentrations were found very low in river water in both pre-monsoon and monsoon seasons. The observed As, Pb and Hg concentration at different locations during pre-monsoon and monsoon seasons are presented in Table 5.12.



**Table 5.12: As, Pb and Hg concentration of Passur River System**

| S<br>I | Sampling Locations  | As (mg/L) |       | Pb (mg/L) |       | Hg (mg/L) |          |
|--------|---|-----------|-------|-----------|-------|-----------|----------|
|        |   | 1QM       | 2QM   | 1QM       | 2QM   | 1QM       | 2QM      |
| 1      | Left Bank of Passur River at 100m u/s of North West corner from the Project boundary  | 0.002     | 0.003 | 0.053     | 0.004 | <0.00015  | <0.00015 |
| 2      | Middle Passur River at 100m u/s of North West corner from the Project boundary        | 0.002     | 0.003 | 0.055     | 0.002 | <0.00015  | <0.00015 |
| 3      | Right Bank of Passur River at 100m u/s of North West corner from the Project boundary | 0.001     | 0.003 | 0.055     | 0.005 | <0.00015  | <0.00015 |
| 4      | Left Bank of Passur River at Project site-Jetty                                       | 0.002     | 0.004 | 0.057     | 0.002 | <0.00015  | <0.00015 |
| 5      | Middle Passur River at Project site-Jetty   | 0.002     | 0.004 | 0.060     | 0.002 | <0.00015  | <0.00015 |
| 6      | Right Bank of Passur River at Project site-Jetty                                      | 0.002     | 0.003 | 0.058     | 0.002 | <0.00015  | <0.00015 |
| 7      | Left Bank of Passur River at South West corner from the Project boundary              | <0.001    | 0.003 | 0.053     | 0.002 | <0.00015  | <0.00015 |
| 8      | Middle of Passur River at South West corner from the Project boundary                 | <0.002    | 0.004 | 0.054     | 0.003 | <0.00015  | <0.00015 |
| 9      | Right Bank of Passur River at South West corner from the Project boundary             | 0.002     | 0.003 | 0.056     | 0.005 | <0.00015  | <0.00015 |
| 10     | Maidara river of the South East corner of the project at Ichamoti-Maidara confluence  | <0.001    | 0.003 | 0.053     | 0.004 | <0.00015  | <0.00015 |
| 11     | Maidara river near proposed township area   | 0.002     | 0.002 | 0.048     | 0.004 | <0.00015  | <0.00015 |
| 12     | Passur river at Passur - Mongla confluence  | 0.002     | 0.004 | 0.050     | 0.032 | <0.00015  | <0.00015 |
| 13     | Passur river at Harbaria of Sundarbans  | 0.004     | 0.003 | 0.043     | 0.044 | <0.00015  | <0.00015 |
| 14     | Passur river at Akram of Sundarbans   | 0.004     | 0.002 | 0.194     | 0.071 | 0.0020    | <0.00015 |
| 15     | Passur river at Hiron point of Sundarbans   | 0.003     | 0.002 | 0.224     | 0.050 | 0.0023    | <0.00015 |

Source: Field Survey- April and July 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

### (e) Oil and Grease

73. In order to measure the concentration of oil and grease on the course of Passur River, five samples have been collected during the low tide period at surface layer. The analysis has been conducted through standard testing method of APHA. Table 5.13 shows the concentration of oil and grease presents in Passur River. During pre-monsoon and monsoon period, the concentration of oil and grease was found negligible, below 5 mg/L. As the river is tidal in nature, the tidal mixing dilutes the spilled oil. The results of the laboratory analysis are shown in Table 5.13.



**Table 5.13: Oil and grease concentration of Passur River System**

| Sl | Sampling Locations   | Oil and Grease (mg/L) |     | ECR, 1997 (mg/L)* | IFC, 2007 (mg/L) |
|----|--|-----------------------|-----|-------------------|------------------|
|    |  | 1QM                   | 2QM |                   |                  |
| 1  | Left Bank of Passur River at South West corner from the Project boundary | <5                    | <5  | 10                | 10               |
| 2  | Mongla-Passur Confluence   | <5                    | <5  |                   |                  |
| 3  | Passur river at Harbaria of Sundarbans                                   | <5                    | 6.3 |                   |                  |
| 4  | Passur river at Hiron point of Sundarbans                                | <5                    | <5  |                   |                  |
| 5  | Akram Point of Sundarbans  | <5                    | <5  |                   |                  |

Source: Field Survey- April and July 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

\*Drinking water quality standards, The Environment Conservation Rules, 1997

## 5.5 Ground water quality monitoring

### 5.5.1 On-site tested parameters

#### (a) pH and Temperature

74. Physical parameter pH and temperature of the monitored samples fully comply with the drinking water quality standards of ECR, 1997 for three seasons. The pH values of third quarter monitoring (October 2014) found to be varying from 7.9 to 8.0 while temperature was found to be in between 26.0°C to 28.0°C (Table 6.14). The first, second and third monitoring results of four selected locations are presented in Table 5.14.

**Table 5.14: pH and Temperature of Ground Water**

| Sl | Locations              | Tube Well Type    | pH value |      |      |              | Temperature (°C) |      |      |               |
|----|------------------------|-------------------|----------|------|------|--------------|------------------|------|------|---------------|
|    |                        |                   | 1Q M     | 2Q M | 3Q M | BD Standard* | 1Q M             | 2Q M | 3QM  | BD Standard*  |
| 1  | Near Proposed Township | Deep (>600 ft)    | 7.6      | 7.7  | 7.9  | 6.5-8.5      | 27.3             | 28.5 | 26.0 | 20 – 30°<br>C |
| 2  | Rajnagar               | Deep (>600 ft)    | 7.6      | 7.8  | 8.0  |              | 29.6             | 29.9 | 28.0 |               |
| 3  | Kalekharber            | Shallow (<250 ft) | 6.3      | 6.5  | NF   |              | 27.5             | 28.7 | NF   |               |
| 4  | Kapasdanga             | Deep (>600 ft)    | 7.6      | 7.7  | 8.0  |              | 29.2             | 28.9 | 28.0 |               |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), \*\*Non-functional tube well

\*Drinking water quality standards, The Environment Conservation Rules, 1997

#### (b) Salinity and Dissolved Oxygen

75. The hand pump tube wells from which the samples were collected in pre-monsoon, monsoon and post monsoon seasons are fully free from salinity (0 ppt). DO level were found in between 6 mg/L to 7.7 mg/L. ECR 1997 defines DO standard as 6mg/L but it is not clearly mentioned whether it is maximum or minimum concentration. WHO does not consider DO as regulatory parameter for drinking water quality standard.



**Table 5.15: Salinity and DO in Groundwater**

| Sl | Locations              | Tube Well Type    | Salinity (ppt) |     |      |              | DO (mg/L) |     |      |              |
|----|------------------------|-------------------|----------------|-----|------|--------------|-----------|-----|------|--------------|
|    |                        |                   | 1QM            | 2QM | 3QM  | BD Standard* | 1QM       | 2QM | 3QM  | BD Standard* |
| 1  | Near Proposed Township | Deep (>600 ft)    | 0              | 0   | 0    | N/A***       | 4.4       | 5.2 | 6.5  | 6 mg/L       |
| 2  | Rajnagar               | Deep (>600 ft)    | 0              | 0   | 0    |              | 6.0       | 6.2 | 7.7  |              |
| 3  | Kalekharber            | Shallow (<250 ft) | 0              | 0   | NF** |              | 4.4       | 6.0 | NF** |              |
| 4  | Kapasdanga             | Deep (>600 ft)    | 0              | 0   | 0    |              | 6.4       | 6.5 | 6.1  |              |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014)

\*Drinking water quality standards, The Environment Conservation Rules, 1997

\*\*Non-functional tube well

\*\*Not availability

### 5.5.2 Laboratory tested parameters

#### (a) TDS, TSS and TH

76. Ground water TDS, TSS and TH value of first (pre-monsoon) and second (monsoon) quarter monitoring have been presented in **Table 5.16**.

77. During first quarter monitoring (April), TDS was found above the drinking water quality standard in three handpump tube wells. In second quarter (July), which was in monsoon, the TDS was found lower and within the drinking water quality standard.

78. TSS was found within the standard in this quarter. However, TSS was found very higher in the tube well in Kalekarber. This tube well was installed at shallow depth which might be a reason of higher TSS.

**Table 5.16: TDS and TH concentrations in Groundwater**

| SL | Locations                  | Type of tube wells | TDS (mg/L)     |     |              | TSS (mg/L)     |     |              | TH (mg/L)      |     |              |
|----|----------------------------|--------------------|----------------|-----|--------------|----------------|-----|--------------|----------------|-----|--------------|
|    |                            |                    | Tested results |     | BD standard* | Tested results |     | BD standard* | Tested results |     | BD standard* |
|    |                            |                    | 1QM            | 2QM |              | 1QM            | 2QM |              | 1QM            | 2QM |              |
| 1  | Township near project site | Deep (>600 ft)     | 1113           | 999 | 1000 mg/L    | -              | 6   | 10 mg/L      | 425            | 250 | 200-500 mg/L |
| 2  | Rajnagar                   | Deep (>600 ft)     | 4090           | 371 |              | -              | 6   |              | 220            | 175 |              |
| 3  | Kalekharber                | Shallow (<250 ft)  | 1055           | 970 |              | -              | 48  |              | 780            | 450 |              |
| 4  | Kapasdanga                 | Deep (>600 ft)     | 643            | 635 |              | -              | 8   |              | 190            | 140 |              |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

\*Bangladesh Standard for Drinking Water (ECR, 1997)

79. TH was found below the standard in Rajnagar and Kapasdanga. Among the four observation tube well, Kalekharber shows higher TH may be due to its shallower depth.

#### (b) Chemical Oxygen Demand



80. The Bangladesh standard for COD in drinking water is only 4.0 mg/L. However, all the monitoring wells showed higher concentration of COD than the ECR'97 during both in pre-monsoon and monsoon season. In pre-monsoon season, the concentration found in between 28-48 mg/L whereas in monsoon it was 28-36 mg/L. The COD concentrations of first and second quarter monitoring are presented in Table 5.17.

**Table 5.17: COD concentrations of monitored ground water locations**

| Sl | Locations                  | Tube Well Type    | COD (mg/L) |     |             |
|----|----------------------------|-------------------|------------|-----|-------------|
|    |                            |                   | 1QM        | 2QM | BD standard |
| 1  | Township near project site | Deep (>600 ft)    | 32         | 32  | 4           |
| 2  | Rajnagar                   | Deep (>600 ft)    | 28         | 28  |             |
| 3  | Kalekerber                 | Shallow (<250 ft) | 32         | 36  |             |
| 4  | Kapasdanga                 | Deep (>600 ft)    | 48         | 32  |             |

NB. Bangladesh Standard for Drinking Water (ECR, 1997)

#### c. Nitrate

81. Nitrates in all the observed groundwater samples are within the safe levels (10.0 mg/l) guided by the ECR 1997 in the section of Bangladesh Standard for Drinking Water Quality. The observed ground water  $\text{NO}_3^{2-}$ ,  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentrations are presented in Table 5.18.

**Table 5.18:  $\text{NO}_3$ ,  $\text{SO}_4$  and  $\text{PO}_4$  Concentrations in Ground Water**

| Sl | Locations                  | Type of tube wells | $\text{NO}_3^{2-}$ (mg/L) |      |              | $\text{SO}_4^{2-}$ (mg/L) |     |              | $\text{PO}_4^{2-}$ (mg/L) |     |              |
|----|----------------------------|--------------------|---------------------------|------|--------------|---------------------------|-----|--------------|---------------------------|-----|--------------|
|    |                            |                    | Tested results            |      | BD standard* | Tested results            |     | BD standard* | Tested results            |     | BD standard* |
|    |                            |                    | 1QM                       | 2QM  |              | 1QM                       | 2QM |              | 1QM                       | 2QM |              |
| 1  | Township near project site | Deep (>600 ft)     | 0.20                      | 0.48 | 10.0         | -                         | 3   | 400          | -                         | 2.2 | 6.0          |
| 2  | Rajnagar                   | Deep (>600 ft)     | 0.60                      | 0.68 |              | -                         | 2   |              | -                         | 2.5 |              |
| 3  | Kalekharber                | Shallow (<250 ft)  | 0.40                      | 0.56 |              | -                         | 3   |              | -                         | 1.2 |              |
| 4  | Kapasdanga                 | Deep (>600 ft)     | 0.80                      | 0.40 |              | -                         | 10  |              | -                         | 6.2 |              |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

\*Bangladesh Standard for Drinking Water (ECR, 1997)

82.  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentrations monitoring have been appended in this study from the second quarter monitoring.  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  were found within the drinking water quality standard.

#### (d) Arsenic, Lead and Mercury

83. As per the Bangladesh Standard, the maximum acceptable concentration of Arsenic in groundwater is 0.05 mg/L. Among the four tubewell, Kalekharber tubewell, which is installed at shallower depth, was found Arsenic contaminated. Pb and Hg concentration were found very low and much below the highest acceptable limit (Table 5.19).



**Table 5.19: As, Pb and Hg concentrations (mg/L) of monitored ground water locations**

| S<br>l | Locations                  | As (mg/L)      |       |                 | Pb (mg/L)      |        |                     | Hg (mg/L)      |          |                      |
|--------|----------------------------|----------------|-------|-----------------|----------------|--------|---------------------|----------------|----------|----------------------|
|        |                            | Tested results |       | BD<br>standard* | Tested results |        | BD<br>standa<br>rd* | Tested results |          | BD<br>stand<br>ard * |
|        |                            | 1QM            | 2QM   |                 | 1QM            | 2QM    |                     | 1QM            | 2QM      |                      |
| 1      | Township near project site | 0.013          | 0.020 | 0.05            | 0.002          | <0.002 | 0.05                | <0.00015       | <0.00015 | 0.001                |
| 2      | Rajnagar                   | 0.006          | 0.009 |                 | <0.002         | <0.002 |                     | <0.00015       | <0.00015 |                      |
| 3      | Kalekharber                | 0.376          | 0.407 |                 | 0.002          | 0.008  |                     | <0.00015       | <0.00015 |                      |
| 4      | Kapasdanga                 | 0.036          | 0.033 |                 | <0.002         | 0.004  |                     | <0.00015       | <0.00015 |                      |

Source: Field Survey- April, July and October 2014

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014)

\*Bangladesh Standard for Drinking Water (ECR, 1997)

## 6 Transportation Monitoring

### 6.1 Location of Traffic Survey

84. The 3<sup>rd</sup> quarter of first year traffic volume computation survey was conducted on October 20, 2014 (Monday) at five pre-selected monitoring locations which are shown in Map 7.1.

85. The selected sites were Babur Bazar, Rupsha Bridge, Bagha Bazar, Babu Bari (access road) and Katakali. The day on which the survey was conducted, was sunny which ensured normal plying of vehicles on the roads.

### 6.2 Traffic Volume Calculation

86. The survey results were used in computing the traffic volume in Passenger Car Unit (PCU). PCU is a matrix used in Transportation Engineering, to assess traffic-flow rate on roadways. A PCU is essentially the impact that a mode of transport has on traffic variables (such as headway, speed, density) compared to a single car. While calculating the traffic volume in PCU, vehicle conversion factors suggested by the Indian Road Congress were used as mentioned in Table 6.1.

Table 6.1: Factors Used for PCU Calculation

| Mode                   | Factor |
|------------------------|--------|
| Auto Rickshaw          | 0.75   |
| Non Motorized Vehicles | 0.50   |
| Bus                    | 3.0    |
| Utility Vehicle        | 1.0    |
| Micro Bus              | 1.75   |
| Motor Cycle            | 0.75   |
| Passenger Car          | 1.0    |

\*Source: Indian Road Congress



## Transportation Technology

### Transportation Technology

The transportation technology industry is a rapidly growing sector of the economy. It encompasses a wide range of products and services, including automobiles, trucks, buses, trains, and airplanes. The industry is characterized by high levels of innovation and investment in research and development.

One of the key challenges facing the transportation technology industry is the need to improve fuel efficiency and reduce emissions. This has led to the development of new technologies such as hybrid and electric vehicles, which are designed to consume less fuel and produce fewer pollutants.

Another major challenge is the need to improve the safety of transportation systems. This has led to the development of new technologies such as advanced driver assistance systems (ADAS) and autonomous vehicles, which are designed to reduce the risk of accidents and improve the overall safety of the transportation system.

In addition to these challenges, the transportation technology industry is also facing a number of other challenges, including the need to improve the efficiency of transportation systems and the need to develop new technologies to meet the growing demand for transportation services.

Despite these challenges, the transportation technology industry remains a key sector of the economy and is expected to continue to grow in the years ahead. As new technologies are developed and implemented, the industry will be able to meet the growing demand for transportation services in a more efficient and sustainable way.

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### 6.3 Results of Monitoring

87. The summary results of vehicular movements at five different locations are shown in Table 6.2 below considering 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> quarterly monitoring survey. Surveys were carried out at three distinct time periods (8.30 AM to 9.30 AM; 12.30 PM to 1.30 PM; and 4.30 PM to 5.30 PM). The computed values of 3<sup>rd</sup> quarterly monitoring PCU/hour suggest that the location selected at *Rupsha Bridge* occupies the largest number of vehicles, compared to all other roads and the value comprises was 801 PCU/hr from 4.30 PM to 5.30 PM. Very low traffic was observed at the access road of Babur Bazar (access road) with values ranging from 35 to 50 PCU/ hr. The value of PCU in 3<sup>rd</sup> quarter monitoring has been found almost similar to 2<sup>nd</sup> quarter monitoring.

**Table 6.2: Calculated PCU in Five Locations at Three Different Time Period**

| Location                     | 8.30 AM to 9.30 AM |        |        | 12.30 PM to 1.30 PM |        |        | 4.30 PM to 5.30 PM |        |        |
|------------------------------|--------------------|--------|--------|---------------------|--------|--------|--------------------|--------|--------|
|                              | 1st QM             | 2nd QM | 3rd QM | 1st QM              | 2nd QM | 3rd QM | 1st QM             | 2nd QM | 3rd QM |
| Babur Bazar<br>(Access Road) | 30                 | 13     | 41.5   | 23                  | 21     | 34.25  | 24                 | 25     | 46     |
| Rupsha Bridge                | 700                | 566    | 655.25 | 836                 | 829    | 637.25 | 841                | 719    | 801    |
| Babur Bazar<br>(High Way)    | 287                | 249    | 237.25 | 316                 | 341    | 366    | 387                | 373    | 359.25 |
| Bagha Bazar                  | 330                | 299    | 373.75 | 376                 | 429    | 464    | 389                | 493    | 457.5  |
| Chilkathi                    | 445                | 523    | 680.5  | 501                 | 634    | 692    | 508                | 733    | 715.25 |

Source: Field Survey, April, 2014, June 2014 and October 2014

88. The vehicular movements observed during the surveys were mostly for the regular activities. If the Power Plant starts functioning, traffic volume at the access road of Babur Bazar may increase significantly. The detail survey findings regarding the traffic volume surveys as well as the detail calculations are attached in Annex - II (Table A to Table E).





### **7.3 Results of Monitoring**

97. The samples have been submitted to SRDI Laboratory in Dhaka for analysis. The parameter considered for earlier monitoring will be same this quarter as well. The result of the first quarter monitoring which was also presented in 2<sup>nd</sup> quarter report has also been provided in the **Table 7.1** again for use in future.



Table 7.1: Chemical Properties of Soil

| Sl No | Location   | 2014                     |                    |                      |                      | 2015    |                    |         |                      | 2016    |                    |         |                      |
|-------|------------|--------------------------|--------------------|----------------------|----------------------|---------|--------------------|---------|----------------------|---------|--------------------|---------|----------------------|
|       |            | Parameter                | Dry season (April) | Remarks              | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) |
| 1     | Baran Para | Top soil(0-15cm)         |                    |                      |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | EC(ds/m)                 | 9.1                | Moderately saline    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | pH                       | 4.2                | Very strongly acidic |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | OM (%)                   | 3.1                | Medium               |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | N (%)                    | 0.16               | Low                  |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | K (%)                    | 1.00               | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Ca (meq/100g)            | 11.3               | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Mg (meq/100g)            | 10.7               | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Na (meq/100g)            | 5.50               | *                    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | P(µg/gm)                 | 2.7                | Very low             |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | S(µg/gm)                 | 523.2              | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | B(µg/gm)                 | 0.45               | Medium               |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Fe(µg/gm)                | 150.3              | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Mn(µg/gm)                | 7.2                | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Zn(µg/gm)                | 1.4                | Medium               |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Lead(Pb) (µg/gm)         | 31.8               | *                    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Chloride (Cl) (µg/gm)    | 762.2              | *                    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Subsurface soil(15-30cm) |                    |                      |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | EC(ds/m)                 | 8.4                | Moderately saline    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | pH                       | 4.3                | Very strongly acidic |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | OM (%)                   | 2.9                | Medium               |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | N (%)                    | 0.15               | Low                  |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | K (%)                    | 1.0                | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Ca (meq/100g)            | 10.48              | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Mg (meq/100g)            | 8.8                | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Na (meq/100g)            | 5.00               | *                    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | P(µg/gm)                 | 2.9                | Very low             |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | S(µg/gm)                 | 513.7              | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | B(µg/gm)                 | 0.36               | Medium               |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Fe(µg/gm)                | 39.1               | Very high            |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Mn(µg/gm)                | 3.3                | High                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Zn(µg/gm)                | 1.5                | Optimum              |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Lead(Pb) (µg/gm)         | 31.8               | *                    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Chloride (Cl) (µg/gm)    | 398.4              | *                    |                      |         |                    |         |                      |         |                    |         |                      |
|       |            | Substratum(30-45cm)      |                    |                      |                      |         |                    |         |                      |         |                    |         |                      |



| Sl No | Location  | Parameter                | 2014               |                   |                      | 2015    |                    |         | 2016                 |         |         |
|-------|-----------|--------------------------|--------------------|-------------------|----------------------|---------|--------------------|---------|----------------------|---------|---------|
|       |           |                          | Dry season (April) | Remarks           | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks | Remarks |
|       |           | EC(ds/m)                 | 9.6                | Moderately saline |                      |         |                    |         |                      |         |         |
|       |           | pH                       | 5.7                | Slightly acidic   |                      |         |                    |         |                      |         |         |
|       |           | OM (%)                   | 1.6                | Low               |                      |         |                    |         |                      |         |         |
|       |           | N (%)                    | 0.08               | Very low          |                      |         |                    |         |                      |         |         |
|       |           | K (%)                    | 1.0                | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Ca(meq/100g)             | 12.6               | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Mg(meq/100g)             | 15.9               | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Na(meq/100g)             | 6.00               | *                 |                      |         |                    |         |                      |         |         |
|       |           | P(µg/gm)                 | 2.00               | Very low          |                      |         |                    |         |                      |         |         |
|       |           | S(µg/gm)                 | 480.9              | Very high         |                      |         |                    |         |                      |         |         |
|       |           | B(µg/gm)                 | 0.73               | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Fe(µg/gm)                | 51.3               | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Mn(µg/gm)                | 3.9                | High              |                      |         |                    |         |                      |         |         |
|       |           | Zn(µg/gm)                | 1.6                | Optimum           |                      |         |                    |         |                      |         |         |
|       |           | Lead(Pb) (µg/gm)         | 37.8               | *                 |                      |         |                    |         |                      |         |         |
|       |           | Chloride (Cl)(µg/gm)     | 692.9              | *                 |                      |         |                    |         |                      |         |         |
|       |           | Top soil (0-15cm)        |                    |                   |                      |         |                    |         |                      |         |         |
|       |           | EC(ds/m)                 | 11.2               | Moderately saline |                      |         |                    |         |                      |         |         |
|       |           | pH                       | 6.1                | Slightly acidic   |                      |         |                    |         |                      |         |         |
|       |           | OM (%)                   | 2.1                | Medium            |                      |         |                    |         |                      |         |         |
|       |           | N (%)                    | 0.11               | Low               |                      |         |                    |         |                      |         |         |
|       |           | K (%)                    | 1.5                | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Ca(meq/100g)             | 12.3               | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Mg(meq/100g)             | 9.8                | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Na(meq/100g)             | 8.5                | *                 |                      |         |                    |         |                      |         |         |
|       |           | P(µg/gm)                 | 2.7                | Very low          |                      |         |                    |         |                      |         |         |
|       |           | S(µg/gm)                 | 401.9              | Very high         |                      |         |                    |         |                      |         |         |
|       |           | B(µg/gm)                 | 0.57               | Optimum           |                      |         |                    |         |                      |         |         |
|       |           | Fe(µg/gm)                | 60.2               | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Mn(µg/gm)                | 5.3                | Very high         |                      |         |                    |         |                      |         |         |
|       |           | Zn(µg/gm)                | 1.7                | Medium            |                      |         |                    |         |                      |         |         |
|       |           | Lead(Pb) (µg/gm)         | 0.00               | *                 |                      |         |                    |         |                      |         |         |
|       |           | Chloride (Cl)(µg/gm)     | 1957.6             | *                 |                      |         |                    |         |                      |         |         |
| 2.    | Chunkur-2 | Subsurface soil(15-30cm) |                    |                   |                      |         |                    |         |                      |         |         |
|       |           | EC(ds/m)                 | 9.1                | Moderately saline |                      |         |                    |         |                      |         |         |
|       |           | pH                       | 6.7                | Neutral           |                      |         |                    |         |                      |         |         |
|       |           | OM (%)                   | 1.8                | Low               |                      |         |                    |         |                      |         |         |
|       |           | N (%)                    | 0.09               | Very low          |                      |         |                    |         |                      |         |         |
|       |           | K (%)                    | 1.6                | Very high         |                      |         |                    |         |                      |         |         |



| SI No | Location | 2014                 |                    |                   |                      | 2015    |                    |         |                      | 2016    |                    |         |                      |
|-------|----------|----------------------|--------------------|-------------------|----------------------|---------|--------------------|---------|----------------------|---------|--------------------|---------|----------------------|
|       |          | Parameter            | Dry season (April) | Remarks           | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) |
|       |          | Ca(meq/100g)         | 12.6               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg(meq/100g)         | 9.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na(meq/100g)         | 8.5                | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | P(µg/gm)             | 2.7                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | S(µg/gm)             | 280.5              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | B(µg/gm)             | 1.1                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Fe(µg/gm)            | 133.9              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mn(µg/gm)            | 2.8                | Optimum           |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Zn(µg/gm)            | 0.99               | Medium            |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Lead(Pb)(µg/gm)      | 0.00               | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Chloride (Cl)(µg/gm) | 1472.5             | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Substratum(30-45cm)  |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | EC(ds/m)             | 10.1               | Moderately saline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | pH                   | 6.6                | Neutral           |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | OM (%)               | 1.9                | Medium            |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | N (%)                | 0.09               | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | K (%)                | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Ca(meq/100g)         | 13.7               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg(meq/100g)         | 11.8               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na(meq/100g)         | 8.5                | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | P(µg/gm)             | 1.3                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | S(µg/gm)             | 320.4              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | B(µg/gm)             | 1.14               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Fe(µg/gm)            | 125.3              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mn(µg/gm)            | 2.7                | Optimum           |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Zn(µg/gm)            | 1.8                | Optimum           |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Lead(Pb)(µg/gm)      | 31.3               | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Chloride (Cl)(µg/gm) | 1715.0             | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Top soil(0-15cm)     |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | EC(ds/m)             | 4.8                | Slightly saline   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | pH                   | 7.0                | Neutral           |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | OM (%)               | 3.0                | Medium            |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | N (%)                | 0.2                | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | K (%)                | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Ca(meq/100g)         | 18.2               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg(meq/100g)         | 15.3               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na(meq/100g)         | 12.0               | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | P(µg/gm)             | 3.2                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | S(µg/gm)             | 545.2              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | B(µg/gm)             | 1.2                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Fe(µg/gm)            | 37.3               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mn(µg/gm)            | 3.8                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |

Kapalirimet



| Sl No                 | Location | Parameter                | 2014               |                   |                      | 2015      |                    |         | 2016                 |         |                    |         |                      |         |  |
|-----------------------|----------|--------------------------|--------------------|-------------------|----------------------|-----------|--------------------|---------|----------------------|---------|--------------------|---------|----------------------|---------|--|
|                       |          |                          | Dry season (April) | Remarks           | Wet season (October) | Remarks   | Dry season (March) | Remarks | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks |  |
|                       |          | Zn(µg/gm)                | 2.0                | High              |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Lead(Pb) (µg/gm)         | 12.5               | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Chloride (Cl)(µg/gm)     | 3741.9             | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Subsurface soil(15-30cm) |                    |                   |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | EC(ds/m)                 | 11.1               | Moderately saline |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | pH                       | 7.2                | Neutral           |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | OM (%)                   | 2.6                | Medium            |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | N (%)                    | 0.2                | Low               |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | K (%)                    | 1.5                | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Ca(meq/100g)             | 11.7               | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Mg(meq/100g)             | 7.1                | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Na(meq/100g)             | 8.5                | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | P(µg/gm)                 | 3.8                | Very low          |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | S(µg/gm)                 | 341.4              | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          |                          |                    | B(µg/gm)          | 0.86                 | Very high |                    |         |                      |         |                    |         |                      |         |  |
| Fe(µg/gm)             | 140.2    |                          |                    | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Mn(µg/gm)             | 3.7      |                          |                    | High              |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Zn(µg/gm)             | 0.94     |                          |                    | Medium            |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Lead(Pb) (µg/gm)      | 0.00     |                          |                    | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Chloride (Cl) (µg/gm) | 2217.4   |                          |                    | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Substratum(30-45cm)   |          |                          |                    |                   |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| EC(ds/m)              | 10.8     |                          |                    | Moderately saline |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| pH                    | 7.3      |                          |                    | Neutral           |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| OM (%)                | 2.8      |                          |                    | Medium            |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| N (%)                 | 0.15     |                          |                    | Low               |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| K (%)                 | 1.5      |                          |                    | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Ca(meq/100g)          | 12.9     |                          |                    | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Mg(meq/100g)          | 10.4     |                          |                    | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
| Na(meq/100g)          | 8.5      |                          |                    | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | P(µg/gm)                 | 3.4                | Very low          |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | S(µg/gm)                 | 345.1              | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | B(µg/gm)                 | 1.4                | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Fe(µg/gm)                | 120.3              | Very high         |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Mn(µg/gm)                | 2.9                | Optimum           |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Zn(µg/gm)                | 0.88               | Medium            |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Lead(Pb) (µg/gm)         | 0.00               | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Chloride (Cl) (µg/gm)    | 1801.6             | *                 |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | Top soil(0-15cm)         |                    |                   |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | EC(ds/m)                 | 11.5               | Moderately saline |                      |           |                    |         |                      |         |                    |         |                      |         |  |
|                       |          | 4                        | Chakgona           |                   |                      |           |                    |         |                      |         |                    |         |                      |         |  |



| Sl No | Location | 2014                      |                    |                   |                      | 2015    |                    |         |                      | 2016    |                    |         |                      |
|-------|----------|---------------------------|--------------------|-------------------|----------------------|---------|--------------------|---------|----------------------|---------|--------------------|---------|----------------------|
|       |          | Parameter                 | Dry season (April) | Remarks           | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) |
|       |          | pH                        | 7.7                | Slightly alkaline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | OM (%)                    | 1.5                | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | N (%)                     | 0.08               | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | K (%)                     | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Ca (meq/100g)             | 22.2               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg (meq/100g)             | 11.7               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na (meq/100g)             | 8.5                | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | P (µg/gm)                 | 5.6                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | S (µg/gm)                 | 444.2              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | B (µg/gm)                 | 0.98               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Fe (µg/gm)                | 55.3               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mn (µg/gm)                | 4.3                | High              |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Zn (µg/gm)                | 0.76               | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Lead (Pb) (µg/gm)         | 0.00               | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Chloride (Cl) (µg/gm)     | 1576.4             | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Subsurface soil (15-30cm) |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | EC (ds/m)                 | 11.3               | Moderately saline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | pH                        | 7.7                | Slightly alkaline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | OM (%)                    | 2.6                | Medium            |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | N (%)                     | 0.13               | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | K (%)                     | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Ca (meq/100g)             | 22.6               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg (meq/100g)             | 16.3               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na (meq/100g)             | 8.5                | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | P (µg/gm)                 | 13.6               | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | S (µg/gm)                 | 415.6              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | B (µg/gm)                 | 0.66               | High              |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Fe (µg/gm)                | 124.1              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mn (µg/gm)                | 6.1                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Zn (µg/gm)                | 1.1                | Medium            |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Lead (Pb) (µg/gm)         | 6.3                | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Chloride (Cl) (µg/gm)     | 2113.5             | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Substratum (30-45cm)      |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | EC (ds/m)                 | 10.9               | Moderately saline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | pH                        | 7.5                | Slightly alkaline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | OM (%)                    | 1.7                | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | N (%)                     | 0.09               | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | K (%)                     | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Ca (meq/100g)             | 13.9               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg (meq/100g)             | 11.1               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na (meq/100g)             | 8.5                | *                 |                      |         |                    |         |                      |         |                    |         |                      |



| SI No                | Location    | Parameter                | 2014               |                   |                      | 2015    |                    |         | 2016                 |         |                    |         |                      |         |
|----------------------|-------------|--------------------------|--------------------|-------------------|----------------------|---------|--------------------|---------|----------------------|---------|--------------------|---------|----------------------|---------|
|                      |             |                          | Dry season (April) | Remarks           | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks |
|                      |             | P(µg/gm)                 | 4.1                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | S(µg/gm)                 | 334.6              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | B(µg/gm)                 | 0.67               | High              |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Fe(µg/gm)                | 75.3               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Mn(µg/gm)                | 3.6                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Zn(µg/gm)                | 1.7                | Optimum           |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Lead(Pb) (µg/gm)         | 6.3                | *                 |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Chloride (Cl)(µg/gm)     | 1715.0             | *                 |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Top soil(0-15cm)         |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | EC(ds/m)                 | 11.7               | Moderately saline |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | pH                       | 7.7                | Slightly alkaline |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | OM (%)                   | 1.7                | Low               |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | N (%)                    | 0.09               | Low               |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | K (%)                    | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Ca(meq/100g)             | 23.6               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
| Mg(meq/100g)         | 11.9        | Very high                |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| Na(meq/100g)         | 8.5         | *                        |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| P(µg/gm)             | 4.5         | Very low                 |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| S(µg/gm)             | 272.3       | Very high                |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| B(µg/gm)             | 0.94        | Very high                |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| Fe(µg/gm)            | 50.3        | Very high                |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| Mn(µg/gm)            | 3.4         | High                     |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| Zn(µg/gm)            | 1.4         | Medium                   |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| Lead(Pb(µg/gm)       | 18.8        | *                        |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| Chloride (Cl)(µg/gm) | 2442.6      | *                        |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
| 5.                   | Bashernhula | Subsurface soil(15-30cm) |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | EC(ds/m)                 | 10.7               | Moderately saline |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | pH                       | 7.7                | Slightly alkaline |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | OM (%)                   | 1.5                | Low               |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | N (%)                    | 0.08               | Very low          |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | K (%)                    | 1.0                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Ca(meq/100g)             | 24.0               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Mg(meq/100g)             | 11.7               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Na(meq/100g)             | 7.0                | *                 |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | P(µg/gm)                 | 3.9                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | S(µg/gm)                 | 317.2              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | B(µg/gm)                 | 0.71               | High              |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Fe(µg/gm)                | 121.4              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Mn(µg/gm)                | 3.9                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |         |
|                      |             | Zn(µg/gm)                | 1.8                | Optimum           |                      |         |                    |         |                      |         |                    |         |                      |         |
| Lead(Pb)             | 18.8        | *                        |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |         |



| Sl No | Location | 2014                  |                    |                   |                      | 2015    |                    |         |                      | 2016    |                    |         |                      |
|-------|----------|-----------------------|--------------------|-------------------|----------------------|---------|--------------------|---------|----------------------|---------|--------------------|---------|----------------------|
|       |          | Parameter             | Dry season (April) | Remarks           | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) | Remarks | Dry season (March) | Remarks | Wet season (October) |
|       |          |                       |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | (µg/gm)               |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Chloride (Cl) (µg/gm) | 1611.1             | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Substratum(30-45cm)   |                    |                   |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | EC(ds/m)              | 10.9               | Moderately saline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | pH                    | 7.7                | Slightly alkaline |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | OM (%)                | 1.5                | Low               |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | N (%)                 | 0.08               | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | K (%)                 | 1.5                | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Ca(meq/100g)          | 24.4               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mg(meq/100g)          | 12.9               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Na(meq/100g)          | 7.5                | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | P(µg/gm)              | 6.1                | Very low          |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | S(µg/gm)              | 321.1              | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | B(µg/gm)              | 0.63               | High              |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Fe(µg/gm)             | 77.3               | Very high         |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Mn(µg/gm)             | 3.2                | High              |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Zn(µg/gm)             | 2.1                | High              |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Lead(Pb) (µg/gm)      | 25.00              | *                 |                      |         |                    |         |                      |         |                    |         |                      |
|       |          | Chloride (Cl)(µg/gm)  | 1489.8             | *                 |                      |         |                    |         |                      |         |                    |         |                      |

## **8 Agriculture Resources Monitoring**

### **8.1 Methodology**

#### **8.1.1 Monitoring Indicators**

98. The major monitoring indicators for agriculture sector as per monitoring plan are major crop area, crop production and crop damage. It is expected that ash might be deposited in the agriculture land and which might influence to reduce the production of crops.

#### **8.1.2 Method**

99. During field visit, extensive consultations/group discussion were made with local people to know the existing inputs use, present cropping patterns by land type, crop damage due to drainage congestion/water logging, salinity or other natural calamities induced impact as well as management practices and crop production in the selected locations of the monitoring area.

#### **8.1.3 Frequency**

100. Land use, major crops area, major crop production and damage are monitored quarterly in a year. For the cropping season 2013-14, these data were collected in April, 2014. Crop production and damage information's were also collected from the same land. Samples were collected in October for Kharif-II (July) in 2014-15. Production and damage data will be collected in the year 2014-15 in March, 2015. It is clearly mentioned that single crop is grown all most everywhere.

#### **8.1.4 Location**

101. The same mouzas have been selected for land resources as well as agricultural resources monitoring. The selected mouzas are Baranpara, Chunkuri-2, Kapalimet, Chakgona and Basherhula. Locations of the monitoring agriculture lands are presented in the **Map 8.1**.





## 8.2 Agricultural Resources

### 8.2.1 Description of the selected agricultural land for monitoring

102. Detailed information of the selected land for lands and agriculture monitoring are presented in the Table 8.1

Table 8.1: Detailed information of the selected land

| Site No. | Location  | GPS                                    | Distance from the plant location(Km) | Plot size (ha) | Land owner                                       |
|----------|---|--|--------------------------------------|----------------|--|
| 1        | Mouza: Baran Para<br>Union:Gongarampur<br>Upazila:Batiaghata<br>District:Khulna           | E-89°<br>30'59.1"<br>N-22°<br>37'57.0" | About 3.5                            | About 0.4      | Name: Anil Krishna Roy<br>Father: Keshab Lal Roy |
| 2        | Mouza:Chunkuri-2<br>Union:Bajua<br>Upazila:Dacope<br>District:Khulna                      | E-89°<br>32'20.0"<br>N-22°<br>34'51.0" | About 1.0                            | About 0.93     | Name: Md.Abul Sheikh<br>Father: Md.Jamir Sheikh  |
| 3        | Mouza:Kapalimet<br>Buridmial<br>Union: Burirdanaga<br>Upazila:Mongla<br>District:Bagerhat | E-89° 36'8.8"<br>N-22°<br>32'18.9"     | About 5.5                            | About 0.14     | Name: Panesh Biswas<br>Father: Nishikanto Biswas |
| 4        | Mouza: Chakgona<br>Union:Rajnagar<br>Upazila:Rampal<br>District:Bagerhat                  | E-89°<br>34'25.3"<br>N-22°<br>34'18.3" | About 1.0                            | About 0.28     | Name: Manoj Das<br>Father: Mahendra Nath Das     |
| 5        | Mouza: Basherhula<br>Union:Rajnagar<br>Upazila:Rampal<br>District: Bagerhat               | E-89°<br>34'25.0"<br>N-22°<br>36'14.0" | About 1.0                            | About 0.47     | Name: Amjad Hajra<br>Father: Chirman Ali Hajra   |

Source: Field survey, 2014

### 8.2.2 Present cropping patterns

103. Detail data on last three years cropping pattern of the selected lands for monitoring were obtained through an extensive discussions with the respective land owners. Based on the discussion, the following land based cropping patterns were identified to exist in the monitoring area for the year 2013-14. Data on cropping patterns were collected in October 2014 for 2014-15. Detailed cropping pattern are presented in the Table 8.2.

#### (a) Monitoring agriculture land-1

104. This land is located at Baranpara and the size of the unit plot is about 0.4 ha. Farmer of the plot cultivated Local Aman (Kumragur) in last Kharif-II season. Chemical fertilizer and liquid pesticides are being used for crop production. Rice straw and bajua grass are mixed with the land to improve the soil fertility level. In the year 2014-15, he cultivated HYV Aman: BRRIdhan30 in the Kharif-II season. He stated that, yield rate of local variety is lower than HYV Aman. It is mentioned



that farmers are growing HYV instead of local rice. Pest like Stem borer and Leaf roller infestation was observed in his land.

## 8.2 Agricultural Resources

105 Chemical fertilizer and pesticides are being used in the land for crop production. Chemical fertilizer used the following rate in his land, Urea: Not applied, MP: 11.2kg/plot and DAP: 37kg/plot. To protect crop from pest infestation granular pesticide Virtako 40WG applied @ 500gm/plot. Detailed cropping pattern is shown in the Table 8.2



Photo 8.1: View of monitoring agriculture land at Baranpara



Photo 8.2: View of monitoring agriculture land at Chunkuri-2



Photo 8.3: View of monitoring agriculture land at Kapalirmet (\*Fallow-Shrimp/Fish culture)



Photo 8.4: View of monitoring agriculture land at Chakgona (\*Fallow-Shrimp/Fish culture)



Photo 8.5: View of monitoring agriculture land at Basherhula



**(b) Monitoring agriculture land-2**

106. This monitoring site is located at Chunkuri-2 and the size of the plot is about 0.93 ha. Farmer of the plot was practicing HYV Aman (BR-23) in Kharif-II season in last year. Chemical fertilizer and liquid pesticides are being used in the land for crop production. Rice straw and bajua grass are mixed with the land to improve the soil fertility level. In 2014-15, farmer of this land cultivated Local Aman such as Benapole in his land due to the high market price of local variety than HYV aman. Stem borer infestation was observed in his land. Chemical fertilizer and pesticides are being used in the land for crop production. Chemical fertilizer used were, Urea: 125kg/plot, TSP: 42kg/plot and MP: 20kg/plot. To protect crop from pest infestation liquid pesticide Karate 2.5 EC was applied @700ml/plot. Detailed cropping pattern is shown in the **Table 8.2**

**(c) Monitoring agriculture land -3**

107. This monitoring site is located at Kapalirmet and the size of the plot is about 0.14 ha. Farmer of the plots is practicing Local Aman (Chapsail) in Kharif-II season last year. In Kharif-I and Rabi season, shrimp is being cultured in this plot every year. Chemical fertilizer and liquid pesticides are being used in the land for crop production. In 2014-15, this land remained fallow due to salinity. Shrimp gher owners of this area, enters saline water from Ghona river for shrimp culture every year. There was no scope to drain/wash out saline water from this area. On the other hand, inadequate rainfall occurs in this year. Farmers of this locality opined that many of them cultivated Aman crops in their land. But most of the crop lands are damaged by saline water. However, the plot owner culture shrimp/fish in his land in this Kharif-II season. He could not cultivate Aman crops this Kharif-II season by lesson learnt from others. He also stated that, he will cultivate next Kharif-II season. Detailed cropping pattern is presented in the **Table 8.2**

**(d) Monitoring agriculture land -4**

108. This monitoring site is located at Chakgona and the size of the plot is about 0.28 ha. Farmer of the plot practiced Local Aman (Chapsail) in Kharif-II season last year. In Kharif-I and Rabi season, shrimp is cultured in this plot every year but this year there is no shrimp culture in this particular piece of land. Chemical fertilizer and liquid pesticides are being used in the land for crop production. Due to adverse situation of salinity, he felt that his land was not suitable for crop cultivation this year (2014-15). He also stated that he will cultivate next Kharif-II season. Detailed cropping pattern is presented in the **Table 8.2**

**(e) Monitoring agriculture land-5**

109. This monitoring site is located in Basherhula and the size of the plot is about 0.47 ha. Farmer of the plot is practicing Local Aman (Benapol) in Karif-II season last year. In 2014-15, the farmer of this monitoring land cultivated Local aman variety Sada mota. Pest like Stem borer infestation was observed in his land. Chemical fertilizer and pesticides are being used in the land for crop production. Chemical fertilizer used were, Urea: 5kg/plot, TSP: 15kg/plot and MP: 10kg/plot. To protect crop from pest infestation liquid pesticide Karate 2.5 EC was applied @500ml/plot. Detailed cropping pattern is shown in the **Table 8.2**



**Table 8.2: Existing cropping pattern of monitoring agriculture land**

| Monitoring agriculture land   | 2013-14               |                          |                     | 2014-15               |                          |                     | 2015-16               |                          |                     |
|-------------------------------|-----------------------|--------------------------|---------------------|-----------------------|--------------------------|---------------------|-----------------------|--------------------------|---------------------|
|                               | Kharif-I (March-June) | Kharif-II (July-October) | Rabi (Nov-February) | Kharif-I (March-June) | Kharif-II (July-October) | Rabi (Nov-February) | Kharif-I (March-June) | Kharif-II (July-October) | Rabi (Nov-February) |
| Monitoring agriculture land-1 | Fallow                | Local Aman               | Fallow              | Fallow                | HYV Aman                 | Fallow              |                       |                          |                     |
| Monitoring agriculture land-2 | Fallow                | HYV Aman                 | Fallow              | Fallow                | Local Aman               | Fallow              |                       |                          |                     |
| Monitoring agriculture land-3 | Fallow                | Local Aman               | Fallow              | Fallow*               | Fallow*                  | Fallow*             |                       |                          |                     |
| Monitoring agriculture land-4 | Fallow                | Local Aman               | Fallow              | Fallow*               | Fallow*                  | Fallow*             |                       |                          |                     |
| Monitoring agriculture land-5 | Fallow                | Local Aman               | Fallow              | Fallow                | Local Aman               | Fallow              |                       |                          |                     |

Source: Based on field information and farmers interviewed, April and October 2014 \*Fallow-Shrimp/Fish culture

### 8.2.3 Crop damage

110. No crop damage was noticed in any monitoring land in 2013-14. The owners of monitoring agriculture land-1 (Baranpara), monitoring agriculture land-2 (Chunkuri-2) and monitoring agriculture land-5 (Basherhula) cultivated HYV and Local Aman crops in this Kharif-II season (2014-15). The rest monitoring lands (Kapalimet and Chakgona) remains fallow due to adverse impact of salinity. The crop damage of this season shall be monitored in coming quarter of the monitoring study. Detailed crop damage information is presented in **Table 8.3**

**Table 8.3: Results of crop damage monitoring**

| Monitoring site               | 2013-14   |              |        | 2014-15   |              |        | 2015-16   |              |        |
|-------------------------------|-----------|--------------|--------|-----------|--------------|--------|-----------|--------------|--------|
|                               | Area (ha) | Prod. (tons) | Causes | Area (ha) | Prod. (tons) | Causes | Area (ha) | Prod. (tons) | Causes |
| Monitoring agriculture land-1 | -         | *Not found   | -      |           |              |        |           |              |        |
| Monitoring agriculture land-2 | -         | *Not found   | -      |           |              |        |           |              |        |
| Monitoring agriculture land-3 | -         | *Not found   | -      |           |              |        |           |              |        |
| Monitoring agriculture land-4 | -         | *Not found   | -      |           |              |        |           |              |        |
| Monitoring agriculture land-5 | -         | *Not found   | -      |           |              |        |           |              |        |
| <b>Total</b>                  | -         | -            | -      |           |              |        |           |              |        |

Source: Based on field information, April 2014, A: water logging due to heavy rainfall, B: water logging due to internal river water, C: water logging, D: Salinity, E: Other



## 9 Fisheries Resources Monitoring

111. Followed by the second quarter monitoring, the third quarter monitoring has been conducted in between 15 October June to 29 October 2014.

### 9.1 Monitoring Location

112. The monitoring activities were carried out at ten pre-selected locations - (i) Akram Point on the confluence of the Passur and the Sibsha, (ii) Haldikhali, (iii) Charpuntia, (iv) Bhadra, (v) Harbaria, (vi) Chandpai, (vii) Jongra, (viii) Mongla Point, (ix) Baro Durgapur and (x) Botiaghata, Chalna Point. The sampling sites are detailed in **Table 9.1**. These sites were selected in inception stage and finalized during first quarter monitoring.

**Table 9.1: The Sampling Locations for Fisheries Resources Monitoring**

| Site                        | Habitat Location           | North          | East           | Habitat                 | Area (ha)     |
|-----------------------------|----------------------------|----------------|----------------|-------------------------|---------------|
| <b>Capture Fish Habitat</b> |                            |                |                |                         |               |
| A                           | Akram Point                | 21° 56' 40.8'' | 89° 35' 5.6''  | Kukilmoni Khal          | 3             |
| B                           | Haldikhali                 | 22° 00' 38.9'' | 89° 33' 29''   | Haldikhali Khal         | 4             |
| C                           | Harbaria                   | 22° 17' 24.4'' | 89° 37' 17.2'' | Harbaria Khal           | 2.4           |
| D                           | Chandpai                   | 22° 21' 53.7'' | 89° 38' 25.8'' | Sheola Khal             | 3             |
| E                           | Mongla Point               | 22° 27' 50.9'' | 89° 35' 6.9''  | Passur River            | 2.4           |
| F                           | Baro Durgapur              | 22° 34' 29.1'' | 89° 33' 28.4'' | Mouth of Moidhara River | 4             |
| G                           | Botiaghata, Chalna Point   | 22° 36' 15.3'' | 89° 31' 36.4'' | Passur River            | 0             |
| <b>Sub-total =</b>          |                            |                |                |                         | <b>19</b>     |
| <b>Shrimp/Fish Farm</b>     |                            |                |                |                         |               |
| 1                           | Bhekatkhali Khal, Rajnagar | 22° 36' 17.0'' | 89° 34' 24.9'' | Shrimp farm             | 42.09         |
| 2                           | Kapashdanga-Muralia        | 22° 37' 34.4'' | 89° 33' 14.5'' | Shrimp farm             | 115.7         |
| 3                           | Chunkuri-2                 | 22° 34' 49.3'' | 89° 32' 38.2'' | Shrimp/<br>fish farm    | 6.07          |
| <b>Sub-total =</b>          |                            |                |                |                         | <b>163.86</b> |
| <b>Grand-total =</b>        |                            |                |                |                         | <b>182.86</b> |

### 9.2 Methods, Tools and Techniques of Monitoring

#### 9.2.1 Fish Habitat Status Monitoring

113. The following indicators have been monitored to understand the fish habitat status and quality: (i) water quality; (ii) bed material; (iii) hydrological condition; (iv) morphological aspects; (v) vegetation cover etc. These indicators would present the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depends. These issues are also important for understanding the condition of spawning and nursery grounds. The sampling sites have been analyzed by using length-wise distribution of different fish species to identify major behavioral fish habitat. The length of different life stages of fish species was identified and collected from literature (Bhuiyan A. L. (1964), Rahaman A.K.A (2005) and Talwar P. K and Jhingran (1991)). The similarity in species composition among the sites



are analyzed using the Jaccard index (JI)<sup>1</sup> for calculating the extent of similarity between pairs of data sets. The linkage distance was calculated with the similarity in species distribution.

114. Moreover, Habitat Suitability Index (HSI) will be determined for the year 2014, 2015 and 2016. The data for basic life requirements for fish community shown in **Table 9.2** that will be estimated at the end of each monitoring year. The HSI will be calculated from the data of basic life requirements for fish community for a complete year. Once the monitoring of the fourth quarter is completed, the HSI value will be calculated and then analyzed by plotting this data with the survival curve of the fish community structure. The acceptance goal of the model is to produce an index between 0 and 1 that has a positive relationship to survival success of sampled individuals of different life stage (fry-brood fish).

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<sup>1</sup> The Jaccard similarity (Jaccard 1902, Jaccard 1912) is defined as the quotient between the intersection and the union of the pairwise compared variables among two objects. The Jaccard similarity or Jaccard similarity coefficient is often called Jaccard index. In the equation  $d^{JAD}$  is the Jaccard distance between the objects  $i$  and  $j$ .

Table 9.2: Data for Basic life Requirements for a Good Fish Community

| Life Requirements                | Variable Sl. | Habitat Variables         | A | B | C | D | E | F | G |
|----------------------------------|--------------|---------------------------|---|---|---|---|---|---|---|
| 2014-2015                        |              |                           |   |   |   |   |   |   |   |
| Food (C <sub>F</sub> )           | V1           | Phytoplankton (%)         |   |   |   |   |   |   |   |
|                                  | V2           | Zooplankton (%)           |   |   |   |   |   |   |   |
| Water Quality (C <sub>WQ</sub> ) | V3           | Turbidity                 |   |   |   |   |   |   |   |
|                                  | V4           | TDS                       |   |   |   |   |   |   |   |
|                                  | V5           | Surface water temperature |   |   |   |   |   |   |   |
|                                  | V6           | Dissolved Oxygen (DO)     |   |   |   |   |   |   |   |
|                                  | V7           | pH                        |   |   |   |   |   |   |   |
|                                  | V8           | Salinity                  |   |   |   |   |   |   |   |
| Reproduction (C <sub>R</sub> )   | V1           | Phytoplankton (%)         |   |   |   |   |   |   |   |
|                                  | V2           | Zooplankton (%)           |   |   |   |   |   |   |   |
|                                  | V3           | Turbidity                 |   |   |   |   |   |   |   |
|                                  | V4           | TDS                       |   |   |   |   |   |   |   |
|                                  | V5           | Surface water temperature |   |   |   |   |   |   |   |
|                                  | V6           | Dissolved Oxygen (DO)     |   |   |   |   |   |   |   |
|                                  | V7           | pH                        |   |   |   |   |   |   |   |
|                                  | V8           | Salinity                  |   |   |   |   |   |   |   |
| 2015-2016                        |              |                           |   |   |   |   |   |   |   |
| Food (C <sub>F</sub> )           | V1           | Phytoplankton (%)         |   |   |   |   |   |   |   |
|                                  | V2           | Zooplankton (%)           |   |   |   |   |   |   |   |
| Water Quality (C <sub>WQ</sub> ) | V3           | Turbidity                 |   |   |   |   |   |   |   |
|                                  | V4           | TDS                       |   |   |   |   |   |   |   |
|                                  | V5           | Surface water temperature |   |   |   |   |   |   |   |
|                                  | V6           | Dissolved Oxygen (DO)     |   |   |   |   |   |   |   |
|                                  | V7           | pH                        |   |   |   |   |   |   |   |
|                                  | V8           | Salinity                  |   |   |   |   |   |   |   |
| Reproduction (C <sub>R</sub> )   | V1           | Phytoplankton (%)         |   |   |   |   |   |   |   |
|                                  | V2           | Zooplankton (%)           |   |   |   |   |   |   |   |
|                                  | V3           | Turbidity                 |   |   |   |   |   |   |   |
|                                  | V4           | TDS                       |   |   |   |   |   |   |   |
|                                  | V5           | Surface water temperature |   |   |   |   |   |   |   |



| Life Requirements          | Variable SI. | Habitat Variables         | A | B | C | D | E | F | G |
|----------------------------|--------------|---------------------------|---|---|---|---|---|---|---|
|                            | V6           | Dissolved Oxygen (DO)     |   |   |   |   |   |   |   |
|                            | V7           | pH                        |   |   |   |   |   |   |   |
|                            | V8           | Salinity                  |   |   |   |   |   |   |   |
| 2016-2017                  |              |                           |   |   |   |   |   |   |   |
| Food ( $C_F$ )             | V1           | Phytoplankton (%)         |   |   |   |   |   |   |   |
|                            | V2           | Zooplankton (%)           |   |   |   |   |   |   |   |
| Water Quality ( $C_{WQ}$ ) | V3           | Turbidity                 |   |   |   |   |   |   |   |
|                            | V4           | TDS                       |   |   |   |   |   |   |   |
|                            | V5           | Surface water temperature |   |   |   |   |   |   |   |
|                            | V6           | Dissolved Oxygen (DO)     |   |   |   |   |   |   |   |
|                            | V7           | pH                        |   |   |   |   |   |   |   |
|                            | V8           | Salinity                  |   |   |   |   |   |   |   |
|                            | V8           | Salinity                  |   |   |   |   |   |   |   |
| Reproduction ( $C_R$ )     | V1           | Phytoplankton (%)         |   |   |   |   |   |   |   |
|                            | V2           | Zooplankton (%)           |   |   |   |   |   |   |   |
|                            | V3           | Turbidity                 |   |   |   |   |   |   |   |
|                            | V4           | TDS                       |   |   |   |   |   |   |   |
|                            | V5           | Surface water temperature |   |   |   |   |   |   |   |
|                            | V6           | Dissolved Oxygen (DO)     |   |   |   |   |   |   |   |
|                            | V7           | pH                        |   |   |   |   |   |   |   |
|                            | V8           | Salinity                  |   |   |   |   |   |   |   |

115. The first associated information shown in the Table above has already been collected for the month of April, 2014, July 2014 and October, 2014 at the selected sites. However, the HSI value will be estimated for the entire year after getting all information on survival rate of different life stage.

### 9.2.2 Fish Migration

116. Fish migration status has been observed at selected sites along the water ways used for carrying machinery and coal. Issues like migratory species diversity, migration pattern, migration purpose, period and extent of migration etc. has been investigated. Migratory species have been identified by analyzing the common species found in the catch assessment survey samples from the sampling sites. Only Age-1 to Brood fish has been allowed to interpret the migration pattern and purpose. The migration extent has been identified through analyzing the length among sampling sites.

### 9.2.3 Fish Biodiversity

117. Fish species diversity and composition has been selected as an indicator for fish monitoring. In the context of fish biodiversity, the critically endangered to vulnerable fish species (enlisted by IUCN), fish densities and catch composition of different strata (Vertical and Horizontal) in the selected habitat have been emphasized to monitor quarterly. Fish biodiversity has been surveyed by Catch Per Unit Effort (CPUE) method. Gears have been selected on the basis of on-going fishing activities. The fish individuals were then counted according to the length of each species from the samples. Diversity has been calculated by analyzing Shannon-Weiner Index<sup>2</sup>. This index has produced values between 0 and 1. According to Shannon-Weiner Index classifies the diversity as –

- i. 0-0.30: Low diversity/equally distribution (VH)
- ii. 0.31-0.50: Moderate Diversity (M)
- iii. 0.51-0.80: High Diversity (HD), and
- iv. 0.80-1.0: Very High Diversity (VHD)

118. Fish species richness (FSR) has been analyzed using the Simpson's Index producing two types of values. The first one includes values between 0 (having only one species in the sample) and 1 (having more than one species with same proportion) indicating general richness of the observed species distribution. The second one includes values that start from 1 (having only one species in the sample) to equal to the total number of species found in the sample. Fish community structure has been analyzed through counting the length-wise fish individuals.

### 9.2.4 Fish-Shrimp Culture Practice

119. For monitoring shrimp/fish farm three farms within the direct impact zone of Power Plant have been surveyed. Stocking pattern of the shrimp/fish farm is the major issue for successful production because of having natural genetic resources from the wild source of the Passur River System. Moreover, mortality rate should be minimized for getting more economical output from the farms. So, stocking pattern and mortality rate and its causes have been surveyed intensively.

### 9.2.5 Fish Production

120. Fish production for riverine fish has been surveyed through Catch per Unit Effort (CPUE). The information on the species-wise production of shrimp/fish farm has been collected from the selected farms for the last catch.

<sup>2</sup> The Shannon is the most widely used species diversity indices for examining overall community characteristics. It is derived from a function used in the field of describing the average degree of uncertainty of predicting the species of an individual picked at random from the community. The uncertainty of occurrence increases both as the number of species increases and as the individuals are distributed more and more evenly among the species already present. The value of this index ranges from 0 to 1. According to this index, 0-0.30: Low diversity/equally distribution (VH); 0.31-0.50: Moderate Diversity (M); 0.51-0.80: High Diversity (HD) and 0.80-1.0: Very High Diversity (VHD).



### 9.3 Results of Monitoring

121. Followed by the first and second quarter monitoring, the third quarter monitoring has been conducted in between 15 October to 25 October 2014.

### 9.4 Results of 3<sup>rd</sup> Monitoring

#### 9.4.1 Fisheries Resources

122. Fisheries resources for the monitoring study are identified as riverine habitats, resident fish species and shrimp/fish farming. Based on these resources, the fisheries monitoring survey has been devised and conducted in different sampling sites comprising both capture and culture fish habitats. The capture fish habitat includes major fishing grounds in the Passur River System. The estimated total area of capture fish habitat is about 183 ha. The culture fish habitat includes three shrimp/fish farms, which are situated in a range of 0.5-1 km distance from the Plant boundary. The farms were selected for monitoring on the basis of the probable dispersion of fly ash from the Plant in future. The culture fish habitat is about 164 ha in total. The fishing activities in the Passur River System (shown in **Photo 9.1**) generally depend on the lunar phase and tide condition. The survey, therefore, has been conducted in the morning to find low tide condition when large scale fishing is made.

123. Fishes are not usually available during high tide condition in this system. In some locations, survey was conducted during high tide as it was not possible to reach that places timely due to issues of accessibility and safety.

#### 9.4.2 Features to be considered

- Following features are considered in conducting the fisheries monitoring:
- The Passur River System, the lone capture fishery, has been aggrading due to siltation
- Reduction of upstream flow since long back when polders were built
- Culture fish habitats are at risk of river bank erosion
- A number of fish died because of indiscriminate activities (e.g. during catching of PL of tiger shrimp many other fries are also damaged)
- Fish diversity is highly dominated during lunar phase and tide condition.

#### 9.4.3 Fish Habitat Status

##### (a) Habitat Classification

124. Habitat classification is analyzed by using the length-wise distribution of different fish species in the sampling sites. The length of different life stages of fish species are identified and collected from literature. Linkage distance was then calculated with the similarity in distribution. The entire stretch of the Passur River System consists of three major behavioral habitats. The sampling sites have been classified (shown in the **Figure 9.1**) on the basis of abundance of different life stages of fish species in those habitats.

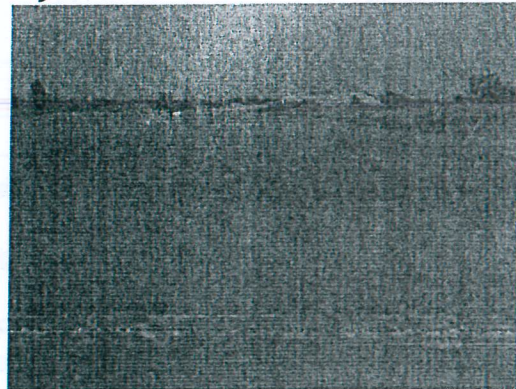
125. During 1<sup>st</sup> monitoring (April, 2014) fish habitat had been classified as the grazing ground (Akram Point and Harbaria), grazing and breeding ground (Haldikhali and confluence of the Passur river at Chalna Point) as well as spawning and nursery ground (Sheola khal at



Chandpai, Passur River at Mongla Point and Maidara River). In the second quarter monitoring (June – July 2014) two habitats – i) Grazing ground, ii) Spawning and Nursery ground have been identified. However, during third quarter monitoring in the month of October 2014 the similarity of size group distribution of fish species among these habitats has been found to beshifted to some extent.

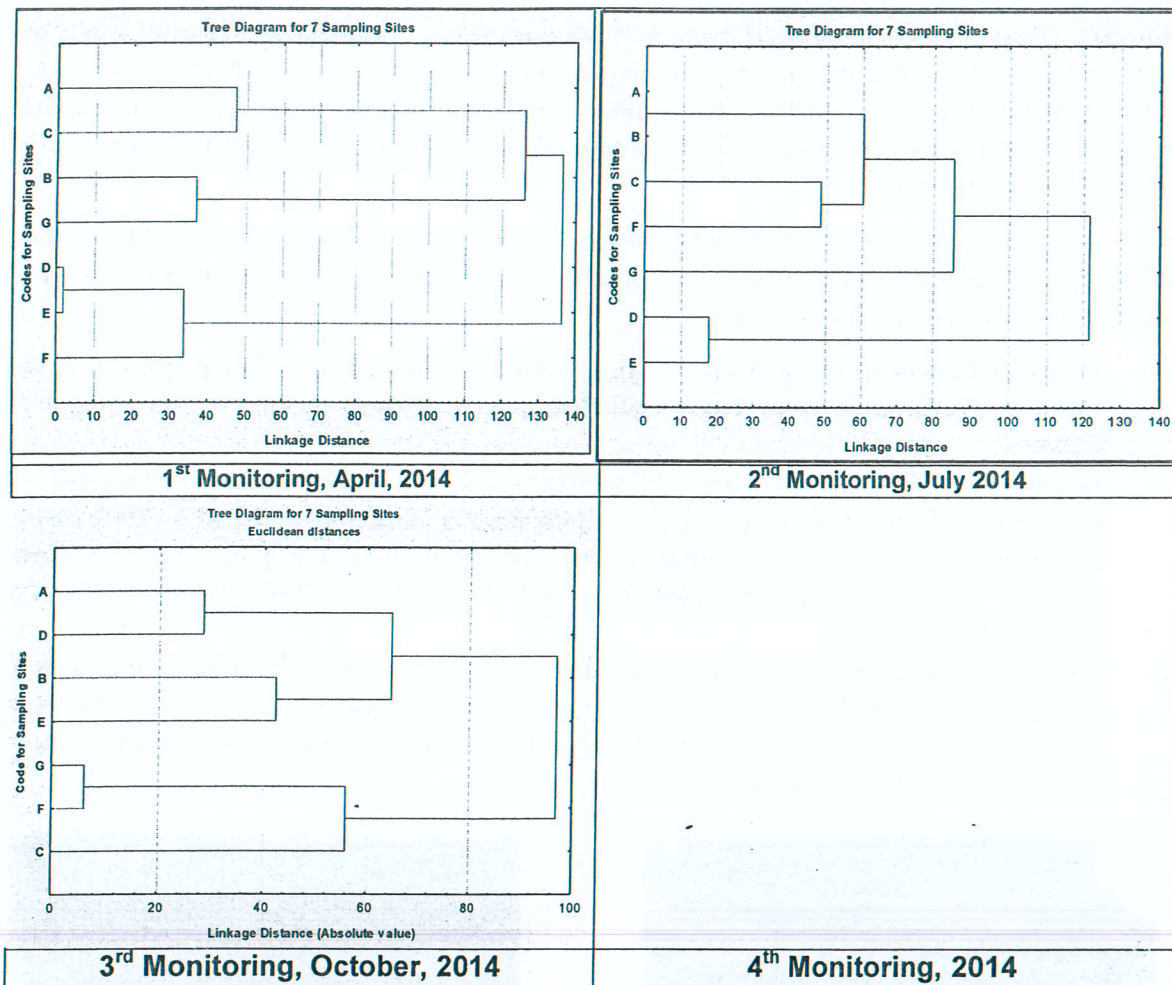
126. In the third quarter monitoring (October, 2014) three habitats – i) Grazing ground, ii) Grazing and Breeding ground; and iii) Spawning, Nursery and Grazing ground have been identified as shown in the **figure-9.1**.

- I. **Grazing Ground:** The Kukilmoni Khal (A) and Sheola Khal (D) respectively at Akram Point and Chandpai have been identified as the grazing ground in the Passur River System.
- II. **Grazing and Breeding Ground:** The linkage distance matrix among the Harbaria Khal (C), Sheola Khal at Chandpai (D), Maidara-Passur confluence (F) and Chalna point of the Passur River (G) shows that the behavioral habitat is the grazing and breeding ground. The most similar sampling sites are F and G in different length frequency for different fish species.
- III. **Spawning, Nursery and Grazing Ground:** Among the sampling sites, the Haldikhali Khal (B) and the Passur River at Mongla point (E) respectively are similar in the distribution of life stages from fry to brood fish. These habitats are classified as the spawning, nursery and grazing ground.



**Photo 9.1: Fish habitat in the Passur River System**

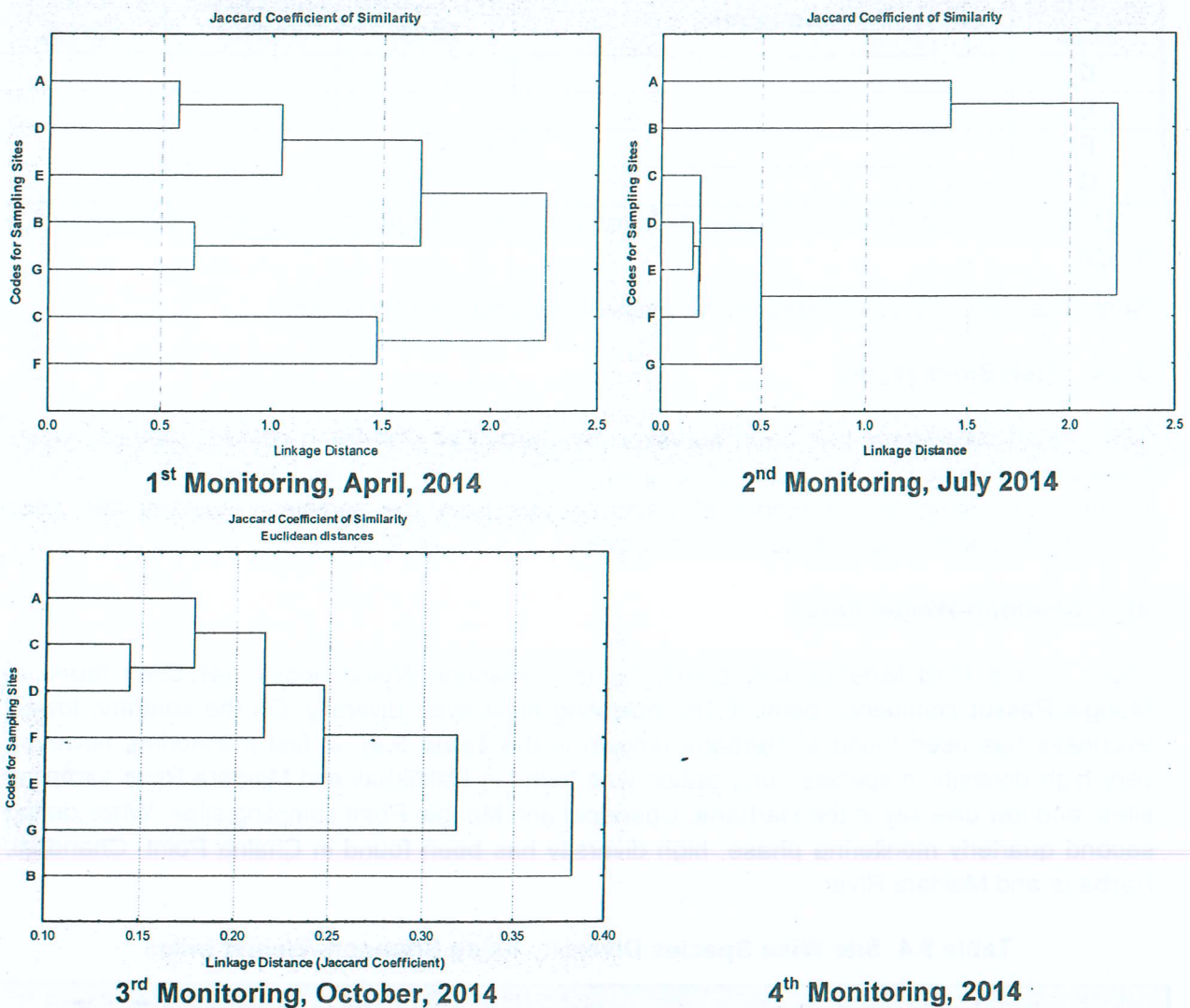




**Figure 9.1: Habitat Classification on the basis of Different Life Stages of Fish Species**

*Note: Life stage is identified through length measurement of the fish individuals*

127. This figure analyse the distances among JI (Jaccard Coefficient Index) indices which are opposite to the JI values. The length-wise distribution relationship among the sampling sites was found different during third, second and first quarter monitoring. Such as, the JI value between site A and D was the highest in the first monitoring but in second monitoring this value became highest between D and E sites. However, in third quarter monitoring highest JI value was found between C and D sampling sites. Because, different length group of different fish species use their habitat for their morphological and physiological suitability in respect of food coverage, water quality and reproductive performance. It has also been found that the length frequency of different fish species were more homogenously distributed among the sampling sites in case of third quarter monitoring phase in the month of October than that of first and second quarter monitoring (Figure 9.2).



**Figure 9.2: Dendrogram Showing Similarity in Binary Species Composition in seven sampling sites**

**(b) Habitat Suitability Index (HSI)**

128. Habitat Suitability Index (HSI) will be determined for 2014, 2015 and 2016. The data for basic life requirements (food coverage, water quality, reproductive performance, etc.) shown in the following **Table 9.3** for a fish community will be collected from water and ecological resources sections. HSI value will then be analyzed by plotting this data with the survival curve of the fish community structure after one year.

**Table 9.3: Habitat Suitability Index (HSI) for selected spot in the study area**

| Sampling Sites | Location | HSI* (2014-2015) | HSI (2015-2016) | HSI (2016-2017) |
|----------------|----------|------------------|-----------------|-----------------|
| A              |          |                  |                 |                 |
| B              |          |                  |                 |                 |
| C              |          |                  |                 |                 |



| Sampling Sites | Location | HSI* (2014-2015) | HSI (2015-2016) | HSI (2016-2017) |
|----------------|----------|------------------|-----------------|-----------------|
| D              |          |                  |                 |                 |
| E              |          |                  |                 |                 |
| F              |          |                  |                 |                 |
| G              |          |                  |                 |                 |

\*HSI value is calculated on the basis of life requirement and age structured population dynamics model

Note: The HIS will be calculated on the basis of one year monitoring data

#### 9.4.4 Fish Bio-diversity

129. Fish biodiversity has been surveyed by Catch Per Unit Effort (CPUE) method. Gears have been selected on the basis of on going fishing activities. Then the fish individuals were counted according to the length of each species from the samples. Diversity has been calculated by analyzing Shannon-Weiner Index.

##### a) Shannon-Weiner Index

130. In the third fisheries monitoring, highest Shannon-Weiner index has been found at Mongla-Passur confluence point (0.76) indicating most even diversity. On the contrary, lowest evenness has been found at Harbaria (shown in the **Table 9.4**). In first monitoring, however, very high diversity in species composition was found in Haldikhali and Maidara River sampling sites, and low diversity in the Harbaria, Chandpai and Mongla Point sampling sites. While during second quarterly monitoring phase, high diversity has been found in Chalna Point, Chandpai, Harbaria and Maidara River.

**Table 9.4: Site Wise Species Diversity using Shannon-Weiner Index**

| Site | Species No                       |                                 |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     | Shannon-Weiner Index* |                    |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|------|----------------------------------|---------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|-----------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|      | 1 <sup>st</sup> QM (April, 2014) | 2 <sup>nd</sup> QM (July, 2014) | 3 <sup>rd</sup> QM | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM | 1 <sup>st</sup> QM    | 2 <sup>nd</sup> QM | 3 <sup>rd</sup> QM | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| A    | 33                               | 0                               | 13                 |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.49                  | 0                  | 0.73               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| B    | 12                               | 0                               | 24                 |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.85                  | 0                  | 0.57               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| C    | 2                                | 12                              | 9                  |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.29                  | 0.77               | 0.40               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| D    | 12                               | 22                              | 15                 |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.31                  | 0.78               | 0.73               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| E    | 7                                | 13                              | 10                 |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.38                  | 0.60               | 0.76               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| F    | 3                                | 13                              | 6                  |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.82                  | 0.77               | 0.54               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| G    | 6                                | 3                               | 5                  |                    |                    |                    |                    |                    |                    |                     |                     |                     | 0.68                  | 0.82               | 0.72               |                    |                    |                    |                    |                    |                    |                     |                     |                     |

\*According to Shannon-Weiner Index, 0-0.30: Low diversity/equally distribution (VH); 0.31-0.50: Moderate Diversity (M); 0.51-0.80: High Diversity (HD) and 0.80-1.0: Very High Diversity (VHD)



**b) Fish Species Richness (FSR)**

131. Fish species richness has been identified through Simpson's Index<sup>3</sup>. Considerable difference was noticed in the fish species richness (FSR) in different habitat classes (Table 9.5 and Figure-9.3). In third monitoring phase, maximum FSR was obtained in Chandpai (n=5), while very low FSR was recorded in Harbaria, Maidara River at Baro Durgapur and in Chalna Point of the Passur river (n=2). Moderate FSR was observed at Akram point, Haldikhali and Mongla-Passur confluence point (n=4). Among habitats in upstream portions of the Passur river, Mongla Point was home to a rich assemblage of Baila, Golda Chingri, Harina Chingri and Poa; Maidara River at Baro Durgapur and Chalna point were rich in Phesa and Poa. Among habitats in lower stream portions, Chandpai was rich in Amadi Chela, Chami Chingri, Motka Chingri, Paissa and Tengra, Harbaria in Paissa and Poma; Haldikhali in Lal Chewa, Loitta, Motka Chingri and Poma and Akram point in Chanda Chela, Gagra Tengra, Loitta and Motka Chingri.

**Table 9.5: Site wise Rich Species Number**

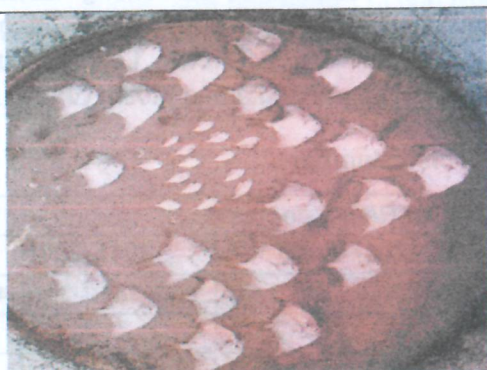
| Site | Location                 | No. of Rich Species |     |     |     |           |     |     |     |           |     |     |     |
|------|--------------------------|---------------------|-----|-----|-----|-----------|-----|-----|-----|-----------|-----|-----|-----|
|      |                          | 2013-2014           |     |     |     | 2014-2015 |     |     |     | 2015-2016 |     |     |     |
|      |                          | 1st                 | 2nd | 3rd | 4th | 1st       | 2nd | 3rd | 4th | 1st       | 2nd | 3rd | 4th |
| A    | Akram Point              | 4                   | 0   | 4   |     |           |     |     |     |           |     |     |     |
| B    | Haldikhali               | 7                   | 0   | 4   |     |           |     |     |     |           |     |     |     |
| C    | Harbaria                 | 1                   | 5   | 2   |     |           |     |     |     |           |     |     |     |
| D    | Chandpai                 | 2                   | 2   | 5   |     |           |     |     |     |           |     |     |     |
| E    | Mongla Point             | 1                   | 10  | 4   |     |           |     |     |     |           |     |     |     |
| F    | Baro Durgapur            | 3                   | 6   | 2   |     |           |     |     |     |           |     |     |     |
| G    | Botiaghata, Chalna Point | 3                   | 3   | 2   |     |           |     |     |     |           |     |     |     |

<sup>3</sup> Simpson's index is a method to calculate the community characteristics of fish in a particular habitat. It is mainly used to know about the species richness of a particular habitat to tell how many species are rich in their abundance. The value of this index ranges from 0 to 1. There is other kind of value which is described in the methodology section. The second value is mainly used to measure the species richness in the sampling sites.



1.1 Fish Species Richness (FSR)

1.1.1 Fish species richness has been identified through Simpson's Index. Considerable difference was noticed in the fish species richness (FSR) in different habitat classes (Table 9.5 and Figure 9.3). In the monitoring phase, maximum FSR was obtained in Chandra (n=5) while very low FSR was recorded in Lohit. Moderate FSR was observed at Akam point, Haldighat and Point of the Pasur river (n=2). Among habitats in upstream portions of the Pasur river, Mongla-Pasur confluence point (n=4). Among habitats of Bala, Gola Chingri, Haina Chingri and Poo, Mongla Point was home to a rich assemblage of fish. Among habitats in Bala Durugah and Chingri point were rich in fish and Poo. Among habitats



Rupchanda in 1<sup>st</sup> Quarter Monitoring



Chela in 2<sup>nd</sup> Quarter Monitoring



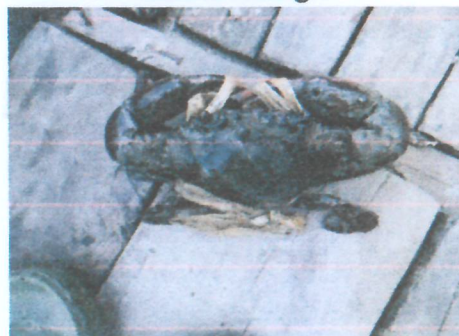
Phesa, Chela, Hilsa, Gagla Tengra



Harina Chingri



Lal Chewa



Crab



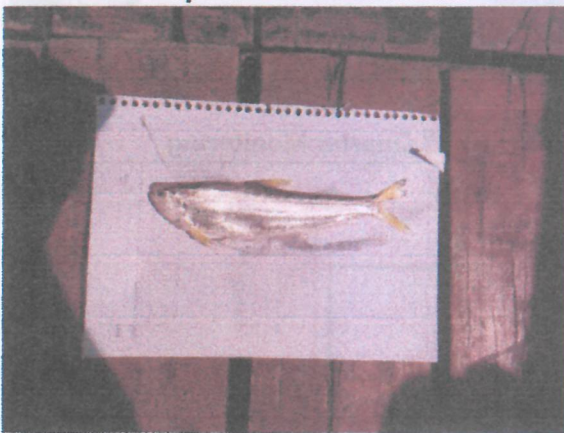


Poma, Rita, Tengra



Poma, Rita, Tengra

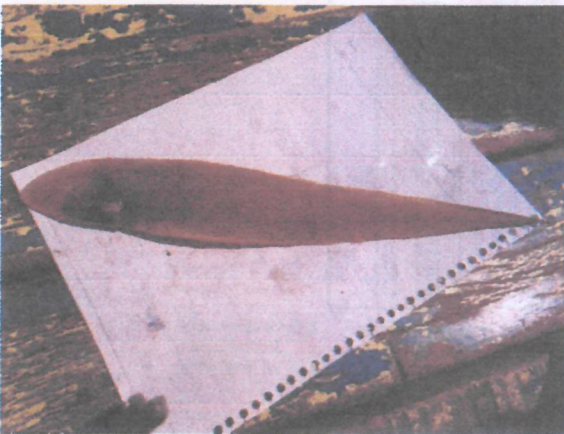
**Fish Species in Downstream of the Passur River at 3<sup>rd</sup> Quarter Monitoring**



Phesa



Poma, Phesa



Kukur Jib



Poma, Phesa



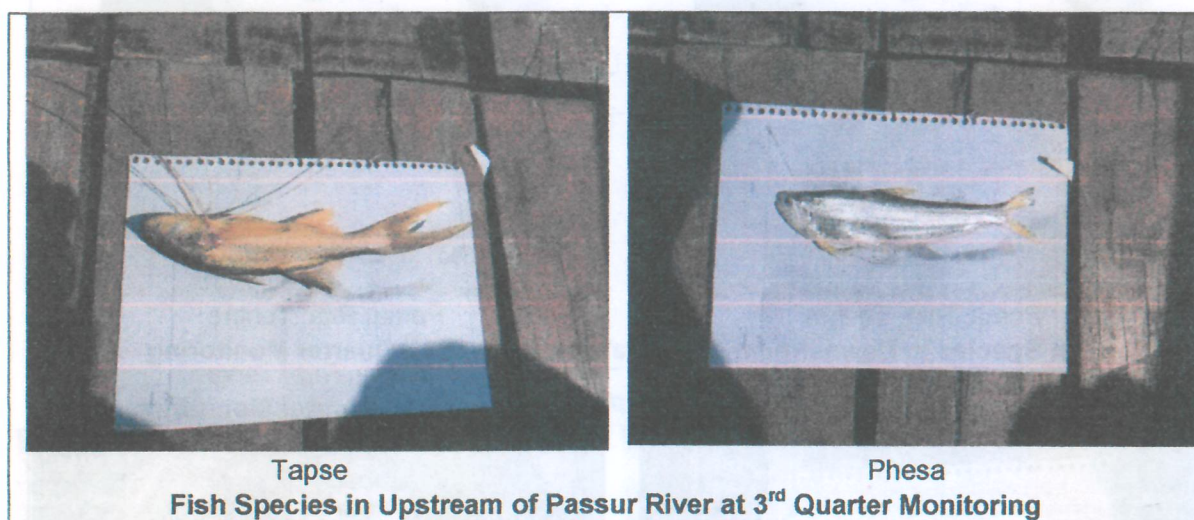
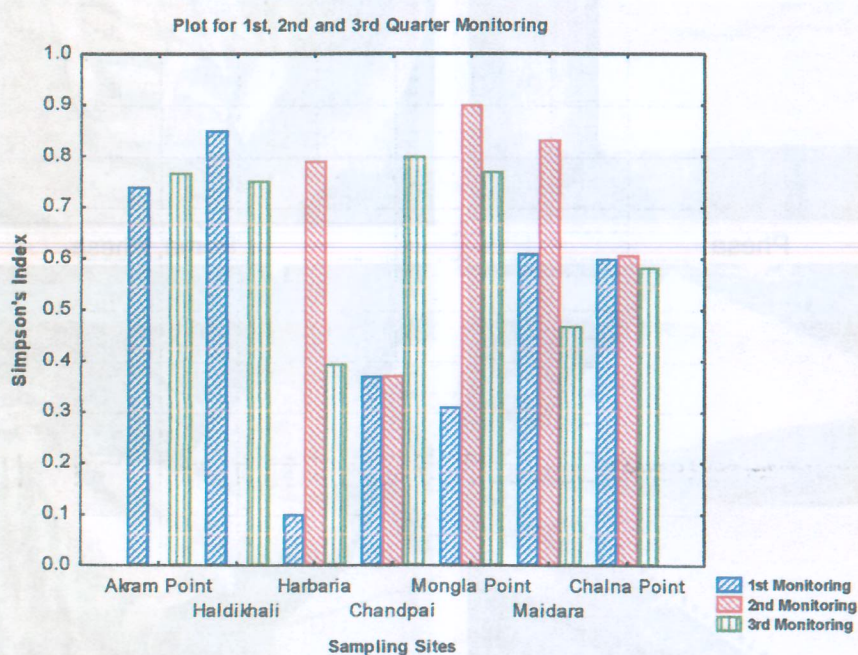


Photo 9.2: Length-wise distribution of fish species



**Figure 9.3: Site wise fish species richness (FSR) in the Passur River System. FSR is identified through Simpson's Index**

### c) Fish Community Structure

132. Fish community structure has been analyzed through counting the length-wise fish individuals (Photo 9.2). The following table 9.6, -9.7 and figure 9.4 for third monitoring shows that juveniles of maximum species were more dominant in the lower stretches of the Passur River. Moreover, larval stage has been observed in higher percentage in Mongla point and Haldikhali. Among these Golda, Poma and Chewa (especially Lal Chewa) species were frequently observed. Adult fish were also found in the upper stretches (Maidara River at Baro



Durgapur and Chalna Point) of the river. Brood fish has only been observed in case of Hilsa, Banspata and Golda species in the Mongla point, Haldikhali and Harbaria of Passur river.

Table 9.6: Occurrence of Species

| Local Name        | Scientific Name                       | Local Status * | 1 <sup>st</sup> QM (April, 2014) % | 2 <sup>nd</sup> QM (July, 2014) % | 3 <sup>rd</sup> QM % (Oct, 2014) | 4 <sup>th</sup> QM % | 5 <sup>th</sup> QM % | 6 <sup>th</sup> QM % | 7 <sup>th</sup> QM % | 8 <sup>th</sup> QM % | 9 <sup>th</sup> QM % | 10 <sup>th</sup> QM % | 11 <sup>th</sup> QM % | 12 <sup>th</sup> QM % |
|-------------------|---------------------------------------|----------------|------------------------------------|-----------------------------------|----------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-----------------------|-----------------------|-----------------------|
| Amadi Chela       | <i>Chela sp.</i>                      | DD             | -                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Hilsa             | <i>Tenualosa ilisha</i>               | NO             | -                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Sagor Baim        |                                       |                | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Bacha             | <i>Eutropiichthys vacha</i>           | CR             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Bagda Chingri     | <i>Penaeus monodon</i>                | DD             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Banspata          | <i>Brachypleura novae-zeelandiae</i>  | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Kukurjib          | <i>Cynoglossus lingua</i>             | NO             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Bele              | <i>Glossogobius giuris</i>            | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Boiragi           | <i>Coilia dussumieri</i>              | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Boishakhi Chingri |                                       | NO             | -                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Chammu Chingri    | <i>Metapenaeus brevicornis</i>        | DD             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Chaka Chingri     | <i>Penaeus indicus</i>                | DD             | +                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Ghora Chela       | <i>Securicula gora</i>                | -              | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Chanda Chela      |                                       |                | -                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Khayra Chela      |                                       |                | -                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Sada Chewa        | <i>Trepauchen vagina</i>              | NO             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Lal Chewa         | <i>Odontamblyopus rubicundus</i>      | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Chhuri            | <i>Trichiurus muticus</i>             | NO             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Sagor Chela       | <i>Megalops cyprinoids</i>            | NO             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Purabi Chela      | <i>Thryssa purava</i>                 | NO             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Kabashi Tengra    | <i>Mystus cavasius</i>                | DD             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Gagra Tengra      |                                       | DD             | -                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Gulsha Tengra     | <i>Mystus bleekery</i>                | DD             | +                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Harina Chingri    | <i>Metapenaeus ensis</i>              | DD             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Ekthuto           | <i>Hyporhamphus limbatus</i>          | NO             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Kakila            | <i>Xenentodon cancila</i>             | NO             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Chapila           | <i>Gudusia chapra</i>                 | NO             | +                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Kuchia            | <i>Monopterusuchia</i>                | DD             | +                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Kain Magur        |                                       | EN             | -                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Loitta            | <i>Harpodon nehereus</i>              | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Motka Chingri     | <i>Macrobrachium villosimanusless</i> | DD             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Mud Crab          | <i>Scylla serrata</i>                 | NO             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Tular Dandi       | <i>Sillaginopsis panijus</i>          | NO             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Paia Chanda       | <i>Scatophagus argus</i>              | DD             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Paissa            | <i>Liza parsia</i>                    | NO             | +                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Pangas            | <i>Pangasius pangasius</i>            | CR             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Tak Chanda        | <i>Leiognathus equulus</i>            | NO             | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Phessa            | <i>Setipinna phasa</i>                | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Teli Phessa       |                                       | -              | -                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Poma              | <i>Poma poma</i>                      | NO             | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Potka             | <i>Chelonodon patoca</i>              | NO             | +                                  | +                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Shilong           | <i>Silonia silondia</i>               | EN             | +                                  | -                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Tailla            | <i>Eleutheronema tetradactylum</i>    | -              | +                                  | -                                 | -                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |
| Tapse             | <i>Polynemus paradiseus</i>           | -              | +                                  | +                                 | +                                |                      |                      |                      |                      |                      |                      |                       |                       |                       |

\*Local Status Source: IUCN Red List



Table 9.7: Length-wise species distribution in sampling sites

| Fish Species   | Site                     | L (< 2cm) | L (2 to 3cm) | L (3 to 5cm) | L (5 to 10cm) | L (10 to 20cm) | L (> 25cm) | Brood Fish |
|----------------|--------------------------|-----------|--------------|--------------|---------------|----------------|------------|------------|
| Amadi Chela    | Chandpai                 | 0         | 0            | 0            | 67            | 33             | 0          | 0          |
| Banspata       | Botiaghata, Chalna Point | 0         | 0            | 0            | 0             | 0              | 100        | 0          |
|                | Haldikhali               | 0         | 0            | 0            | 40            | 30             | 0          | 30         |
|                | Maidara                  | 0         | 0            | 0            | 0             | 50             | 50         | 0          |
| Bele           | Haldikhali               | 0         | 0            | 0            | 0             | 100            | 0          | 0          |
|                | Harbaria                 | 0         | 0            | 33           | 50            | 17             | 0          | 0          |
|                | Mongla Point             | 3         | 3            | 87           | 8             | 0              | 0          | 0          |
|                | Maidara                  | 0         | 0            | 0            | 50            | 50             | 0          | 0          |
| Boiragi Chela  | Chandpai                 | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                | Haldikhali               | 0         | 0            | 20           | 80            | 0              | 0          | 0          |
| Chakkhu Dhela  | Haldikhali               | 0         | 0            | 67           | 33            | 0              | 0          | 0          |
| Chami Chingri  | Chandpai                 | 0         | 100          | 0            | 0             | 0              | 0          | 0          |
| Chanda Chela   | Akram Point              | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                | Chandpai                 | 0         | 0            | 100          | 0             | 0              | 0          | 0          |
| Chela          | Haldikhali               | 0         | 0            | 78           | 22            | 0              | 0          | 0          |
| Chhuri         | Akram Point              | 0         | 0            | 0            | 0             | 0              | 100        | 0          |
|                | Haldikhali               | 0         | 0            | 0            | 0             | 0              | 100        | 0          |
| Ekthuto        | Akram Point              | 0         | 0            | 0            | 0             | 100            | 0          | 0          |
| Golda Chingri  | Chandpai                 | 0         | 0            | 0            | 0             | 100            | 0          | 0          |
|                | Harbaria                 | 0         | 0            | 0            | 0             | 0              | 0          | 100        |
|                | Mongla Point             | 87        | 0            | 4            | 9             | 0              | 0          | 0          |
| Hilsa          | Haldikhali               | 0         | 0            | 0            | 50            | 50             | 0          | 0          |
|                | Mongla Point             | 0         | 0            | 0            | 0             | 29             | 57         | 14         |
| Harina Chingri | Akram Point              | 0         | 0            | 100          | 0             | 0              | 0          | 0          |
|                | Chandpai                 | 0         | 100          | 0            | 0             | 0              | 0          | 0          |
|                | Haldikhali               | 0         | 100          | 0            | 0             | 0              | 0          | 0          |
|                | Mongla Point             | 17        | 0            | 67           | 17            | 0              | 0          | 0          |
| Kain Magur     | Mongla Point             | 0         | 0            | 0            | 0             | 0              | 100        | 0          |
| Lal Chewa      | Chandpai                 | 0         | 0            | 56           | 13            | 31             | 0          | 0          |
|                | Haldikhali               | 0         | 61           | 37           | 2             | 0              | 0          | 0          |
| Loitta         | Akram Point              | 0         | 0            | 0            | 0             | 100            | 0          | 0          |
|                | Haldikhali               | 0         | 1            | 3            | 14            | 82             | 0          | 0          |
| Maya Chela     | Haldikhali               | 0         | 0            | 6            | 94            | 0              | 0          | 0          |
| Motka Chingri  | Akram Point              | 0         | 100          | 0            | 0             | 0              | 0          | 0          |
|                | Chandpai                 | 0         | 100          | 0            | 0             | 0              | 0          | 0          |
|                | Haldikhali               | 0         | 0            | 100          | 0             | 0              | 0          | 0          |
|                | Harbaria                 | 0         | 100          | 0            | 0             | 0              | 0          | 0          |
| Paissa         | Akram Point              | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                | Chandpai                 | 0         | 0            | 0            | 60            | 40             | 0          | 0          |
|                | Haldikhali               | 0         | 0            | 0            | 50            | 50             | 0          | 0          |

| Fish Species            | Site                     | L (< 2cm) | L (2 to 3cm) | L (3 to 5cm) | L (5 to 10cm) | L (10 to 20cm) | L (> 25cm) | Brood Fish |
|-------------------------|--------------------------|-----------|--------------|--------------|---------------|----------------|------------|------------|
| Pangas                  | Harbaria                 | 0         | 2            | 0            | 53            | 45             | 0          | 0          |
|                         | Haldikhali               | 0         | 0            | 0            | 67            | 33             | 0          | 0          |
|                         | Mongla Point             | 0         | 0            | 0            | 83            | 0              | 17         | 0          |
| Phessa                  | Akram Point              | 0         | 0            | 50           | 50            | 0              | 0          | 0          |
|                         | Botiaghata, Chalna Point | 0         | 0            | 0            | 0             | 40             | 60         | 0          |
|                         | Haldikhali               | 0         | 0            | 0            | 0             | 100            | 0          | 0          |
|                         | Mongla Point             | 0         | 0            | 0            | 0             | 0              | 100        | 0          |
|                         | Maidara                  | 0         | 0            | 0            | 0             | 44             | 56         | 0          |
| Poma                    | Akram Point              | 0         | 0            | 50           | 0             | 25             | 25         | 0          |
|                         | Botiaghata, Chalna Point | 0         | 0            | 0            | 9             | 68             | 23         | 0          |
|                         | Chandpai                 | 0         | 0            | 100          | 0             | 0              | 0          | 0          |
|                         | Haldikhali               | 4         | 33           | 46           | 17            | 0              | 0          | 0          |
|                         | Harbaria                 | 0         | 0            | 0            | 0             | 99             | 0          | 1          |
|                         | Mongla Point             | 31        | 6            | 0            | 19            | 41             | 3          | 0          |
|                         | Maidara                  | 0         | 0            | 0            | 0             | 55             | 45         | 0          |
| Sada Chewa              | Haldikhali               | 0         | 0            | 0            | 56            | 44             | 0          | 0          |
| Tapse                   | Botiaghata, Chalna Point | 0         | 0            | 0            | 0             | 67             | 33         | 0          |
|                         | Chandpai                 | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                         | Haldikhali               | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                         | Harbaria                 | 0         | 0            | 0            | 0             | 0              | 33         | 67         |
|                         | Maidara                  | 0         | 0            | 0            | 0             | 100            | 0          | 0          |
| Teli Phessa             | Haldikhali               | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
| Gang Tengra             | Chandpai                 | 0         | 0            | 0            | 97            | 3              | 0          | 0          |
|                         | Haldikhali               | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                         | Harbaria                 | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
|                         | Chandpai                 | 0         | 0            | 100          | 0             | 0              | 0          | 0          |
|                         | Haldikhali               | 0         | 0            | 0            | 100           | 0              | 0          | 0          |
| Tular Dandi (Nona bele) | Botiaghata, Chalna Point | 0         | 0            | 0            | 0             | 0              | 100        | 0          |
|                         | Maidara                  | 0         | 0            | 0            | 0             | 50             | 50         | 0          |
| Vetki                   | Mongla Point             | 0         | 0            | 0            | 0             | 50             | 50         | 0          |





**Figure 9.4: Habitat Distribution of Different Life Stages of Fish Species**

*Note: N.B.: Color ranges from deepest green to deepest red. 0-4.99% Occurrence signifies Deepest Green; 5-9.99%-Shaded Green; 11-14.99%-Normal Green; 15-19.99%-Light Green; 20-24.99%; 25-29.99%-Lightest Green; 30-34.99%; 35-39.99%; 40-44.99; 45-49.99; 50-54.99-Light Magenta; 55-59.99-Deep Magenta; 60-64.99%; 65-69.99%; 70-74.99%; 75-79.99%-Light Red; 80-84.99%-Deep Red; 85-89.99%; 90-94.99%; 95-100%-Deepest Red*

#### 9.4.5 Fish Migration

##### (a) Migratory Species Diversity

133. Migratory species have been identified by analyzing the common species available in the regular catch from the sampling sites. Fish species like Poma, Lal Chewa and Gang Tengra attain the maximum abundance among the migratory fish species observed in the third quarter monitoring. The availability of all other species found in this quarter is same as previous. The relative abundance of the migratory species is given in Figure 9.5 below.

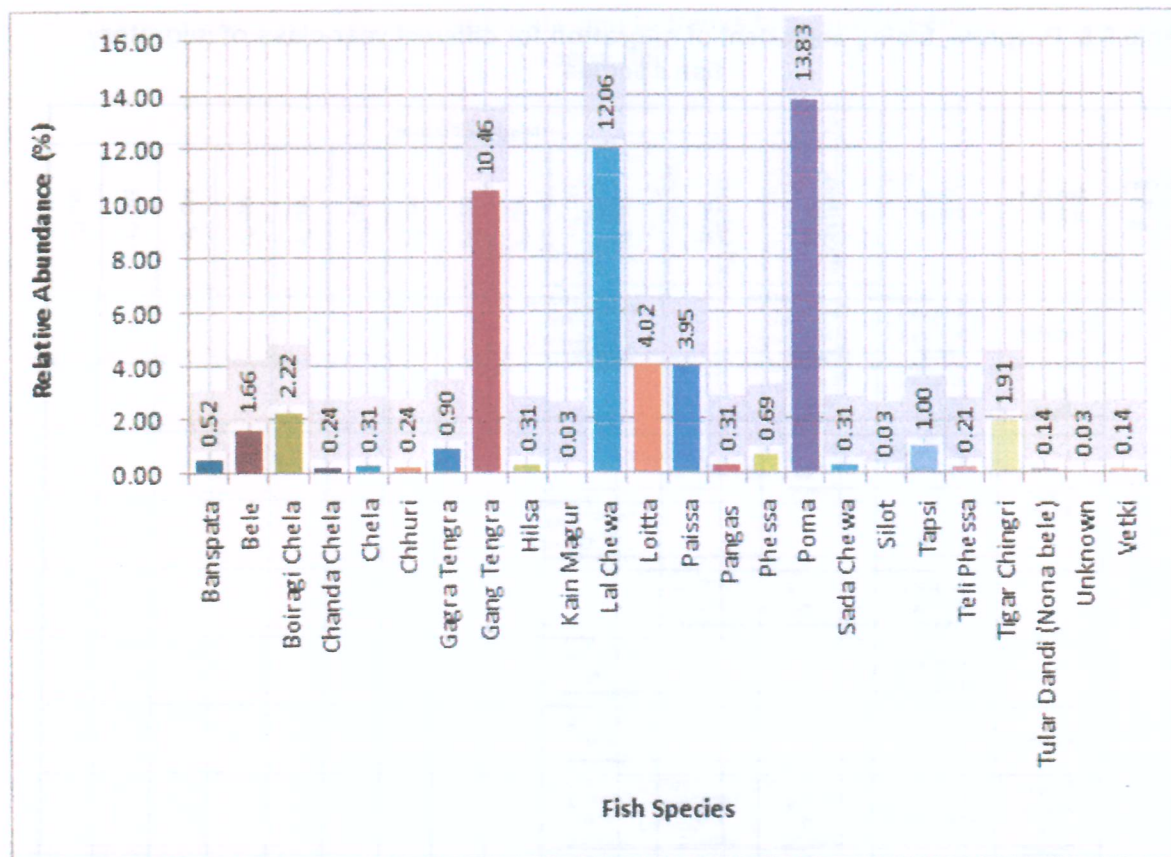


Figure 9.5: Relative abundance of migratory fish species in sampling sites

(b) **Migration Extent, Time and Purpose**

134. Major fish species showed interesting pattern in distribution for exploiting different purposes mentioned in the Table 9.8 through out the sampling sites. This means such fish species are migratory in nature. Sixteen (16) fish species were found common in most of the sites. The longest distance from site to site is from the Akram Point to the Chalna Point in the study reach. Only five species have been observed within this range like Tapse, Boiragi, Poma, Baila, Tular Dandi (Nona Bele), Hilsa and Pheasa indicating long range of distribution (Table 9.8). However, the Chhuri species showed very limited distribution and collected only from two nearest location (Akram Point and Haldikhali).



Table 9.8: Purpose, timing and extent of migration for different year-class of migratory fish species

| Migratory Fish Species | Sampling Sites            | Year Class*                | Migration Purpose                |                                 |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|------------------------|---------------------------|----------------------------|----------------------------------|---------------------------------|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|                        |                           |                            | 1 <sup>st</sup> QM (April, 2014) | 2 <sup>nd</sup> QM (July, 2014) | 3 <sup>rd</sup> QM (Oct, 2014) | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| Tapse                  | Haldikhal                 | Juvenile and Age-1 adult   | Feeding and Growing              | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile and Age-1 adult   | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chalna Point              | Age-1 adult and Brood fish | Feeding and Growing              | Spawning                        | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        |                           | Adult                      | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Juvenile and Age-1 adult   | Feeding and Growing              | Feeding and Growing             |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        |                           | Adult and Brood Fish       | -                                | -                               | Breeding and Spawning          |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Juvenile                   | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Age-1 adult                | Feeding and Growing              | Feeding and Growing             | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Boiragi                | Haldikhal                 | Juvenile and Age-1 adult   | Feeding and Growing              | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile and Age-1 adult   | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Fry                        | Breeding and Spawning            | Breeding and Spawning           | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chaina Point              | Juvenile and Age-1 adult   | Feeding and Growing              | -                               |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Juvenile                   | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Fry                        | -                                | Nursing                         | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Juvenile                   | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Chapila                | Haldikhal                 | Juvenile                   | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile                   | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Fry                        | -                                | Nursing                         | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Age-1 adult                | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Loita                  | Haldikhal                 | Juvenile                   | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |

| Migratory Fish Species | Sampling Sites            | Year Class*                    | Migration Purpose                |                                 |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|------------------------|---------------------------|--------------------------------|----------------------------------|---------------------------------|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|                        |                           |                                | 1 <sup>st</sup> QM (April, 2014) | 2 <sup>nd</sup> QM (July, 2014) | 3 <sup>rd</sup> QM (Oct, 2014) | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
|                        |                           | and Age-1 adult                | and Growing                      |                                 | and Growing                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile                       | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Age-1 adult                    | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Juvenile                       | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Fry, Juvenile and Age-1 adult  | -                                | Nursing, Feeding and Growing    | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chalna Point              | Age-1 adult                    | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Poma                   | Haldikhali                | Juvenile                       | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile                       | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Age-1 adult                    | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Fry and Juvenile               | Breeding and Spawning            | Nursing                         | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Juvenile                       | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Haldikhali                | Fry and Juvenile               |                                  |                                 | Nursing                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Adult and Brood Fish           |                                  |                                 | Breeding and Spawning          |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Fry, Juvenile and Age-1 adult  |                                  |                                 | Spawning, Feeding and Growing  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Adult                          |                                  |                                 | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chalna Point              | Juvenile, Adult and Brood Fish | Breeding and Spawning            | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Chhuri                 | Haldikhali                | Adult                          | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Adult                          | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Chela                  | Haldikhali                | Adult                          | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile and Adult             | Feeding and Growing              | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Juvenile                       | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |



| Migratory Fish Species | Sampling Sites            | Year Class*              | Migration Purpose                |                                 |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|------------------------|---------------------------|--------------------------|----------------------------------|---------------------------------|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|                        |                           |                          | 1 <sup>st</sup> QM (April, 2014) | 2 <sup>nd</sup> QM (July, 2014) | 3 <sup>rd</sup> QM (Oct, 2014) | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| Gang Tengra            | Haldikhali                | Adult                    | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Adult                    | Feeding and Breeding             | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Adult                    | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Adult                    | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Gagra Tengra           | Chandpai                  | Juvenile and Age-1 adult | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Age-1 adult              | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Juvenile and Adult       | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Adult                    | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Gulsha Tengra          | Haldikhali                | Adult                    | Feeding and Breeding             | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Akram Point               | Adult                    | Feeding and Breeding             | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Age-1 adult              | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Potka                  | Haldikhali                | Adult                    | Feeding and Breeding             | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Fry                      | Spawning                         | Spawning and Nursing            | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Fry                      | Spawning                         | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Paira Chanda           | Akram Point               | Adult                    | Feeding                          | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Fry                      | Breeding and Spawning            | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Chewa                  | Akram Point               | Juvenile and Adult       | Feeding                          | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Fry and Juvenile         | Spawning                         | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Haldikhali                | Juvenile and Adult       | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Juvenile and Adult       | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Juvenile                 | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Juvenile                 | -                                | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Bele                   | Akram Point               | Adult                    | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Haldikhali                | Juvenile-1,              | -                                | -                               | Nursing                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |

| Migratory Fish Species  | Sampling Sites            | Year Class*                  | Migration Purpose                |                                 |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|-------------------------|---------------------------|------------------------------|----------------------------------|---------------------------------|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|                         |                           |                              | 1 <sup>st</sup> QM (April, 2014) | 2 <sup>nd</sup> QM (July, 2014) | 3 <sup>rd</sup> QM (Oct, 2014) | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
|                         |                           | Juvenile and Adult           |                                  |                                 | and Growing                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Harbaria                  | Juvenile and Adult           | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chandpai                  | Fry                          | Breeding and Spawning            | Nursing                         | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chandpai                  | Juvenile and Adult           | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Mongla Point              | Fry                          | Breeding and Spawning            | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Mongla Point              | Fry, Juvenile-1 and Juvenile | -                                | -                               | Nursing and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chalna Point              | Fry                          | Breeding and Spawning            | Nursing                         | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | South-west of the Project | Juvenile and Age-1 adult     | -                                | Feeding and Growing             | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Tular Dandi (Nona bele) | Akram Point               | Adult                        | Feeding                          | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | South-west of the Project | Adult                        | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chalna Point              | Adult                        | Feeding                          | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Tairel                  | Akram Point               | Adult                        | Feeding                          | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Mongla Point              | Juvenile                     | Feeding                          | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Phessa                  | Akram Point               | Adult                        | Feeding                          | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Akram Point               | Juvenile                     | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Haldikhali                | Juvenile                     | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chalna Point              | Juvenile and Adult           | Feeding                          | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chalna Point              | Adult                        | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Mongla Point              | Adult                        | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | Chandpai                  | Juvenile and Adult           | Feeding                          | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | South-west of the Project | Juvenile and Adult           | Feeding                          | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                         | South-west of the Project | Adult                        | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |



| Migratory Fish Species | Sampling Sites            | Year Class*                   | Migration Purpose                |                                 |                                |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|------------------------|---------------------------|-------------------------------|----------------------------------|---------------------------------|--------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|                        |                           |                               | 1 <sup>st</sup> QM (April, 2014) | 2 <sup>nd</sup> QM (July, 2014) | 3 <sup>rd</sup> QM (Oct, 2014) | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| Paissa                 | Akram Point               | Juvenile and Adult            | Feeding                          | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Haldikhali                | Juvenile and Adult            | Feeding                          | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Harbaria                  | Juvenile-1 and Juvenile       | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Fry                           | Breeding and Spawning            | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chandpai                  | Juvenile and Adult            | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Fry                           | Breeding and Spawning            | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Fry, Juvenile and Age-1 adult | Breeding and Spawning            | Feeding and Growing             | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Banshpata              | Chandpai                  | Juvenile                      | Feeding                          | -                               | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Haldikhali                | Juvenile and adult            | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Fry and Adult                 | Feeding                          | Nursing                         | -                              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | South-west of the Project | Adult                         | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Chalna Point              | Adult                         | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Hilsa                  | Haldikhali                | Juvenile                      | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Adult                         | -                                | -                               | Spawning                       |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Pangas                 | Haldikhali                | Juvenile                      | -                                | -                               | Feeding and Growing            |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|                        | Mongla Point              | Juvenile and Adult            | -                                | -                               | Feeding                        |                    |                    |                    |                    |                    |                    |                     |                     |                     |

Source: Field findings at different times

\*Only Age-1 to Brood fish has been allowed to interpret the migration purpose; F = Feeding; Sp = Spawning

135. It has been interpreted from the Table 9.8 that in the month of October Brood fish of Hilsa species migrate to the upper reaches for spawning. Some species like Paissa, Poma, Tapse and Banspata migrate to the upper reaches of the Passur River for feeding purpose.

## 9.5 Shrimp/Fish Farm

136. For monitoring shrimp/fish farm, three farms has been selected within the 10km radius of the proposed power plant. Stocking pattern of the shrimp/fish farm is one of the major issues for successful production because of having natural genetic resources from the wild source of the



Passur River System. Moreover, maximization of growth rate and minimization of mortality rate should be ensured for achieving more economical output from the farms. So, stocking pattern, growth rate and mortality rate and its causes have been surveyed intensively.

**(a) Stocking Pattern**

137. It is reported by the farmers of the shrimp farms that availability of wild seed (PL) has been declining over the years. For which, most of the farmers are compelled to stock hatchery produced seeds along with some wild seeds in their farms. However, similar to the first and second monitoring phase, most of stocks are collected from wild source of the Passur River in the third monitoring phase also. However, stocking densities were lower than that of the second monitoring in all the shrimp farms (Table 9.9). The last stocking period starts from June and continues up to September.

**Table 9.9: Stocking Pattern of Fish/Shrimp farm**

| Location                   | Distance from Plant (km) | Fish Species   | Stocking Density (No./ha) | Stocking Date   | Stocking Source |          |
|----------------------------|--------------------------|----------------|---------------------------|-----------------|-----------------|----------|
|                            |                          |                |                           |                 | Natural         | Hatchery |
| Bhekatkhali Khal, Rajnagar | 0.5                      | Bagda          | 5,702                     | mid-Aug         | Passur River    | Jessore  |
|                            |                          | Gusha Chingri  | Natural Stocking          | April-September |                 | -        |
|                            |                          | Harina Chingri |                           |                 |                 |          |
|                            |                          | Rui (kg)       | 5                         | First-Sept      |                 |          |
|                            |                          | Catla (kg)     | 2                         | First-Sept      |                 | -        |
| Kapashdanga-Muralia        | 1                        | Bagda          | 2,593                     | First-July      | -               | Jessore  |
|                            |                          | Vetki          | Natural Stocking          | April-September | Passur River    | -        |
|                            |                          | Paissa         |                           |                 |                 |          |
|                            |                          | Phessa         |                           |                 |                 |          |
|                            |                          | Bhangan        |                           |                 |                 |          |
|                            |                          | Golda Chingri  |                           |                 |                 |          |
|                            |                          | Gulsha Tengra  |                           |                 |                 |          |
| Chunkuri-2                 | 0.8                      | Bagda          | 11,532                    | First-June      | Passur River    | Jessore  |
|                            |                          | Paissa         | Natural Stocking          | April-September |                 | -        |
|                            |                          | Tengra         |                           |                 |                 |          |
|                            |                          | Bele           |                           |                 |                 |          |
|                            |                          | Tilapia (kg)   | 40                        | Last August     | -               | Jessore  |
|                            |                          | Rui (kg)       | 40                        | Last August     | -               |          |
|                            |                          | Vetki          | Natural Stocking          | April-September | Passur River    | -        |
|                            |                          | Harina Chingri |                           |                 |                 |          |



| Location | Distance from Plant (km) | Fish Species  | Stocking Density (No./ha) | Stocking Date | Stocking Source |          |
|----------|--------------------------|---------------|---------------------------|---------------|-----------------|----------|
|          |                          |               |                           |               | Natural         | Hatchery |
|          |                          | Chami Chingri |                           |               |                 |          |
|          |                          | Catla (kg)    | 13                        | Last August   | -               | Jessore  |
|          |                          | Mrigel (kg)   | 13                        | Last August   | -               |          |

Source: Field Survey, 2014

**(b) Shrimp/Fish Growth Rate and Mortality**

138. Table 9.10 shows that the growth rate of Bagda has decreased in case of Chhoto Charer Gher in Rajnagar and increased in Gher of Kapashdanga-Muralia but remained same in Gher of Chunkuri-2 between second and third quarter monitoring. The mortality rate is highest in the Gher in Chunkuri-2 and lowest in the Gher in Kapashdanga-Muralia. The mortality mainly occurs due to viral infection and is mostly experienced in the farms which do not maintain water quality. Sometimes viral infection may take place from the nearby affected Gher.

Table 9.10: Growth Rate and Mortality of Fish/Shrimp

| Gher No. | 1 <sup>st</sup> QM<br>(April, 2014) |               | 2 <sup>nd</sup> QM<br>(July, 2014) |               | 3 <sup>rd</sup> QM<br>(Oct, 2014) |               | 4 <sup>th</sup> QM      |               | 5 <sup>th</sup> QM      |               | 6 <sup>th</sup> QM      |               | 7 <sup>th</sup> QM      |               | 8 <sup>th</sup> QM      |               | 9 <sup>th</sup> QM      |               | 10 <sup>th</sup> QM     |               | 11 <sup>th</sup> QM     |               | 12 <sup>th</sup> QM     |               |
|----------|-------------------------------------|---------------|------------------------------------|---------------|-----------------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|-------------------------|---------------|
|          | Growth Rate<br>(cm/day)             | Mortality (%) | Growth Rate<br>(cm/day)            | Mortality (%) | Growth Rate<br>(cm/day)           | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) | Growth Rate<br>(cm/day) | Mortality (%) |
| 1        | 0.3                                 | 15-20         | 0.2                                | 40            | 0.25                              | 50            |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |
| 2        | 0.3                                 | 30-35         | 0.3                                | 94            | 0.25                              | 10            |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |
| 3        | 0.2                                 | 25-30         | 0.2                                | 25            | 0.20                              | 65            |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |                         |               |

Source: Field Survey, 2014

Table 9.11: Total Catch in the Sampling Sites

| Sampling Site | Catch Per Unit Effort (kg/haul)     |                                    |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|---------------|-------------------------------------|------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|               | 1 <sup>st</sup> QM<br>(April, 2014) | 2 <sup>nd</sup> QM<br>(July, 2014) | 3 <sup>rd</sup> QM | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| A             | 142                                 | 0                                  | 0.28               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| B             | 6                                   | 0                                  | 1.25               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| C             | 4                                   | 0.2                                | 3.15               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| D             | *                                   | 4                                  | 3.82               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| E             | *                                   | 0.2                                | 0.02               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| F             | *                                   | 0.5                                | 1.46               |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| G             | 11                                  | 0.4                                | 3.50               |                    |                    |                    |                    |                    |                    |                     |                     |                     |

\* Weight of fry is not considered for catch assessment



### 9.5.1 Fish Production

#### (a) Capture Fish Production

139. In third monitoring phase, the highest productivity has been found in Sheola Khal at Chandpai of the Passur River System, and lowest in the Akram Point (Table 9.11). Moreover, as expected higher productivity was observed in the third monitoring phase as compared to that of the second monitoring. However, during the month of October the lower reach of the river (Haldikhali and Akram point) has mainly been observed as the ideal home of fry which are not included in production measure.

140. During this quarterly monitoring it is observed that Ber and Behundi Jal are frequently used to catch fish. The total catch through Ber and Behundi Jal is 14.4 and 6.7 kg respectively (Table 9.12). The following table also expresses that Ber Jal is used in lower reach and upper reach of the Passur River. Moreover, spear has been found in upper, middle and lower reaches of the Passur River. However, the total catch is found to be higher in third quarter monitoring than that found in the second quarter monitoring (Table-9.13).

**Table 9.12: Total Catch in Different Gears in the Sampling Sites**

| Site | Gear         | Houl Duration (hour) | Haul No | Total Weight (Kg) |
|------|--------------|----------------------|---------|-------------------|
| A    | Ber Jal      | 2:30                 | 1       | 2.3               |
|      | Spear        | 6:00                 | 8       | 0.2               |
| B    | Current Jal  | 1:00                 | 1       | 1.3               |
| C    | Behundi Jal  | 6:00                 | 1       | 3.5               |
|      | Charpata Jal | 7:37                 | 1       | 4.1               |
| D    | Behundi Jal  | 5:00                 | 1       | 3.2               |
| E    | Jhaki Jal    | 3:00                 | 50      | 1.4               |
|      | Spear        | 6:00                 | 252     | 3.5               |
| F    | Ber Jal      | 2:00                 | 1       | 8.6               |
|      | Spear        | 1:00                 | 8       | 4.6               |
| G    | Ber Jal      | 4:00                 | 1       | 3.5               |

**Table 9.13: Total Catch in the Sampling Sites**

| Sampling Site | Total Catch (kg)                    |                                    |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|---------------|-------------------------------------|------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|               | 1 <sup>st</sup> QM<br>(April, 2014) | 2 <sup>nd</sup> QM<br>(July, 2014) | 3 <sup>rd</sup> QM | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| A             | 28*                                 | 0                                  | 3                  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| B             | 65                                  | 0                                  | 1                  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| C             | 1,559                               | 0.5                                | 8                  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| D             | **                                  | 12                                 | 3                  |                    |                    |                    |                    |                    |                    |                     |                     |                     |

| Sampling Site | Total Catch (kg)                    |                                    |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|---------------|-------------------------------------|------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|               | 1 <sup>st</sup> QM<br>(April, 2014) | 2 <sup>nd</sup> QM<br>(July, 2014) | 3 <sup>rd</sup> QM | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
| E             | **                                  | 0.6                                | 5                  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| F             | **                                  | 1.2                                | 13                 |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| G             | **                                  | 1.6                                | 4                  |                    |                    |                    |                    |                    |                    |                     |                     |                     |

\*Average Weight 0.15kg/mud crab and average weight 0.6 kg/mud eel

\*\* Weight of Fry is not considered for catch assessment

**(b) Culture Fish Production**

141. During this third quarterly monitoring on shrimp/fish farm it is found that the highest production comes from the shrimp farm of Chunkuri-2 and lowest from Gher in Bhekatkhali (Table 10.14). Moreover, the production from all the sampling Ghers is found higher in third monitoring phase as compared to the first and second quarter monitoring.



Table 9.14: The Present Catch in Three Sampling Ghers

| Sampling Site | Total Catch (kg)                 |      |                                 |      |                    |     |                    |     |                    |     |                    |     |                    |     |
|---------------|----------------------------------|------|---------------------------------|------|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|--------------------|-----|
|               | 1 <sup>st</sup> QM (April, 2014) |      | 2 <sup>nd</sup> QM (July, 2014) |      | 3 <sup>rd</sup> QM |     | 4 <sup>th</sup> QM |     | 5 <sup>th</sup> QM |     | 6 <sup>th</sup> QM |     | 7 <sup>th</sup> QM |     |
|               | Species                          | ton  | Species                         | ton  | Species            | ton | Species            | ton | Species            | ton | Species            | ton | Species            | ton |
| 1             | Bagda                            | 5    | Bagda                           | 6.42 | Bagda              | 4.8 |                    |     |                    |     |                    |     |                    |     |
|               | Vetki                            | 1.57 | Bele                            | 0    | Gusha Chingri      | -   |                    |     |                    |     |                    |     |                    |     |
|               | Bele                             | 0.98 | Cheng                           | 0    | Harina Chingri     | -   |                    |     |                    |     |                    |     |                    |     |
|               | Harina Chingri                   | 0.78 | Bhangan                         | 0    | Rui (kg)           | -   |                    |     |                    |     |                    |     |                    |     |
|               | Chali Chingri                    | 0.11 | Chali Chingri                   | 0    | Catla (kg)         | -   |                    |     |                    |     |                    |     |                    |     |
|               | Chaka Chingri                    | 0.08 |                                 |      | -                  | -   |                    |     |                    |     |                    |     |                    |     |
|               | Sub-total =                      | 8.52 |                                 | 6.42 |                    | 4.8 |                    |     |                    |     |                    |     |                    |     |
| 2             | Bagda                            | 4    | Bagda                           | 1    | Bagda              | 7   |                    |     |                    |     |                    |     |                    |     |
|               | Harina Chingri                   | 2    | Harina Chingri                  | 0.33 | Vetki              | 1   |                    |     |                    |     |                    |     |                    |     |
|               | Chali Chingri                    | 0.18 | Chali Chingri                   | 0.08 | Paissa             | 10  |                    |     |                    |     |                    |     |                    |     |
|               | -                                | -    | Golda Chingri                   | 0.01 | Phessa             | 2.4 |                    |     |                    |     |                    |     |                    |     |
|               | -                                | -    | Bele                            | 0.08 | Bhangan            | 1.7 |                    |     |                    |     |                    |     |                    |     |
|               | -                                | -    | Tengra & Paissa                 | 0.04 | Golda Chingri      | 0.9 |                    |     |                    |     |                    |     |                    |     |
|               | Sub-total =                      | 6.00 |                                 | 2.00 |                    | 23  |                    |     |                    |     |                    |     |                    |     |
| 3             | Bagda                            | 1.38 | Bagda                           | 2.4  | Bagda              | 1.5 |                    |     |                    |     |                    |     |                    |     |
|               | Harina Chingri                   | 0.34 | Harina Chingri                  | 0.34 | Paissa             | 10  |                    |     |                    |     |                    |     |                    |     |
|               | Chali Chingri                    | 0.17 | Chali Chingri                   | 0.17 | Tengra             | 10  |                    |     |                    |     |                    |     |                    |     |
|               | Sub-total =                      | -    | -                               | -    | Bele               | 20  |                    |     |                    |     |                    |     |                    |     |

| Sampling Site | Total Catch (kg)                    |                                    |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|---------------|-------------------------------------|------------------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|
|               | 1 <sup>st</sup> QM<br>(April, 2014) | 2 <sup>nd</sup> QM<br>(July, 2014) | 3 <sup>rd</sup> QM | 4 <sup>th</sup> QM | 5 <sup>th</sup> QM | 6 <sup>th</sup> QM | 7 <sup>th</sup> QM | 8 <sup>th</sup> QM | 9 <sup>th</sup> QM | 10 <sup>th</sup> QM | 11 <sup>th</sup> QM | 12 <sup>th</sup> QM |
|               | -                                   | -                                  | Tilapia<br>22      |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  | Rui<br>28          |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  | Vetki<br>-         |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  | Harina<br>Chingri  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  | Charmi<br>Chingri  |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  | Catla<br>56        |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  | Mrigel<br>50       |                    |                    |                    |                    |                    |                    |                     |                     |                     |
|               | -                                   | -                                  |                    |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Sub-total =   | 1.89                                | 2.91                               | 197.5              |                    |                    |                    |                    |                    |                    |                     |                     |                     |
| Grand-total = | 17.00                               | 11.33                              | 226.5              |                    |                    |                    |                    |                    |                    |                     |                     |                     |

Source: Field Survey, 2014





## 10 Ecosystem and Biodiversity Monitoring

### 10.1 Indicators of Monitoring

142. Indicators for terrestrial and aquatic ecosystems have been selected through prior anticipation of probable impacts on ecological resources in different phases of the proposed Project.
143. Plant composition and diversity is important for vegetation study which indicates vegetation structure of an area. Plant health is directly related with biomass productivity. Plant health of an area may be changed due to change in environmental parameters like temperature, composition of gaseous components, soil salinity, humidity and nutrients, air particulate, dust etc. Plant diseases and proportion of healthy/ unhealthy plant is needed to observe for assessing the plant health condition.
144. Canopy status of terrestrial vegetation indicates plant health and biomass properties of an area. Vegetation canopy structure may be changed for the change of plant growth rate due to change of soil properties, plant physiological disorders due to change of climatic parameters or even for different human interventions. To monitor vegetation canopy status of the study area, canopy cover will be monitored in different time intervals.
145. Lichens often grow on trees and shrubs, absorbing nutrients from the atmosphere. Lichens are very sensitive to air pollution, particularly to sulfur dioxide, fluoride, and ammonia. The acidity of a tree's bark can also affect lichen abundance. Presence of lichen coverage on homestead trees would be a bio indicator for monitoring air quality standard of the study area.
146. Birds are important class in terrestrial faunal community which are very much sensitive to their habitat condition. Changes of environmental parameters, Land use and vegetation composition directly impact on bird's habitat of a locality. Broadly, two types of bird are found in an area; local and migratory. To observe local bird habitat suitability, number of bird nest and nesting bird species can be a good indicator. Number of wetlands where migratory birds come year year will be considered to observe migratory bird habitat suitability.
147. Monitoring of butterfly is an important means of measuring change in the environment as well as state of habitats for biodiversity. Insects are by far the most species rich group of animals, representing over 50% of terrestrial biodiversity. Contrary to most other groups of insects, butterflies are well visible and mostly sensitive to changes of environmental parameters.
148. Benthos and planktons play important role as food and oxygen source for various aquatic biota. Phytoplanktons also have great contribution to ensure primary productivity of aquatic ecosystems. Good water quality is essential to support healthy benthic and plankton communities. Changes of any water quality parameters may have impact on benthic and planktonic composition and population. Dolphin is another important ecological indicator which indicates water quality as well as aquatic habitat suitability of an aquatic system. This aquatic mammal is still present in all the river systems of the study area. Any change of water quality and river bed siltation may change occurrence of dolphin in a river system. Therefore, occurrence of dolphin is needed to be monitored.
149. Invasion of alien species may come with coal vessel from other countries. Alien species may be harmful to local aquatic ecosystem if they are highly aggressive in succession or reproduction. Alien invasion will therefore be observed regularly during Plant operation phase.
150. Followed by the above justification and rational, following indicators have been selected for regular monitoring what would be the base for identifying the impacts for proposed Power Plant in future.



*Terrestrial Ecosystems*

- a) Plant Species composition and diversity
- b) Plant health
- c) Vegetation canopy
- d) Lichen
- e) Bird habitats
- f) Butterfly occurrence

*Aquatic Ecosystems*

- a) Benthos
- b) Planktons
- c) Dolphin

**10.2 Location of Monitoring**

**(a) Terrestrial Ecosystems**

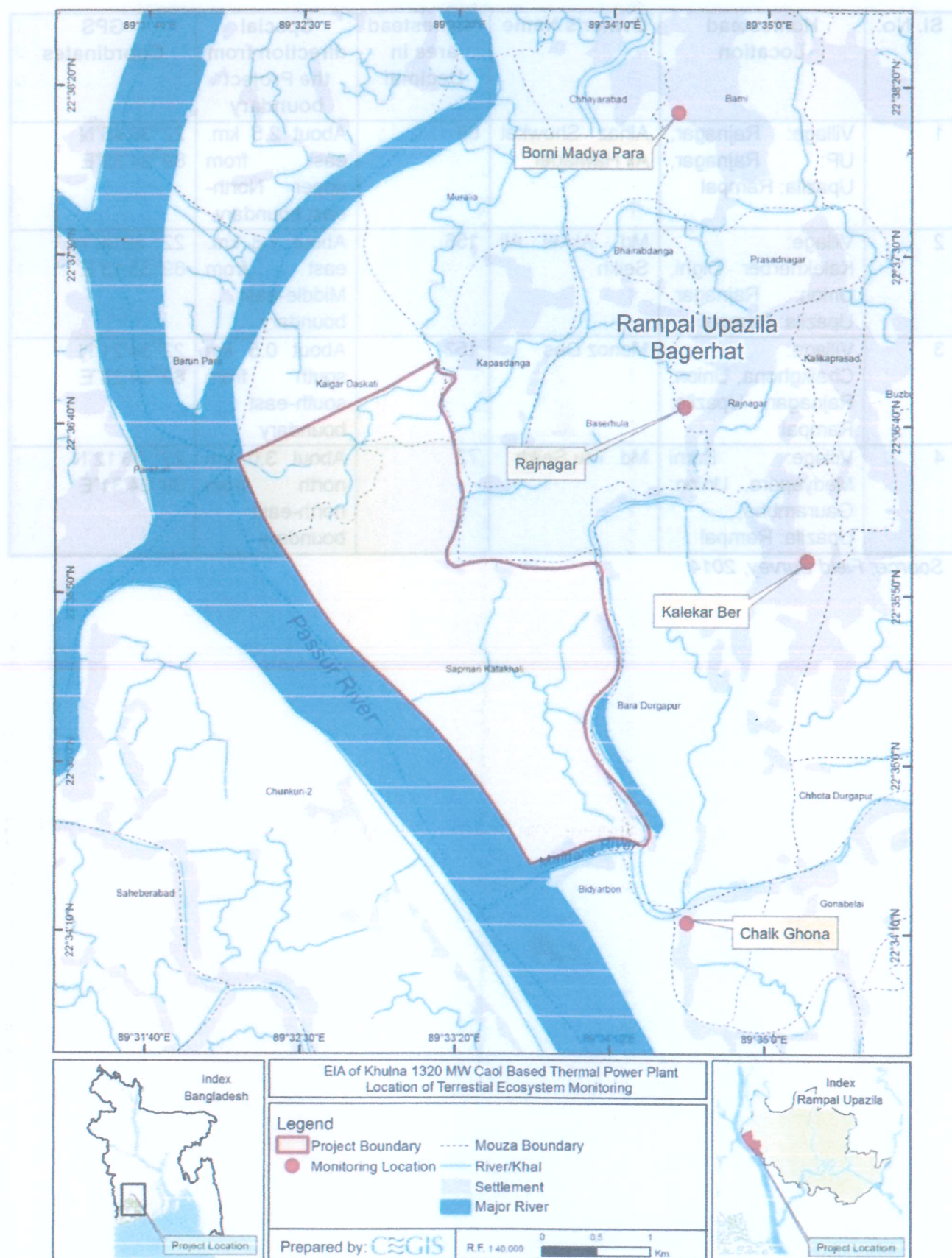
151. Four homesteads have been selected for monitoring indicators of terrestrial ecosystem in the study area. Locations of the homesteads have been selected considering wind direction and possible spatial dispersion of air pollutants (if any) e.g. SO<sub>x</sub>, NO<sub>x</sub>, SPM, etc from the power plant in future. **Table 10.1** presents the selected locations, owners, homestead area and special direction from the Project boundary.

152. Table 10.1: Locations of Terrestrial Ecosystem Monitoring

| Sl. No. | Homestead Location   | Owner's Name                  | Homestead area in Decimal | Special direction from the Project boundary                 | GPS Coordinates           |
|---------|--|-------------------------------|---------------------------|---|---------------------------|
| 1       | Village: Rajnagar,<br>UP: Rajnagar,<br>Upazila: Rampal               | Alhaz Showkat<br>Ali Hawlader | 80                        | About 2.5 km.<br>east from<br>upper North-<br>east boundary | 22°36'45"N<br>89°34'33"E  |
| 2       | Village: Kalekherber Dighi,<br>Union: Rajnagar,<br>Upazila: Rampal   | Md. Akkel Ali<br>Seikh        | 156                       | About 1.8 km.<br>east from<br>Middle-east<br>boundary       | 22° 36'00"N<br>89°35'13"E |
| 3       | Village: Chalkghona, Union:<br>Rajnagar, Upazila:<br>Rampal          | Mono Das                      | 152                       | About 0.5 km<br>south from<br>south-east<br>boundary        | 22°34'21"N<br>89°34'28"E  |
| 4       | Village: Barni<br>Madyapara, Union:<br>Gaurambha,<br>Upazila: Rampal | Md. Titu Seikh                | 72                        | About 3.0 km<br>north from<br>north-east<br>boundary        | 22° 38'12"N<br>89°34'31"E |

Source; Field Survey, 2014





Map 10.1: Terrestrial Ecosystem Monitoring Locations



**(b) Aquatic Ecosystems**

153. Different locations of river systems as well as lentic waterbodies have been selected to observe the changes in the three selected indicators: benthos, plankton and Dolphin occurrence for aquatic ecosystem monitoring. In addition, to monitor the stagnant water ecosystem condition, two ponds have been selected. Only Benthos and planktonic species have only been monitored in these ponds. Monitoring locations of aquatic ecosystems is presented in **Table 10.2**.

**Table 10.2: Location of Aquatic Indicators Monitoring**

| Indicator  | Location  | GPS Coordinate  |
|--|---|---|
| Benthos and Plankton species composition in river system       | Passur-Maidara confluence point   | 22°34'34"N<br>89°33'37"E  |
|  | Project Jettyghat at Passur river   | 22°35'21"N<br>89°32'51"E  |
|  | Passur River near Harbaria  |   |
|  | Passur River near Akram Point   | 21°59'33"N<br>89°31'54"E  |
| Benthos and Plankton species composition in stagnant waterbody | Kalekherber Dighi   | 22°36'00"N<br>89°35'13"E  |
|  | Kaigardaskanthi Gucchagram Pond   | 22°36'35"N<br>89°32'05"E  |
| Dolphin occurrence of River systems                            | 6 locations of Passur River Channel from Chalna Bazar to Akram point (Passur River along Project site, Karamjal, Harbaria, Sharankhola, Akrampoint, Sibsa river near Akram Point) | 22°36'33"N<br>89°32'00"E  |
|  | Along Maidara River from Passur-Maidara confluence point to upstream reach  | From 22°34'34"N<br>89°33'37"E to last reaches of two river branches (Ichamoti ; Near Chalkghona village and Maidara-Saltakhali near Salitakhali village |

Source: CEGIS Selection through field surey, 2014





### 10.3 Baseline of Ecosystem and Bio-diversity

#### 10.3.1 Terrestrial Ecosystem

154. Terrestrial ecosystem supports most of the floral and faunal communities which are directly related to the environmental parameters like temperature, air quality, sunlight, soil nutrients etc. Homesteads vegetation occupies maximum portions of terrestrial ecosystems in the study area. As such, observation on different indicators of selected homestead vegetation and dweller wildlife will be helpful to assess the ecological impacts for the proposed project.

##### a. Description of the selected homestead

155. The homestead in Rajnagar is located at a distance of 2.5 km east from the upper North-east boundary of the project site. This is situated in a low lying area and numerous small swamps exist inside and surrounding the homesteads. Water retention capacity of surface soil of this homestead is very low for which very little number of grasses and other herbs are present.

156. Land elevation of selected homestead at Kalekar Ber dighi village is comparatively flood free. This is located at about at 1.8 km east from Middle-east boundary of the project.

157. Chalkghona village is located at about 0.5 km south from south-east boundary of the project. The selected homestead of this village is close to Maidara River to its north side and saline water shrimp farms to its south periphery. Presence of shallow ditches and peripheral waterbodies support to grow staple coverage of saline tolerant plant species.

158. Barni village is located at about 3.0 km north from north-east boundary. Sampled homestead at Barni is situated at the middle part of the village. This homestead is also dominated by planted tree species and soil condition is similar to the Rajnagar site. Vegetation of this homestead have been severely been damaged by during Cyclone Aila.

##### b. Species Composition of selected homestead vegetation

###### *Homestead at Rajnagar*

159. Among the trees, Gewa (*Excochcaria agallocha*) is dominating among all trees. Moist and saline soil favors luxurious succession of this mangrove plant in homestead vegetation. Beside this, Safeda (*Manilkara zapota*) and Boroi (*Zizyphus sp*) are the two species of fruit yielding trees. Monocots including Narikel (*Cocos nucifera*) and Khejur (*Phoenix sylvestris*) occupied the top canopy of the vegetation. Three Bola (*Hibiscus tiliaceus*) three and one Sundari (*Heritiera fomes*) tree are also found. The homestead has no grasses or undergrowth vegetation.

###### *Homestead at Kalekar Ber dighi*

160. Narikel (*Cocos nucifera*) and Khejur (*Phoenix sylvestris*) occupies the top canopy. Aam (*Mangifera indica*), Safeda (*Manilkara zapota*), Peyara (*Psidium guajava*) and Boroi (*Zizyphus sp*) are common trees with height about 3-5 m. Rendi Koroi (*Albizia saman*) and Raj Koroi (*A. richardiana*) are timber trees. Beside this, Bakul (*Mimusops elengii*) and few number of Kola (*Musa sp*) are found on these homestead platforms. Among the creepers and herbs, Swamalata (*Cuscuta reflexa*) and Durba (*Cynodon sp*) are found.

###### *Homestead at Chalkghona*

161. Similar to the above homesteads, Narikel is the dominating tree species occupying the top canopy in the selected homestead at Chalkghona. As the homestead is near the peripheries of river and shrimp gher, soil salinity supports luxurious growth of mangrove plant Gewa (*Excochcaria agallocha*). This homestead has two shallow ditches which contain brackish water throughout the year and 2 Gol (*Nipa fruticans*) bushes are also existing there. Most of the medium size trees like Safeda (*Manilkara zapota*), Aam (*Mangifera indica*), Peyara (*Psidium guajava*), Papay (*Carica*



papaya) etc are fruit bearing trees. Beside this, some ornamental plants also exist. Detail plant species (trees and monocots only) are listed in Table 10.1.



Photo 10.1: A part of homestead vegetation at Kalekarber

#### Homestead at Barni

162. This homestead contains 21 types of tree species. Except Narikel (*Cocos nucifera*), Khejur (*Phoenix sylvestris*) and Taal (*Borassus flabellifer*), most of trees are young in age. The devastating cyclone Aila caused huge damage to the tree species. The house owner then planted many timber and fruit yielding trees in the home yard. Detail plant species composition of this homestead has been mentioned in Table 10.3.

Table 10.3: Species Composition of studied homestead vegetation

| Species Name               | Local Name         | Family      | No. of Plants |                   |            |          |
|----------------------------|--------------------|-------------|---------------|-------------------|------------|----------|
|                            |                    |             | Barni         | Kalekar Ber Dighi | Chalkghona | Rajnagar |
| <i>Acacia moniliformes</i> | Akashmoni          | Leguminosae | 6             | -                 | -          | 3        |
| <i>Aegle marmelos</i>      | Bel                | Rutaceae    | -             | -                 | 2          | -        |
| <i>Albizia richardiana</i> | Chambol            | Leguminosae | 2             | 8                 | 3          | -        |
| <i>Albizia saman</i>       | Sirish/Rendi Koroi | Leguminosae | 6             | 7                 | 3          | 2        |
| <i>Anona</i>               | Ata                | Anonaceae   | -             | 1                 | -          | -        |



| Species Name                  | Local Name   | Family        | No. of Plants |                   |            |          |
|-------------------------------|--------------|---------------|---------------|-------------------|------------|----------|
|                               |              |               | Barni         | Kalekar Ber Dighi | Chalkghona | Rajnagar |
| <i>squamosa</i>               |              |               |               |                   |            |          |
| <i>Areca catechu</i>          | Supari       | Palmae        | 10            | 18                | -          | -        |
| <i>Avecenia alba</i>          | Baen         | Aviceniaceae  | -             | -                 | 2          | -        |
| <i>Azadirachta indica</i>     | Neem         | Meliaceae     | -             | -                 | 3          | 2        |
| <i>Borassus flabelifer</i>    | Taal         | Palmae        | 6             | 8                 | 2          | -        |
| <i>Carica papaya</i>          | Pepey        | Caricaceae    | -             | -                 | 5          | -        |
| <i>Citrus medica</i>          | Kagoji Lebu  | Rutaceae      | -             | -                 | 2          | -        |
| <i>Cocos nucifera</i>         | Narikel      | Palmae        | 10            | 56                | 39         | 17       |
| <i>Cordia dichotoma</i>       | Bohal        | Boraginaceae  | -             | -                 | 1          | -        |
| <i>Diospyrus pregrina</i>     | Deshi Gab    | Ebenaceae     | -             | -                 | 3          | -        |
| <i>Dyospyros blancoi</i>      | Bilati Gab   | Ebnaceae      | -             | 12                | -          | -        |
| <i>Excoecaria agallocha</i>   | Gewa         | Euphorbiaceae | 8             | 6                 | 36         | 100      |
| <i>Feronia lemonia</i>        | Kaotbel      | Rutaceae      | 1             | -                 | 1          | 1        |
| <i>Ficus religiosa</i>        | Aswath       | Moraceae      | 3             | -                 | -          | -        |
| <i>Ficus sp</i>               | Zeer Bat     | Moraceae      | 2             | -                 | -          | -        |
| <i>Gardenia augusta</i>       | Gondhoraj    | Rubiaceae     | -             | -                 | 2          | -        |
| <i>Hibiscus rosa sinensis</i> | Jaba         | Malvaceae     | -             | 2                 | 3          | 2        |
| <i>Hibiscus</i>               | Bola         | Malvaceae     | -             | -                 | -          | 3        |
| <i>Herritiera fomes</i>       | Sundari      | Sterculiaceae | -             | -                 | -          | 1        |
| <i>Ixora coccinea</i>         | Rangan       | Rubiaceae     | 1             | -                 | 1          | -        |
| <i>Mangifera indica</i>       | Aam          | Anacardiaceae | 6             | 6                 | 7          | 3        |
| <i>Manilkara zapota</i>       | Safeda       | Zapotaceae    | 2             | 1                 | 1          | 1        |
| <i>Mimusops elengii</i>       | Bakul        | Zapotaceae    | -             | 1                 | -          | -        |
| <i>Moringa oleifera</i>       | Sazna        | Moringaceae   | -             | -                 | 2          | -        |
| <i>Musa sp</i>                | Kola         | Musaceae      | 6             | -                 | 10         | -        |
| <i>Nypa fruticans</i>         | Gol          | Palmae        | -             | -                 | 2          | -        |
| <i>Phoenix sylvestris</i>     | Khejur       | Palmae        | 12            | 10                | 24         | 25       |
| <i>Phyllanthus acidus</i>     | Naul/Orboroi | Euphorbiaceae | -             | -                 | 2          | -        |
| <i>Pongamia sp</i>            | Koroj        | Leguminosae   | -             | -                 | 2          | 3        |
| <i>Psidium guajava</i>        | Peyara       | Myrtaceae     | 2             | 8                 | 17         | 2        |



| Species Name                 | Local Name  | Family        | No. of Plants |                   |            |          |
|------------------------------|-------------|---------------|---------------|-------------------|------------|----------|
|                              |             |               | Barni         | Kalekar Ber Dighi | Chalkghona | Rajnagar |
| <i>Punica granatum</i>       | Dalim       | Lythraceae    | -             | -                 | 4          | -        |
| <i>Quisqualis indica</i>     | Madhabilata | Combrataceae  | -             | -                 | 4          | -        |
| <i>Sonneratia apetala</i>    | Kewra       | Lythraceae    | -             | -                 | 3          | -        |
| <i>Spondius pinnata</i>      | Amra        | Anacardiaceae | 1             | -                 | -          | -        |
| <i>Swietenia mehogani</i>    | Mehogani    | Meliaceae     | 11            | 17                | 1          | 2        |
| <i>Syzygium cumini</i>       | Jaam        | Myrtaceae     | -             | 2                 | 2          | -        |
| <i>Syzygium samarengense</i> | Jamrul      | Myrtaceae     | 1             | -                 | -          | -        |
| <i>Tamarindus indica</i>     | Tentul      | Leguminosae   | 2             | 2                 | 1          | 1        |
| <i>Terminalia catapa</i>     | Kathbadam   | Combrataceae  | 5             | -                 | 1          | -        |
| <i>Zizyphus mauritiana</i>   | Kul         | Rhamnaceae    | -             | 2                 | 4          | 2        |
| -                            | Palm Oil    | Palmae        | -             | 4                 | -          | -        |
| -                            | Shewly      | -             | -             | -                 | 4          | -        |

Source: Field Monitoring, April 2014 and June 2014

### c. Species Diversity of homestead vegetation

163. A total number of 47 plant species belonging to 22 families have been enumerated from the 4 studied plots (except Homestead plot at Rajnagar). These species represent 8 monocots. Among the families, Palmae hold 7 species and *Cocos nucifera* having higher abundance. Species diversity of each studied homestead is briefly described in following **table 10.4**.

**Table 10.4: Composition, Density and Abundance of top 5 species in studied homesteads**

| Location   | Sl. No. | Species Name                | Local Name | Family        | Total Number of individuals | Density | Abundance |
|------------|---------|-----------------------------|------------|---------------|-----------------------------|---------|-----------|
| Chalkghona | 1       | <i>Cocos nucifera</i>       | Narikel    | Palmae        | 39                          | 7.8     | 975       |
|            | 2       | <i>Excoecaria agallocha</i> | Gewa       | Euphorbiaceae | 36                          | 7.2     | 720       |
|            | 3       | <i>Phoenix sylvestris</i>   | Khejur     | Palmae        | 24                          | 4.8     | 600       |
|            | 4       | <i>Psidium guajava</i>      | Peyara     | Myrtaceae     | 17                          | 3.4     | 567       |
|            | 5       | <i>Carica papaya</i>        | Pepey      | Caricaceae    | 5                           | 1.0     | 500       |
| Barni      | 1       | <i>Swietenia mehogani</i>   | Mehogani   | Meliaceae     | 11                          | 2.2     | 550       |
|            | 2       | <i>Excoecaria agallocha</i> | Gewa       | Euphorbiaceae | 8                           | 1.6     | 400       |
|            | 3       | <i>Areca catechu</i>        | Supari     | Palmae        | 10                          | 2       | 333       |
|            | 4       | <i>Musa sp</i>              | Kola       | Musaceae      | 6                           | 1.2     | 300       |



| Location          | Sl. No. | Species Name                 | Local Name | Family        | Total Number of individuals | Density | Abundance |
|-------------------|---------|------------------------------|------------|---------------|-----------------------------|---------|-----------|
| Kalekar Ber Dighi | 5       | <i>Phoenix sylvestris</i>    | Khejur     | Palmae        | 12                          | 2.4     | 240       |
|                   | 1       | <i>Cocos nucifera</i>        | Narikel    | Palmae        | 56                          | 11.2    | 1120      |
|                   | 2       | <i>Excoecharia agallocha</i> | Gewa       | Euphorbiaceae | 6                           | 1.2     | 600       |
|                   | 3       | <i>Swietenia mahagoni</i>    | Mehogani   | Meliaceae     | 17                          | 3.4     | 567       |
|                   | 4       | <i>Areca catechu</i>         | Supari     | Palmae        | 18                          | 3.6     | 450       |
| Rajnagar          | 5       | <i>Dyospyros blancoi</i>     | Bilati Gab | Ebnaceae      | 12                          | 2.4     | 300       |
|                   | 1       | <i>Excoecharia agallocha</i> | Gewa       | Euphorbiaceae | 25                          | 5       | 1250      |
|                   | 2       | <i>Phoenix sylvestris</i>    | Khejur     | Palmae        | 25                          | 5       | 500       |
|                   | 3       | <i>Cocos nucifera</i>        | Narikel    | Palmae        | 17                          | 3.4     | 340       |
|                   | 4       | <i>Psidium guajava</i>       | Peyara     | Myrtaceae     | 2                           | 0.4     | 200       |
| Rajnagar          | 5       | <i>Pongamia pinnata</i>      | Koroj      | Leguminosae   | 3                           | 0.6     | 150       |

Source: Field Monitoring, April 2014 and June 2014

#### d. Diversity Index of Sampling homesteads vegetation

164. The average Diversity Index of this area is 2.47. Chalkghona possess top diversity rating with presence of 34 plant species. Following table provides the plant diversity index of different studied homesteads.

Table 10.5: Diversity Index of homestead plant species

| Location          | Total No. of Tree Species | Diversity Index (H) |
|-------------------|---------------------------|---------------------|
| Barni             | 20                        | 2.75                |
| Kalekar Ber Dighi | 19                        | 2.35                |
| Chalkghona        | 34                        | 2.80                |
| Rajnagar          | 15                        | 1.99                |

Source: Vegetation Survey, April 2014 and June 2014

#### e. Plant health

165. Plant health of this area is not satisfactory. Vegetation structure of this area is tree dominant. Random saline shrimp farming is a major threat to plant health of this area. Starting of shrimp farming in this area triggered incursion of salinity of soils. For this reason, plant succession, growth and productivity have fallen down in this area.

#### Plant Diseases and symptoms in homestead vegetation

166. Plant diseases observation of an area is needed to evaluate plant health and productivity. During field survey, some tree species were selected for regular observation of plant disease in the study area. In this regards, 5 different plant species (*Cocos nucifera*, *Manilkara zapota*, *Mangifera indica*, *Borassus flabellifer* and *Psidium guajava*) have been observed in each homesteads.

167. Leaf spot, leaf blast, nut fall, spot canker on fruits are common diseases of the plants in the study area. A brief discussion was conducted with house owners about the diseases of selected economic plants which exist in their homesteads. Most symptoms of plant diseases are descriptive. Although, all plant diseases symptoms are not visible in a same time of the year, but it was tried to observe the existing disease symptoms. Leaf spot and spot canker on fruits is the common



symptoms of *Cocos nucifera*. In addition, diameter loss at top portion of this monocot is also common symptom of this plant. In case of *Mangifera indica*, leaf blast is also found at Chalkghona village. Most of the homesteads plants are affected by fungal or bacterial pathogens. To observe fungal diseases symptom clearly, post wet season is the best time as most of the fungal pathogen germinate and penetrate in moist condition.



**Photo10.2 : Disease affected Coconut and Date palm plants of the studied homesteads**  
(Upper photos are Rajnagar and lower both have been taken from Chalkghona)

#### *Number of disease affected trees*

168. Disease affected plants has recovered and become more lively green than previous monitoring season in June 2014. However, still some unhealthy plants on each studied homestead were seen in this quarter. Coconut (*Cocos nucifera*) and Date palm (*Phoenix sylvestris*) are the main victim species of disease infection. Sample homestead at Rajnagar and Chalkghona are found having higher numbers of infected plants of said victim species. Diameter of these two monocots species have been reduced at upper portions, and canopy coverage and fruit production have been reduced as well. Immature death of leaves is another common symptom. Excess saturation and salinity of soil may be main reason for this symptom. Height of homestead platforms of Rajnagar and Chalkghona are comparatively lower than other portions of the study area. Moreover, existence of surrounding shrimp farms is another reason for increase of soil salinity.

169. Following table represents the proportion of healthy and unhealthy plants in studied homesteads.



Table 10.6: Proportion of healthy and unhealthy plants in studied homesteads

| Location         | Plant Name                  | Total No. of Plant | No. of Healthy Plant |                      |                      | No. of Unhealthy Plant |                      |                      |
|------------------|-----------------------------|--------------------|----------------------|----------------------|----------------------|------------------------|----------------------|----------------------|
|                  |                             |                    | 1st QM<br>(Apr 2014) | 2nd QM<br>(Jun 2014) | 3rd QM<br>(Oct 2014) | 1st QM<br>(Apr 2014)   | 2nd QM<br>(Jun 2014) | 3rd QM<br>(Oct 2014) |
| Rajnagar         | <i>Cocos nucifera</i>       | 17                 | NS                   | 7                    | 11*                  | NS                     | 10                   | 5                    |
|                  | <i>Phoenix sylvestris</i>   | 25                 | NS                   | 10                   | 21                   | NS                     | 15                   | 4                    |
|                  | <i>Manilkara zapota</i>     | 1                  | NS                   | 1                    | 1                    | NS                     | 0                    | 0                    |
|                  | <i>Albizia saman</i>        | 2                  | NS                   | 2                    | 2                    | NS                     | 0                    | 0                    |
|                  | <i>Excoecaria agallocha</i> | 100                | NS                   | 100                  | 98*                  | NS                     | 0                    | 1                    |
|                  | <i>Mangifera indica</i>     | 3                  | NS                   | 2                    | 3                    | NS                     | 1                    | 0                    |
|                  | <i>Psidium guajava</i>      | 2                  | NS                   | 0                    | 2                    | NS                     | 2                    | 0                    |
| Barni            | <i>Cocos nucifera</i>       | 10                 | 3                    | 7                    | 10                   | 7                      | 3                    | 0                    |
|                  | <i>Phoenix sylvestris</i>   | 12                 | 12                   | 7                    | 8                    | 0                      | 5                    | 4                    |
|                  | <i>Borassus flabellifer</i> | 6                  | 3                    | 5                    | 6                    | 3                      | 1                    | 0                    |
|                  | <i>Mangifera indica</i>     | 6                  | 3                    | 3                    | 5                    | 3                      | 3                    | 1                    |
|                  | <i>Excoecaria agallocha</i> | 18                 | 18                   | 18                   | 18                   | 0                      | 0                    | 0                    |
|                  | <i>Swietenia mehogani</i>   | 11                 | 11                   | 11                   | 11                   | 0                      | 0                    | 0                    |
|                  | <i>Areca catechu</i>        | 10                 | 10                   | 4                    | 8                    | 0                      | 6                    | 2                    |
|                  | <i>Manilkara zapota</i>     | 1                  | 1                    | 1                    | 1                    | 0                      | 0                    | 0                    |
|                  | <i>Psidium guajava</i>      | 2                  | 0                    | 1                    | 2                    | 2                      | 1                    | 0                    |
| Kalekarber Dighi | <i>Cocos nucifera</i>       | 56                 | 21                   | 50                   | 55                   | 35                     | 5                    | 1                    |
|                  | <i>Phoenix sylvestris</i>   | 10                 | 10                   | 7                    | 10                   | 0                      | 3                    | 0                    |
|                  | <i>Mangifera indica</i>     | 5                  | 3                    | 5                    | 5                    | 1                      | 1                    | 0                    |
|                  | <i>Manilkara zapota</i>     | 1                  | 1                    | 1                    | 1                    | 0                      | 0                    | 0                    |
|                  | <i>Borassus flabellifer</i> | 8                  | 8                    | 8                    | 8                    | 0                      | 0                    | 0                    |
|                  | <i>Zizyphus sp</i>          | 1                  | 1                    | 1                    | 1                    | 0                      | 0                    | 0                    |
|                  | <i>Psidium guajava</i>      | 8                  | 7                    | 8                    | 8                    |                        | 0                    | 0                    |
|                  | <i>Tamarindus indica</i>    | 2                  | 2                    | 2                    | 2                    | 0                      | 0                    | 0                    |
| Chalkghona       | <i>Cocos nucifera</i>       | 39                 | 35                   | 20                   | 34                   | 25                     | 19                   | 5                    |
|                  | <i>Phoenix sylvestris</i>   | 24                 | 24                   | 14                   | 23                   | 0                      | 10                   | 1                    |
|                  | <i>Albizia saman</i>        | 3                  | 1                    | 3                    | 3                    | 0                      | 0                    | 0                    |
|                  | <i>Excoecaria agallocha</i> | 36                 | 36                   | 36                   | 35                   | 0                      | 0                    | 1                    |
|                  | <i>Manilkara zapota</i>     | 1                  | 1                    | 1                    | 1                    | 0                      | 0                    | 0                    |
|                  | <i>Psidium guajava</i>      | 17                 | 16                   | 10                   | 17                   | 1                      | 7                    | 0                    |
|                  | <i>Mangifera indica</i>     | 7                  | 5                    | 6                    | 7                    | 2                      | 1                    | 0                    |
|                  | <i>Borassus flabellifer</i> | 2                  | 2                    | 2                    | 2                    | 0                      | 0                    | 0                    |

Note: NS = Not Surveyed

\*=1 Cocos have been cut and 1 *Excoecaria* have been died



#### f. Vegetation canopy status

170. Canopy status of terrestrial vegetation indicates plant health and biomass properties of an area. Vegetation canopy structure may be changed for any change in plant growth rate due to soil properties change, plant physiological disorders for the change of climatic parameters or even for different human interventions. To monitor vegetation canopy status of the study area, canopy cover is monitoring in different time intervals.

##### *Species representation in different canopy layers of homestead vegetation*

171. *Cocos nucifera* occupied top canopy of all the studied homestead vegetation. *Phoenix sylvestris* is prevalent as second top layer followed by *Excochordia agallocha*. Most of the fruit yielding trees like *Manilkara zapota*, *Mangifera indica* possess upper bole of canopy layer. Lower bole are occupied by small fruit yielding trees like *Psidium guajava*, *Musa* sp. Very few grass species and undergrowth vegetation were found in the studied homesteads.

##### *Estimated Canopy cover in homestead vegetation of sampling sites*

172. Overall canopy cover is found unchanged except in Chalkghona site. Vegetative growth of each plant by the influence of rain water is the reason for this improvement. In addition, Plantation of new saplings is an additive factor. Following table represent the % of canopy coverage of the studied homesteads.

**Table 10.7: Vegetation Canopy Cover in different studied homesteads**

| Location   | % of canopy Coverage |                      |                      |
|------------|----------------------|----------------------|----------------------|
|            | 1st QM<br>(Apr 2014) | 2nd QM<br>(Jun 2014) | 3rd QM<br>(Oct 2014) |
| Rajnagar   | NS                   | 19                   | 19                   |
| Barni      | NS                   | 26                   | 18                   |
| Kalekarber | NS                   | 20                   | 24                   |
| Chalkghona | NS                   | 13                   | 24                   |

Note: NS = Not Surveyed

#### g. Lichen cover

173. The decreasing trend of lichen coverage has been observed on plant bark in the studied homestead vegetation. After the rainy season, lichen is found in vegetative stage but the affected area of plant is not expanding. However, on average, vegetation at Kalekarber recorded highest lichen coverage as there are larger numbers of long trees with denser canopy than other locations. Table 10.8 refers average percentage of lichen coverage of the studied locations.

**Table 10.8: Lichen Coverage in different studied homestead vegetation**

| Location   | % of Lichen Coverage |                      |                      |           |           |           |
|------------|----------------------|----------------------|----------------------|-----------|-----------|-----------|
|            | 1st QM<br>(Apr 2014) | 2nd QM<br>(Jun 2014) | 3rd QM<br>(Oct 2014) | 4th<br>QM | 5th<br>QM | 6th<br>QM |
| Raj Nagar  | NS                   | 5.1                  | 2.5                  |           |           |           |
| Barni      | NS                   | 7.8                  | 3.1                  |           |           |           |
| Kalekarber | NS                   | 4.3                  | 3.2                  |           |           |           |
| Chalkghona | NS                   | 2.1                  | 2.6                  |           |           |           |

Note: NS = Not Surveyed



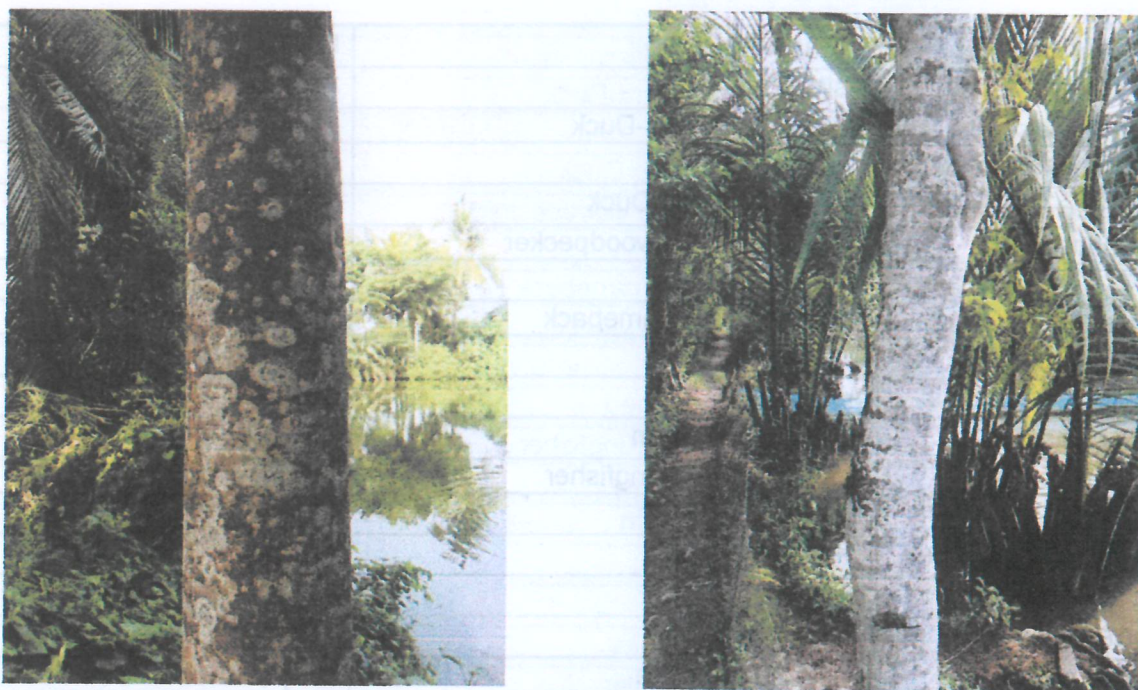


Photo 10.3 : Lichen on an Chambol tree at Kalekarber and Gewa tree trunks at Chalkghona

#### h. Bird Habitat

##### *Local birds and their nesting behavior*

174. The study area supports numerous local bird species. Most of which, dwell in homestead vegetation. Existence of vast shrimp farms as well as canals and rivers also favour good number of water dependent bird species in this area. Most of the birds are nesting on tall trees of homesteads. Coconut and Gewa followed top priority for nesting. Small bird like Tailor bird, prefer small bushy shrubs. Although, birds do not follow any local boundary, a clear conception on available bird species have been gathered through discussions with studied homestead owners as well as physical observation. A list of local bird species is presented in Table 10.9

Table 10.9: Local Bird Species of the study area

| Scientific Name               | Common Name             | Local Name      |
|-------------------------------|-------------------------|-----------------|
| <i>Accipiter badius</i>       | Shikra                  | Shikra          |
| <i>Acridotheres fuscus</i>    | Jungle Myna             | Jhuti Shalik    |
| <i>Acridotheres tristis</i>   | Common Myna             | Bhat Shalik     |
| <i>Actitis hypoleucos</i>     | Common Sandpiper        | Chah Pakhi      |
| <i>Aegithina tiphia</i>       | Common Iora             | Pati Fatikjal   |
| <i>Alcedo atthis</i>          | Common Kingfisher       | Pati Machranga  |
| <i>Amaurornis phoenicurus</i> | White-breasted Waterhen | Dholabook Dahuk |
| <i>Ardeola grayii</i>         | Indian Pond Heron       | Deshi Kanibok   |
| <i>Athene brama</i>           | Spotted Owlet           | Khuruley Pencha |
| <i>Bubulcus ibis</i>          | Cattle Egret            | Go Boga         |
| <i>Butorides striatus</i>     | Little Heron            | Choto Bok       |
| <i>Casmerodius albus</i>      | Great Egret             | Jattha Bok      |
| <i>Centropus bengalensis</i>  | Lesser Coucal           | Kana Kukka      |
| <i>Copsychus saularis</i>     | Oriental Magpie-Robin   | Udoi Doel       |



| Scientific Name                   | Common Name                  | Local Name             |
|-----------------------------------|------------------------------|------------------------|
| <i>Cypsiurus balasiensis</i>      | Asian Palm Swift             | Ashio Talbatashi       |
| <i>Dendrocygna bicolor</i>        | Fulvous Whistling-Duck       | Boro Sarali            |
| <i>Dendrocitta vagabunda</i>      | Rufous Treepie               | Khoira Harichacha      |
| <i>Dendrocygna javanica</i>       | Lesser Whistling Duck        | Choto Sarali           |
| <i>Dendrocopos macei</i>          | Fulvous breasted woodpecker  | Kathkurali             |
| <i>Dicrurus macrocercus</i>       | Black Drongo                 | Kala Fingey            |
| <i>Dinopium benghalense</i>       | Black ramped Frameback       | -                      |
| <i>Egretta garzetta</i>           | Little Egret                 | Choto Boga             |
| <i>Eudynamis scolopacea</i>       | Asian Koel                   | Kokil                  |
| <i>Gallinula chloropus</i>        | Common Moorhen               | Jolmurgi               |
| <i>Halcyon smyrnensis</i>         | White-throated Kingfisher    | Dholagola Machranga    |
| <i>Haliastur indus</i>            | Brahminy Kite                | Shonkho Chil           |
| <i>Ixobrychus cinnamomeus</i>     | Cinnamon Bittern             | Nolkhoka               |
| <i>Ixobrychus sinensis</i>        | Yellow Bittern               | -                      |
| <i>Ketupa zeylonensis</i>         | Brown fish owl               | Bhutum pecha           |
| <i>Lanus schach</i>               | Long-tailed Shrike           | Lenja Latora           |
| <i>Macronous gularis</i>          | Striped Tit Babbler          | -                      |
| <i>Megalaima haemacephala</i>     | Coppersmith Barbet           | Choto Boshonto Bauri   |
| <i>Merops orientalis</i>          | Green Bee Eater              | Suichora               |
| <i>Motacilla maderaspatensis</i>  | White-browed Wagtail         | -                      |
| <i>Nectarinia asiatica</i>        | Purple Sunbird               | Durgo Tuntuni          |
| <i>Netapus coromandelianus</i>    | Cotton pygmy goose           | Bali Hansh             |
| <i>Oriolus xanthornus</i>         | Black-hooded Oriole          | Kalamatha Benebou      |
| <i>Orthotomus sutorius</i>        | Common Tailorbird            | Pati Tuntuni           |
| <i>Passer domesticus</i>          | House Sparrow                | Charui                 |
| <i>Phalacrocorax niger</i>        | Little Cormorant             | Choto Pankouri         |
| <i>Porzana fusca</i>              | Ruddy-breasted Crake         | Ranga Ulti             |
| <i>Porphyrio porphyrio</i>        | Purple Swampphen             | Kalim                  |
| <i>Pycnonotus cafer</i>           | Red Vented Bulbul            | Bulbuli                |
| <i>Rhipidura albicollis</i>       | White-throated Fantail       | Dholagola Chatighurani |
| <i>Sterna albifrons</i>           | Little tern                  | Choto Gangchil         |
| <i>Streptopelia chinensis</i>     | Spotted Dove                 | Tila Ghughu            |
| <i>Streptopelia tranquebarica</i> | Red Collared Dove            | Penchi Ghughu          |
| <i>Stumus contra</i>              | Asian pied starling          | Go Shalik              |
| <i>Tachybaptus ruficollis</i>     | Little Grebe                 | Choto Duburi           |
| <i>Todiramphus chloris</i>        | Collared Kingfisher          | Dholaghar Machranga    |
| <i>Treron bicincta</i>            | Orange-breasted Green Pigeon | -                      |
| <i>Tyto abba</i>                  | Barn owl                     | Laksmi pecha           |
| <i>Upupa epops</i>                | Hoopoe                       | Hudhud                 |
| <i>Vanells indicus</i>            | Red-wattled Lapwing          | Lal Hotiti             |

Source: Field Monitoring, April 2014





**Photo10.4: Some local birds of the study area**

*Migratory birds and their habitats*

175. According to local knowledgeable people, different species of migratory birds are observed in shrimp ghers and other large waterbodies during winter. To evaluate habitat suitability from the next year, number of wetlands inside the study area will be considered where migratory birds usually come.

176. Information on migratory birds and their habitats along the study area will be presented after visiting the study area during next monitoring. However, a brief discussion has been made with local knowledgeable persons during previous monitoring (June 2014) to know about the locations of migratory birds' wetland/habitat. The name and locations of the wetlands inside the study area which favour migratory birds have been mentioned in following table.

**Table 10.10: Location of wetland for Migratory bird habitat inside the study area**

| Location Name       | Mouza                      | Wetland type             | Approximate distance from project Boundary (Km.) |
|---------------------|----------------------------|--------------------------|--|
| Choto Charargher    | Boro Durgapur              | Saline Water Shrimp Farm | 0.10   |
| Boro Charargher     | Boro Durgapur              | "                        | 0.10   |
| Putimari Gher       | Boro Durgapur              | "                        | 1.10   |
| Golbunia Gher       | Boro Durgapur              | "                        | 0.1  |
| Shukariar Gher      | Basherhula                 | "                        | 1.25   |
| Koigar Daskati Gher | Koigar Daskati and Muralia | "                        | 0.25   |
| Badyamari Gher      | Bidyarbon                  | "                        | 1.00   |
| Chalkghonar Beel    | Chalkghona                 | "                        | 1.50   |

Source: Field Monitoring, June 2014

*Bird species and number of Bird nests in sampling sites*

177. No bird nest has been observed in the 4 studied homesteads during this monitoring season.



Table 10.11: Bird nest monitoring datasheet

| Bird Name           | No. of Bird Nest observed |   |    |   |                      |   |   |    |        |   |   |   |        |   |   |   |        |   |   |   |        |   |   |   |
|---------------------|---------------------------|---|----|---|----------------------|---|---|----|--------|---|---|---|--------|---|---|---|--------|---|---|---|--------|---|---|---|
|                     | 1st QM<br>(Apr 2014)      |   |    |   | 2nd QM<br>(Jun 2014) |   |   |    | 3rd QM |   |   |   | 4th QM |   |   |   | 5th QM |   |   |   | 6th QM |   |   |   |
|                     | R                         | B | K  | C | R                    | B | K | C  | R      | B | K | C | R      | B | K | C | R      | B | K | C | R      | B | K | C |
| Little Cormorant    | NS                        | - | NS | - | 12                   | - | - |    | -      | - | - | - |        |   |   |   |        |   |   |   |        |   |   |   |
| Little Egret        | NS                        | - | NS | 1 | 4                    | - | - |    | -      | - | - | - |        |   |   |   |        |   |   |   |        |   |   |   |
| Asian Pied Starling | NS                        | 1 | NS | - | -                    | - | - | 11 | -      | - | - | - |        |   |   |   |        |   |   |   |        |   |   |   |
| Tailor Bird         | NS                        | - | NS | 1 |                      | - | - |    | -      | - | - | - |        |   |   |   |        |   |   |   |        |   |   |   |

Note: R = Rajnagar, B = Barni, K = Kalekarber C= Chakgona, NS = Not Surveyed, '-' = Not Found

### i. Butterfly occurrence

178. A total numbers of 28 butterfly species have been recorded from the study area. Among which, 5 species were not directly sighted during field visit in this monitoring period but were identified through public discussion. Rice Swift, Common Crow, Grass-yellow, Common Emigrant, Blue Tiger are the common butterflies in the study area frequently seen along the flowering plants, near marshes and bushes. Recorded butterfly species and their occurrences are listed in Table 10.12 below.

Table 10.12: Occurrences of Butterflies in the study area

| Common Name         | Scientific Name              | Occurrence of Butterfly species |    |   |   |                      |   |   |   |                      |    |    |    |
|---------------------|------------------------------|---------------------------------|----|---|---|----------------------|---|---|---|----------------------|----|----|----|
|                     |                              | 1st QM<br>(Apr 2014)            |    |   |   | 2nd QM<br>(Jun 2014) |   |   |   | 3rd QM<br>(Oct 2014) |    |    |    |
|                     |                              | R                               | B  | K | C | R                    | B | K | C | R                    | B  | K  | C  |
| Rice Swift          | <i>Borbo cinnara</i>         | -                               | -  | - | - | -                    | - | - | - | -                    | ** | *  | ** |
| Common Pierrot      | <i>Castalius rosimon</i>     | -                               | -  | - | - | -                    | - | - | - | -                    | *  | -  | *  |
| Common Emigrant     | <i>Catopsilia pomona</i>     | -                               | -  | - | - | -                    | - | - | - | *                    | *  | ** | *  |
| Common Gull         | <i>Cepora nerissa</i>        | -                               | -  | - | - | -                    | - | - | - | -                    | *  | -  | -  |
| Indian sunbeam      | <i>Curetis thetis</i>        | -                               | -  | - | - | -                    | - | - | - | -                    | -  | -  | *  |
| Swamp Tiger         | <i>Danaus affinis</i>        | -                               | -  | - | - | -                    | - | - | - | -                    | -  | -  | -  |
| Stripped Tiger      | <i>Danaus genutia</i>        | -                               | -  | - | - | -                    | - | - | - | *                    | -  | *  | -  |
| Common palmfly      | <i>Elymnias hypermnestra</i> | -                               | -  | - | - | -                    | - | - | - | -                    | *  | *  | -  |
| Spotted Pea-blue    | <i>Euchrysops cnejus</i>     | -                               | -  | - | - | -                    | - | - | - | -                    | -  | -  | -  |
| Common Crow         | <i>Euploea core</i>          | -                               | -  | - | - | *                    | - | * | * | *                    | *  | -  | *  |
| Papuan Grass-yellow | <i>Eurema blanda</i>         | -                               | -  | - | - | -                    | - | - | - | *                    | ** | -  | *  |
| Small Grass-yellow  | <i>Eurema smilax</i>         | -                               | ** | - | - | -                    | - | - | - | -                    | -  | -  | -  |



| Common Name         | Scientific Name                 | Occurrence of Butterfly species |   |   |   |                      |    |   |   |                      |    |   |   |
|---------------------|---------------------------------|---------------------------------|---|---|---|----------------------|----|---|---|----------------------|----|---|---|
|                     |                                 | 1st QM<br>(Apr 2014)            |   |   |   | 2nd QM<br>(Jun 2014) |    |   |   | 3rd QM<br>(Oct 2014) |    |   |   |
|                     |                                 | R                               | B | K | C | R                    | B  | K | C | R                    | B  | K | C |
| Danaid Eggfly       | <i>Hypolimnys misippus</i>      |                                 |   |   |   | -                    | -  | - | - | -                    | -  | - | - |
| Common Cerulean     | <i>Jamides celeno</i>           |                                 |   |   |   | -                    | -  | - | - | -                    | -  | * | - |
| Peacock pansy       | <i>Junonia almana</i>           |                                 |   |   |   | -                    | -  | - | - | -                    | ** | - | - |
| Grey Pansy          | <i>Junonia atlites</i>          |                                 |   |   |   | -                    | -  | - | - | -                    | *  | - | - |
| Chocolate Argus     | <i>Junonia hedonia</i>          |                                 |   |   |   | *                    | -  | * | - | -                    | -  | - | - |
| Lemon Pansy         | <i>Junonia lemonius</i>         |                                 |   |   |   | -                    | -  | - | - | -                    | *  | - | - |
| Evening Brown       | <i>Melanitis leda</i>           |                                 |   |   |   | -                    | -  | - | - | -                    | -  | - | - |
| Common Rose         | <i>Pachliopta aristolochiae</i> |                                 |   |   |   | -                    | -  | - | - | -                    | -  | - | - |
| Common Rose         | <i>Pachliopta aristolochiae</i> |                                 |   |   |   | -                    | -  | - | - | -                    | -  | - | * |
| Orchard Swallowtail | <i>Papilio aegaeus</i>          |                                 |   |   |   | *                    | ** |   |   | -                    | -  | - | - |
| Lime Butterfly      | <i>Papilio demoleus</i>         |                                 |   |   |   | -                    | -  | - | * | -                    | -  | - | * |
| Foscu Swallowtail   | <i>Papilio fuscus</i>           |                                 |   |   |   | -                    | -  | - | - | -                    | -  | - | - |
| Common gull         | <i>Papilio nerissa</i>          |                                 |   |   |   | -                    | -  | - | - | -                    | -  | * | - |
| Common Leopard      | <i>Papilio phalantha</i>        |                                 |   |   |   | -                    | -  | - | - | -                    | *  | * | - |
| Blue Tiger          | <i>Tirumala hamata</i>          |                                 |   |   |   | -                    | -  | - | - | -                    | ** | * | - |
| Dainty Grass-blue   | <i>Zizula hylax</i>             |                                 |   |   |   | -                    | -  | - | - | -                    | *  | * | - |

Note: Occurrence Status; \*\*= Occasional, \*\*\* = Common, '-'=Not Found

'R'=Rajnagar, 'B'=Barni, 'K'=Kalekarber, 'C'=Chalkghona



Picture 10.5 : Common butterflies of the study area



## 10.4 Aquatic Ecosystem Monitoring

179. Rivers, canals, ponds and saline water shrimp farms are the main wetlands in the study area. Of which, river bears the flowing/ lotic and pond bears the stagnant/lentic water systems. Shrimp farmers have unauthorizedly merged the canals surrounding the shrimp farm into the shrimp aquaculture pond. Therefore, canals no longer remain as flowing or stagnant water system.

### 10.4.1 Monitoring Locations

180. Passur is the only external river beside the project area which maintains connectivity with all flowing water systems of the study area. On the other hand, Maidara River including two branches (Maidara Sailtakhali and Ichamoti) exists as internal river system. Hence, status of benthos, planktons and aquatic mammals (Dolphin) in different locations of the study area has been monitored. In the case of stagnant (lentic) water system, indicator specimen has been collected from two big ponds inside the study area. Village pond is the only type of stagnant water body in the study area as maximum ditches, canals and beels have merged with saline water shrimp farms. All types of these wetlands are directly or indirectly connected with flowing river system.

181. Benthos and planktons have been monitoring for two seasons (Dry and Wet) of each year. According to that, dry season monitoring for these indicators will be monitored in next monitoring period.

### 10.4.2 Dolphin

#### *Dolphin migration route in study area*

182. Two dolphin species (Ganges River Dolphin and Irrawaddi Dolphin) travel through the Passur river throughout the year. The Ganges river dolphin migrates from estuary regions to upstream connected rivers like Rupsha and Madhumoti. Though Irrawardi Dolphin is mostly habituated in estuary regions of Bangladesh, but this aquatic mammal is also sighted in Passur river. Ganges Dolphins also roam through Maidara river throughout the year. Siltation and narrowing of upstream branches is limiting the length of migration area of this river day by day.

#### *Dolphin occurrence in Passur River*

183. Dolphins were observed different locations throughout the Passur Channel from Chalna Bazar to Akram Point. In this monitoring, more occurrences has been sighted in the selected monitoring locations.

184. A total numbers of 13 Ganges River dolphins have sighted during 20 km transect at Passur River near project sight. The survey was conducted during continuing ebb tide of the river in calm situation and a minor time during starting of flood tide. Dolphin occurrences were high at confluence points of Passur- Maidara and Passur-Mungla River. Detail survey result is presented in figure 10.1.





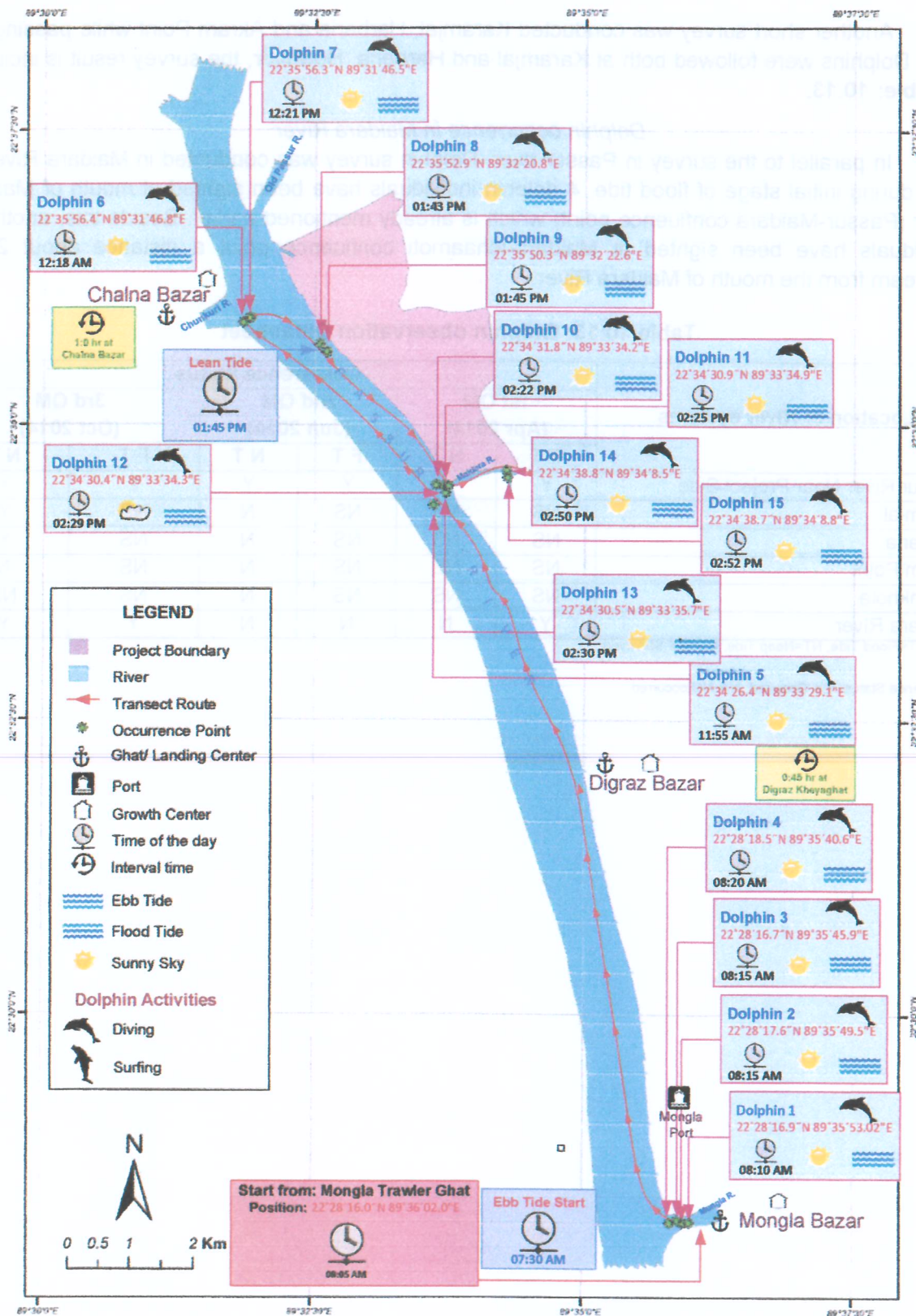


Figure 10.1: Occurrence of Dolphin at Passur and Maidara River along the project site (October 2014)



185. Another short survey was conducted Karamjal, Harbaria and Akram Point while passing the river. Dolphins were followed both at Karamjal and Harbaria. However, the survey result is included in Table: 10.13.

*Dolphin occurrence in Maidara River*

186. In parallel to the survey in Passur river, Dolphin survey was conducted in Maidara River as well, during initial stage of flood tide. 4 dolphin individuals have been sighted at mouth of Maidara River (Passur-Maidara confluence point) which is already mentioned earlier. Beside this, another 2 individuals have been sighted at Maidara-Ichaamoti confluence point a distance about 2 km upstream from the mouth of Maidara River.

**Table 10.13: Dolphin observation Datasheet**

| Location of River systems      | Occurrence Status    |    |                      |    |                      |    |
|--------------------------------|----------------------|----|----------------------|----|----------------------|----|
|                                | 1st QM<br>(Apr 2014) |    | 2nd QM<br>(Jun 2014) |    | 3rd QM<br>(Oct 2014) |    |
|                                | FT                   | NT | FT                   | NT | FT                   | NT |
| Passur River Near Project Side | Y                    | Y  | Y                    | Y  | Y                    | Y  |
| Karamjal                       | NS                   | NS | NS                   | N  | NS                   | Y  |
| Harbaria                       | NS                   | NS | NS                   | N  | NS                   | Y  |
| Akram Point                    | NS                   | NS | NS                   | N  | NS                   | N  |
| Sarankhola                     | NS                   | NS | NS                   | N  | NS                   | NS |
| Maidara River                  | Y                    | N  | N                    | N  | Y                    | Y  |

Note: FT=Flood Tide, NT=Neap Tide, NS=Not Surveyed,

Occurrence Status: Y = Occurred, N = Not occurred

## 11 Sundarbans Forest Health Monitoring

### 11.1 Monitoring Indicator

187. The following indicators have been selected for the monitoring of Sundarbans Forest health:

- i. Species richness, diversity, evenness, dominancy
- ii. Regeneration, recruitment, seedling survival
- iii. Canopy cover, tree height, diameter, pneumatophore and biomass,
- iv. Disease and damage (Timber, branch, leaves)
- v. Soil nutrient and quality:
  - Soil nutrients- macro, micro and heavy metal
  - Bulk density, organic carbon
  - Soil pH, salinity

188. Monitoring frequency for different indicators are different. In this quarter, the following indicators were observed

- Regeneration and recruitment
- Canopy cover, pneumatophore
- Crab hole density

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### 11.2 Monitoring location

189. Five sites were selected on the basis of the survey conducted from April 3 to 6, 2014 (Map 11.1). Among them, four sites along the Passur River at Karomjol, Harbaria, Akram point and Hiron point and another near Sutarkhali forest office. Distance from the proposed Project site, coal transportation route, and protection of the permanent sample plot and cover the maximum vegetation types were the major criteria for site selection.

### 11.3 Method

#### 11.3.1 Sampling design

190. In each site, a transect line was laid out perpendicular to river or canal bank. Along, the transect line three circular nested subplots of 12.62 m radius were laid out at 100 m intervals in order to capture maximum tree species (Figure 11.2). Because of variation of species composition in SRF observation plots were laid out from coast, river or canal side to landward zone (forest proper side). The location of the first subplot was 40 m away from ecotone (riverside) to inner ward of forest in order to save the subplot from river bank erosion.





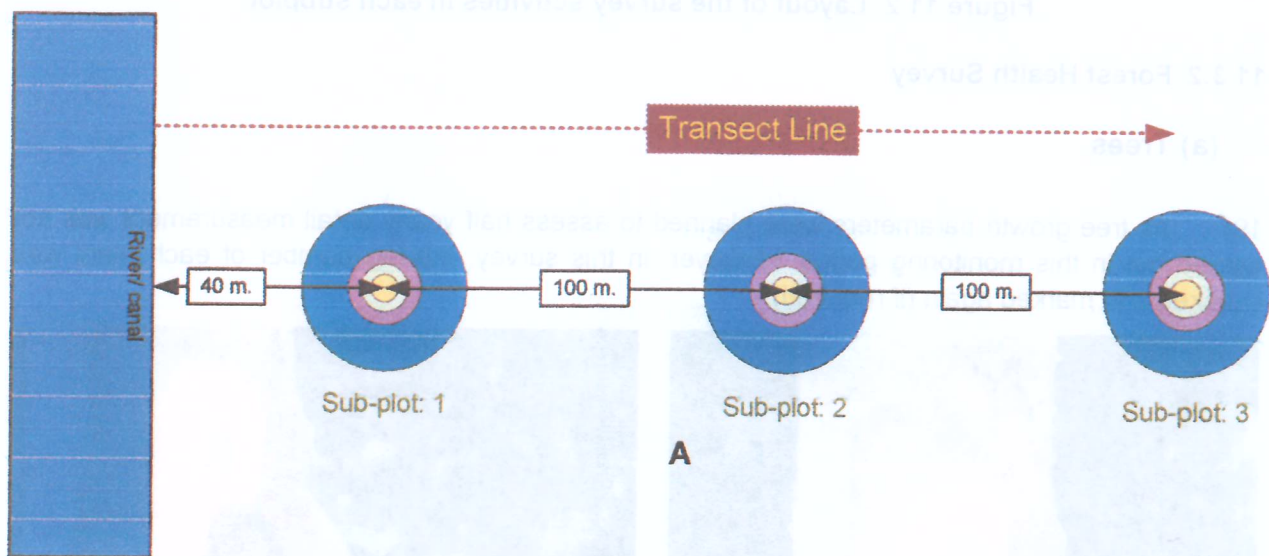


Figure 11.1: Layout of thye subplots and transect line perpendicular from ecotone (river or canal bank)

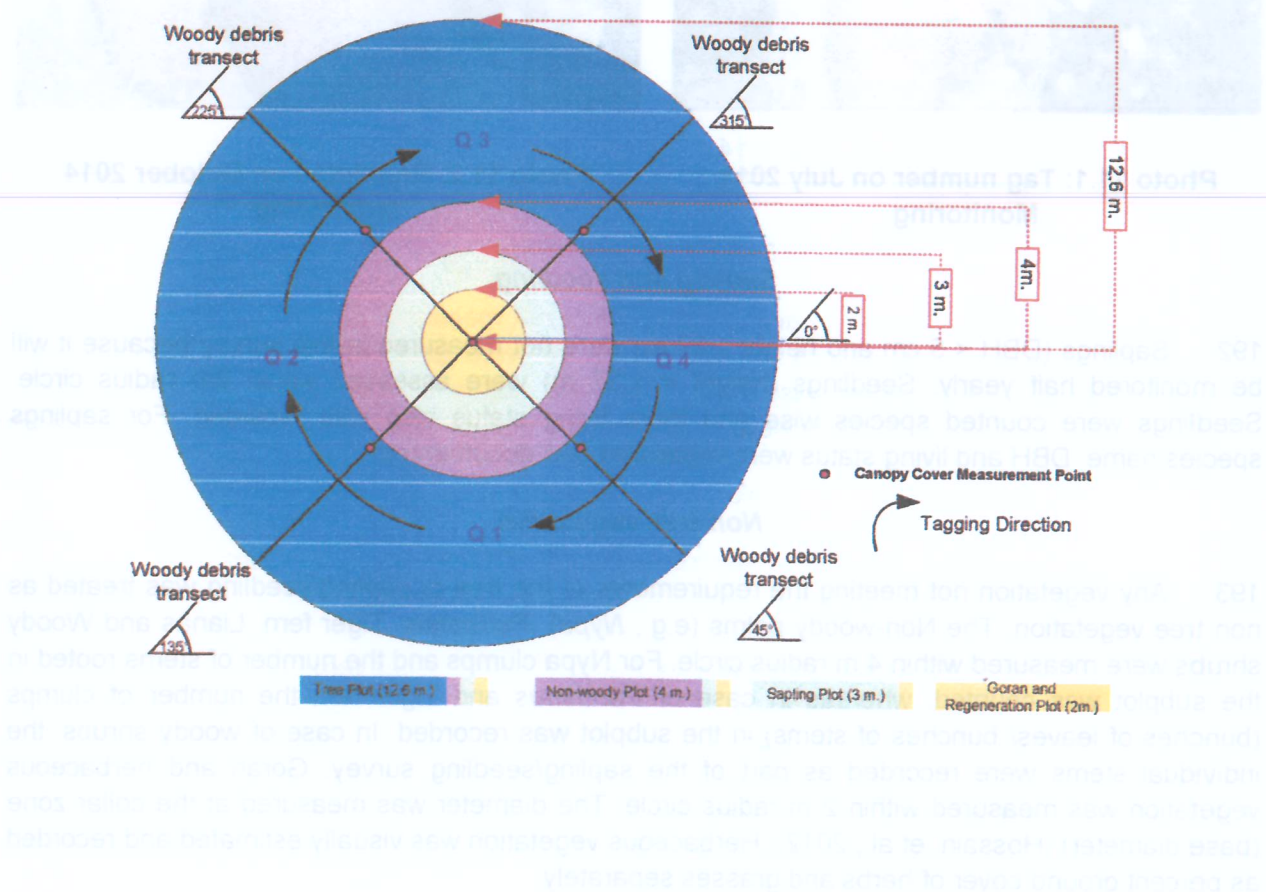




Figure 11.2: Layout of the survey activities in each subplot

### 11.3.2 Forest Health Survey

#### (a) Trees

191. As tree growth parameters were planned to assess half yearly detail measurement was not carried out in this monitoring period. However, in this survey, the tag number of each plant was checked and marked again (if required).



Photo 11.1: Tag number on July 2014 Monitoring



Photo 11.2: Repainted on October 2014 monitoring

#### *Sapling and seedling*

192. Saplings (DBH < 5 cm and height 1.37 m) were not measured in this survey because it will be monitored half yearly. Seedlings (height < 1.37 m) were assessed within 2m radius circle. Seedlings were counted species wise and their living status also was recorded. For saplings species name, DBH and living status were measured and documented.

#### *Non-tree vegetation*

193. Any vegetation not meeting the requirements of the tree or sapling/seedling was treated as non tree vegetation. The Non-woody palms (e.g., *Nypa*), *Pandanus*, Tiger fern, Lianas and Woody shrubs were measured within 4 m radius circle. For *Nypa* clumps and the number of stems rooted in the subplot was counted, whereas in case of *Pandanus* and Tiger fern the number of clumps (bunches of leaves/ bunches of stems) in the subplot was recorded. In case of woody shrubs, the individual stems were recorded as part of the sapling/seedling survey. Goran and herbaceous vegetation was measured within 2 m radius circle. The diameter was measured at the collar zone (base diameter) (Hossain, et al., 2012). Herbaceous vegetation was visually estimated and recorded as percent ground cover of herbs and grasses separately.

#### *Pneumatophore*

194. Pneumatophore, the specialized root system in mangrove plays a vital role in root respiration by gas exchanging in this anaerobic condition of mangrove. During tidal inundation it goes under



water. So, if oil spill happen, the Pneumatophore will be affected by oil coat on its surface. That might hamper the gas (oxygen) exchange process which ultimately will affect the plant growth. Considering this issue; within a circular area of one meter radius, total number of pneumatophore was recorded with its living status whether live or dead.



**Photo 11.3: Surveyor counting Pneumatophore of *Heritiera fomes* in Harbaria monitoring site**

#### **Crab hole**

195. Crab plays important role in Mangrove ecosystems such as decomposing litter fall thereby increase fertility. In order to work out the crab density, usually crab hole abundance is monitored. For this purpose in this study the crab hole were counted within a area of 2 m radius circle in each subplot.





**Photo 11.4: Surveyor counting pneumatophore at Hiron point site in SRF**

#### **(b) Canopy cover**

196. Canopy cover (%) was estimated by a spherical densiometer which is a gridded convex mirror that provides a simple and inexpensive approach of measuring canopy cover. The densiometer was held at a distance of 30–40 cm in front of the body and at an elbow height, so that head is not visible in the mirror. After leveling the instrument using the level bubble, the dots not occupied by canopy were systematically counted. In each subplot, the readings were taken at five points facing at north, south, east, and west direction including subplot center point. First one was taken standing at subplot centre and other four were taken at the middle point of the four transects between center and periphery. The canopy cover was estimated by taking the average of these five readings.

### **11.4 Monitoring Result and discussion of SRF Health**

#### **11.4.1 Canopy cover**

197. The canopy cover percentage was found to remain same in subsequent two monitoring in SRF ( $P < 0.05$ ). This insignificant difference in canopy cover percentage reveals that the foliage condition of all the monitoring sites were very good and having less insect damage.

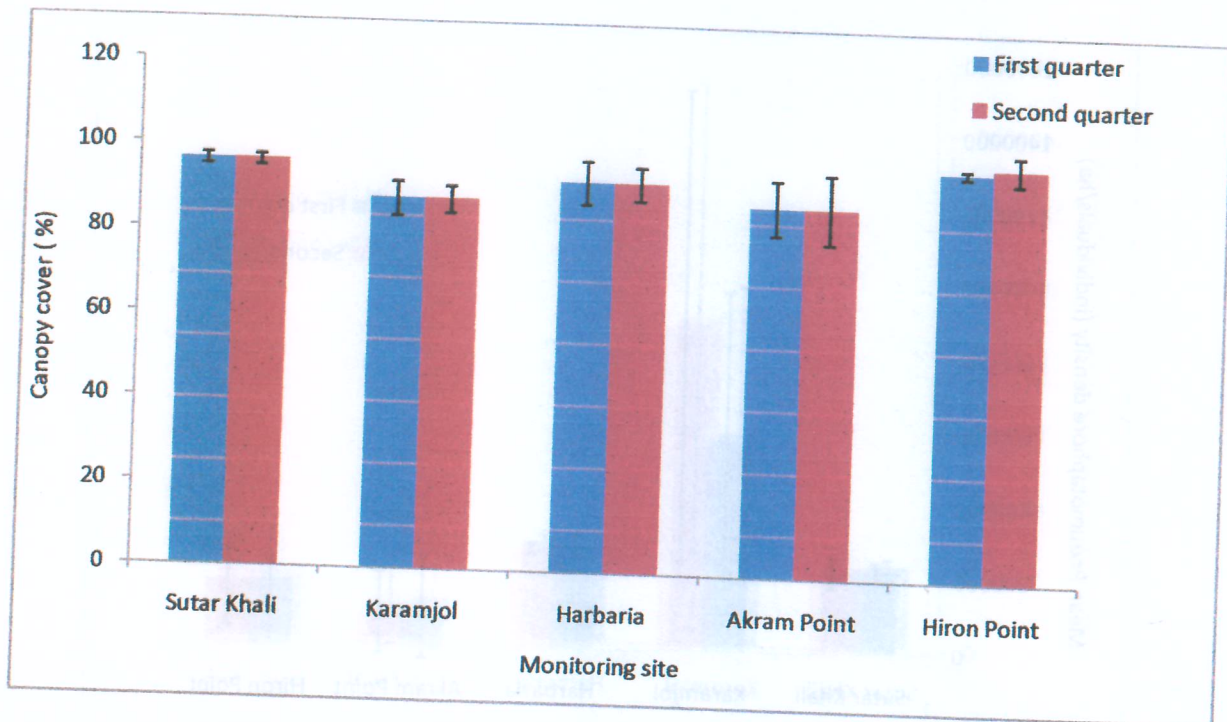
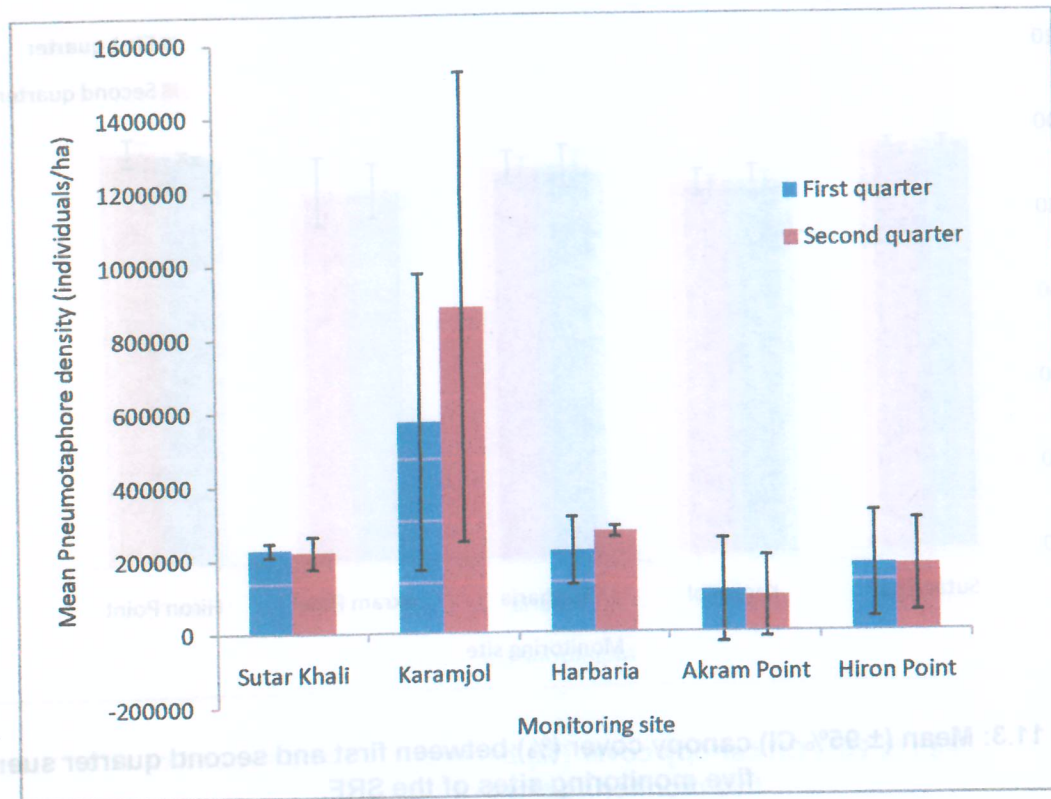


Figure 11.3: Mean ( $\pm$  95% CI) canopy cover (%) between first and second quarter survey in five monitoring sites of the SRF.

#### 11.4.2 Pneumatophore

198. Mean pneumatophores density did not significantly varied between the two subsequent monitoring ( $P > 0.05$ ) in each of the five monitoring sites. A similar trend was found at Sutar Khali, Harbaria, Harbaria and Akram point site. However, though huge difference was detected in Karamjol between the two surveys, in paired t-test, no significant change was made. The higher 95% CI in Karamjol could be responsible for such invariability.

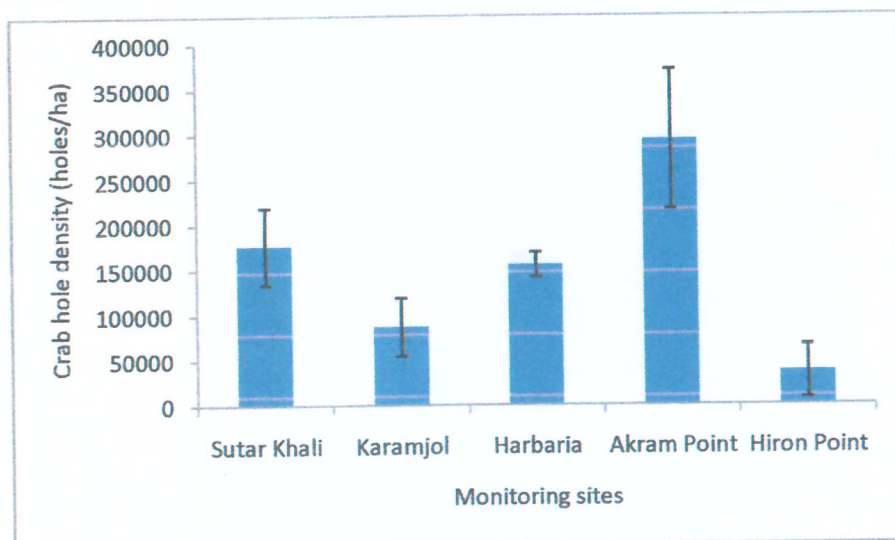




**Figure 11.4: Average ( $\pm$  95% CI) number of pneumatophores between first and second quarter survey in five monitoring sites of the SRF.**

#### 11.4.3 Crab hole

199. Crab hole density was highest at Akram point, while this figure was found lowest at Hiron Point. In Sutar Khali and Harbaria, the density of crab hole were found similar (Figure 11.5).



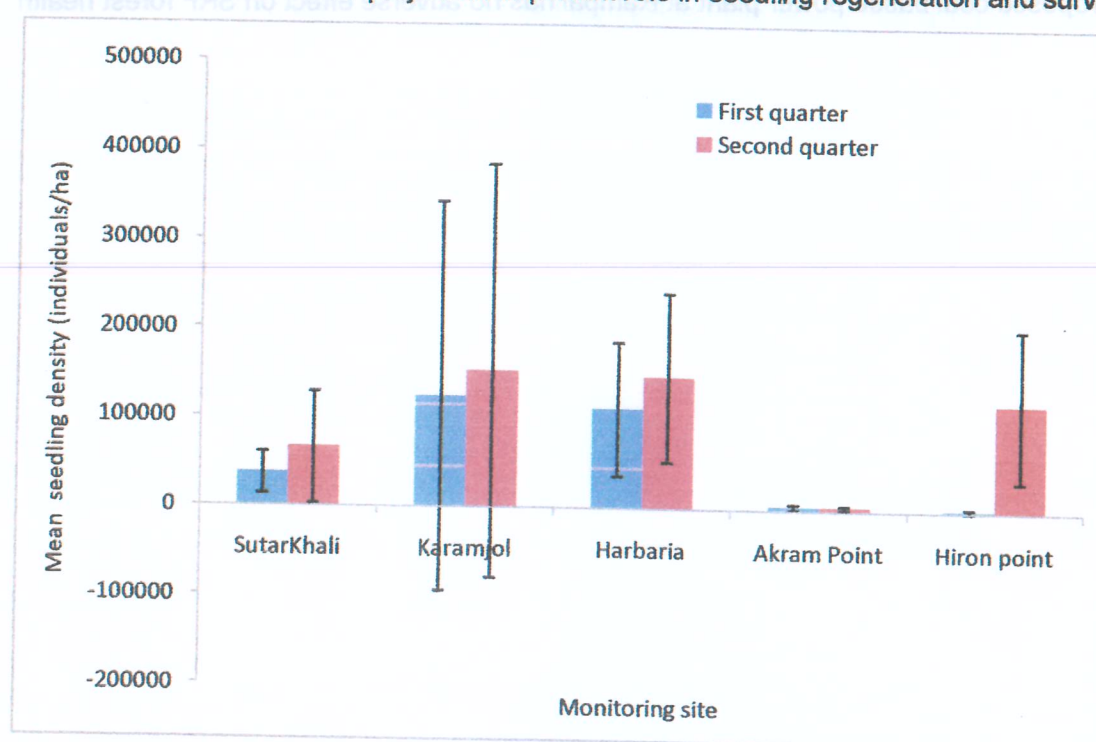
**Figure 11.5:**

**Table 11.1: Mean ( $\pm$  95% CI) crab hole density between first and second quarter suervy in five monitoring sites of the SRF.**

| Monitoring site | Crab density (holes ha <sup>-1</sup> ) | 95% CI   |
|-----------------|--|----------|
| Sutar Khali     | 176949.89                              | 42578.94 |
| Karamjol        | 87150.47                               | 32489.35 |
| Harbaria        | 155493.39                              | 13690.23 |
| Akram Point     | 294298.40                              | 77289.46 |
| Hiron Point     | 37350.20                               | 29115.57 |

#### 11.4.4 Regeneration status

200. Statistically, no significant variation has been found in the sapling sites ( $P < 0.05$ ) in case of seedling regeneration (Figure 11.8). However, an increasing trend of seedling recruitment was found in all sites except Akram Point (Table 11.2). Lower abundance of pneumatophores, higher crab hole density, and salinity may be responsible for this negative seedling recruitment in Akram point because these factors have played an important role in seedling regeneration and survival.



**Figure 11.8: Mean ( $\pm$  95 % CI) seedling density between first and second quarter suervy in five monitoring sites of the SRF.**



**Table 11.2: Mean ( $\pm$  95 % CI) Seedling recruitment between first and second quarter survey in five monitoring sites of the SRF.**

| Site        | Seedling recruitment (New individual ha <sup>-1</sup> ) | 95 % CI  |
|-------------|---|----------|
| SutarKhali  | 28873.56  | 52202.47 |
| Karamjol    | 28873.56  | 22743.98 |
| Harbaria    | 35760.83  | 19872.43 |
| Akram Point | -264.895  | 1401.693 |
| Hiron point | 106222.9  | 92949.1  |

### 11.5 Conclusion

201. This monitoring has exhibited with an insignificant difference in all sorts of forest health indicators. However, in Akram point, the negative seedling recruitment has been found which is the consequence of the site quality such as high salinity and high crab hole density. Based on the study findings during the three month time interval, it can be concluded that the construction programme of the proposed coal based power plant at Rampal has no adverse effect on SRF forest health.

## 12 Socio-economic Condition and Socio Safeguard Monitoring

### 12.1 Introduction

202. The third quarter monitoring intends to explore the state of socio-economic condition in respect to the 6 months prior first quarter monitoring. Similar to the first quarter, the entire data for this phase is extracted from Household Survey and consultations. These findings will also be explored and verified in upcoming third phase monitoring.

### 12.2 Methodology

203. In third quarter monitoring a total number of 116 households from 7 mouzas were surveyed. Of them, 96 households were selected from both directly and indirectly affected stakeholders. Here directly affected refers to those entitled households who lost their lands and have rights to be compensated and or rehabilitated; conversely, indirectly affected refers to those who are not inclusive to Resettlement Action Plan but have chance to be impacted by the project activities during construction and operation period of the project. However, the rest 20 households were selected from resettled village located at Gobindapur village, Shelter-4. Comparing with the first quarter monitoring, two additional households were found in resettled location and thereby considered for survey. Therefore, the total surveyed households in third quarter are 116 which was 114 in the first quarter monitoring.

204. Separate monitoring tools were applied for accomplishing the monitoring, for instance; semi-structured questionnaire for Household Survey, and separate checklists for consultations. Checklists and questionnaires were formulated accompanying with the guideline of International Finance Corporation (IFC) on "Performance Standards on Environmental and Social Sustainability".

### 12.3 Salient features of the households

#### *Household and population*

205. The demographic features of monitoring households vary slightly in surveying mouzas between two phases of monitoring cycle. Due to increased number of household (116) in third quarter monitoring survey, the changes found in comprising male and female numbers compared to the first quarter of survey are shown in Table 12.1. Therefore, males 54% and female 46% found in third quarter survey which were 56% and 44% respectively in first quarter of survey (Table 12.1).

**Table 12. 1: Household and population by mouza in quarters**

| Name of Mouza           | HHs<br>by quarters |                 | Population (%) by quarters |                 |                 |                 |                 |                 |
|-------------------------|--------------------|-----------------|----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                         |                    |                 | Male                       |                 | Female          |                 | Total           |                 |
|                         | 1 <sup>st</sup>    | 3 <sup>rd</sup> | 1 <sup>st</sup>            | 3 <sup>rd</sup> | 1 <sup>st</sup> | 3 <sup>rd</sup> | 1 <sup>st</sup> | 3 <sup>rd</sup> |
| Bajua                   | 16                 | 16              | 8                          | 8               | 6               | 6               | 14              | 14              |
| Bara Durgapur           | 16                 | 16              | 8                          | 8               | 5               | 6               | 13              | 14              |
| Barni                   | 22                 | 22              | 11                         | 11              | 10              | 9               | 21              | 20              |
| Gobindapur <sup>4</sup> | 18                 | 20              | 6                          | 6               | 5               | 6               | 11              | 12              |
| Kapasdanga              | 16                 | 16              | 9                          | 8               | 9               | 8               | 17              | 16              |
| Pankhali                | 16                 | 16              | 9                          | 9               | 6               | 7               | 16              | 16              |
| Rajnagar                | 10                 | 10              | 5                          | 4               | 3               | 4               | 8               | 8               |
| <b>Total</b>            | <b>114</b>         | <b>116</b>      | <b>56</b>                  | <b>54</b>       | <b>44</b>       | <b>46</b>       | <b>100</b>      | <b>100</b>      |

<sup>4</sup> In Gobindapur resettled village it was found that two (2) households were resettled newly at. Therefore, these two new households were considered in the third quarter monitoring.

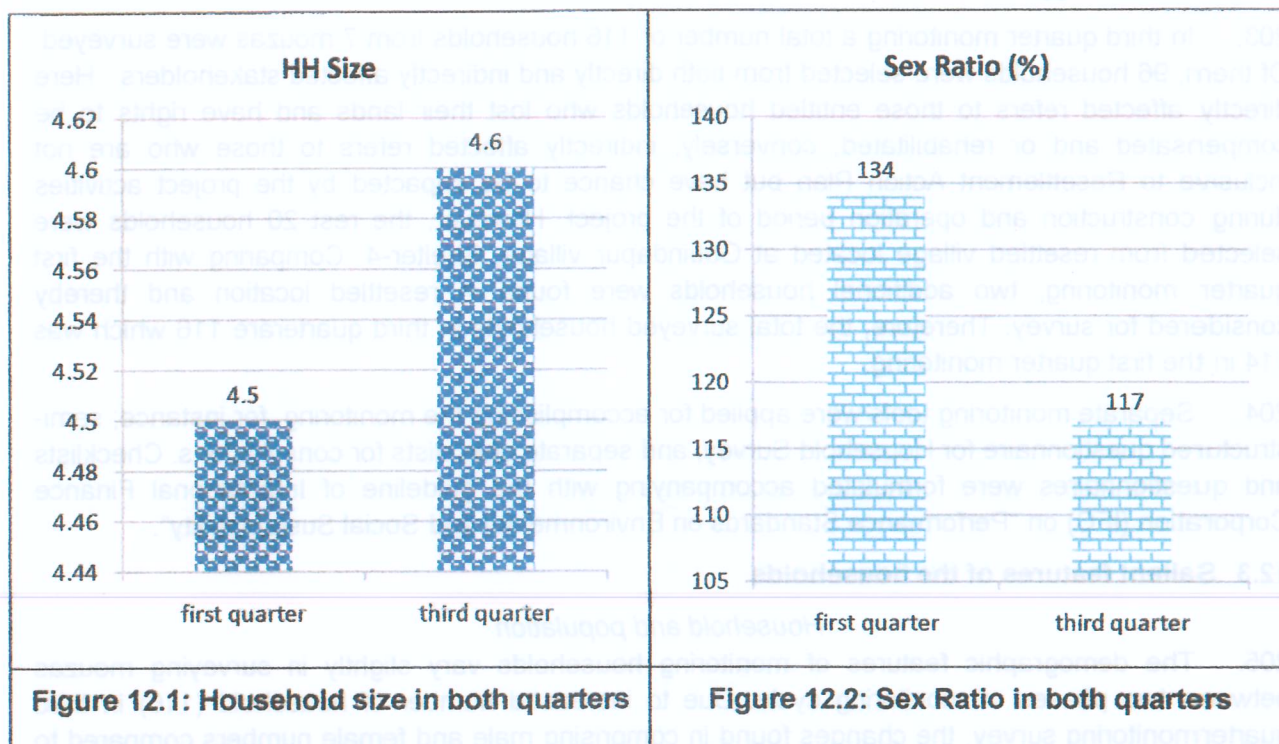


Source: HH survey, CEGIS, 2014

[Note: 1<sup>st</sup>=First quarter monitoring; 3<sup>rd</sup>=Third quarter monitoring]

206. In third quarter of monitoring the average male-female ratio has decreased about 18% (Figure 12.2) from the first quarter of monitoring and stands on 115% which is higher than the national figure of sex ratio is 100.3% (BBS 2011).

207. The average household size is 4.6 (Figure 12.1), which is a bit higher than that of the first quarter of survey as well as the national household size of 4.50 (HIES 2010<sup>5</sup>). Some common factors i.e. marriage, live-birth, and death during last six months may be the cause of such variation in household size.

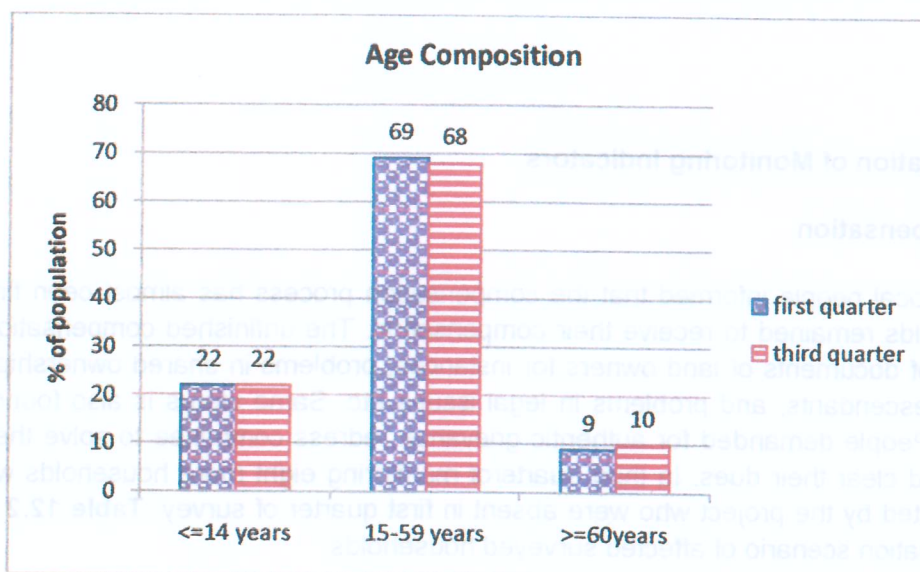


Source: HH survey, CEGIS, 2014

#### Age composition

208. The age composition of population is presented in the following figure 12.3. It is found that population within the age group of 15-59 years has decreased by about 1% in third quartersurvey than that the in first quarter survey. In contrast, 1% of population has increased in 60 years and above old age group while 0-14 year's old age group's member remained constant in third quarter survey. The variation found is for adding new households which comprised of higher number of elderly people.

<sup>5</sup> HIES 2010 refers to Household Income and Expenditure Survey conducted by the Bangladesh Bureau of Statistics (BBS) in 2010.

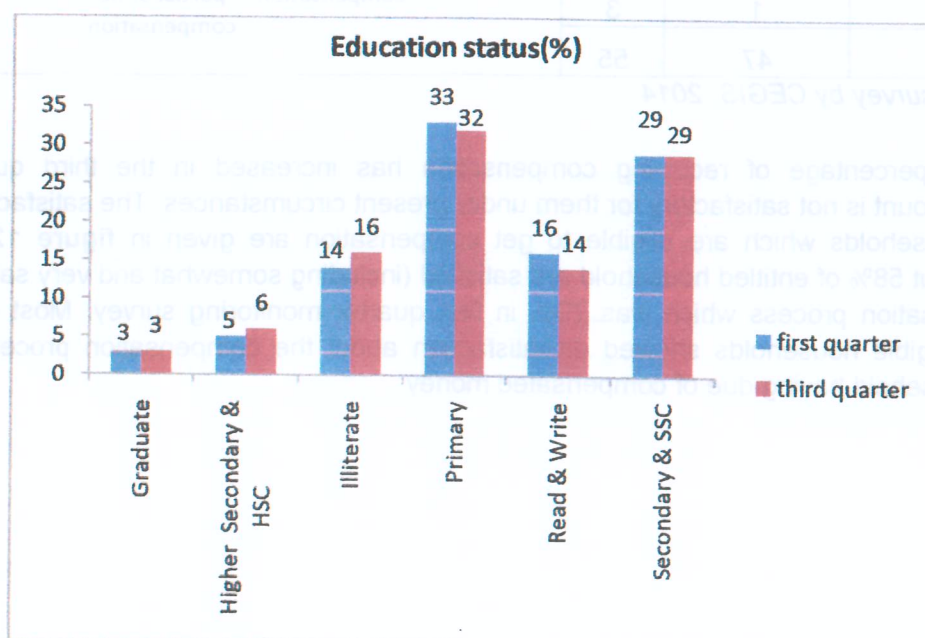


Source: HH survey, CEGIS, 2014

**Figure 12.3: Age composition in both quarters of survey**

#### Education and literacy status

209. Educational and literacy status shows almost same feature except a little change and are shown in Figure 12.4. It is found that the highest percentages of population comprise in primary level education in both (first & second) phases of monitoring survey with a decrease of about 1% in the third phase. The percentages of illiterate and Higher secondary educated population have increased but in case of the able to read and write population, it has decreased in third quarter of monitoring.



Source: HH survey by CEGIS, 2014

**Figure 12.4: Educational status of surveyed population**



## 12.4 Exploration of Monitoring Indicators

### 12.4.1 Compensation

210. The local people informed that the compensation process has almost been finished only a few households remained to receive their compensation. The unfinished compensation implies the complicity of documents of land owners for instances; problems in shared ownership, indentifying hereditary descendants, and problems in legal issues etc. Same status is also found during third monitoring. People demanded for authentic grievance redress committee to solve the land related problems and clear their dues. In third quarter of monitoring eight more households were found as directly affected by the project who were absent in first quarter of survey. Table 12.2 below shows the compensation scenario of affected surveyed households.

**Table 12.2: Directly affected households and their compensation status**

| Mouza         | Directly affected surveyed HHs (By monitoring quarters) |                 |   |
|---------------|---|-----------------|---|
|               | 1 <sup>st</sup>   | 3 <sup>rd</sup> |   |
| Bara Durgapur | 10  | 15              | <p><b>Compensation Status</b></p> <p>% of households</p> <p>Receiving full compensation      Receiving partial or no compensation</p> <p>■ first quarter      ■ third quarter</p> |
| Kapasdanga    | 20  | 16              |   |
| Barni         | 16  | 21              |   |
| Rajnagar      | 1   | 3               |   |
| Total         | 47  | 55              |   |

Source: HH survey by CEGIS, 2014

211. The percentage of receiving compensation has increased in the third quarter but the receiving amount is not satisfactory for them under present circumstances. The satisfactory levels of affected households which are eligible to get compensation are given in figure 12.5. In third quarter, about 58% of entitled household are satisfied (including somewhat and very satisfied) about the compensation process which was 70% in first quarter monitoring survey. Most of the newly surveyed eligible households showed dissatisfaction about the compensation process additional with the household having due of compensated money.

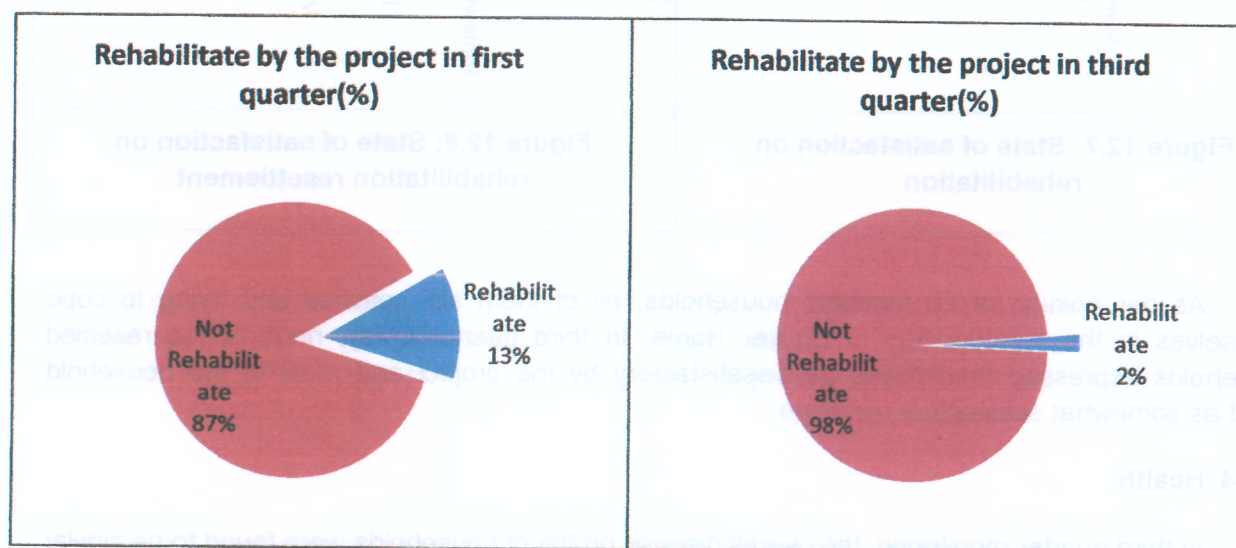


Source: HH survey by CEGIS, 2014

Figure 12.5: Opinion of directly affected households on compensation

#### 12.4.2 Rehabilitation

212. The rehabilitation status has also been justified by the population of 55 directly affected surveying households. During third quarter of survey, less directly affected members are rehabilitated by the project. Local people alleged that the project authority recruited a number of laborers as per the concern of local leaders. Therefore most of the really affected members could not avail the chance of laboring in project site whereas the indirectly affected members having link with those leaders got chance for laboring. People also alleged that the project authority terminated the labors without any prior formal notice which aggravated their economic condition.



Source: HH survey by CEGIS, 2014

Figure 12.6: Rehabilitation status of directly project affected people

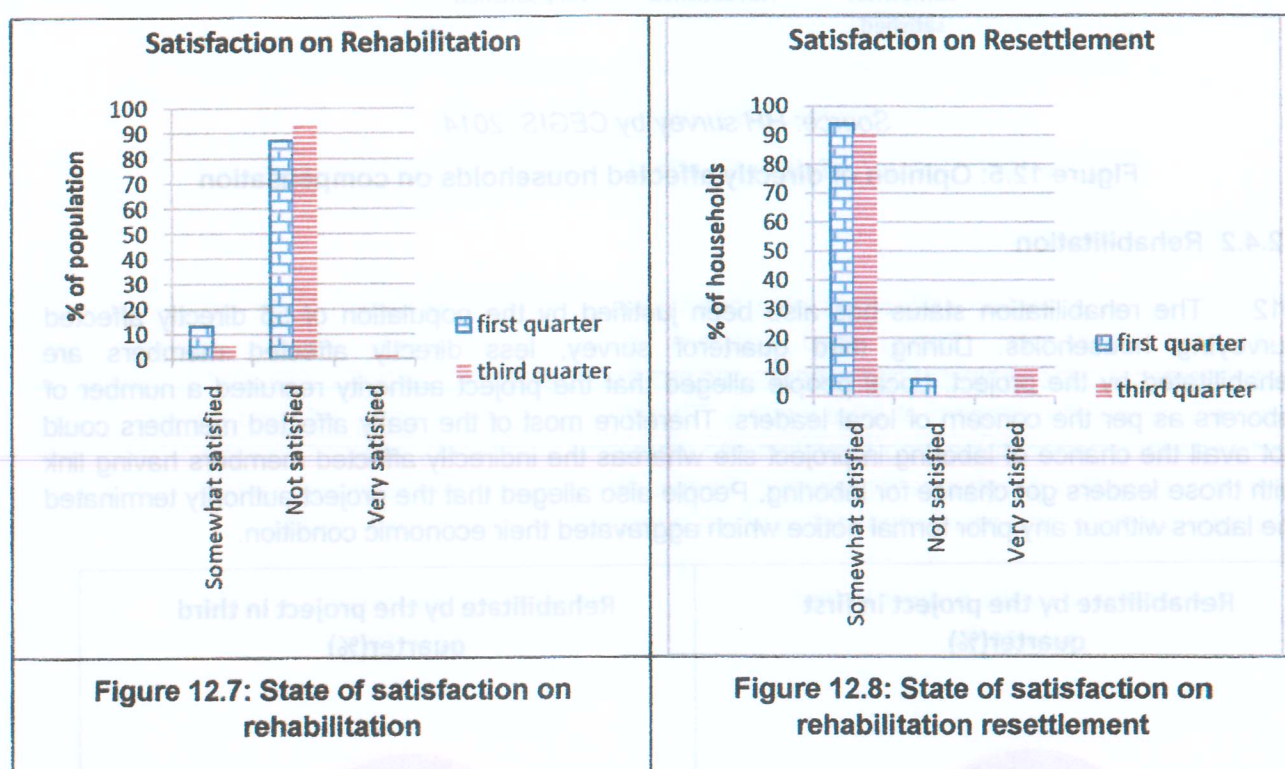
213. Due to undefined recruitment process following by project authority, the satisfaction level of directly affected people has deteriorated and most of the affected households (about 93%) showed dissatisfactory opinion to the project authority during third quarter of monitoring survey (Figure 5 &



6). Though, a number of recruitment played an important role in rehabilitation yet actual deserving people did not get this support by the project authority.

### 12.4.3 Resettlement

214. In terms of resettlement, 20 resettled households have been found in the third quarter monitoring survey at Gobindapur Shelter Home which was 18 in the first quarter survey. A number of households have taken temporary shelter to their relatives or reside in others houses on by rental basis which would be about 100 in number. The remaining households (about 10 in number) are still living at the edge of project boundary. The Shelter Home of Gobindapur has been extended and some more households will get the opportunities to resettle there. Some households from the project have already completed the formal procedures to be resettled in Gobindapur Shelter Home.



215. As per opinion of 20 resettled households, all of them are satisfied and trying to cope themselves in the surroundings of Shelter Home. In third quartersurvey, none of the resettled households expressed themselves as dissatisfactory by the project and most of the household found as somewhat satisfactory condition.

### 12.4.4 Health

216. In third quarter monitoring, the overall disease profile of households were found to be similar to that of the first quarter monitoring which is presented below by ranking. According to the observation, almost similar disease profiles have been found in all the surveyed mouzas. The affect of skin disease and asthma which could be the major indicator for monitoring the impact of project in diseases profile is almost unseen in first quarter of survey.



Table12. 3: Common diseases profile of surveyed mouzas

| SI No | Disease         | Ranking |
|-------|-----------------|---------|
| 1     | Influenza/Fever | 1       |
| 2     | Cough/cold      | 2       |
| 3     | Gastric         | 4       |
| 4     | Diabetes        | 5       |
| 5     | Diarrhea        | 6       |
| 6     | Asthma          | 8       |
| 7     | Skin disease    | 7       |
| 8     | Hypertension    | 3       |

Source: HH survey by CEGIS, 2014

#### 12.4.5 Labor and Working conditions

217. The project authority stated that they are trying to prepare better working condition/environment for the labors. As such, permanent and temporary labor sheds have been constructed in the project site for residing and taking respite purposes. The sanitary latrines have been made for the labors. The project authority has also provided transportation support for the labors; therefore they started boat service for the labors where the labors do not have to pay rent for boat. In terms of labors wage, it has been consider Tk. 360 per head from the project authority but the labors received Tk. 290 while remaining money has been taken by the *Sardars* who provide labors to the project site. The local people claimed that for earning this amount each labor has to work over 9 hours per day though they have verbally contracted to work for 8 hours per day.

218. The labors informed that there have no written contracts regarding their engagement with the project authority; therefore they do not know about the right which they deserve. Moreover, in terms of dismissal no formal procedures have been maintained yet. In most cases, the influence of political leaders played important roles for labors recruitment and dismissal. The labors are restricted to form any type of labor organization by the project authority as well as *Sardars*.

219. The project authority alleged that they are trying to provide all sorts of supports to the labors from their side. Their medical team provides medical supports to the labors and they also rehabilitate the labors if injured in any case during by the project site work. Also, following the International Labor Rules no children have been engaged in any types of project work however they were not able to maintain gender balance in laboring work because the women surrounding the project site are not engaged in any wage laboring activities except the homestead works.



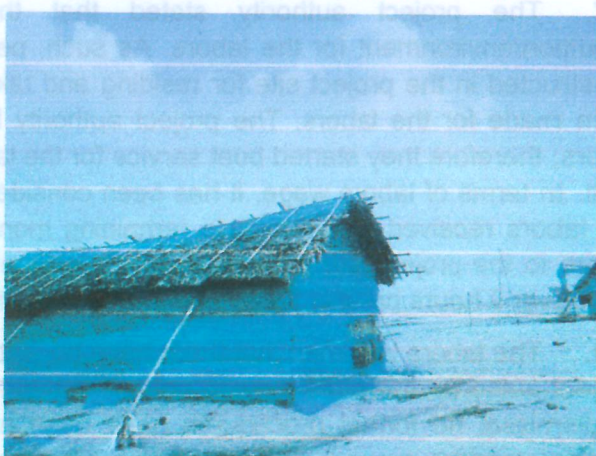


**Photo12.1 : Labourers using safety measures**



**Photo 12.2 : Temporary shelter during work**

**Photo 12.3: Safe water supply during work**



**Photo 12.4 : Sanitation for worker**

**Photo 12.5 : Temporary accomodation for workers**

#### **12.4.6 Community Health Safety and Security**

220. Concerning the issues of community health safety and security, the project area has been protected through boundary wall all-around the project site and there will be only two gates in the project site. During third quarter of monitoring the construction work of boundary wall was found in progress and about 40% of which has so far been completed. An *Ansar* Camp has also been established in the project site for ensuring security and safety. No road communication has been established between project site and outer areas yet; therefore there is no risk of any road accident and no accident occurred during last 6 month after first quarter survey. However a labor was injured during project work so the project authority established a departmental store for him by its own fund.

221. The project authority informed that they have opened a medical camp in the project area where they provide treatment and medical facilities to the local community as well as their labors. This camp is opened once in a week and over 150 people get treatments in each week by this camp.

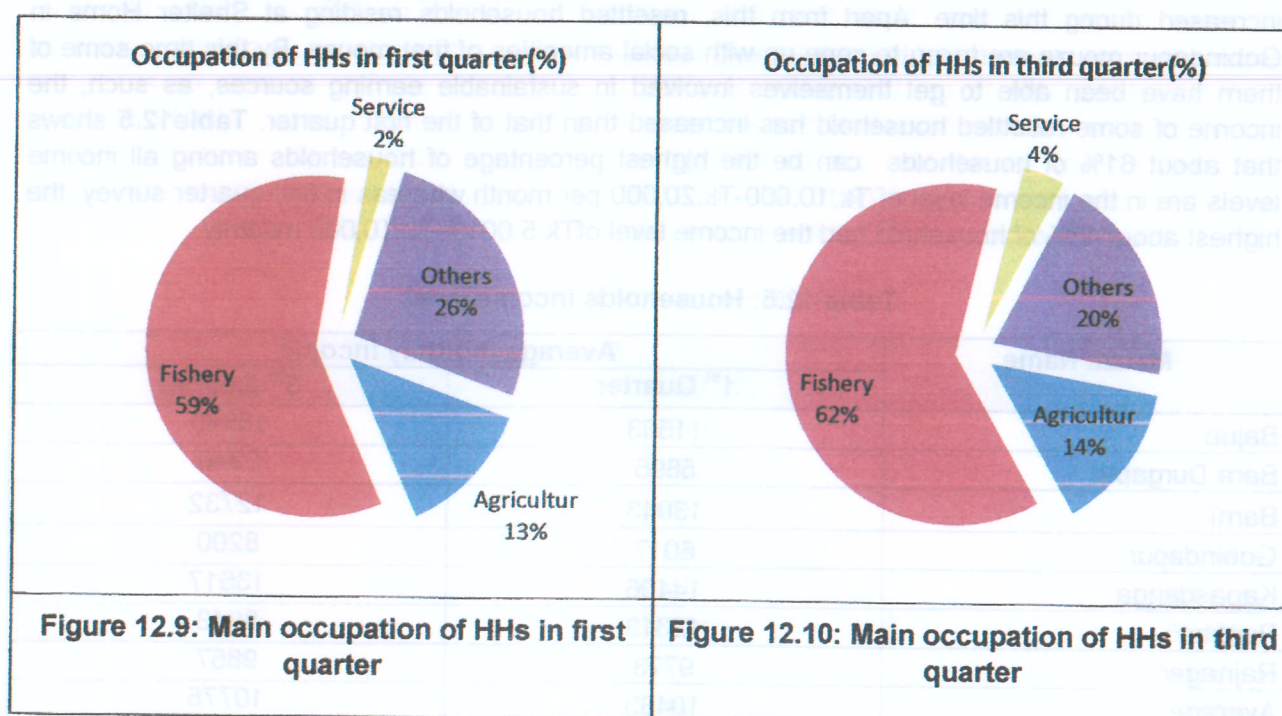




Photo 12.6 : Construction of boundary wall

#### 12.4.7 Livelihood and occupation

222. It is found that a significant proportion of the heads of households (over 62%) are directly involved in fishery related primary occupation (fishery, fish and other small business, agriculture labor etc.) which has little increased in third quarter survey than that of the first quarter. The reason for such increase may be that it has the peak time of fish capturing while a large number of the family members might be involved in that occupation. Details of primary occupation of households head is presented in Figure 12.9 & 12.10.



Source: HH survey by CEGIS, 2014

#### 12.4.8 Land ownership and Land price

223. Land ownership pattern is an important indicator for determining social status. None of the affected household involved in land purchasing activities during last six months of third quarter



monitoring survey. Therefore, no changes were found in land ownership pattern of the studied mouzas.

224. Land price is one of the main indicators for finding out the socio-economic development. During third quarter survey, no major changes have been observed in the land prizes compared to the first quarter of survey. The price increased by about 2% in Baradurgapur and Kapasdanga mouza while those of other 5 mouzas remained unchanged.

**Table12. 4: Land price per acre**

| SI No | Mauza          | Price per acre (taka in lakh) |             |               |
|-------|----------------|-------------------------------|-------------|---------------|
|       |                | Before Project                | April, 2014 | October, 2014 |
| 1     | Bajua          | 380,000                       | 380,000     | 380,000       |
| 2     | Bara Durga pur | 160,000                       | 320,000     | 330,000       |
| 3     | Barni          | 260,000                       | 340,000     | 340,000       |
| 4     | Kapasdanga     | 240,000                       | 340,000     | 360,000       |
| 5     | Pankhali       | 400,000                       | 400,000     | 400,000       |
| 6     | Rajnagar       | 280,000                       | 310,000     | 310,000       |

Source: HH survey by CEGIS, 2014

#### 12.4.9 Household Income

225. The monthly income of the household members who are engaged in seasonal fish capturing occupation has increased than the monthly income of the first quarter. The people informed that the period from the end of August to the end of November is the peak time for capturing fish in local rivers, canals, khals etc. for which the income of the people engaged in this occupation has increased during this time. Apart from this, resettled households residing at Shelter Home in Gobindapur mouza are trying to cope up with social amenities of that mouza. By this time some of them have been able to get themselves involved in sustainable earning sources, as such, the income of some resettled household has increased than that of the first quarter. Table12.5 shows that about 61% of households can be the highest percentage of households among all income levels are in the income level of Tk.10,000-Tk.20,000 per month whereas in first quarter survey, the highest about 43% of household had the income level ofTk.5,001tk-Tk.10,000 monthly.

**Table 12.5: Households income level**

| Mauza Name    | Average monthly Income  |                         |
|---------------|-------------------------|-------------------------|
|               | 1 <sup>st</sup> Quarter | 3 <sup>rd</sup> Quarter |
| Bajua         | 11583                   | 15840                   |
| Bara Durgapur | 5895                    | 6340                    |
| Barni         | 13043                   | 12732                   |
| Gobindapur    | 6017                    | 8200                    |
| Kapasdanga    | 14406                   | 13517                   |
| Pankhali      | 12313                   | 8943                    |
| Rajnagar      | 9773                    | 9857                    |
| Average       | 10433                   | 10775                   |

Source: HH survey by CEGIS, 2014

#### 12.4.10 In and out migration

226. Seasonal labors in-migration has increased in third quarter of the monitoring survey with an increase of wage laborers by 4% working in the project site. The labors of project site are migrated



from Koyra, Protapnagar and Satkhira. No changes have been found in case of fishery and agricultural in-migrants as well as out migrant workers. Percentages of migrant labors/workers are presented in Table 12.6.

**Table 12.6: Status of temporary in/out-migration as percentage of workable population**

| Migration types  | Quarters (%)    |                 | Reason                                 | Area                              |
|------------------|-----------------|-----------------|--|-----------------------------------|
|                  | 1 <sup>st</sup> | 3 <sup>rd</sup> |  |                                   |
| In-migration     | 5               | 5               | Harvesting paddy/Gher                  | Faridpur, Gopalgang               |
|                  | 2               | 4               | Plantation of paddy/<br>Fish capturing | Koyra, Protapnagar                |
|                  | -               | 2               | Wage labors in project site            | Koyra, Protapnagar, Satkhira etc. |
| <b>Sub total</b> | <b>7</b>        | <b>11</b>       | -                                      | -                                 |
| Out-migration    | 2               | 2               | Seasonal laboring                      | Khulna, Bagerhat, Dhaka           |

Source: Informal discussion by CEGIS, 2014

#### 12.4.11 Corporate social activities

227. The project authority of Rampal power plant has started to involve themselves in corporate social activities. During the third quarter of socio-economic monitoring the study team found these activities in progress.

##### *Free Health Services and Facilities*

228. As corporate social activities, the project authority provides free medical facilities in the project site. About 150 beneficiaries of which 70% female and 30% male received medical support from that center which remains opened once in a week (every Wednesday). Medicines are also provided by this center in free of cost. People of Rajnagar, Baradurgapur, Barni and Bajua mouzas mainly came for having medical support but the number of beneficiaries of this center is expanding from areas which are at a considerable distance from the centre. The local people opined that they have received effective medical facilities for many diseases i.e. cold-cough, fever, dysentery, back-pain, lower abdominal pain and pressure. People are pleased for such benefits but urged for sufficient number of physician and supporting staffs for intensive medical support.







Photo 12.6: Free health services and facilities in the project

#### *Donation in Cultural and Religious Festivals*

229. The project authority has also involved themselves in social activities by donating money in the cultural and religious festivals in the mouzas around the project site. So far, they donated money in four Puja Mandaps for observing Durga puja. The project authority alleged that they will try to contribute in most of the cultural and religious activities in the surrounding mouzas as per their ability.



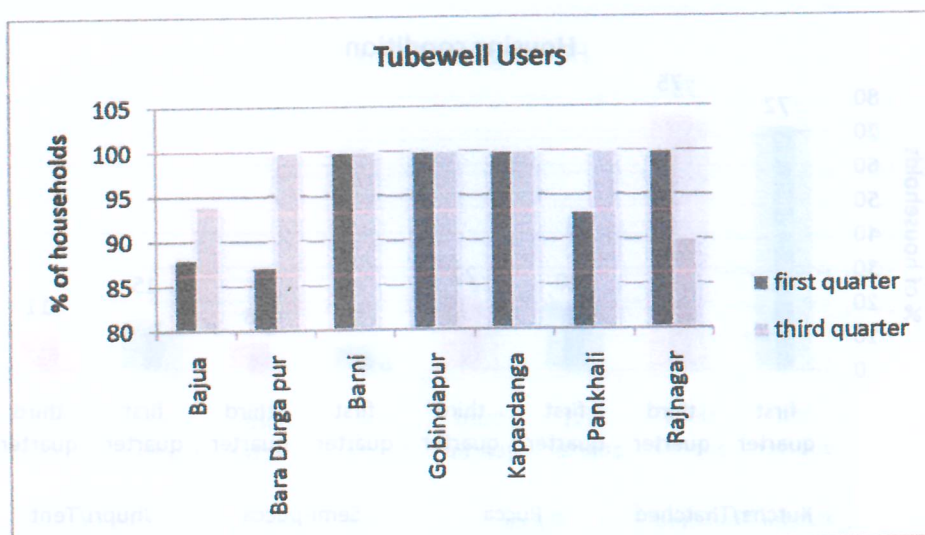
Photo 12.7: Project authority donated for puja

#### 12.4.12 State of Social Amenities

##### *Drinking water*

230. Data has been collected for understanding the provision and access to water for drinking and other domestic purposes. Figure 12.11 indicates that during third quarter of monitoring the number of tubewell users are increasing in most of the mouzas except Rajnagar compared to that of the first quarter monitoring survey. Sharing of tubewell has increased the percentages of its users. The water quality of the tubewell is not good, as such, the project authority have planned to arrange fresh drinking water for the local community by establishing tubewell or rain harvesting tanks.



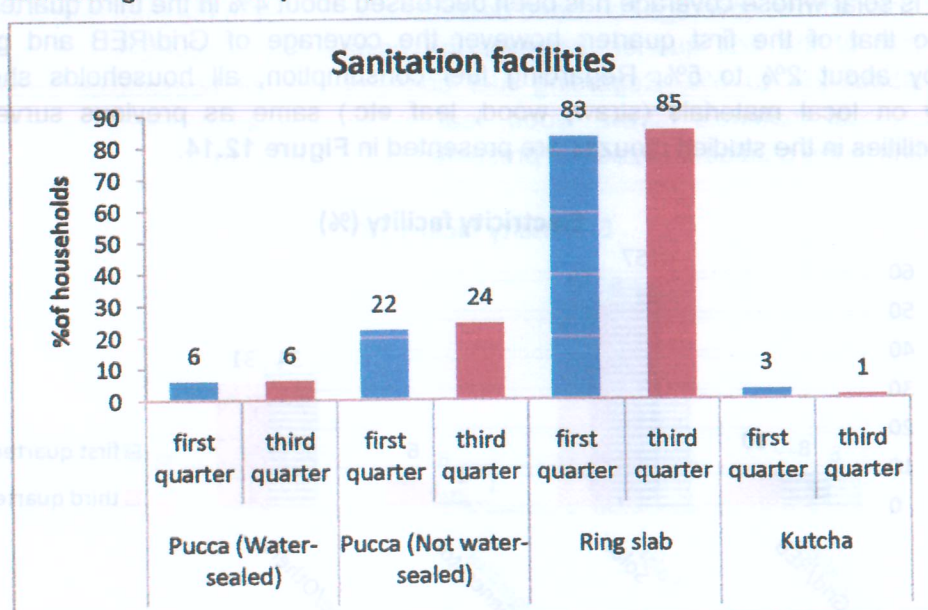


Source: HH survey by CEGIS, 2014

Figure 12. 11: Drinking water status by using tubewell

#### Sanitation

231. Sanitation facilities have been assessed in terms of the availability of *pucca* or ring-slab latrines (Figure 12.12). In third quarter of monitoring the sanitation facilities has insignificantly improved by increasing number of *pucca* (nit water-sealed) and ring slab latrines.



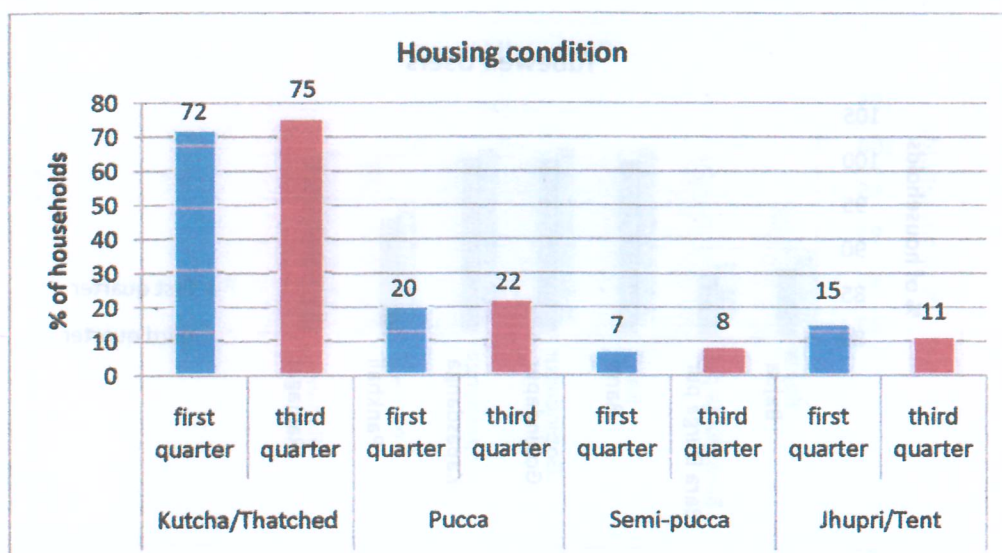
Source: HH survey by CEGIS, 2014

Figure 12.12 Availability of Pucca and Ringslab latrines

#### Housing condition

232. Housing condition reflects the economic and social status of the households. Because of being saline prone area people of this area are not eager to invest huge amount for constructing *pucca* houses as well as more amounts required to maintain them. In third quarter of monitoring survey, insignificant changes have been found in the number of dwelling houses compared to that of the first quarter (Figure 12.13). All types of houses depict a little increased trend except the *jhupri*/tent houses.



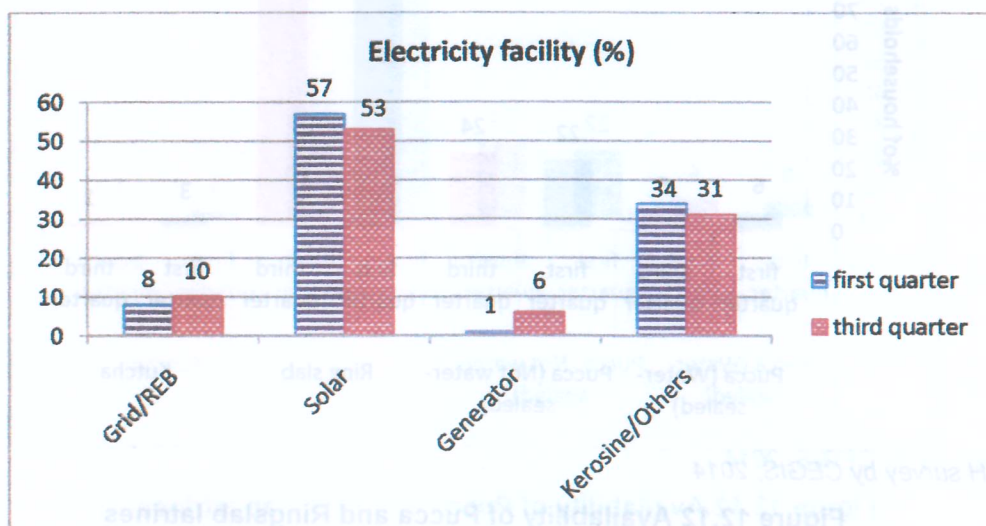


Source: HH survey by CEGIS, 2014

Figure 12.13 Type of main dwelling house

#### Electricity coverage and fuel consumption

233. Electricity coverage and fuel consumption can be highly supported after the project. There is no Grid/REB coverage in most of the studied mouzas though the electricity connection has been covered in some area of Rajnagar mouza but the supply has not yet been started. The main source of electricity is solar whose coverage has been decreased about 4% in the third quarter of monitoring compared to that of the first quarter; however the coverage of Grid/REB and generator has increased by about 2% to 5%. Regarding fuel consumption, all households show invariable dependency on local materials (straw, wood, leaf etc.) same as previous survey. Details of electricity facilities in the studied mouzas are presented in Figure 12.14.



Source: HH survey by CEGIS, 2014

Figure 12.14: Electricity facilities of study mouzas

## **12.5 Conclusion**

234. In terms of socio-economic condition, the status is found to be almost similar in both phases with a slight variation in few cases. However, the project authority has taken several initiatives for instance, free-medical services and donations for religious festivities which increased its popularity. They also intended to start similar corporate social works in future and being appreciated and welcomed by the local as well as adjacent people. It was stated that, as the study area is undeveloped and poverty rate is higher any initiative with an intention to standardize socio-economic condition of the local people is highly desirable.





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## Annex I: Checklist of Monitoring Environmental Compliances

| SL  | Category               | Measures  | Due Diligence |              | Remarks |
|---|------------------------|---|---------------|--------------|---------|
|   |                        |   | Complied      | Not complied |         |
| PS 1: Assessment and Management of Environmental and Social Risks and Impacts |                        |   |               |              |         |
| 1.1   | Noise Control Measures | Regular conduction of noise survey around and inside the site boundary by EPC contractor                                |               |              |         |
|   |                        | Monitoring Noise with country's ambient standards, and occupational health and safety standards by EPC contractor       |               |              |         |
|   |                        | Introducing vehicle speed limit and speed limit monitoring system   |               |              |         |
|   |                        | Green Plantation around the project boundary  |               |              |         |
|   |                        | Switching off/throttled downing of machines/equipments/generators which are not in use                                  |               |              |         |
| 1.2   | Air Quality Measures   | Conduct Air Quality survey in the Project area by EPC contractor  |               |              |         |
|   |                        | Monitoring Air Quality with country's ambient standards, and occupational health and safety standards by EPC contractor |               |              |         |



| SL  | Category                  | Measures   | Due Diligence |              | Remarks |
|-----|---------------------------|--|---------------|--------------|---------|
|     |                           |  | Complied      | Not complied |         |
| 1.3 | Dust Control Measures     | Conducting dust monitoring and visual inspection around the site boundary              |               |              |         |
|     |                           | Fencing the construction site by drum sheet or Tarjja of any other fencing             |               |              |         |
|     |                           | No use of earthen and undeveloped roads by vehicles related to the project use         |               |              |         |
|     |                           | Installation of water spraying system to control fugitive dusts                        |               |              |         |
|     |                           | Introducing vehicle speed limit and speed limit monitoring system                      |               |              |         |
| 1.4 | Water Quality Controlling | Fencing the construction site by drum sheet or Tarjja of any other fencing             |               |              |         |
|     |                           | Arrangement of runoff drainage for reducing any water logging                          |               |              |         |
|     |                           | Location of backfilling stockpile in safe area and protected from wind and rain action |               |              |         |
|     |                           | No storing of backfilling materials/spoil stored on river bank/slope                   |               |              |         |
| 1.5 | Waste Management System   | No disposal of waste and untreated waste water to river or canal                       |               |              |         |
|     |                           | Provision of onsite waste management system  |               |              |         |

| SL  | Category                      | Measures   | Due Diligence |              | Remarks |
|-----|-------------------------------|--|---------------|--------------|---------|
|     |                               |  | Complied      | Not complied |         |
|     |                               | Disposal of waste and treated waste management in a designated area/canal/channel  |               |              |         |
|     |                               | No burning of solid waste  |               |              |         |
|     |                               | Prepare Proper resettlement action plan and compensation plan if the project needs any land acquisition addressing compensation, restoration, livelihood, living standards etc. based on proper socio economic studies |               |              |         |
| 1.6 | Compensation and Resettlement | Resettlement of the PAPs   |               |              |         |
|     |                               | cash for compensation of land (CCL) before resettlement  |               |              |         |
|     |                               | formal agreement with the affected people prior to migration/resettlement  |               |              |         |
|     |                               | Sufficient standing crop compensation  |               |              |         |
|     |                               | Compensation for shiftable structures  |               |              |         |
|     |                               | Retention of salvageable materials?  |               |              |         |
|     |                               | Compensation for loss of trading income?   |               |              |         |
|     |                               | One time moving assistance   |               |              |         |
|     |                               | Grant to cover loss of regular wage income   |               |              |         |



| SL  | Category              | Measures  | Due Diligence |              | Remarks |
|-----|-----------------------|---|---------------|--------------|---------|
|     |                       |   | Complied      | Not complied |         |
|     |                       | Provide/take extra care/caution for the disadvantaged/vulnerable group/s (i.e. women, children, widow, ethnic minorities, indigenous people etc.) |               |              |         |
|     |                       | Provision of monitoring the compensation and resettlement process   |               |              |         |
|     |                       | No impacts on livelihoods living standards which has been consider in Social and Monitoring Plan  |               |              |         |
| 1.7 | Livelihood and living | Development of policy which prioritizes the local laborers in employment opportunities  |               |              |         |
|     |                       | Proper management of Project traffic sign, speed limit signal etc.  |               |              |         |
|     |                       | Provision of separate water and sanitation facilities for the construction workers in the project area.   |               |              |         |
|     |                       | Carry out technically and financially feasible alternative study  |               |              |         |
| 1.8 | Others                | The Project concerned about local heritage or culturally important site.  |               |              |         |
|     |                       | If yes, has the company taken/will the company take any mitigative measures?  |               |              |         |

| SL                            | Category                             | Measures   | Due Diligence |              | Remarks |
|-------------------------------|--------------------------------------|--|---------------|--------------|---------|
|                               |                                      |  | Complied      | Not complied |         |
|                               |                                      | Are the mitigative measures satisfactory?  |               |              |         |
|                               |                                      | Will the project disturb any ecologically critical area?   |               |              |         |
|                               |                                      | If yes, has the company taken/will the company take any mitigative measures?   |               |              |         |
|                               |                                      | Are the mitigative measures satisfactory?  |               |              |         |
|                               |                                      | Use of efficient machineries in the construction activities  |               |              |         |
| 1.9                           | Green House Gas Controlling Measures | Regular maintenance of vehicles, generator and machinery in accordance with manufacturer's specifications                  |               |              |         |
|                               |                                      | Use of approved pollution control devices fitted in the equipments and machineries   |               |              |         |
|                               |                                      | Switching off and throttling of machines/equipments/generators which are not in use  |               |              |         |
| PS 2. Labor working Condition |                                      |  |               |              |         |
| 2.1                           | Safety Management                    | Installation/Construction of Safety Fence around the project area  |               |              |         |
|                               |                                      | Use of Personnel Protective Equipments (i.e. safety suit, safety goggles, ear plug, safety shoes, gloves, dust mask, etc.) |               |              |         |



| SL  | Category           | Measures   | Due Diligence |              |  | Remarks |
|-----|--------------------|--|---------------|--------------|--|---------|
|     |                    |  | Complied      | Not complied |  |         |
|     |                    | Safety trainings for workers<br>(i.e. fire control, working at height, working in heat, first aid etc.)          |               |              |  |         |
|     |                    | Practice of Tool box meeting, safety talks,  |               |              |  |         |
|     |                    | Safe Storage of Hazardous Chemicals<br>(e.g. fuel, flammable chemical, toxic chemicals, etc.)                    |               |              |  |         |
|     |                    | Maintaining Material Safety Data Sheet (MSDS)  |               |              |  |         |
|     |                    | Provision of Health care facilities such as doctor, hospital etc available at/nearby the plant construction site |               |              |  |         |
|     |                    | Preparation and Follow of Emergency Response Plan  |               |              |  |         |
|     |                    | adequate fire precautions in the project area.   |               |              |  |         |
|     |                    | extinguishers, escape routes)  |               |              |  |         |
|     |                    | documentation and reporting of occupational accidents, diseases, and incidents                                   |               |              |  |         |
|     |                    | policies and procedures for managing and monitoring the performance of third party employers in relation to OHS  |               |              |  |         |
| 2.2 | Workers Well Being | Establishment Grievance Mechanisms   |               |              |  |         |

| SL   | Category                      | Measures   | Due Diligence |              | Remarks |
|--|-------------------------------|--|---------------|--------------|---------|
|  |                               |  | Complied      | Not complied |         |
|  |                               | Ensuring fair treatment, non discrimination and equal opportunity  |               |              |         |
|  |                               | Compliance of project's labor policy with the national labor law   |               |              |         |
|  |                               | No Child Labor   |               |              |         |
|  |                               | No incident of forced labor  |               |              |         |
|  |                               | Provision of Welfare facilities for Worker/Labor   |               |              |         |
| PS 4. Community Health, Safety and Security (Construction Phase) |                               |  |               |              |         |
| 4.1  | Community Safety and Security | Installation/Construction of Safety Fence around the project area  |               |              |         |
|  |                               | Risks and impacts on the health and safety of the community (i) before construction (ii) during construction, (iii) after construction |               |              |         |
|  |                               | Engagement of Community in Risk Assessment Process   |               |              |         |
|  |                               | Consideration of Community Health and Safety in Designing infrastructure and equipments  |               |              |         |
|  |                               | Establishing Risk Based Criteria for Assessment of Community Health and Safety of Power Plant  |               |              |         |
|  |                               | Practicing safe management for hazardous materials which may pose threat to the community  |               |              |         |
|  |                               | Available common natural hazards in the community  |               |              |         |



| SL  | Category                               | Measures   | Due Diligence |              |  | Remarks |
|-----|--|--|---------------|--------------|--|---------|
|     |  |  | Complied      | Not complied |  |         |
|     |  | Availability Emergency Response Plan by EPC contractor   |               |              |  |         |
|     |  | Maintaining open communication channel with the local community  |               |              |  |         |
|     |  | training and instruction to the security personnel about their behavior and communication with the local people  |               |              |  |         |
|     |  | Aware the security personnel about the right of the community people   |               |              |  |         |
|     |  | Respect between Project security personnel and community people  |               |              |  |         |
|     |  | Social conflict diminish mechanism for the community dwellers  |               |              |  |         |
| 4.2 | Community Health                       | Provision of providing health service facilities to community if the project poses any health risk like sexually transmitted disease, communicable disease, vector-related |               |              |  |         |
| 4.3 | Youth Empowerment                      | Providing training program for the local youth potential to get involved in the project related activities.  |               |              |  |         |
| 4.4 | Public Communication, Consultation and | Disclosure of EIA Report   |               |              |  |         |
|     |  | Organised stakeholder consultation meeting   |               |              |  |         |

| SL                   | Category                               | Measures  | Due Diligence |              | Remarks |
|----------------------|--|---|---------------|--------------|---------|
|                      |  |   | Complied      | Not complied |         |
|                      | Awareness                              | Sharing of project information shared with local people,  |               |              |         |
|                      |  | Organizing environmental and social awareness programs/meetings   |               |              |         |
|                      |  | PS 6. Biodiversity and Sustainable Management of Living Natural Resources                                     |               |              |         |
| (Construction Phase) |  |   |               |              |         |
| 6.1                  | Management of Impacts on Fisheries     | Conduction of construction work and dredging during fish breeding season (June-August)                        |               |              |         |
|                      |  | Use of sediment fences, traps and basins for trapping the sediment, if required                               |               |              |         |
|                      |  | Installation of proper run on/runoff drains   |               |              |         |
|                      |  | Availability of dispersants for controlling accidental oil spillage   |               |              |         |
| 6.2                  | Management of Impacts on Birds Habitat | Steps to protect birds' habitats in project areas, if the construction activities impact bird colony, habitat |               |              |         |
|                      |  | Introduce bird conservation program (if the construction activities impact bird colony)                       |               |              |         |
| 6.3                  | Conservation of Ecosystem              | Implementation of on-site waste and air quality management plan   |               |              |         |
|                      |  | Limiting soil extraction activities limited within the defined area   |               |              |         |



| SL | Category | Measures   | Due Diligence |              | Remarks |
|----|----------|--|---------------|--------------|---------|
|    |          |  | Complied      | Not complied |         |
|    |          | Limiting the vegetation clearance and base stripping process within the project boundary |               |              |         |
|    |          | Safety fence around the construction site  |               |              |         |
|    |          | Creation any alternate passage for wildlife movement (if required)                       |               |              |         |
|    |          | Limiting the use of night light  |               |              |         |
|    |          | Using shade (directed downwards) around the outdoor lights                               |               |              |         |
|    |          | Provision of cut-off time to switch off unnecessary lights at night                      |               |              |         |
|    |          | No plantation of non-native species  |               |              |         |
|    |          | Retaining top soil for future habitat restoration  |               |              |         |
|    |          | No degradation of critical habitat?  |               |              |         |

### Annex III: Photo Album



Sundarbans Forest Health Monitoring Team



Plot layouting at Akram Point



Estimation of canopy cover at Karamjal

Taking Tree Diameter at Breast Height (DBH)





Tree re-marking with paint at Sutarkhali and Karamjal



Assessment of Fish Catch



Consultation with fishermen at Harbaria



Taking Tree Diameter at Breast Height (DBH)





Counting seedlings and pneumatophores



Canopy Coverage



Team discussion to find the monitoring location



Taking Noise Level at Hiron Point



Taking Noise Level at Akram Point



- Render any other related services as and when requested.

The scope of the services can be specified as bellows.

| Monitoring Parameter     | Indicators                                      |
|--------------------------|---|
| Socio-economy            | Livelihood and Occupation                       |
|                          | Income and expenditure                          |
|                          | Displacement and Migration                      |
|                          | Cultural and heritage                           |
|                          | Health and sanitation                           |
|                          | Risks and accidental assessment                 |
|                          | Transportation and communication                |
|                          | Public and private Infrastructure development   |
| Ecology and Biodiversity | Bio-indicator Assessment                        |
|                          | Movement of indigenous/ native species          |
|                          | Envision of exotic species and regime dominance |
|                          | Species composition (Flora and Fauna)           |
|                          | Assessment the services of dependent ecosystem  |
| Agriculture              | Land use and canopy coverage                    |
|                          | Soil quality (Salinity, pH, OM,)                |
|                          | Cropping pattern and crop intensities           |
|                          | Irrigation and crop production                  |
|                          | Farmers survey result                           |
| Fisheries                | Fish diversity and specification                |
|                          | Fish production and availability                |
|                          | Fisher survey result                            |
| Noise level              | Sound level at the sensitive zone               |
| Water resources          | DO, BOD, COD, Salinity , TDS, TS, pH, Hg, Pb    |
|                          | Total Hardness, Hg, NO3 and PO4                 |
|                          | River Morphology,                               |
|                          | Tidal inundation                                |
|                          | Drainage Network                                |
|                          | Erosion and Accretion                           |
|                          | Ground water quality                            |
| Air quality              | SOx   |
|                          | NOx   |

| Monitoring Parameter | Indicators           |
|----------------------|----------------------|
|                      | SPM (PM10 and PM2.5) |
|                      | CO                   |

## Reporting Requirements

As it is proposed to carry out the monitoring program for three (3) years, the schedule of deliverables has to be re-scheduled. The proposed deliverables are scheduled below

- An Inception Report shall be submitted within 30 (thirty) days from the commencement of the assignment
- Submission of 1<sup>st</sup> quarterly monitoring report at the end of three (3) months from the date of signing contract;
- Submission of 2<sup>nd</sup> quarterly monitoring report at the end of six (6) months from the date of signing contract;
- Submission of 3<sup>rd</sup> quarterly monitoring report at the end of nine (9) months from the date of signing contract;
- Submission of Annual (1<sup>st</sup>) monitoring report at the end of one (1) year from the date of signing contract;
- Submission of 5<sup>th</sup> quarterly monitoring report at the end of fifteen (15) months from the date of signing contract;
- Submission of 6<sup>th</sup> quarterly monitoring report at the end of eighteen (18) months from the date of signing contract;
- Submission of 7<sup>th</sup> quarterly monitoring report at the end of twenty one (21) months from the date of signing contract;
- Submission of Annual (2<sup>nd</sup>) monitoring report at the end of twenty four (24) months from the date of signing contract;
- Submission of 9<sup>th</sup> quarterly monitoring report at the end of twenty seven (27) months from the date of signing contract;
- Submission of 10<sup>th</sup> quarterly monitoring report at the end of thirty (30) months from the date of signing contract;
- Submission of 11<sup>th</sup> quarterly monitoring report at the end of thirty three (33) months from the date of signing contract;
- Submission of Annual (3<sup>rd</sup>) monitoring report at the end of thirty three months from the date of signing contract;
- All report shall be submitted to BIFPCL in (five) hard copies and soft copy on CD.





Environmental Impact Assessment (EIA) of  
the Proposed Dredging Project at the Outer  
Bar area of Pussur Channel

Submitted by:

Institute of Water Modelling(IWM)

to  
Mongla Port Authority  
Ministry of Shipping  
Peoples' Republic of Bangladesh



## **CHAPTER 1: INTRODUCTION**

### **1.1 General**

This Draft Environmental Impact Assessment (EIA) report has been prepared to comply with the reporting requirement as stipulated in the Terms of Reference (ToR) as well as in Contract Agreement for the consultancy services “Environmental Impact Assessment (EIA) of the Proposed Dredging Project at the Outer Bar area of Pussur Channel”. The report describes precisely the major project interventions, relevant regulations, impact identifications, mitigations, environmental management plans and conclusions and recommendations carried out during the study period for Mongla Port Authority (MPA). The EIA Report has been prepared following EIA Guidelines of Department of Environment (DoE) and that of Water Resources Planning Organization (WARPO) to fulfill one of the major obligations of Terms of Reference (ToR).

EIA is mandatory study process to assess the environmental consequences of an existing or proposed project and to delineate any environmental management measures that must be integrated into the plan to ensure that the project is technically, economically, socially and environmentally acceptable. Flood Action Plan (FAP) promotes EIA as an early planning tool with the inclusion of peoples’ participation as an integral part. The EIA preparation led to the identification of potential environmental impacts due to proposed dredging activities and feasible remedial measures as included in the Environmental Management Plan (EMP). The proposed dredging programme at Outer Bar of Pussur Channel to improve navigability will have some adverse impacts on various components of environment during construction and operation phases. In order to mitigate these adverse impacts and to comply with the regulatory requirements of DoE the EIA has been taken up to integrate environmental mitigation measures in the project design.

### **1.2 Background**

Mongla Port, the second gateway of Bangladesh is the most eco-friendly seaport of the country, situated at the confluence of Pussur River and Mongla Nulla, approximately 71 nautical miles (about 131 km) upstream from the Fairway buoy (approaches to the Pussur River) of the Bay of Bengal. The Port is well protected by the largest mangrove forest known as the Sundarbans, part of which has been declared as "World Heritage" in 1997 by UNESCO. Since 1950, Chalna Port continued to function as a Government Directorate under Ministry of Communication and in May 1977 the Directorate was converted to an autonomous organization named "Port of Chalna Authority" which is again renamed “Mongla Port Authority” on 08 March 1987. The Port provides facilities and services to the international Shipping lines and other concerned agencies providing shore based facilities like 5 (five) Jetty berths (total length 914m), have a capacity of about 6.5 million tones general cargo/break bulk and 30,000 TEUS. The midstream berth (7 buoys & 14 anchorages) have a capacity of about 6.00 million tones. Total 33 ships can take berth in the Port (in the Jetties, buoys & anchorage) at a time. However, alike other modern port of the world Mongla Port is keen to provide highest port facilities, so that bigger draft ships can enter in to the port channel safely.

The Pussur River forms part of a very big and complex river system. Numerous tributaries and channels connect the Pussur River with other rivers like Sibsa, the Ganges and Jamuna Rivers. Flow conditions in all these rivers determined the current and morphological condition in the Pussur River. The navigation channel at the Pussur River entrance crosses a wide bar known as outer bar. The bar is relatively stable with sea bed elevation of -6.4 m CD (Chart Datum). With the existing depth in the outer bar, maximum 8.5 m draft vessel can cross the outer bar and enter the port at normal high tide. But the depths over the anchorage area of the channel permit anchoring of more than 9 m draft vessels. Outer bar area is only obstacle for the ships of 9 m and above to enter into the anchorage area. If the depth of the outer bar would be increased to make safe passage of 9 m draft vessels in normal high tide, Mongla port could handle more ships means handling of more cargoes.

ECNEC approved the dredging project on 27.09.2006 and was originally scheduled for implementation from 2006-07 to 2008-09. However, due to non allocation of fund in the ADP, non receipt of tenders, re- tendering owing to high quoted price, justification of technical viability as suggested by the ministry, and finally revision of the project as decided by ECNEC, the implementation of the project has been delayed and re-scheduled from 2007-08 to 2012-2013.

From various studies of the past it has been evident that the morphological behavior of the river system, sedimentation and erosion pattern of the Pussur River is frequently changing. The continuous and high siltation in the channel poses extreme threat of uncertainty to safe maneuvering including economic handling of the ocean going vessels. Therefore, to ensure safe navigation route, intelligent dredging at proper location, alignment and timing for optimum dredging volume (Capital and maintenance) is a need of the day.

Prior to implementation of the proposed dredging project, it is imperative to conduct a thorough study on Environmental Impact Assessment (EIA) and assess adverse biophysical and socio environmental impact, if any, with recommendation of appropriate mitigation plan. A report on EIA is required to be submitted to DOE to obtain Environment clearance on conducting dredging at Outer Bar area of Pussur Channel.

### **1.3 Type of Project**

In Bangladesh all development projects are categorized into three categories namely Category Red (projects with significant adverse environmental impacts), Orange/Amber (projects with some adverse environmental impacts, but of lesser degree than those of Red category projects) and Green category (projects with minimal/insignificant adverse impact). As per National Environment Policy 1992 all developmental activities need to ensure environmental impact assessment. The environmental clearance certificate is required from the DoE. As per ECA 1995 and ECR 1997, the project falls in Red category. Accordingly the EIA report has been prepared.



## **1.4 Project Rationale**

The proposed intervention will allow more than 9 meter draft vessel to ply at the Outer Bar area which will lead to increase traffic and more cargo handling at Mongla port. This will allow faster transport of goods and increased export. This will result in increased earnings of foreign exchange. There will be increased direct and indirect employment opportunities. At Mongla port there is main import of automobile vehicles (luxury cars), food/grain commodities and other value added products. The foreign investors will be more attracted to Mongla Export Processing Zone due to arrival of more cargo vessel with desired draft facility to the port.

## **1.5 Objectives**

The EIA aims to identify the likely potential impacts, both positive and negative, of the proposed interventions to quantify and where possible, value these so that they can be used in a multi-criteria analysis for rational decision making by the project authority and policy makers. The overall aim is to ensure that the recommended intervention is carried out in environmentally sound and sustainable manner and that the EMP recommendations are abide by the project proponent during all the phases of the project cycle. The specific objective of the study is to:

- Conduct “Environmental Impact Assessment (EIA) study for the proposed dredging project at the Outer Bar area of the Pussur Channel” to increase navigability to facilitate easy entrance and maneuvering of more than 9 m draft ships in the anchorage area of Mongla Port;
- Assess biophysical and socio environmental impact, if any, with recommendation of appropriate mitigation plan in the project area; and
- Prepare report on EIA to obtain Environmental clearance from DOE.

## **1.6 Scope of Works**

As spelled out in TOR (Annex-4), the studies need to be carried out in support of EIA are:

- An inventory of the marine species and habitats in the areas to be dredged and surrounding impact areas including Sundarban;
- A hydrodynamic model to evaluate the potential for the proposed dredging of the Outer Bar area and its impact on hydraulic conditions on morphology of the upstream navigation channels like Pussur and Sibsa rivers;
- Sediment sampling and laboratory testing to determine the quality of the potential for release of contaminants during dredging;
- Water quality sampling at the dredging area to provide baseline water quality condition.
- Selection of suitable location for disposal of dredged spoil;
- Assess the environmental impact of the proposed dredging activities;

and other key stakeholders. Participatory Rapid Rural Appraisals (PRRAs) adopting Focus Group Discussions (FGDs) and other techniques were conducted in the project area.

After field data collection on different aspects of environment, an environmental baseline description has been developed. This was followed by the initial screening and scoping, bounding and assessment. The impact assessment began with the establishment of scenario 'future without project' assuming that the past trend will continue in future and this was followed by the scenario 'future with project' after implementation of study findings. The impact was predicted by assuming the difference between the scenarios. The methodology compares the present situation to that in the future both with and without the proposed intervention. The impacts of project intervention on identified environmental components are presented in the matrix where the column shows the IECs and the rows project activity (impact factors) indicating their respective linkages in the matrix cells by indication of positive and negative trends. Mitigation measures for addressing potential negative impact and indicative plan to enhance positive impact has been indicated in this EIA report.

### 1.10 Limitations of the Study

This EIA is prepared based on past experience on similar types of activities as well as field investigation and public consultations carried out in connection with the project. Proposed dredging activity has not yet started. As such all the anticipated impacts could not be fully comprehended at this pre-dredging stage. However, attempts were made to identify most of the potential impacts both positive and negative due to the dredging operation within limited time periods. The study took place without recruitment of the contractor to execute the dredging operation in question. Details of equipments and accessories could not be specified.

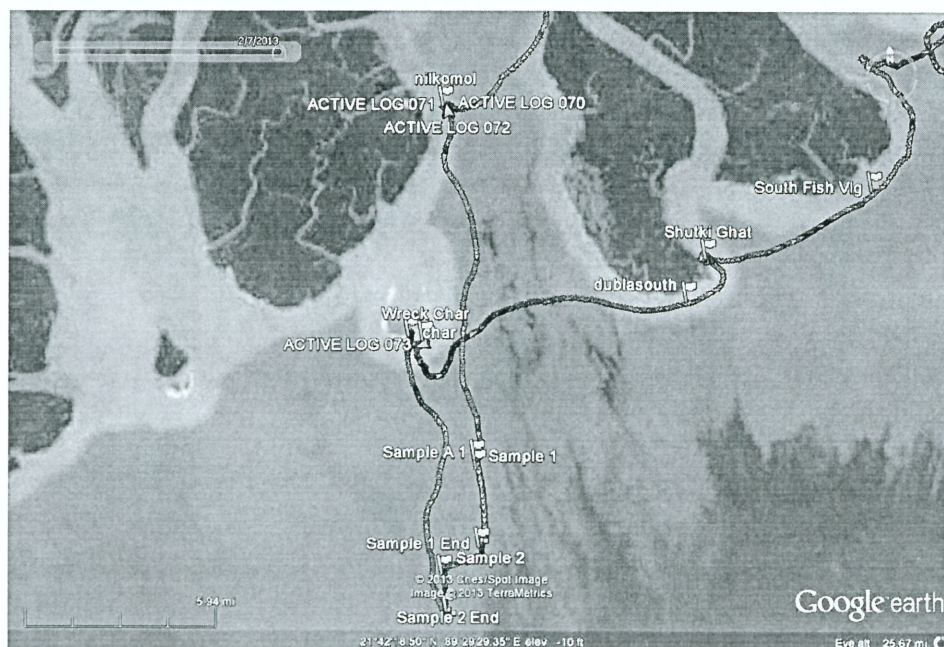


Figure 1.1: Map showing route taken during field visit to the proposed dredging site and sampling locations.



socioeconomic needs and realities;

- Include tree plantation programs in all relevant development schemes;
- Conserve Wildlife and Bio diversity, strengthen related research and help dissemination and exchange of knowledge in these areas, and
- Conserve and develop wetlands and protection of migratory birds.

Under Environmental Action Plan Section of the Policy, under sub section 'Forest, wildlife and biodiversity', it suggests that:

- Priority will be given to the protection of wildlife, wetlands, birds and animals;
- Steps will be taken to protect present forest resources, prevent deforestation and affect extensive afforestation;
- Growing more trees and enriching forest resources in the rural areas will be given priority through extensive implementation of social forestry and homestead forestry;
- Development projects in all sectors will incorporate and implement the government decision of afforestation, and
- Alternative building materials and fuel sources instead of wood and import of wood will be encouraged.

Section 5 "Institutional arrangement" requires:

- Department of Environment will review and approve all environmental Impact Assessments.

Under Environmental Action Plan Section of the Policy, under sub section 'Legal Framework', it suggests that:

- Concerned ministries will ensure that proposed legislations are environmentally compatible.

The Environmental Policy of 1992, which amongst other policies, seeks to ensure that transport systems, including roads and inland waterways, do not pollute the environment or degrade resources. The Policy states that Environmental Impact Assessments (EIA) should be conducted before projects are undertaken.

### **2.3 National Water Policy**

Water resource management is a critical issue for the country because of recurrent floods in the monsoon and drought in the dry season, massive river sedimentation and bank erosion, pollution of surface and ground water and increasing demand of water by the growing economy and population.

The National water policy 1999 was passed to ensure efficient and equitable management of water resources, proper harnessing and development of surface and ground water, availability of water to all concerned and institutional capacity building for water resource management. It has

also addressed issues like river basin management, water rights and allocation, public and private investment, water supply and sanitation and water need for agriculture, industry, fisheries, wildlife, navigation, recreation, environment, preservation of wetlands etc.

The goal of the policy is to provide policy guidance to all the agencies involved in the water sector. There are six specific objectives of the policy which cover a wide range of aspects. The policy puts a lot of emphasis on water resource planning and management and GO-NGO integration. There are separate policy sections on 'Water and industry', 'Water and agriculture', 'Water and river transport', 'Water for recreation and hydro power', 'Water supply and health'. There are three specific sections on 'Water, fisheries and wildlife', 'Water for environment', 'Conservation and development of haor, baor and Beels'.

The Policy also advocates people's participation in water resource management and People's participation in water development projects is recognized as an essential part of project planning process. This provision of the policy would facilitate the formation of water user groups and community based organizations.

#### **2.4 National Water Management Plan 2001 (Approved in 2004)**

The National Water Resources Council approved on March 31, 2004 a 25-year National Water Management Plan. The plan provides a framework within which all concerned with the development, management and use of water resources water services in Bangladesh can plan and implement their own activities in a coordinated and integrated manner. The planned activity programs have been presented in the eight sub-sectoral clusters: i) Institutional Development, ii) Enabling Environment, iii) Main River, iv) Towns and Rural Areas, v) Major Cities; vi) Disaster Management; vii) Agriculture and Water Management, and viii) Environment and Aquatic Resources. Each cluster comprises of a number of individual programs, with overall a total of 84 sub-sectoral programs identified and presented in the investment portfolio. It will be implemented in three phases. It was approved at the seventh meeting of the National Water Resources Council. It calls for a coordinated approach of concerned ministries and departments to stop water-logging and to incorporate the issues of arsenic mitigation, river administration, dredging and fisheries resources. To mitigate the environmental risks of water sector project development, the plan suggested for a holistic view, which includes the environment itself as an important water sector stakeholder with an entire cluster of programs devoted to it. Furthermore, programs within the environment cluster are strategically timed in order that public awareness raising, the establishment and enforcement of regulatory mechanisms and long term planning are addressed as priority. Water Resources Planning Organization (WARPO) was assigned to monitor the national water management plan.

#### **2.5 Coastal Zone Policy, 2005**

Coastal zone policy initiated as a harmonized policy that transcends beyond sectoral perspectives. The policy provides general guidance so that the coastal people can pursue their livelihoods under secured conditions in a sustainable manner without impairing the integrity of the natural environment. The policy framework underscores sustainable management of natural resources



like inland fisheries & shrimp, marine fisheries, mangrove and other forests, land, livestock, salt, minerals, sources of renewable energy like tide, wind and solar energy. It also emphasis on conservation and enhancement of critical ecosystem- necessary measures will be taken to conserve and develop aquatic and terrestrial including all the ecosystems of importance identified by the Bangladesh National Conservation Strategy (Mangrove, coral reef, tidal wetland, sea grass bed, barrier island, estuary, closed water body, etc).

## **2.6 Coastal Development Strategy, 2006**

Costal Development Strategy has been approved by the Inter-Ministerial Steering Committee on ICZMP on February 13, 2006. The strategy is based on the Coastal Zone Policy and takes into account the emerging trends: increasing urbanization, changing pattern of land use, declining land and water resources, unemployment and visible climate change impacts. The strategy has 9 strategic priorities and the following 3 are relevant priorities with proposed type of interventions:

Safety from man-made and natural hazards - i) Strengthening and rehabilitation of sea dykes; and ii) reduction of severe vulnerability in the coastal zone through multi-purpose cyclone shelters-including coping mechanism.

Sustainable management of natural resources - i) environmentally and socially responsive shrimp farming; ii) introduction of renewable energy in coastal areas; and iii) development of marine fisheries and livelihood.

Environmental conservation – i) Marine and coastal environmental development; ii) strengthening of Coast Guard for improvement of coastal safety and security in coordination with other law enforcing agencies.

## **2.7 National Fisheries Policy, 1996**

The National Fisheries Policy, 1996 recognizes that fish production has declined due to environmental imbalances, adverse environmental impact and improper implementation of fish culture and management programs. The policy suggests following actions:

- Shrimp and fish culture will not be expanded to the areas which damage mangrove forest in the coastal region
- Biodiversity will be maintained in all natural water bodies and in marine environment
- Chemicals harmful to the environment will not be used in fish shrimp farms
- Environment friendly fish shrimp culture technology will be used
- Control measures will be taken against activities that have a negative impact on fisheries, resources and vice-versa
- Laws will be formulated to ban the disposal of any untreated industrial effluents into the water bodies.

## **2.8 The Mongla Port Authority Ordinance 1976 and The Mongla Port Authority (Amendment) Ordinance 1982 & 1987**

The Mongla Port Authority Ordinance 1976 and The Mongla Port Authority (Amendment) Ordinance 1982 & 1987 which establishes the role, powers and function of the Port of Mongla as an Authority, but contains no environmental controls.

## **2.9 The Mongla Port Authority (Amendment) Act 1995**

Section 41A of this Act states " Penalty for pollution etc.- Any person who throws or allows to fall into the water, shore, bank or land within the limits of the Port any goods, ballast, ashes or any other thing whatsoever causing pollution of the water or environment shall be punishable with fine which may extend to one lakh Taka."

## **2.10 Inland Shipping Ordinance 1976 and Inland Shipping (Amendment) Act 1990**

Inland Shipping Ordinance 1976 and Inland Shipping (Amendment) Act 1990 which deals with the administration, registration, competency and so on of inland water transport. The parent law will be amended to contain a substituted chapter heading:

Chapter V: Protection of Vessels and Passengers and Environment with insertion of a new section:

57B. Prevention of Pollution

No person shall, by discharge from inland ship or inland-ship facility or inland-ship activity cause pollution of inland water.

## **2.11 Proposed Legislation**

Protection of the Marine Environment of Bangladesh Act 1990, which primarily addresses pollution in the coastal and national waters and seaports of Bangladesh, and outside national waters, is not yet enacted. The Act provides control for oil or pollutants discharged, spilled or dumped into Bangladesh water from ships, ship transfer to land, land, ports, exploration of the sea bed, pipelines and offshore installations. It proposes the establishment of spill contingency plans without detailing the way in which this might function.

Draft Rules for the Environmental Control of Inland Water Transport applied to inland water and waterways throughout Bangladesh which are categorized as navigable by inland water transport, and to all waters served by inland water transport including ports and the approaches to ports. The proposed Rules control impacts from all inland water transport, ports, ship-related facilities, and ship related activities for the protection of inland water in regard to air emissions, handling and storage of harmful materials, solid and liquid waste discharges, dredging, and disposal of dredged sediments.

Proposed Draft Rules for Inland Ship Safety 1994 under the Department of Shipping (DoS) Institutional Development Action Plan as part of the implementation plan for establishing an



- (iv) Prohibits the destruction of fishes by explosives, gun, bow, in inland or coastal areas,
- (v) Prohibits the destruction of fish by poisoning, pollution and effluents,
- (vi) Prescribes the seasons during which the catching of fish can occur
- (vii) Prescribe the minimum size
- (viii) Prohibits fishing in all waters or any specified time

The following outlines the legal and regulatory framework for management of the water resources environment.

- (i) The 1995 Environmental Conservation Act;
- (ii) The 1997 Environmental Conservation Rules, including the Water Quality Standards (WQS);
- (iii) The 1997 EIA Guidelines for Industries issued by the DoE;
- (iv) The 1999 Environmental Court Act.

#### **2.14 Bangladesh Environmental Conservation Act (ECA) 1995**

Environment Conservation Act 1995 (ECA '95) is currently the main legislation relating to environment protection in Bangladesh. This Act of 1995 is officially the 'Bangladesh Environment Conservation Act 1995' promulgated for environment conservation, environmental standard development and environment pollution control and abatement. It has repealed the Environment Pollution Control Ordinance 1977. The main objectives of ECA '95 are:

- Conservation and improvement of environment, and
- Control and mitigation of pollution of environment.

The main strategies of the Act can be summarized as:

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

The Department of Environment (DOE) is executing the Act. A Director General (DG) heads DOE. The power of the DG, as given in the Act, may be outlined as follows:

- Identification of different types and causes of environmental degradation and pollution.

Instigating the investigation and research into information regarding environment

- Forest area
- Biodiversity area
- Similar other areas.

**Figure 2.1** and **Table 2.1** present map and list of protected areas of Bangladesh respectively. (2) The activities or processes which cannot be continued or initiated in Ecologically Critical area shall be specified by the Government as per standards described in following Rules 12 and 13 of the ECR '97)"

According to the rules, any project/development intervention of the Red Category is to obtain environmental clearance in two steps - first to obtain site/location clearance (based on the application along with necessary papers, including the Initial Environmental Examination (IEE) which will contain the scope of work of the proposed EIA, if required, and then to obtain Environmental clearance (by submitting the application along with necessary papers including the EIA). The Department of Environment may take up to sixty days to issue the site clearance (from the date of receiving the application), sixty days to approve the EIA and thirty more days to issue the Environmental Clearance, provided everything goes well.

This may be quite a lengthy process if DOE uses the full extent of the time limits. The rules however provide the Director General a discretionary authority to grant Environmental Clearance' to an applicant exempting the requirement of site/location clearance, provided he considers it appropriate. [Section 7(4), 2nd Paragraph, Page 3105 of the Bangladesh Gazette of 27 August 1997].



- (v) Declaring Environmentally Critical Areas (ECAs) where the ecosystem has been degraded to a critical state. ECA status confers protection on land and water resources through a series of environmental regulations.
- (vi) (The Forestry Department is responsible for Sensitive Area protection in the following four types of legally protected areas: wildlife sanctuaries, game reserves, reserve forests and natural reserve forests).

### **2.17 Convention on Biodiversity**

Bangladesh is a signatory of the Convention of Biodiversity committing the Government to the protection of biodiversity throughout Bangladesh. This requires the GOB to make a commitment to provide resources for the Protection and Management of Biodiversity.

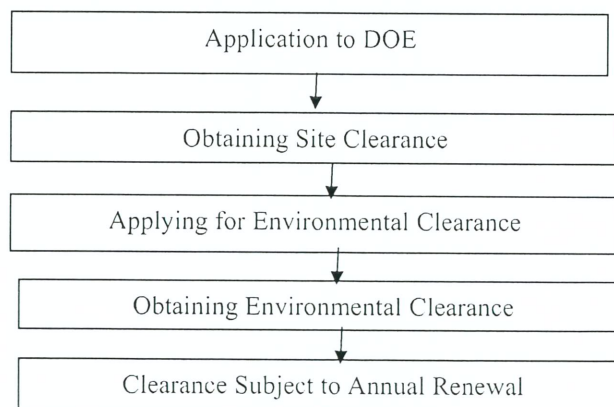
### **2.18 World Heritage Sites and Ramsar**

There are sites within the project area that are part of the World Heritage sites within the Sundarbans. The three seaward sanctuaries within the Sundarbans form the World Heritage site. These sites are regarded as being of the highest importance for Biodiversity Protection within the Sundarbans Reserve Forest despite the concerns raised about their representativeness (Saunders, 2000). RAMSAR signatories agree to protect important wetland systems and their functionality. The Sundarban is recognized as a RAMSAR site and as such the GoB has committed to “the conservation and wise use of wetlands by national action and international co-operation as a means to achieving sustainable development”

### **2.19 Environmental Clearance Procedure**

Legislative bases for EIA in Bangladesh are the ECA 1995 and the ECR 1997. DOE is the regulatory body responsible for enforcing the ECA'95 and ECR'97. It is the responsibility of the proponent to conduct an EIA of development proposal, the responsibility to review EIAs for the purpose of issuing Environmental Clearance Certificate (ECC) rests on DOE. The proposed dredging will follow the procedures for ‘Orange B’ /Red Category, which includes submission of:

- An Initial Environmental Examination (IEE); An Environmental Impact Assessment (EIA) with an Environmental Management Plan (EMP);
- Environment clearance has to be obtained by the MPA from DoE. The environmental clearance procedure can be summarized as follows for Red Category projects:



### **3.0 DESCRIPTION OF PROJECT ACTIVITIES**

#### **3.1 General**

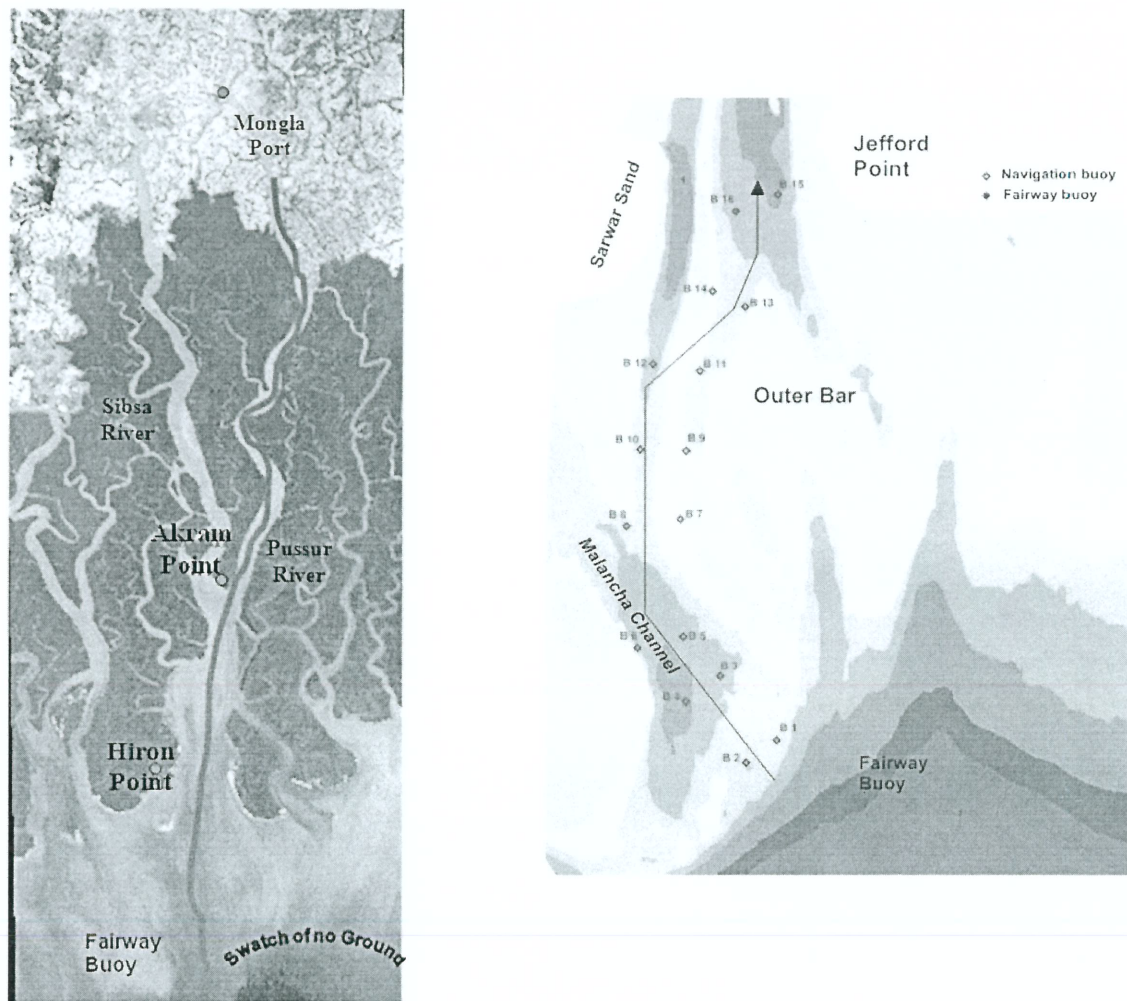
The removal of sediments by mechanical dredging can have adverse impacts on marine species, habitats and ecosystem services. The impact may be due to physical or chemical changes in the environment at or near the dredging site. The extent of the impact depends on the size, characteristics and sensitivity of the dredged area and the dredging technique. The impacts of dredging activities are strongly influenced by the contamination of the sediment (if any) and local factors like water depth, rate of flow, tidal currents, wave action, type of seabed and sediment concentration of the water under natural circumstances, as well as the dredging method, the extent of the areas dredged (in terms of area and depth), the frequency and duration of dredging activities, the characteristics and the sensitivity of the areas dredged and their surroundings (in terms of distribution and importance of habitats and species), the dredging techniques applied as well as relationships with other uses and users of the system (cumulative aspects).

#### **3.2 Study Area and the Major Problems**

The navigation channel at the Pussur river entrance crosses a wide bar known as Outer bar. It exists between latitudes  $21^{\circ}35.29'$  and  $21^{\circ}40.691'$  at around 45 km seaward of Hiron Point and exposed to the open sea. **Figure 3.1** shows the layout of the coastline, channels, the bar area and the existing navigation way together with navigation buoys. The bar is relatively stable and allows vessels having maximum draft of 8.5 m to cross it during normal high tide condition. However, depths at the anchorage area in the upstream towards Mongla port through Pussur Channel permits anchoring of more than 9 m draft vessel. So the Outer bar is the only obstacle for the ships of 9 m and above to enter into the anchorage area.

**Figure 3.2** Shows the Sundarban Mangrove Forest and the proposed dredging location at Outer Bar area of Pussur Channel.



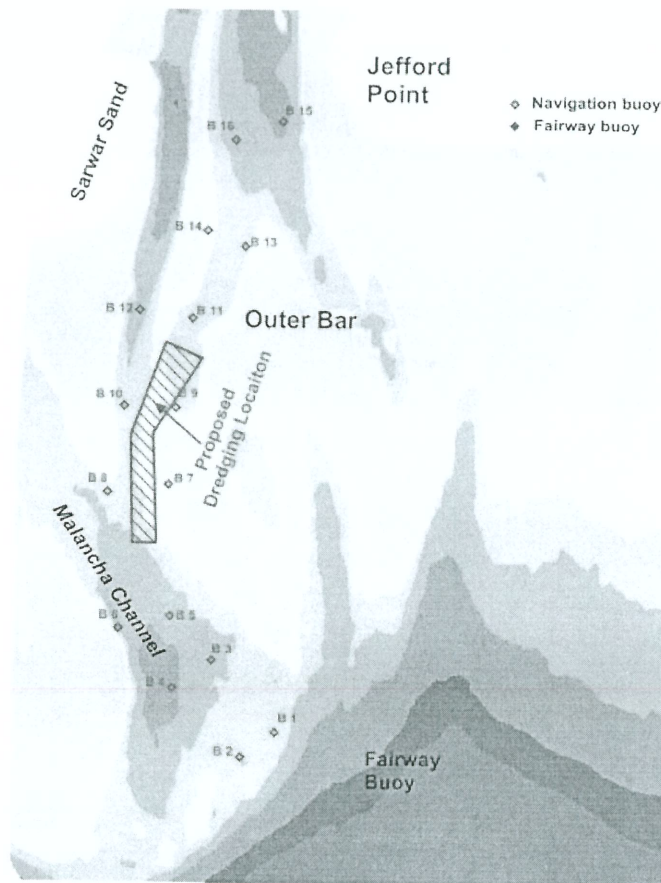


**Figure 3.1: The Study Area**

### 3.3 Activities Involved in Dredging

The proposed dredging operation at Outer Bar area of Pussur Channel has been considered to improve navigability of Mongla port so that vessels with more than 9 meter draft can efficiently move in the channel. The intervention will have a varying dredging width from 400 m to 800 m covering a length of about 6.5 km as shown in **Figure 3.3**.

The activities involved in dredging are primarily mobilization of the contractor with dredging equipment and accessories (suction pipe, discharge pipe, suction pump, discharge pump, anchorage system, etc.), pre-dredging hydro graphic survey at the proposed dredging location, dredging will be carried out preferably by trailing suction hopper dredger (TSHD), disposal of dredged spoil at suitable site and post-dredging hydro graphic survey.



**Figure 3.3: Proposed Dredging Location and Alignment**

### **3.4 Use of Equipment and Capacity**

For the proposed dredging operation Trailer Hopper dredger will be used fitted with accessories such as suction pipe of 800 mm diameter, discharge pipe of 750 mm diameter, anchorage system, etc. MPA will ensure that selected dredging company will deploy dredger suitable for dredging in the offshore area in hot and tropical climate and fully equipped with all accessories. The dredger will carry dredged spoil to facilitate dumping of the materials at the designated locations as shown in **Figure 3.4**. Average fuel consumption per cubic meter dredging will be one litre. Capacity of the dredger will be 1000 to 1500 cubic meter dredging per hour. The dredgers to be deployed for the work will not be more than 10 years old.

### **3.5 Resources and Utilities**

Dredging operation will continue for about 16 (sixteen) months starting from April/May 2014 to June/July 2015. A total of 10 persons including expatriates and locals will operate the Dredger. All solid waste will be collected in container to store and will be dumped in sanitary manner in the shore. Liquid waste will be handled in sanitary manner by observing recommended code of practice/standard.



| Sl.<br>No. | Activity  | Years/ Months |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
|------------|---|---------------|---|---|---|---|---|---|---|---|---|------|---|---|---|---|---|
|            |   | 2014          |   |   |   |   |   |   |   |   |   | 2015 |   |   |   |   |   |
|            |   | A             | M | J | J | A | S | O | N | D | J | F    | M | A | M | J | J |
| 1.0        | Mobilization  |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 2.0        | Reconnaissance<br>Site Visit                                |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 3.0        | Collection and<br>review of data,<br>maps, and charts       |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 4.0        | Dredging plan<br>and operation at<br>site                   |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 4.1        | Preparation of<br>dredging plan<br>based on model<br>result |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 4.2        | Dredging<br>operation                                       |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 5.0        | Completion of<br>dredging<br>operation &<br>demobilization  |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |
| 6.0        | Reporting   |               |   |   |   |   |   |   |   |   |   |      |   |   |   |   |   |

**Figure 3.5: Activity Schedule**

### 3.6 Work Schedule

A well planned work schedule in the form of bar chart is absolutely essential as a management tool for timely delivery of outputs of activities and milestones. The bar chart is the most widely and conveniently used schedule for the management of proposed dredging activities. The activity schedule is shown in **Figure 3.5**. This schedule may be changed depending on the field requirements as identified during the course of dredging operation.

### 3.7 Implementing and Executing Agencies

The Ministry of Shipping, Government of Bangladesh will be the Executing Agency (EA), and Mongla Port Authority will be implementing Agency for the proposed dredging at the Outer Bar area of Pussur Channel.

## **4 DESCRIPTION OF BASELINE CONDITION**

### **4.1 Introduction**

Determination of baseline conditions of biophysical environmental components of the project area is vital for robust impact assessment. In the following Sections a brief description of the existing biophysical environment in and around the project is precisely described.

Historically, transportation by vessels operating on rivers and oceans has been essential to the expansion of both the national and international trade. Rivers, canals, and oceans provide the “road” over which ever increasing amounts of cargo are transported, and they tie together the disparate elements of the world’s economy. Before the advent of railroads and modern highways, ships provided the only practical way to move large amounts of cargo from location to location; now, in the modern world, carriage by ship or barge remains the most economical way to move goods, particularly those dealt in high volume and at low unit value, such as mineral ores and food grains. World-wide, it is estimated that by weight, some ninety percent of all international trade of goods moves by ship, an astounding figure, especially given the tremendous expansion in world trade in past decades.

Water transportation is environmentally sound, since ships and barges, when compared to other means of transportation, have the smallest number of accidental spills or collisions (DOT 1999). Further, water transportation is more fuel efficient per ton of cargo moved than other modes of transportation. But these assessments focus only on the actual operation of transportation systems and do not consider, for example, potential environmental problems associated with dredging, an activity essential for contemporary maritime transportation.

Larger vessels offer cost efficiencies for ship operators, they present new problems for port managers. As ships have become larger, they have acquired deeper drafts, demanding deeper water to accommodate their hulls. It is not ship draft alone that must be considered in navigational dredging. Other factors, such as increased beam and windage, create maneuverability problems in narrow channels. The needs of ports to accommodate larger vessels with deeper drafts, taken together with the natural process of sedimentation, create demands for the dredging of shipping lanes. In connection with maritime transportation, dredging is needed in three types of situations: i) to maintain present widths and depths by counteracting the natural redistribution of coastal sediments, ii) to widen and deepen existing channels for access by new, larger vessels, and iii) to create new port facilities where they have not existed before.

Dredging is recognized as having the potential for significant environmental impacts. There are environmental effects of the dredging itself, that is, the picking up of sediments, and of the later disposal of those sediments. With respect to the dredging some general environmental perturbations that may occur, include:

- disruption of bottom living communities,
- suspension of particulates in the water column,
- modification of local circulation and sediment transport patterns,



- increased salinity by channel deepening, salt water encroachment.

Likewise, the disposal of dredged materials may also have important environmental implications such as:

- burying bottom living communities,
- increasing water turbidity,
- modifying local circulation

Where the dredged materials are contaminated, there is also the risk of introducing toxic materials into marine food chains, posing human health hazards and damaging the potential for commercial and recreational fishing.

## **4.2 Physical Environment**

### **4.2.1 An Overview of Coastal and Marine Environment of Bangladesh**

Bangladesh is endowed with vast marine and coastal waters having an area of about 1.5 times more than that of her total land mass. The environment is under the dynamic interface between terrestrial systems and marine systems dominated by wave actions and tidal currents from the Bay of Bengal. The land territory of Bangladesh is linked to the seabed and subsoil in the Bay by a singular process of erosion and deposition that has (a) lifted much of Bangladesh's landmass out of the sea, and (b) shaped the highly unusual seabed throughout the Bay (ITLOS, 2010). The countries exclusive economic zone (EEZ) spans 166,000 sq. km and the shelf area covers roughly 66,440 sq. km (**Table 4.1**). Bangladesh sits in a broad and deep concavity at the northern limit of the Bay of Bengal, with Myanmar to its east and India to its west (ITLOS, 2010).

**Table 4.1: Coastal area within the Exclusive Economic Zone of Bangladesh (200m depth)**

| Depth (m)               | Area (km <sup>2</sup> ) |
|-------------------------|-------------------------|
| < 10                    | 24,000                  |
| 10 - 24                 | 8,400                   |
| 25 - 49                 | 4,800                   |
| 50 - 74                 | 5,580                   |
| 75 - 99                 | 13,410                  |
| 100 - 200               | 10,250                  |
| Total Continental Shelf | 66,440                  |
| Total EEZ               | 166,000                 |

*Source: Khan et al. 1997; Hussain and Hoq, 2010*

This marine and associated coastal zone in Bangladesh is characterized by sprawling estuaries, dense mangrove forest, coral reef-associated island and the world's longest sea beach. There are many sedimentary islands in the estuary and along the coastline, and about seven sq. km of new land emerges from the sea every year (ITLOS, 2010). Fishing is the most significant economic activity on these islands besides serving as an important base of operations for the Bangladesh Navy and Coast Guard with a great potential of ecotourism.

The geographical position and climatic condition of Bangladesh have made her coastal areas one of the highly productive areas of the world (Islam, 2003). Recent surveys gave an estimate of demersal standing stock between 150,000 and 160,000 t. within the exploited 10-100 meter shelf area (Saetre 1981, Khan 1983, Lamboeuf 1987). Eight species of Tuna and Skipjack (Khan, 1983) and a number of potential species of Mackerels, Shark, Ray, Sardines, Anchovies, Shad and cephalopods, soles and flat-fish, lobster, etc., are available in Bangladesh waters but detailed pelagic survey is yet to take place to provide a reliable estimate of their standing stock. The coastal and marine fisheries have been playing considerable roles not only in the social and economic development of the country but also in the regional ecological balance (Salam, et al. 2011).

Though the highest priority has always been accorded to the freshwater fisheries (as reflected in the number of projects implemented), it is impossible to acquire sustainable development and fulfill the protein requirement of the teeming millions from this subsector alone despite the marine fisheries has the lion's share of foreign exchange earnings. But most of these resources have been over-fished and are declining at an alarming rate (Khan *et al.*, 2003). If similar level of management and development attention is paid to the marine sector through a holistic approach, it will pave the way to a greater achievement towards sustaining the fish stocks for livelihoods and food security for future generations.

#### **4.2.2 Geo-morphology**

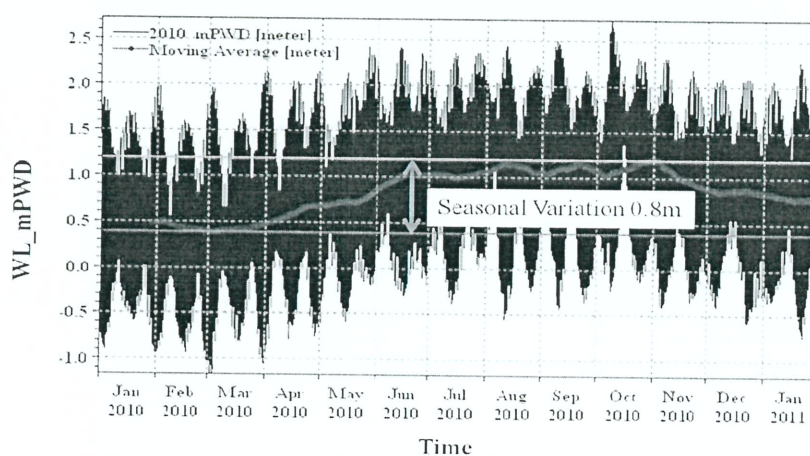
The characteristics of the coastal morphology of Bangladesh (Islam 2004) are:

- A vast network of rivers and channels;
- An enormous discharge of river water, heavily laden with sediments, mainly suspended;
- A large number of islands within the rivers and channels and seaward of the coast line ;
- The “swatch of no ground” : a submarine canyon running NE-SW about 24 km south of the Bangladesh coast, partially across the continental shelf;
- A shallow northern Bay of Bengal, funneling to the coastal area of Bangladesh in the north;
- Strong tidal and wind actions; and
- Tropical cyclones and their associated storm surges.

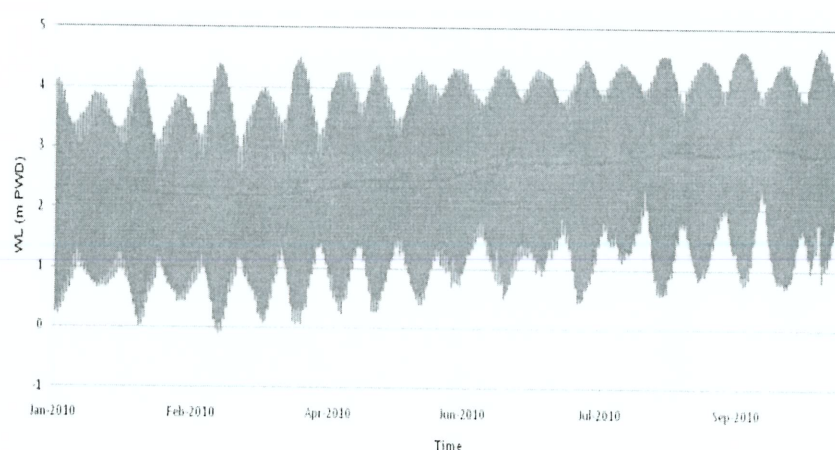
The oceanography of the Bay of Bengal is dominated by three main factors: (i) wind direction; (ii) precipitation; and (iii) river discharges, all impacting on fish distribution and abundance. Surface currents in this region run clockwise from January to July and counter clockwise from August to December, consistent with the direction of the monsoon winds (Longhurst 1998). Three main rivers (the Ganges, Brahmaputra and Meghna) drain vast areas of the Himalayas, India and Bangladesh and discharge into the Bay of Bengal. The rivers render the surface waters of the northern part of the Bay almost riverine during the post-monsoon months (September and October); the lowest salinity (10.5 ppt) is observed during this time (Mustafa and Prova Dey 1994). In comparison, near-estuarine conditions prevail from January to June. The highest salinity (33 ppt) is reported in March (Mustafa and Prova Dey 1994). Strong salinity gradients exist from



seasonal variation of about 0.8m (**Figure 4.3**). At Mongla, the maximum tidal range and the seasonal variation are about 4.39 m and 0.87 m respectively (**Figure 4.4**).



**Figure 4.3: Water Level Variation at Hiron Point**



**Figure 4.4: Water Level Variation at Mongla Port**

Semi-diurnal tides with a tidal period of about 12 hours 25 minutes are predominant in the Bay of Bengal. The tidal range of the Project area is approximately 3 to 4m between the successive lowest and highest tides. According to the Bangladesh Tide Tables 2012, Mean Tidal Level is 2.310m and 1.70m at Mongla, and Hiron Point along Pussur River, respectively (**Table 4.2**). The tidal regime is larger at Mongla than at Hiron Point.

**Table 4.2: Tidal levels at Mongla, and Hiron Point of the Pussur River in 2012 (m CD)**

| Stations    | Lowest tide level | Mean level | Highest tide level |
|-------------|-------------------|------------|--------------------|
| Mongla      | -0.261            | 2.310      | 4.882              |
| Hiron Point | -0.256            | 1.700      | 3.656              |

*Source: Bangladesh Tide Tables 2012*

### **Water flow/discharge**

IWM in March 2011 measured maximum discharge of 36,987 m<sup>3</sup>/sec in Pussur River at Akram Point, during spring flood (high) tide. Near Mongla port in the same month the maximum discharge at Mongla Nulla at spring flood tide was 6,597 m<sup>3</sup>/sec. **Table 4.3** summarizes maximum flows in Pussur river during March 2011.

**Table 4.3: Maximum discharge during flood and ebb tide conditions**

| No | Location                          | Name of the Channel | Measurement Period       | Type of tide | Max flow during flood tide (m <sup>3</sup> /sec) | Max flow during ebb tide (m <sup>3</sup> /sec) |
|----|-----------------------------------|---------------------|--------------------------|--------------|--|--|
| 1  | Mongla Nulla( DS of Mongla Nulla) | Pussur              | 03-30-2011(half hourly)  | Neap         | 4,952  | 4,386  |
|    |                                   |                     | 03-06-2011(half hourly)  | Spring       | 6,597  | 8,545  |
| 2  | Akram Point                       | Pussur              | 03-13-2011 (half hourly) | Neap         | 16,792   | 17,171   |
|    |                                   |                     | 03-21-2011 (half hourly) | Spring       | 36,987   | 31,732   |

*Source: IWM, 2011*

### **4.2.4 Temperature**

The annual variation in temperature in the Bay of Bengal is not large, about 2°C in the south and 5°C in the north. According to Mustafa and Prova Dey 1994, sea surface temperatures (SST) are highest in September (24.8° C) and lowest in January to February (24.1° C).

In the Bay water has an inverse relationship with depth of water that is if the depth increases the temperature decreases (**Figure 4.5**). The figure shows that the sea water temperature decreases rapidly with depth.



very high values of EC, TDS, BOD and COD, which means that water is contaminated by chemical pollutants (i.e. oil and grease from ships).

**Table 4.4: Water quality data from the proposed dredging site and adjoining areas**

| Sample Site   | Surface Water Temp (°C) | Salinity (ppt) | Conductivity (mS/cm) | TDS (gm/lit) |
|---|-------------------------|----------------|----------------------|--------------|
| Site 1: N 21°38'45.4";<br>E 89°29'10.8"                                 | 22.2                    | 25.0           | 39.3                 | 24.0         |
| Site 2: N 21°35'46.6";<br>E 89°27'46.5"                                 | 21.8                    | 25.2           | 39.6                 | 24.2         |
| Near Sarwar Sand<br>N 21°40'00.0";<br>E 89°27'95.5"                     | 22.6                    | 21.3           | 30.0                 | 20.5         |
| Between Sarwar Sand &<br>Dublar Char<br>N 21°42'32.4";<br>E 89°29'50.0" | 22.3                    | 19.5           | 31.3                 | 18.7         |

*Source: Field Survey, 2013*

**Table 4.5: Water quality data at the Outer Bar area of proposed dredging site**

| Sl. No. | Parameters                               | Unit  | Concentration Present | Bangladesh Standard for Drinking Water | Remarks                      |
|---------|--|-------|-----------------------|--|------------------------------|
| 1       | pH                                       | -     | 7.91                  | 6.5 – 8.5                              | Within Limit                 |
| 2       | Electrical Conductivity at 25°C          | μS/cm | 40300                 | -                                      | -                            |
| 3       | Turbidity                                | NTU   | 4.14                  | 10                                     | Within Limit                 |
| 4       | Dissolved Oxygen (DO)                    | Mg/l  | 6.65                  | 6                                      | Good                         |
| 5       | Total Dissolved Solids (TDS)             | Mg/l  | 27011                 | 1000                                   | Very High                    |
| 6       | Total Suspended Solids (TSS)             | Mg/l  | 258                   | 10                                     | Very High                    |
| 7       | Chemical Oxygen Demand (COD)             | Mg/l  | 1144                  | 4                                      | Very High                    |
| 8       | Biochemical Oxygen Demand (BOD5)         | Mg/l  | 100                   | 0.2                                    | Very High                    |
| 9       | Manganese (Mn)                           | Mg/l  | -                     | 0.1                                    | Below Detectable Limit (BDL) |
| 10      | Total Alkalinity (as CaCO <sub>3</sub> ) | Mg/l  | -                     | -                                      | BDL                          |

*Source: Field Survey 2013; Data analyses by BRTC, BUET*

#### 4.2.6 Quality of bed materials at the proposed dredging site

Table 4.6 shows chemical properties of bed material at the proposed dredging site of MPA. The table shows high salinity of sea bed materials at the Outer Bar area along with the presence of heavy materials such as Nicle (Ni), Lead (Pb) and Cadmium (Cd).

**Table 4.6: Chemical properties of bed material at the proposed dredging site**

| Sample No. | Year/ Date  | pH  | Salinity (EC) ds/m | Organic Matter % | Ca                            | K              | N %            | P         | B              | Zn       | Cd   | Pb    | Ni    |
|------------|-------------|-----|--------------------|------------------|-------------------------------|----------------|----------------|-----------|----------------|----------|------|-------|-------|
|            |             |     |                    |                  | Milli-equivalent /100 gm soil |                |                | µg/g soil |                |          |      |       |       |
| 1          | 5 Feb, 2013 | 6.9 | 12.3 High Salinity | 0.40 Very low    | 8.38 Very high                | 1.14 Very high | 0.020 Very low | 9.7 Low   | 2.02 Very high | 0.88 Low | 0.37 | 20.85 | 48.27 |
| 2          | 5 Feb, 2013 | 6.9 | 14.4 High Salinity | 0.34 Very low    | 7.50 High                     | 1.28 Very high | 0.017 Very low | 6.2 Low   | 1.01 Very high | 0.64 Low | 0.34 | 7.48  | 29.95 |

Source: IWM Field Survey

### 4.3 Biological Environment

#### 4.3.1 Introduction

Though the marine biodiversity remains less studied than the other freshwater and terrestrial biodiversity, yet it is noted that there are more animal phyla in the marine domain than the land. Thirty-five phyla (11 pelagic) are marine; of these 14 are endemic whereas only 14 occur in freshwater, where none are endemic, 11 are terrestrial with one phylum being endemic and 15 phyla are symbiotic with four being endemic.

The Bangladesh coast supports about 587,400 ha of natural mangroves (Mahmood, 1986) providing the habitat of several species, particularly the younger stages of shellfish and finfish (Mahmood, et al. 1994). A total of 50 species of crabs (Quader, 1994), 30 species of mollusks (Salam, et al. 2011) have so far been recorded from the coastal and marine habitats of the Bay of Bengal. Fourteen species of seaweeds were recorded from the St. Martin's Island (Rahman, 1999). Four species of Acropora and 10 other coral reef genera have been reported from off shore islands, seafronts of newly formed islands and some low lying coastal areas are often carpeted with sea grass (Hussain and Hoq, 2010).

#### 4.3.2 Fishery Resources

Fishery is an important renewable resource in Bangladesh. Bangladesh is endowed with vast marine, brackish and inland waters having fisheries potentials. It has a land area of 1,47,570 sq. km. and has declared an Exclusive Economic Zone (EEZ) from her base line to 200 nautical miles seaward in 1974. As a result along with 710 km. (coast line) an area of about 1,66,000 sq. km., which is greater than actual land of Bangladesh, is now under the economic jurisdiction of the country for exploitation, exploration, conservation, and management of its living and non-living resources (DOF, 1999). Contribution of fisheries sector in the national economy of Bangladesh is



|           |      |      |      |          |
|-----------|------|------|------|----------|
| 1998-1999 | 4666 | 3764 | 8255 | 0.455966 |
| 1999-2000 | 3795 | 2919 | 7871 | 0.370855 |
| 2000-2001 | 3855 | 3162 | 8395 | 0.376653 |
| 2001-2002 | 4675 | 3168 | 6935 | 0.456813 |
| 2002-2003 | 3120 | 2487 | 8158 | 0.304854 |
| 2003-2004 | 3767 | 3076 | 8357 | 0.368075 |
| 2004-2005 | 3941 | 3310 | 8595 | 0.385108 |
| 2005-2006 | 4259 | 3444 | 8276 | 0.416143 |

*Source: BBS, 1999; Ray and Khan, 2003, MFSMUC, 2007*

Fifteen kilometers south of the proposed dredge site is the northern boundary of the ‘Swatch of No Ground’ – and important habitat for the marine fisheries and mammals (cetaceans – dolphins, porpoises and whales). Waters of the Bay of Bengal are included in the Indian Ocean Cetacean Sanctuary established according to Article V(1)(c) of the International Convention on the Regulation of Whaling (IWC, 1980) [although Bangladesh is not a member of the Convention] and were prioritized as part of a proposed marine mammal initiative for South Asia endorsed at the 11th Meeting of the Scientific Council of the Convention on the Conservation of Migratory Species of Wild Animals (CMS, 2002).

The results of survey conducted in the Sundarbans mangrove forest (Smith et al. 2006) and near-shore cetaceans indicate that Bangladesh serves a regionally vital role as a reservoir of cetacean abundance and diversity supporting relatively large populations of at least two species (Irrawaddy dolphins and finless porpoises) known to be at risk in other areas of their ranges. However, declines in population sizes are expected unless threats, particularly gillnet entanglement, are reduced.

Artisanal coastal fisheries include both commercial and subsistence fishing. The last survey (1988) showed that of the total of 67,300 artisanal fishing boats, only 6,000 were mechanized. Most people living in coastal communities make their livelihood from fishing, and – unlike inland fishing communities – are almost totally dependent on fishing. Fisheries in Bangladesh, and in particular marine and brackish-water fisheries, are faced with a dilemma. On the one hand, fisheries provide the people of Bangladesh with protein at a reasonable price, and generate employment, income and foreign exchange. On the other hand, fisheries – particularly the in-shore marine and estuarine fisheries – are under stress due to overfishing, environmental and habitat degradation, and competing uses of water systems.

Detritus, generated mainly by phyto- and zoo-plankton, is one of the important groups in the ecosystem and major energy flows connect it to other groups (Table 4.8).

matrix, relatively sedentary habits, and role as a forage base for higher trophic levels, comprise the most likely component in which cumulative impacts of dredging and disposal might appear.

One of the other methods for establishing the baseline condition is by Sediment Profiling Imagery (SPI). The data gathered from SPI is used for determining the impacts of dredging on the sea bed and also for the disposal area. This method could not be used. However, **Table 4.9** presents Benthic fauna identified from mud sample of Sampling Site No. 1

The soil sample is dominated by sand. In total 17 specimens of animals were observed. They are all Polychaetes (Phylum Annelida). The identification is done up to family level (**Table 4.9**).

**Table 4.9: Benthic fauna identified from mud sample of Sampling Site No. 1**

| Serial | Fauna : Taxa                          | Number    | Remarks                                   |
|--------|---------------------------------------|-----------|---|
| 1      | Burrowing polychaetes (Glyceridae)    | 2         | One rotten                                |
| 2      | Tube dwelling polychaetes (Eunicidae) | 7         | Rotten                                    |
| 3      | Tubicolous unknown polychaetes        | 2         | Tube present                              |
| 4      | Pelagic unknown polychaetes           | 2         | Rotten, one seems to be in breeding stage |
| 5      | Unknown polychaetes                   | 4         | Rotten                                    |
|        | <b>TOTAL</b>                          | <b>17</b> |   |

**Comments:**

- The dominance of polychaete number indicates the abundance of organic materials in the sampling area.
- The site is very important in terms of biological diversity of invertebrate animals.
- The site seems to be natural breeding ground of polychaetes.
- Polychaetes are the good source of food for animals, especially bottom feeder fish and shrimps. As a food, naturally these animals serve as a source of lipids for fish and shrimp to get mature and produce eggs.
- The area is ecologically sensitive.

**Table 4.10** presents Benthic fauna identified from mud sample of Sampling Site No. 2. The soil sample is dominated by sand. About 5% of plant materials observed. In total 3 specimens of animals were observed. They are all polychaetes (Phylum Annelida). The identification is done up to family level (**Table 4.10**).

**Table 4.10: Benthic fauna identified from mud sample of Sampling Site No. 2**

| Serial | Animals                        | Number   | Remarks           |
|--------|--------------------------------|----------|-------------------|
| 1      | Tubicolous unknown polychaetes | 3        | Tube present only |
| 2      | Unknown rotten plant materials | -        | Not counted       |
|        | <b>TOTAL</b>                   | <b>3</b> |                   |



**Comments:**

- The dominance of tubicolous polychaete numbers in the sample indicates the area is sand dominated.
- The number of polychaetes representative is low and some sources of pollution are expected.
- The area ecologically degraded.

**Water Samples:** No sieves were used for sampling the phyto- and zoo-planktons and as a result the samples hardly contained any planktons. In general, the sampling site 1 which is nearer to the shoreline is more biologically rich than site 2A. The samples collected did not comply with the standard sampling protocols meant for collecting and preserving benthic fauna and conduct limnological studies. However, proper sampling protocol and preservation could help in establishing the biological richness and identifying the gaps in information of the area.

## **5. SOCIAL IMPACT ASSESSMENT**

### **5.1 The Context**

Mongla port is the second biggest and most eco-friendly sea-port of the country, situated in the Mongla Upazila of Bagerhat district. The port is located at the confluence of Pussur River and Mongla Nulla, approximately 71 nautical miles (about 131 km) upstream from the Fairway Buoy (approaches to the Pussur River) of the Bay of Bengal. The port is well protected by the world largest mangrove forest known as Sundarbans. The port was developed initially about 18 km up at Chalna, which was opened to foreign vessels as an anchorage on 11 December 1950. The anchorage was shifted to Mongla in 1954 as the place could accommodate sea-going vessels with greater draughts. The port of Mongla had long retained its name Chalna (Uddin 2006).

The Mongla port has trade links with almost all major ports of the world, although vessels arriving here are mostly from ports of Asia, the Middle East, Australia, Europe and North America and the ships rarely come to Mongla from the countries of Latin America or Africa. In addition to promotion of imports and exports of the country, the port contributes to development of many industries and trading houses in surrounding places and along with this, of new infrastructures and job opportunities. Many local people are working in the port directly in loading and unloading vessels (Uddin 2006; Rahman 2006).

Pussur River is a big river in the Sundarbans area as an extension of the Rupsa River. South of Khulna, the Bhairab or the Rupsa flows further south and is renamed as Pussur near Chalna and falls into the Bay of Bengal flowing to the right of Trikona and Dubla Island (Dublarchar). South of Mongla Upazila the river flows into the Sundarbans. The river is joined by Mongla canal at about 32 km south from Chalna. Flowing further south the river meets the Shibsa at about 32 km north from its mouth and debouches into the sea keeping its original name Pussur. The river is very deep and navigable throughout the year and large marine ships can easily enter Mongla Sea Port through it. The Pussur is an important river route through which Khulna-Barisal steamboats and other vessels ply. The total length of the river is about 142 km. The Pussur and all its distributaries are tidal channels (Chowdhury 2006).

The Mongla Port Authority provides facilities and services to the international shipping lines and other concerned agencies providing shore based facilities, so that bigger draft ships can enter into the port channel safely. Based on this port, the community of Mongla Upazila developed their socio-economic and livelihood status. But due to morphological behaviour of the river system, sedimentation and erosion pattern of the Pussur River it is frequently changing. The continuous and high siltation in the channel poses extreme threats and uncertainty to safe manoeuvring including economic handling of the ocean going vessels. Therefore, to ensure safe navigation route, intelligent dredging at proper location, alignment and timing for optimum dredging volume is a need of the day.

Prior to implementation of the proposed dredging project, it is imperative to conduct a systematic study on Social Impact Assessment (SIA) to assess the socio-environmental impact, if any, with recommendation of appropriate mitigation plan. Generally, the aim of SIA is to identify the



human consequences of a proposed action, giving particular attention to the mitigation of adverse or unintended aspects and particularly important in developing countries where large numbers of people are dependent on the resource base for their subsistence and livelihood (Sadler and McCabe 2002). A report on SIA along with EIA report is required to be submitted to the DoE to obtain Environmental Clearance in conducting dredging at the Outer Bar area of Pussur Channel.

## **5.2 Study Aim and Objectives**

The broad aim of the study is to identify the need and social impact assessment of the proposed dredging project at the Outer Bar area of Pussur Channel.

The objectives of the study are:

- ✓ To explore the social impacts of the proposed dredging project at the Outer Bar area of Pussur Channel;
- ✓ To identify the positive and negative impacts of proposed dredging project on socio-economic environment of the area;
- ✓ To know the people's view about the proposed interventions.

## **5.3 The Project Area**

The Pussur River forms part of a very big and complex river system. Numerous tributaries and channels connect the Pussur River with other rivers like Sibsa, the Ganges and Jamuna. Flow conditions in all these rivers determined the current and morphological condition in the Pussur River. The navigation channel at the Pussur River entrance crosses a wide bar known as Outer Bar. It exists between 21°35'29'' and 21 ° 40'69'' at around 45km seaward of Hiron Point and exposed to the open sea. The bar is relatively stable and allows vessels having maximum draft of 8.5m to cross it during normal high tide condition. However, depths at the anchorage area in the upstream towards Mongla Port through Pussur Channel permit anchoring of more than 9m draft vessels. So the Outer Bar is the only obstacle for the ships of 9m and above to enter into the anchorage area. If the depth of the Outer Bar would be increased to make safe passage of 9m draft vessels in normal high tide, Mongla Port could handle more ships means handling of more cargoes.

## **5.4 Social Impact Assessment (SIA) Methodology**

Both primary and the secondary data sources were used. Basically qualitative approach was used for primary data collection considering the field condition. Few quantitative and qualitative data were collected from different secondary sources. In addition, data were collected following good practice guidelines using appropriate methods and for a reasonable length of time to allow long-term trends to be assessed.

### **5.4.1 Checklist Preparation and Testing**

Considering the objectives of the study a checklist was prepared for the study. Following the ToR

and practical requirements of the project, the checklist was prepared which was shared with other experts of the project. Based on their feedbacks, some points were added or dropped and final checklist was prepared.

#### 5.4.2 Semi-structured Interviews

Sensitive and thoughtful interview yields fruitful results and understanding. According to Pretty et al. (1995) and Alam (2009), semi-structured interviewing is a guided conversation in which only the topics are predetermined and new questions or insights arise as a result of the discussion and visualized analysis. In semi-structured interviews the context, the participants, the way the interview is conducted, and timing are important as the questions themselves.

In semi-structured interviews consultant has to be self-critical, aware of biases, open, and a good listener and observer. Also need prior preparation, the use of an interview guide or checklist, use of different visual tools to encourage participation and dialog, to be an attentive listener and humble, to assess and judge responses, and to record responses and observations (Pretty et al. 1995). For the present study, semi-structured interviews were conducted for Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs).

Under the qualitative methods FGDs, KIIs and public consultations in addition to observations were carried out findings of which have been presented below (**Table 5.1**):

**Table 5.1:** Methods followed with number of participants

| Method                   | Number | Number of Participants | Organization/locality  |
|--------------------------|--------|------------------------|--|
| Focus group discussions  | 3      | 21                     | <ul style="list-style-type: none"> <li>• Khulna Forest Department (Wildlife Circle)</li> <li>• Khulna Forest Division (Conservator of Forests office)</li> <li>• Dublarchar island</li> </ul>                                |
| Key informant interviews | 6      | 6                      | <ul style="list-style-type: none"> <li>• District Fishery Officer (Khulna)</li> <li>• Director, Department of Environment (Khulna)</li> <li>• Project Director, Dredging at the Outer bar Area of Pussur Channel.</li> </ul> |
| Public consultations     | 4      | 17                     | <ul style="list-style-type: none"> <li>• Local people of Mongla</li> <li>• Local people of Dublarchar island</li> <li>• Local people of Nilkomol</li> <li>• Tourist Boatmen</li> </ul>                                       |

#### 5.4.3 Focus Group Discussions (FGDs)

Discussion with the local people and stakeholders, acting the consultant as a facilitator is considered important technique for data collection. FGDs are a strategy that aims to generate



discussion and interaction within small groups of local people. Through discussions, the consultant attempts to learn about socio-cultural characteristics and processes within groups. These FGDs were different from the consultation and other discussion meetings that the consultant facilitated throughout the investigation process (especially at the beginning and ending). The participants primarily shared their experiences and information with the consultant without any hesitation.

Alam (2009) and Henderson (2009) mentioned that the truthfulness of the information and the speed of generation are higher when they come from groups. It also helps to identify key knowledgeable persons and explore the limitations provided by the power relationships among participants. The strength of FGD relies on allowing the participants to agree or disagree with each other so that it provides an insight into how a group thinks about an issue, about the range of opinion and ideas, and the inconsistencies and variation that exists in a particular community in terms of beliefs and their experiences and practices. For this study 3 FGDs were conducted in three different places using a semi-structured questionnaire. One is conducted at the office of Khulna Forest Department (Wildlife Circle); another at the offices of Conservator of Forests, Khulna Forest Division and the last one at the Dublarchar island of Sundarbans.



Photo 1: Discussion with the fishing community at Dublarchar Island



Photo 2: Discussion with the local people at Mongla Port



Photo 3: Discussion with the DFO, FD, Khulna

#### **5.4.4 Key Informant Interviews (FGDs)**

KIIs are qualitative in-depth interviews with people who know what was going on in the community. The purpose of key informant interviews was to collect information from a wide range of people including community leaders, professionals, or residents who have firsthand knowledge about the community. These community experts, with their particular knowledge and understanding, can provide insight on the nature of problems and give recommendations for solutions. Before selecting key informants it is important to map out the population of interest, or target population. This target population could include all community residents living in a particular area, or could be a particular portion or group within that geographical region (such as a racial/ethnic minority, adolescents, or women). Once the consultant identifies the target population he can better brainstorm possible key informants who are knowledgeable and closely linked to the study issues.

This technique is very appropriate for the present study to understand the motivation and beliefs

of community residents on a particular issue, to get information from people with diverse backgrounds and opinions, and be able to ask in-depth and probing questions. For the present study 6 KIIs were conducted with a semi-structured questionnaire; this helps to get more candid or in-depth answers because sometimes the FGDs prohibit researchers from candidly discussing sensitive topics or getting the depth of information. Sometimes the FGDs can prevent some participants from frankly voicing their opinions about sensitive topics.

For the present study the KIs were District Fishery Officer (Khulna), Director of Department of Environment (Khulna), personnel's of Mongla Port Authority and resident of Dublarchar Island.



Photo 4: Discussion with the Director of DoE, Khulna



Photo 5: Discussion with the Project Director, Dredging at the Outer bar Area of Pussur Channel



Photo 6: Discussion in Mongla Port Authority office

#### **5.4.5 Public Consultations (PCs)**

Public consultation is a new participatory tool to gained information from people. Public consultation, or simply consultation, is a regulatory process by which the public's input on matters affecting them is sought. Its main goals are to improve efficiency, transparency and public involvement in large-scale projects or laws and policies. It usually involves notification (to publicise the matter to be consulted on), consultation (a two-way flow of information and opinion exchange) as well as participation (involving interest groups in the drafting of policy or legislation). In this study 17 public consultations were carried out including Forest Department personnel's, peoples of Mongla, Nilkomol and Dublarchar island as well as tourist boatmen.



Photo 7: Discussion with the Director of DoF, Khulna



Photo 8: Discussion with the Chief Conservator of Forests, Khulna



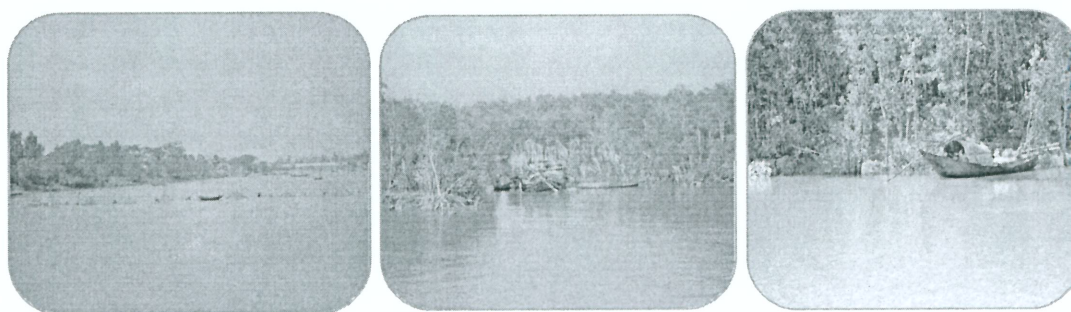
#### 5.4.6. Observations

Observation is a method to be used for data collection when a study is carried out on a dynamic situation and identify the interrelationship of the person and the situation (Alam 2009). Observation basically focuses on community and ethnic groups; knowing immediate impact of an event and aspects of everyday life and get an insider's view of reality. A good physical observations both road and waterways were made at different places in the proposed dredging project area at the outer bar area of the Pussur Channel. While doing observations consultants also made necessary interaction and sharing points with the local future potential affected persons.

### 5.5 Findings of the Social Impact Assessment (SIA):

#### 5.5.1 Situation Analysis of the Project Area

General occupation of the community people of Sundarbans are Goalpata (*Nypha fruiticans*) harvester, honey collector, shrimp fry collector, fisherman and NTFPs collector. The proposed project intervention has no direct impact to any community as the dredging will be conducted at the Outer Bar area of the Pussur Channel. Local community said that the proposed dredging area is the fishing ground and our survey also verified it. The consultant observed that two fishing groups were catching fish from the side of the Outer Bar. Mongla Port Authority also reported that sometimes propeller of the ships been affected by the fishermen's fishing net. Dublarchar island is the nearest locality from the project area where more than 3000 fishermen were living on a seasonal basis and they used to catch fish from the deep sea. Forest Department mentioned that community of Dublarchar enters into forest to collect Goalpata to make their temporary houses who also collect their daily firewood. Sarwar Sand or Mujiberchar was the newly accredited land which was found located near the project area. The land is composed of pure sand and already several mangrove floral species been naturally regenerated. During field visit it was observed that fishermen used that land for taking rest during fishing period.

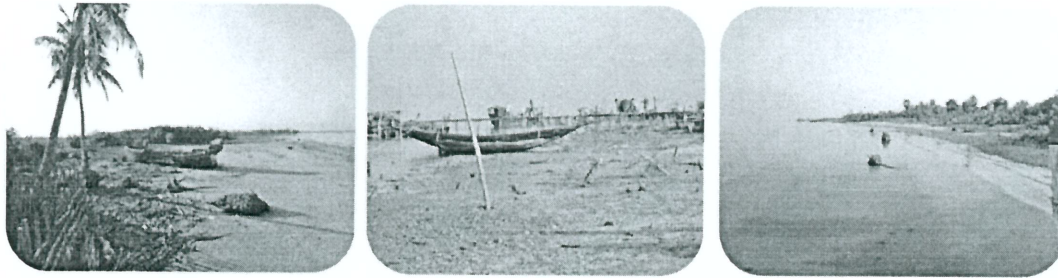


Photos 9-11: Livelihoods of the Sundarbans

#### 5.5.2 Dublarchar Island

Dublarchar is an island with a beautiful beach and only one island near the outer bar area of the Pussur Channel. The other attraction of the island was the fishing activities that used to take place

every year between mid-October and mid-February (*Kartik* to *Falgun* months). Fishermen from other parts of the country, especially from Chittagong, assemble there (more than 3000 fishermen) during the period to catch fish and dry them on the sunny beach. The proposed dredging intervention will increase the capacity of catching fish for the fishing community especially for the Dublarchar fishing community which would be a kind of livelihood augmentation.



**Photos 12-14:** Landscape view of Dublarchar

They reported that when the dredging intervention will be finished, they will catch fishes near their locality within 2-3 km. Although the intervention will hamper the fishing community on a temporary basis but it will create an increased scope for the future to catch more fishes. They also added if the dredging materials are deposited at the Dublarchar this will be better for the fishing community as the land height will be raised and will help them protecting against tidal surge. Dredging materials can be transported by the dredging ship. They also added: if the dredging materials are deposited at the Sarwar Sand this will be much better by increasing opportunity to catching fish within a short distance and also increase the employment opportunity of new people.



**Photos 15-17:** Livelihood of Dublarchar fishing

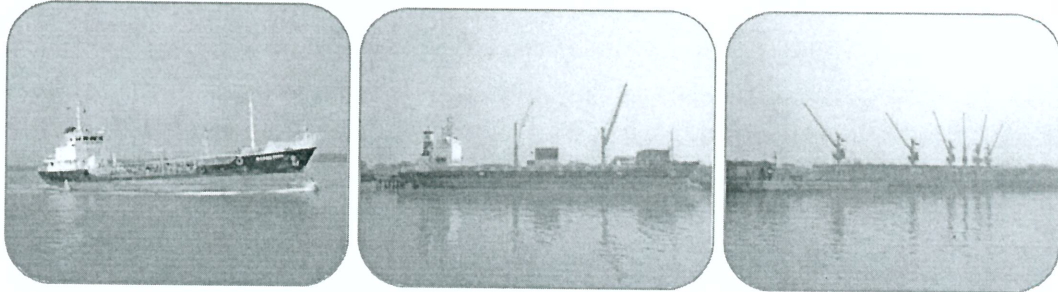
### **5.5.3 Mongla Port**

The main purpose of the proposed dredging intervention is to create safe passage for the 9m draft vessel to enter at the Mongla port. Mongla port has capacity to handle more ships than the present time. After completion of dredging, more ships will be able to enter directly to the Mongla which means increase the opportunity of business and socio-economic development of the area. Local communities are supportive to the proposed dredging intervention. Nevertheless, more ships in Mongla port have a chance to increase the spread of HIV/AIDS by the seamen those who come from different countries. Community mentioned that several NGOs and practitioners are working

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in that area with the sex workers who are imparting training on safety of them as well as customers. Moreover, day by day this business has been reducing due to awareness raising activities of government and NGOs.



**Photos 18-20:** Ships are waiting for unloading at the Mongla

#### **5.5.4 Forest Department (FD)**

According to Forest Department dredged spoil cannot be disposed within Sundarbans Reserve Forest (SRF) area. They think that if the dredging materials are dumped into the forest boundary that will hamper the forest biodiversity and the rate of mortality of forest trees will increase by the siltation and salinity. FD also opined that if the dredging materials are dumped into the Dublarchar Island that will hamper the existing natural floral as well as faunal species of the island. In case of dumping of the dredging materials into the Sarwar Sand Island, FD has the opinion that this will increase the illegal activities like cutting of forest trees and poaching of wild animals by the newly settled fishing community in the Sarwar Sand Island. But if the dredging materials are dumped into the deep sea they have no objections.

#### **5.5.5 Department of Environment (DoE)**

DoE has no objection if the dredging intervention will be started to follow the EIA guidelines of DoE properly. They have a suggestion that dredging intervention should be carried out in a way that could have a minimal or no negative impact to the fish community, marine aquatic resources and wildlife of the Sundarbans.

#### **5.5.6 Department of Fisheries (DoF)**

DoF has no negative opinion about the proposed dredging but care should be taken during intervention activities as the project does not create any negative impact on the local fish habitat as well as other aquatic resources like dolphin, sea turtle and other zooplankton. DoF suggested that the dredging materials may be dumped into the Sarwar Sand Island that can have minimum negative impact on the deep sea aquatic resources and it will create a new scope for the fishermen community. However, DoE will not allow spoil dumping as Sarwar Sand Island lies within SRF jurisdiction. Spoil dumping will damage mangrove vegetation.

### 5.5.7 Sarwar Sand Island

Sarwar Sand Island (some called it as *Mujiberchar*) is a barren and newly accredited island which is located near the Outer Bar project area. The island accredited approximately 4-5 years ago and is composed of pure sand which flown with the sea wave/tidal wave and regular tidal inundation. From the field observation, it was revealed that the island is suitable for natural regeneration of mangrove floral species. Already this island is occupied by several mangrove tree species like Keora (*Sonneratia apetala*), Baen (*Avicennia officinalis*), Gewa (*Excoecaria agallocha*), Kakra (*Bruguiera gymnorrhiza*), Dhundul (*Xylocarpus granatum*), Hargoza (*Acanthus ilicifolius*) along with different grass species like Malia (*Cyperus javanicus*) and Nal (*Eriochlea procera*). From the discussion with the fishermen in Dublarchar Island, it was revealed that if the dredging materials deposited at the Sarwar Sand Island the island will be raised and they would be able to use it as their new land to catch more fishes within short period of time from the deep sea. This island will create a new scope for huge employment and income to the fishermen community. However, as per concern of forest department no spoil disposal shall be allowed on Sarwar Sand Island due to the fact that it falls within SRF (a world heritage site).



**Photos 21-23:** Landscape view of Sarwar Sand

### 5.6 Overall SIA of the Proposed Project:

**Table 5.2:** Overall SIA findings of the proposed project

| SN | Component                         | Positive impact | Negative impact                     | Remarks   |
|----|-----------------------------------|-----------------|-------------------------------------|---|
| 1  | Economy                           | Highly positive | Lighter ships may be affected       | Still positive  |
| 2  | Employment generation             | Highly positive | Some lighter seamen may be affected | Still highly positive as they will get work in other places |
| 3  | Fishing communities and resources | Highly positive | Minor affect during dredging period | Significantly positive                                      |
| 4  | Commercial factors                | Highly positive | No negative impact                  | Highly positive for the locality and country                |
| 5  | Traffic and transport             | Highly positive | No negative impact                  | Increased the movement of vessels                           |



|    |                             |                   |   |  |
|----|-----------------------------|-------------------|---|--|
| 6  | Development process         | Highly positive   | No negative impact  | Highly positive for the locality and country   |
| 7  | Resettlement                | Minor positive    | Minor negative impact during dredging period                                    | If dredging materials will be deposited in Dublarchar it will have minor negative impact temporarily but will have positive impact after dredging. Contemporarily, Sarwar Sand will be raised and new settlement will be introduced. However, DoE will not allow any spoil dumping within SRF jurisdiction, as this will damage mangrove vegetation. |
| 8  | Living standard             | Highly positive   | No negative impact  | Positive due to increased income of fishes and in Mongla Port area   |
| 9  | Public utilities            |                   | Slightly negative impact during dredging period by water supply and solid waste | No mentionable negative impact   |
| 10 | Position of women           | Create employment | No negative impact  | Due to increased space of the islands (Dublarchar and/or Sarwar Sand) as well as in Mongla Port area   |
| 11 | Sanitation and health       |                   | Some impact during dredging period  | No mentionable negative impact   |
| 12 | Chance of increase HIV/AIDS |                   | Highly negative impact  | Need to ensure health care service by government and NGOs  |
| 13 | Safety                      | Positive impact   | No negative impact  | Due to increased capacity of patrolling of coast guard   |
| 14 | Culture                     | Positive impact   | No negative impact  | Increase social interaction among fisher community and in Mongla   |
| 15 | Community organization      | Positive          | No negative impact  | Likely to develop some community organizations   |
| 16 | Social relation             | Highly positive   | No negative impact  | Backward linkage (Mongla) affect will be highly positive and outer bar area relation will also improve   |

## **5.7 Conclusions and Recommendations**

The SIA study suggests that the project is immediately needed for the Mongla Port to increase the vessel movement and to restart the Mongla Port in full pace. Our survey suggests that all the affected persons and concerned authorities are willing to start the dredging activities. Although the dredging project has some minor negative impacts but overall the project have positive impacts on several fields like economy, employment generation, fishing communities and resources, traffic and transport movement, commercial factors and community development. Therefore, the proposed dredging activities should be carried out with involving local community with less affect to the marine ecosystem and Sundarbans. In line with the findings of the present study the followings may be recommended:

- a. The dredging activities needs to be done in a way that it must affect less the marine ecosystem and Sundarbans
- b. The dredging activities needs to be done without affecting the livelihood of the people operating around the proposed area;
- c. Needs to ensure the participation of local people as a labour and involved them with other project activities as much as possible;



## **6.0 ANALYSIS OF ALTERNATIVE SITES**

### **6.1 Introduction**

Consideration of suitable site selection for dredging as well as safe disposal of dredged spoils is essential to arrive at feasible and environmentally sound option. For the present project several alternatives were considered by the Consultants by using modelling tool and analyzing hydro-morphological characteristics of the offshore Outer Bar area of Pussur Channel. One of the main challenges of dredging program is disposal of dredged spoil, which requires technical, environmental and social considerations. The dredged spoil is, in principle, disposed on the locations where natural sedimentation may not be expected and there is no scope of re-suspension of dredged spoil into the dredged channel. These locations are the inner bends, abandoned channels, deeper channel with strong currents, along the shoals and on slope of swatch of no ground.

In the present dredging project, IWM in February 2013 has conducted detailed field survey at three alternative locations around proposed dredging site at Outer bar of Pussur Channel. The bathymetric survey result shows that approximately 3.2 million cubic meter of dredged spoil will be required to handle in an environmentally safe and sound manner. **Figure 6.1** shows the locations of alternative dumping sites in the offshore area of Pussur Channel.

### **6.2 Disposal of Dredged Materials**

The extent to which dredging as well as disposal of dredged materials might affect marine features is highly varied and site specific. Factors influencing the potential effects of dredging and disposal are:

- Magnitude and frequency of dredging activity;
- Method of dredging and disposal;
- Channel size and depth;
- The size, density and quality of the material;
- Intertidal area;
- Background levels of water and sediment quality, suspended sediment and turbidity;
- Tidal range;
- Current direction and speed;
- Rate of mixing;
- Seasonal variability and meteorological conditions, affecting wave conditions and freshwater discharges;
- Proximity of the marine feature to the dredging or disposal activity, and
- Presence and sensitivity of animal and plant communities (including birds, sensitive benthic communities, fish and shellfish).

### **6.3 Analysis of Alternatives**

Coastal disposal of dredged material constitutes one of the most important problems in coastal zone management and in some coastal areas represents the major anthropogenic disturbance to the benthos. Macro-faunal communities typical of environmentally stressed or high energy habitats are more resilient than those of more environmentally stable habitats. Invertebrate recovery following dredged material disposal in relatively unstressed marine environments generally takes between 1 and 4 years, while in more naturally stressed areas, recovery is generally achieved within 9 months, although deeper polyhaline habitats can take up to 2 years to recover. Differences in recovery times are attributed to the number of succession stages required to regain the original community composition and that species typical of naturally unstressed assemblages do not possess life-history traits to allow rapid decolonization of disturbances. Since the natural disturbance regime appears to be very important in determining the response of a benthic community following dredged material disposal, it is recommended that when predicting the potential environmental impact of an operation, the nature of the physical environment in combination with the status and role of associated marine benthic communities should be considered.

Selection of proper dredging and transport equipment and techniques must be compatible with disposal site and management requirements. Three major alternatives are available:

- Open-water disposal.
- Confined disposal.
- Beneficial use.

Each of the major alternatives involves its own set of unique considerations, and selection of a management alternative should be made based on environmental, technical, and economic considerations.

Promising areas for dumping dredged material may be: (1) areas with high natural sediment concentrations; (2) areas with erodible material; (3) areas with a potentially high current velocity, either natural or artificial; (4) areas in the vicinity of deep troughs; (5) areas with material of low level contamination.

One of the objectives of the study is to identify a potential dumping site for the dredged material. To search for a suitable disposal site, multidisciplinary Consultants visited Sarwar Sand (N 21°42'18.6"; E 89°27'23.2") located about 10 km north-northwest from the mid-point of the proposed dredging location. Dublarchar is located about 16.5 km north-northeast of the central dredged location. The place (**Figure 6.1**) was visited to meet the fishermen and related stakeholders for their opinion regarding disposal site. Another site "Deep Sea" (**Figure 6.1**) located around 23 km south of the proposed dredging location has also been considered as the disposal site of dredged spoil. In the previous tenders of MPA and in their application to DoE for environmental clearance regarding disposal of dredged spoil, it was mentioned that the disposal site at Deep sea will allow washing out of the dredged spoil to deep sea.



Multi-criteria analysis of three potential options considering salient socio-economic and environmental parameters has been carried out to obtain the best possible dredged spoil disposal site is shown in **Table 6.1**. The number used in the table varies from 0 to 5 where '0' (zero) means no impact and 5 means maximum impact while '+' indicates beneficial and '-' indicates harmful impacts.

**Table 6.1: Multi-criteria analysis of three dredged spoil disposal sites**

| Parameters                               | Option-1<br>Sarwar Sand<br>(10 KM) | Option-2<br>Dublarchar<br>(16.5 KM) | Option-3<br>Deep Sea<br>(23 KM) |
|--|------------------------------------|-------------------------------------|---------------------------------|
| Distance                                 | +3                                 | +2                                  | +1                              |
| Vegetation Loss                          | -5                                 | -5                                  | -1                              |
| Beach improvement                        | +2                                 | +2                                  | 0                               |
| Human habitation                         | 0                                  | +3                                  | 0                               |
| Costs                                    | +3                                 | +2                                  | -1                              |
| Controlled placement of dredged material | +1                                 | +1                                  | +4                              |
| Volumetric capacity                      | -1                                 | +1                                  | +5                              |
| Potential conflicts                      | -4                                 | -4                                  | -2                              |
| Monitoring                               | +1                                 | +1                                  | +2                              |
| Regulation                               | -4                                 | -4                                  | -2                              |
| Recolonization Potential                 | +2                                 | +2                                  | +3                              |
| Terrestrial Biodiversity loss            | -3                                 | -3                                  | 0                               |
| Benthic biodiversity                     | 0                                  | 0                                   | -1                              |
| Turbidity                                | -1                                 | -1                                  | -2                              |
| Natural habitat loss                     | -2                                 | -2                                  | -1                              |
| Fishing community                        | +2                                 | +2                                  | +0                              |
| <b>Total</b>                             | <b>-6</b>                          | <b>-3</b>                           | <b>+5</b>                       |

Option-3 (i.e. disposal in the deep sea) of **Table 6.1** obtained the highest value and leads to the most viable option for dumping dredged spoils.

The basis of the choosing scoring numbers for each of the options against the parameters applied in multi-criteria analysis (i.e. Table 6.1) are described in **Table 6.2**.

**Table 6.2: Descriptions on parameters of multi-criteria analysis**

|   |  |
|---|--|
| Distance                                | Transporting dredged material to distant site may cost more, require more logistic support, disrupt navigation, etc., so the farthest site will have less score based on cost consideration.   |
| Vegetation Loss                         | Loss of terrestrial vegetation due to dumping of dredged soil or loss of phytoplanktons – the primary producer - due to turbidity, oil spill, etc.   |
| Beach improvement                       | Beneficial use of the dredged material, if any.  |
| Human habitation                        | There is no human habitation near the dredging site, however seasonal habitation of the fishermen in the islands is present. Whether disposal of the dredge material will benefit the seasonal human habitations?  |
| Costs                                   | Transporting dredged material to distant site may cost more, so the farthest site will have a negative score on the project.   |
| Controlled placement of dredge material | Includes planning, volume, material characterization and evaluation, site characterization, disposal site management, containment, etc.  |
| Volumetric capacity                     | Capacity of the disposal site to accommodate the volume of dredged material.   |
| Potential conflicts                     | Any potential conflicts with the existing regulations, policies of the government or any other nature.   |
| Monitoring                              | Access to monitoring may either be easy or difficult, costly, etc.   |
| Regulation                              | Existing regulations, procedures, protocol, etc., that need to be followed.  |
| Recolonization Potential                | Disturbance to the habitat is obvious and temporary in nature. Any information based on which it may be determined that the disturbed habitat (along with the benthic, demersal fauna) will recover within a time frame and the species will recolonize. |
| Terrestrial Biodiversity loss           | Dredged materials dumped on the coastal vegetation or disturbance due to dredging or disposal to the terrestrial biodiversity, particularly the species dependent on the resources that occur at the dredging site.                                      |
| Benthic biodiversity                    | Based on the baseline information assess the status of the benthic biodiversity. If there are more species it will mean positive.  |
| Turbidity                               | Considering the physical characteristics determine the impact of the turbidity plume, concentration, etc. For example the turbid conditions will prevail longer if there is little movement of suspended materials due to less current or wave action.   |
| Natural habitat loss                    | Relates to the area, level of physical alteration of the natural habitat.  |
| Fishing community                       | Benefits harvested by the Fishing community after the dredging operation.  |



#### 6.4 Final site for disposal of dredged spoil

From the above comparative analyses among three potential options, Option-3 in **Table 6.1** obtained the maximum score and has been assessed as the most suitable site for disposal of dredged spoil. In order to ensure safe disposal of the dredged spoil it is to be released at the designated location during the low tide condition. The place to release the dredged spoil is shown in **Figure 6.1** which is located around 23 km South-southeast from central point of the proposed dredging location. The figure also shows that the designated location falls well outside the identified fishing ground of Swatch of no Ground. Trailer Hopper dredger will be used in the dredging operation and will carry dredged spoil to facilitate dumping of the materials at the designated location.

A typical scenario of depth averaged velocity field during low tide is shown in **Figure 6.2**. The directions of the velocities indicate that the disposal of dredged spoil if released during low tide at the designated location as shown in **Figure 6.1** will be guided to the deep sea.



Figure 6.2: Typical depth average velocity field at low tide condition

## **7. IDENTIFICATION OF IMPACTS**

### **7.1 Project Bounding**

The primary requirement of any EIA study is to delineate the geographical boundary of the “project area” and the “impact area”. The “project location” is the physical location of the project, which mainly covers the Outer Bar in the Offshore of Bay of Bangal in the Pussur Channel (**Figure 3.1**). “Impact area” encompasses the geographic extent of the significant environmental and socio-economic impacts resulting from implementation of the proposed dredging activities of Mongla Port Authority.

### **7.2 Scoping /Identification of Important Environmental and Social Components (IESCs)**

For maintaining navigable depths in waterways, dredging operation causes disturbance in the natural condition of the waterway and its surroundings. Fauna and flora are likely to be affected, particularly where recurrent dredging is carried out year after year.

The scoping process has identified 15 project area impacts and direct operational impacts of public nuisance (noise, vibration, air pollution due to gaseous emission, etc.), and traffic disturbance. Important environmental components, which may be affected by dredging activity is presentd in **Table 7.1**.

**Table 7.1: Important Environmental and Social Components (IESCs)**

| <b>A. PROJECT AREA IMPACT</b>       | <b>B. DIRECT IMPACT</b>                              |
|-------------------------------------|--|
| 1. Waterway transportation          | 1. Public Nuisance (Noise, Vibration, Air pollution) |
| 2. Erosion of channel bed and bank  | 2. Traffic disturbance.                              |
| 3. Economic Livelihood              |  |
| 4. Common Resource Rights           |  |
| 5. Wage paid Employment             |  |
| 7. Sedimentation                    |  |
| 7. Water Quality                    |  |
| 8. Capture Fishery                  |  |
| 9. Culture Fishery                  |  |
| 10. Turbidity                       |  |
| 11. Contamination of disposal site  |  |
| 12. Human Nutrition                 |  |
| 13. Road Transportation             |  |
| 14. Loss of benthic flora and fauna |  |
| 15. Mangrove vegetation             |  |

### **7.3 Assessment of Impact on Important Environmental and Social Components (IESCs)**

Based on field investigation data and past experience the IESCs have been identified and shown in **Table 7.2**. The IESCs have been rated with positive and negative trends under future without project and with project scenarios. They have been valued prior to drawing up suitable mitigation



and compensation programs.

**Table 7.2: Impact Identification Matrix on IESCs**

| Important Environmental and Social Components (IECs) | Future Without Project | Future with Project (No Mitigation) |
|--|------------------------|-------------------------------------|
| <b>PROJECT AREA IMPACTS</b>                          |                        |                                     |
| Navigation:  |                        |                                     |
| Waterway Transport                                   | -                      | +                                   |
| Channel Sedimentation                                | -                      | +                                   |
| Erosion of Channel                                   | 0                      | 0*                                  |
| Water Salinity                                       | -                      | -                                   |
| Surface Water Quality                                | -                      | -                                   |
| Contamination of disposal site                       | 0                      | -                                   |
| Turbidity  | 0                      | -                                   |
| Economic Livelihoods:                                |                        |                                     |
| Women  | 0                      | +                                   |
| Port Labourer  | -                      | +                                   |
| Fishing HH   | 0                      | +                                   |
| Boatmen HH   | -                      | +                                   |
| Land less HH   | 0                      | +                                   |
| Common Resource Rights:                              |                        |                                     |
| Benthic flora and fauna                              | 0                      | -                                   |
| Mangrove Vegetation                                  | 0                      | 0                                   |
| Agricultural Output:                                 |                        |                                     |
| Capture Fisheries                                    | -                      | +                                   |
| Culture Fisheries                                    | 0                      | 0                                   |
| Wage Paid Employment:                                |                        |                                     |
| Dredging operation                                   | -                      | +                                   |
| Social Management                                    | -                      | +                                   |
| Human Nutrition                                      | -                      | +                                   |
| Navigability   | -                      | +                                   |
| <b>DIRECT IMPACTS DUE TO INTERVENTION</b>            |                        |                                     |
| Public Nuisance                                      | 0                      | -                                   |
| Traffic disturbance                                  | 0                      | -                                   |

Rating of Impacts:

- + Positive trend
- 0 Present baseline status
- Negative trend
- 0\* To be taken care in the project design

## **7.4 Development Options**

Two options are considered to assess impact due to the proposed intervention. These options are summarized below.

Option-0: Base condition, where there will be no intervention as such.

Option-1: Dredging at the Outer Bar of Pussur Channel. The major activities under this option are:

- Capital dredging at Outer Bar area, and
- Disposal of the spoil materials in the Swatch of No Ground/deep sea.

## **7.5 Impacts Matrix of the Proposed Dredging Operation**

In describing the impacts related to the engineering interventions for the project one can distinguish between the temporary impacts directly related to the dredging operation and the long-term impacts associated with the modified physical environment and a consequence of the works. In addition, a systematic distinction can be made for the components of the environment, affected by various measures or activities, i.e. between impacts on the resources system and impacts on the user system. **Table 7.3** present impact matrices for dredging. Many of the impacts listed can be mitigated substantially by adopting standard working procedures and ensuring responsible behaviour of the contractor. Impacts of dredging are summarized below:

- Substrate removal and thus habitat and species removal (recolonization or recovery of disturbed areas may be possible);
- Spreading of sediments and associated contaminants in the surrounding. Settlement of these suspended sediments can result in the smothering or blanketing of subtidal communities and/or adjacent intertidal communities;
- Alteration of the bottom topography and hydrography, and thus destruction of local habitats and the risk of direct physical/mechanical stress to benthic, demersal and/or pelagic species;
- Alteration of the sediment composition, i.e. of substrate characteristics in the surrounding of the dredging site, resulting in a change of nature and diversity of benthic and demersal communities, e.g. decline of individual density, species abundances or biomass;
- Re-suspension of sediments and short-term increases in the level of suspended sediment giving rise to changes in water quality which can effect marine flora and fauna, both favourably and unfavourably, such as increased turbidity and the possible release of organic matter, nutrients and or contaminants depending upon the nature of the material in the dredging area;
- Release of nutrients resulting in increase in eutrophication and direct impact on organisms due to reduced transparency and consumption of oxygen (the increase in turbidity due to re-suspension of sediments caused by dredging);
- Habitat changes from hydromorphological regimes changes;



- Effects on fish or sea snakes or marine turtles or fish-eating bird species or cetaceans (dolphins, whales) from increased turbidity as well as related effects on estuary functions, such as changes in biodiversity or reduction of spawning areas, affecting migratory or daily movement routes of fish, marine turtles, dolphins, etc.

Figures 7.1 and 7.2 present impacts on biophysical and ecological environment.

**Table 7.3: Impact matrix for the dredging works**

| Phase                 | System affected   | Potential impact   | Potential positive impact | Potential neutral or negative impact   |
|-----------------------|---|--|---------------------------|--|
| During dredging Works | Impact on Resource System (physical, biological and ecological) | -  |                           | <ul style="list-style-type: none"> <li>• Disturbance of aquatic (plankton &amp; benthos) organisms in the river bed.</li> <li>• Risk of pollution of surface water from oil spills and leaks.</li> <li>• Deterioration of water quality by disposal of liquid and solid waste.</li> <li>• Disturbance of fish and mammals in the river.</li> <li>• Increased water turbidity.</li> <li>• Loss of aquatic vegetation.</li> <li>• Risk of pollution of air, surface water and contamination of disposal site.</li> </ul> |
|                       | Impact on User System (socio-economic and cultural aspects)     | <ul style="list-style-type: none"> <li>• Employment opportunities</li> <li>• Improved navigable depth.</li> </ul>  |                           | <ul style="list-style-type: none"> <li>• Noise, dust, exhaust gas emission, oil spill from dredging equipments.</li> <li>• Obstacle to navigation traffic.</li> <li>• Occupational health and safety risk.</li> <li>• Obstruction to fishing.</li> </ul>   |
| Post Dredging Works   | Impact on Resource System                                       | <ul style="list-style-type: none"> <li>• Improved waterway traffic.</li> <li>• Biodiversity.</li> </ul>  |                           | <ul style="list-style-type: none"> <li>• Hydro-morphological adjustment.</li> <li>• Erosion and sedimentation.</li> </ul>  |
|                       | Impact on User System   | <ul style="list-style-type: none"> <li>• Navigation traffic.</li> <li>• Employment.</li> <li>• Socio-economic development.</li> <li>• Attraction of tourists.</li> </ul> |                           | <ul style="list-style-type: none"> <li>• Erosion and accretion.</li> <li>• Need maintenance dredging.</li> </ul>   |



**Figure 7.1: Potential impacts of dredging on the ecosystem and natural resources indicating important environmental factors**



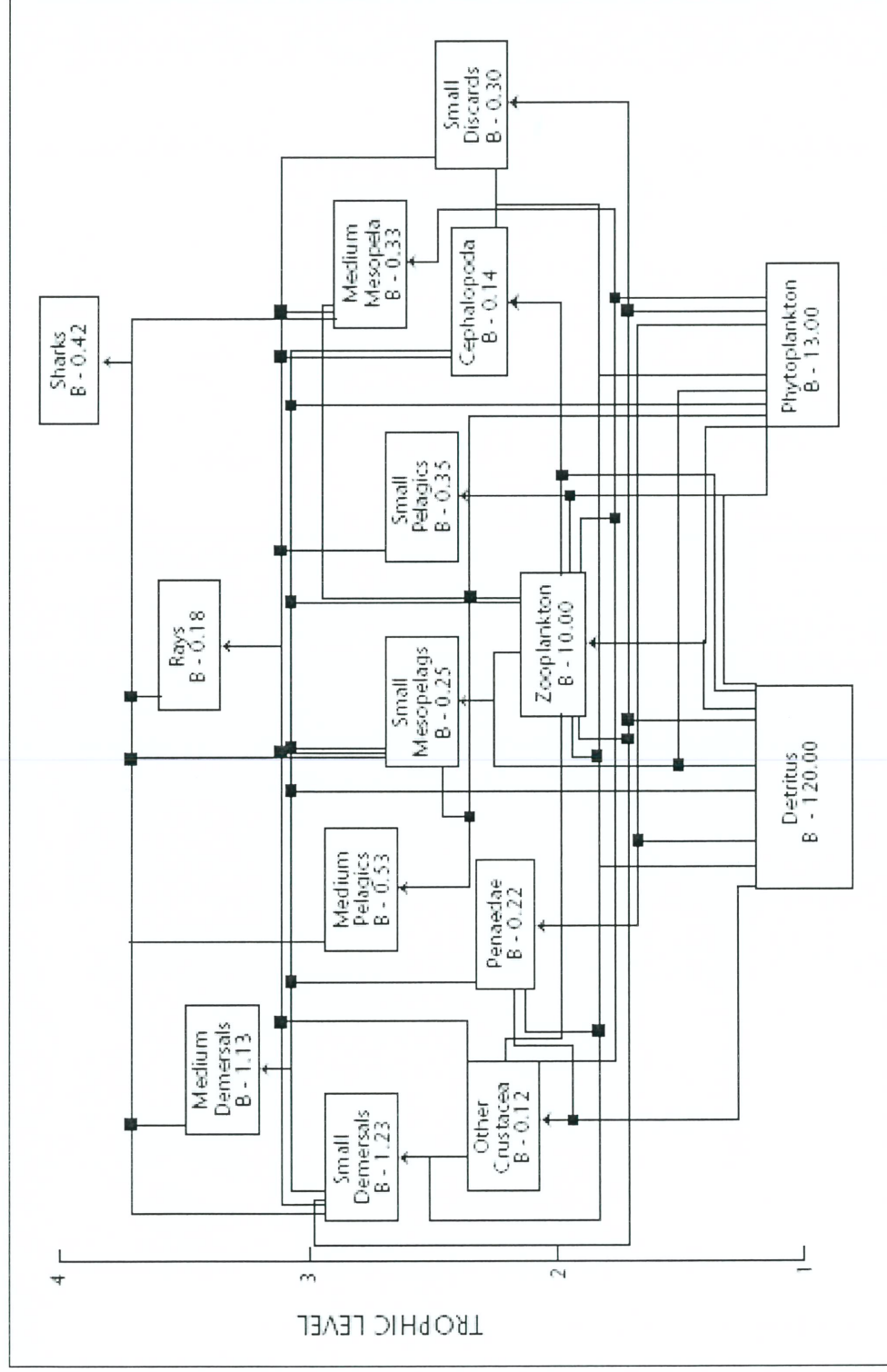


Figure 7.2: Trophic model of the coastal waters of Bangladesh, Bay of Bengal (after M.G. Mustafa 2003). Dredging removes/affects the aquatic animals within the trophic levels 1 and 2 (DASHED BOX - indicated by parentheses) which form the basis of the food chain and ultimately all animals dependent on these food chain links are affected.





and compensation programs.

**Table 7.2: Impact Identification Matrix on IESCs**

| Important Environmental and Social Components (IECs) | Future Without Project | Future with Project (No Mitigation) |
|--|------------------------|-------------------------------------|
| <b>PROJECT AREA IMPACTS</b>                          |                        |                                     |
| Navigation:  |                        |                                     |
| Waterway Transport                                   | -                      | +                                   |
| Channel Sedimentation                                | -                      | +                                   |
| Erosion of Channel                                   | 0                      | 0*                                  |
| Water Salinity                                       | -                      | -                                   |
| Surface Water Quality                                | -                      | -                                   |
| Contamination of disposal site                       | 0                      | -                                   |
| Turbidity  | 0                      | -                                   |
| Economic Livelihoods:                                |                        |                                     |
| Women  | 0                      | +                                   |
| Port Labourer  | -                      | +                                   |
| Fishing HH   | 0                      | +                                   |
| Boatmen HH   | -                      | +                                   |
| Land less HH   | 0                      | +                                   |
| Common Resource Rights:                              |                        |                                     |
| Benthic flora and fauna                              | 0                      | -                                   |
| Mangrove Vegetation                                  | 0                      | 0                                   |
| Agricultural Output:                                 |                        |                                     |
| Capture Fisheries                                    | -                      | +                                   |
| Culture Fisheries                                    | 0                      | 0                                   |
| Wage Paid Employment:                                |                        |                                     |
| Dredging operation                                   | -                      | +                                   |
| Social Management                                    | -                      | +                                   |
| Human Nutrition                                      | -                      | +                                   |
| Navigability   | -                      | +                                   |
| <b>DIRECT IMPACTS DUE TO INTERVENTION</b>            |                        |                                     |
| Public Nuisance                                      | 0                      | -                                   |
| Traffic disturbance                                  | 0                      | -                                   |

Rating of Impacts:

- + Positive trend
- 0 Present baseline status
- Negative trend
- 0\* To be taken care in the project design

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Two options are considered to assess impact due to the proposed intervention. These options are summarized below.

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In describing the impacts related to the engineering interventions for the project one can distinguish between the temporary impacts directly related to the dredging operation and the long-term impacts associated with the modified physical environment and a consequence of the works. In addition, a systematic distinction can be made for the components of the environment, affected by various measures or activities, i.e. between impacts on the resources system and impacts on the user system. **Table 7.3** present impact matrices for dredging. Many of the impacts listed can be mitigated substantially by adopting standard working procedures and ensuring responsible behaviour of the contractor. Impacts of dredging are summarized below:

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- Release of nutrients resulting in increase in eutrophication and direct impact on organisms due to reduced transparency and consumption of oxygen (the increase in turbidity due to re-suspension of sediments caused by dredging);
- Habitat changes from hydromorphological regimes changes;



- Effects on fish or sea snakes or marine turtles or fish-eating bird species or cetaceans (dolphins, whales) from increased turbidity as well as related effects on estuary functions, such as changes in biodiversity or reduction of spawning areas, affecting migratory or daily movement routes of fish, marine turtles, dolphins, etc.

Figures 7.1 and 7.2 present impacts on biophysical and ecological environment.

**Table 7.3: Impact matrix for the dredging works**

| Phase                 | System affected   | Potential impact   | Potential positive impact | Potential neutral or negative impact   |
|-----------------------|---|--|---------------------------|--|
| During dredging Works | Impact on Resource System (physical, biological and ecological) | -  |                           | <ul style="list-style-type: none"> <li>• Disturbance of aquatic (plankton &amp; benthos) organisms in the river bed.</li> <li>• Risk of pollution of surface water from oil spills and leaks.</li> <li>• Deterioration of water quality by disposal of liquid and solid waste.</li> <li>• Disturbance of fish and mammals in the river.</li> <li>• Increased water turbidity.</li> <li>• Loss of aquatic vegetation.</li> <li>• Risk of pollution of air, surface water and contamination of disposal site.</li> </ul> |
|                       | Impact on User System (socio-economic and cultural aspects)     | <ul style="list-style-type: none"> <li>• Employment opportunities</li> <li>• Improved navigable depth.</li> </ul>  |                           | <ul style="list-style-type: none"> <li>• Noise, dust, exhaust gas emission, oil spill from dredging equipments.</li> <li>• Obstacle to navigation traffic.</li> <li>• Occupational health and safety risk.</li> <li>• Obstruction to fishing.</li> </ul>   |
| Post Dredging Works   | Impact on Resource System                                       | <ul style="list-style-type: none"> <li>• Improved waterway traffic.</li> <li>• Biodiversity.</li> </ul>  |                           | <ul style="list-style-type: none"> <li>• Hydro-morphological adjustment.</li> <li>• Erosion and sedimentation.</li> </ul>  |
|                       | Impact on User System   | <ul style="list-style-type: none"> <li>• Navigation traffic.</li> <li>• Employment.</li> <li>• Socio-economic development.</li> <li>• Attraction of tourists.</li> </ul> |                           | <ul style="list-style-type: none"> <li>• Erosion and accretion.</li> <li>• Need maintenance dredging.</li> </ul>   |



Figure 7.1: Potential impacts of dredging on the ecosystem and natural resources indicating important environmental factors



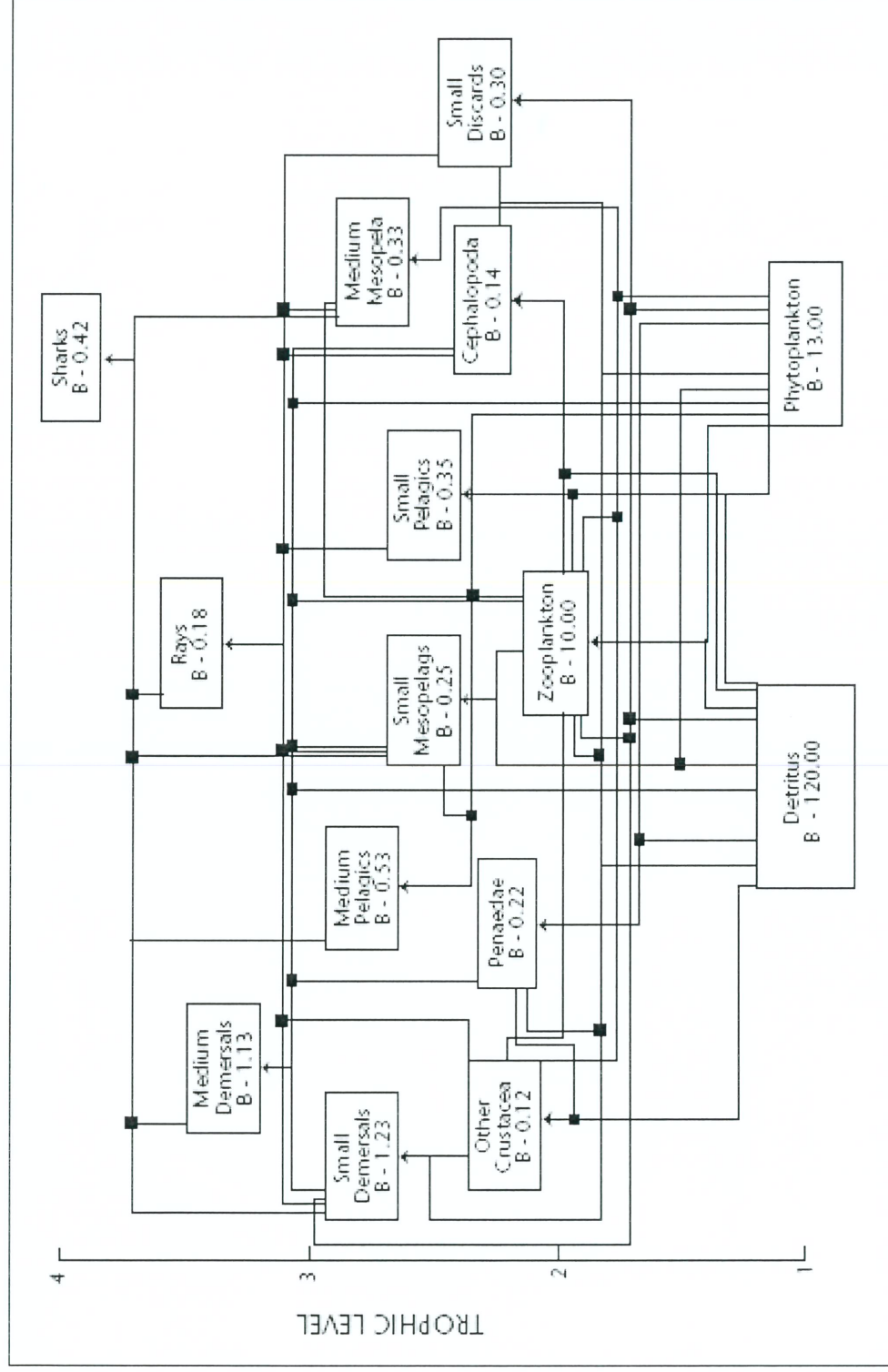


Figure 7.2: Trophic model of the coastal waters of Bangladesh, Bay of Bengal (after M.G.Mustafa 2003). Dredging removes/affects the aquatic animals within the trophic levels 1 and 2 (DASHED BOX - indicated by parentheses) which form the basis of the food chain and ultimately all animals dependent on these food chain links are affected.





## 8. IMPACT MITIGATION AND ENVIRONMENTAL MANAGEMENT PLAN (EMP)

### 8.1 Impact Mitigation

This Chapter presents potential impacts due to proposed dredging and its mitigation measures along with environmental management plan (EMP) to offset /reduce those impacts. The aim of EMP is to plan and design the interventions with a view to minimizing environmental negative impacts and maximizing benefits. As part of the aims and objectives of environmental assessment it is necessary to identify mitigation measures to avoid, minimize or ameliorate these negative impacts. In addition there are deliberate, specifically targeted measures that can be taken to readdress losses from negative impacts. Table 8.1 presents primary and subsequent impacts on the benthic flora and fauna due to dredging activity.

The ecological safety of dredging works is currently one of the most discussed topics in the dredging sector. Ecologists are concerned about the state of the marine environment and continuously monitor the execution of dredging works and their influence on the sea.

The impact of turbidity by dredging works on the environment can be reduced by modifying the overflow chutes in a way that the excess water flowed back into the sea below the water line or by choking the overflow using trailing suction hopper dredgers. Choking the overflow is a very efficient technique to reduce the spreading of sediments. But it comes only to full value when the system is fully automated and does not require the constant concentration of the dredge crew.

**Table 8.1: Impact due to Dredging and Mitigation Measures**

| Development Activity                             | Primary Impacts or Environmental Disturbance   | Secondary and Tertiary Level Environmental Impacts  | Mitigation Measures   |
|--|--|---|---|
| 1. Actual Dredging or Burrowing of 'Cutter Head' | 1a. Disturbance of seafloor, the suspension of fine sediments and the re-deposition of coarse fractions. | 1a1. Direct physical destruction of benthic habitat, and attenuation of light - impeding photosynthesis of sea grass, phytoplanktons, macro-algae and other autotrophs. | 1a1a. Use of 'Silt Curtains' at burrow pit, ensuring that lower end of 'skirt' is resting upon the seafloor, and ensuring that top of the 'skirt' is always above the surface of sea. |
|  |  |   | 1a1b. Monitoring and where necessary repairing and/or replacing leaky pipes and faulty couplings of the spoil discharge pipes.  |

| Development Activity | Primary Impacts or Environmental Disturbance  | Secondary and Tertiary Level Environmental Impacts  | Mitigation Measures   |
|----------------------|---|---|---|
|                      |   |   | 1a1c. Applying velocity reduction measures where spoils are deposited such as baffles to precipitate solids and curtail turbid influences in effluent stream.   |
|                      |   |   | 1a1d. Decrease time frame over which the dredging operation is to take place, to avoid the daily re-suspension of sediments.  |
|                      |   |   | 1a1e. Ameliorate the impacts of the daily re-suspension of sediments by the suctioning of sediments that have resettled.  |
|                      |   |   | 1a1f. Ameliorate re-suspension of sediments by confining dredging operations to calmer sea states.  |
|                      |   |   | 1a1g. Assist re-colonization of seafloor by benthic plants and invertebrates by ensuring that the gradient or slope of the walls of burrow pit or channel is not at an angle steeper than 35 degrees.               |
|                      |   | 1a2. "Blanketing" or smothering effects on benthic habitat and sessile and slow-moving invertebrates.         | 1a2a. Institute monitoring programme to ensure that light penetration at seafloor is at least 25% of surface irradiance 2,000 ft. downstream of silt curtains.  |
|                      | 1b. Decrease in Dissolved Oxygen and increase in BOD.                                   | 1b1. Physiological stress and lethal effects on benthic invertebrates and to a lesser extent, fin-fishes.     | 1b1a. Completion of dredging operation in as short a time-frame as possible.  |
|                      | 1c. Suspended Solids from undissolved components of human waste and domestic effluents. | 1c1. Suspended solids would impeded light penetration in the water column and erode or arrest photosynthesis. | 1c1a. Application of BEST Treatment technology reduces TSS to less than 10 mg/l, this in combination with effluent recycling and reuse regime reduces suspended solids to insignificant levels in the water column. |



## **8.2 Environmental Management Plan**

EMP aims at providing specific environmental friendly action plan which will be carried out during the project cycle for sustainable development to achieve project objectives. The action plan is intended to avoid/mitigate the negative impacts to an acceptable level and make the project environmentally sound. The plan also includes monitoring to ascertain whether the measures taken are adequate, and to verify whether any unanticipated impacts occur. The main components considered for EMP are: Compensation plan, Mitigation Plan, Enhancement Plan, Monitoring Plan, Institutional setup and People's participation.

EMP recommendations should be fully integrated with the project design, since many features depend closely on this. MPA should engage experienced Consultant to monitor the performance of dredging in connection with hydrological, morphological and environmental impacts of dredging. However, the port authority shall address adequately the following environmental issues during the project planning, design, implementation and post implementation stages of the project:

### **Planning and Design Phase:**

- Establishment of pre-project socio-economic baseline status;
- Preparation of guideline for handling wastes in sanitary manner.

### **Operation Phase:**

- Traffic obstruction;
- Operation risk;
- Handling dredging equipment;
- Control of public nuisance;
- Health safety and insurance for workers;
- Engage monitoring consultant to check dredging work and its performance.

### **Maintenance Phase:**

- Monitoring erosion and accretion pattern around intervention area;
- Monitor water quality at the intervention and disposal sites;
- Monitoring benthic species at the intervention and disposal areas;
- Monitoring of impacts and post project assessment, and
- Socio-economic monitoring (Navigation traffic, fisheries catch, benthic flora & fauna, health & nutrition).

## **8.3 Impact Timing**

A 5-year period has been proposed for assessment of the likely impacts of the interventions. For medium term and long term impacts a baseline data collection and a monitoring program is needed.

## **8.2 Environmental Management Plan**

EMP aims at providing specific environmental friendly action plan which will be carried out during the project cycle for sustainable development to achieve project objectives. The action plan is intended to avoid/mitigate the negative impacts to an acceptable level and make the project environmentally sound. The plan also includes monitoring to ascertain whether the measures taken are adequate, and to verify whether any unanticipated impacts occur. The main components considered for EMP are: Compensation plan, Mitigation Plan, Enhancement Plan, Monitoring Plan, Institutional setup and People's participation.

EMP recommendations should be fully integrated with the project design, since many features depend closely on this. MPA should engage experienced Consultant to monitor the performance of dredging in connection with hydrological, morphological and environmental impacts of dredging. However, the port authority shall address adequately the following environmental issues during the project planning, design, implementation and post implementation stages of the project:

### **Planning and Design Phase:**

- Establishment of pre-project socio-economic baseline status;
- Preparation of guideline for handling wastes in sanitary manner.

### **Operation Phase:**

- Traffic obstruction;
- Operation risk;
- Handling dredging equipment;
- Control of public nuisance;
- Health safety and insurance for workers;
- Engage monitoring consultant to check dredging work and its performance.

### **Maintenance Phase:**

- Monitoring erosion and accretion pattern around intervention area;
- Monitor water quality at the intervention and disposal sites;
- Monitoring benthic species at the intervention and disposal areas;
- Monitoring of impacts and post project assessment, and
- Socio-economic monitoring (Navigation traffic, fisheries catch, benthic flora & fauna, health & nutrition).

## **8.3 Impact Timing**

A 5-year period has been proposed for assessment of the likely impacts of the interventions. For medium term and long term impacts a baseline data collection and a monitoring program is needed.



#### **8.4 Impact Monitoring Approaches and Parameters**

The environmental monitoring component will come under the direction of an Environmental Engineer to be engaged for the project to assist MPA. The longer term monitoring of the project will be carried out to address any change in socio-economic condition, change in benthic community, water quality, fishery, etc. A management feedback system is required so that information from the monitoring can be fed back into decision taking and corrective action if required. Cost of monitoring including required resource personnel shall be included in the project budget.

To assess impacts of dredging and disposal material, benthic grabs may be obtained in the vicinity of a dredge area and disposal area when the operation is in progress. The objectives of sampling will be:

1. to define the impacts of dredging and disposal on the benthos;
2. determine the spatial extent of dredged material dispersion from the discharge point, and
3. follow the rate of recovery of the benthos;
4. a seasonal survey, sampling to ascertain benthic conditions may be conducted to yield a background against which the short-term impacts of dredging and disposal could be used to assess the potential for long-term impacts.

## **9. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS**

### **9.1 Findings**

The findings of the proposed dredging project based on EIA prepared are as follows:

- The proposed dredging planned for improvement of navigability at the Outer Bar area of Mongla Port is not going to create any long term irreversible impact on the ambient environment. In most cases, the implementation of the dredging operation will cause short term environmental impacts;
- Handling of spoils will not require any land acquisition for the project. The spoil will be disposed in the deep sea;
- The dredged spoil is relatively free from toxic materials so that there is little risk to handle the spoils;
- The implementation of project will improve navigability of deep draft vessels, thereby increasing foreign trade of the country and overall socio-economic development;
- Mitigation and monitoring measures have been developed in the EMP. The EMP will be implemented by the Port Authority and the authority will engage monitoring Consultant for supervision and monitoring of dredging activities, and
- Public consultation conducted during EIA preparation reveals that the key stakeholders including port users, inhabitants, etc. are in favour of the project.

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### **9.2 Conclusions**

Disposal of dredged spoil has been one of the major challenges in this EIA study and is addressed involving technical, social and environmental considerations. Three potential alternative sites i) Dublarchar, ii) Sarwar sand Island and iii) Deep sea were selected and conducted comparative analyses against pertinent technical and socio-environmental parameters to choose the most preferred site for dumping of the dredged spoil. The analyses assessed deep sea as the most suitable site for disposal. In order to ensure safe disposal of the dredged spoil it is to be released during the low tide condition. The typical scenario of depth averaged velocity field during low tide condition as shown in **Figure 6.2** summarizes the directions of the velocities. It indicates that the disposal of dredged spoil if released during low tide at the designated location as shown in **Figure 6.1** will be guided to the deep sea. Trailer Hopper dredger has been preferred to be used in the dredging operation which will carry dredged spoil to facilitate dumping of the materials at the designated location.

The environmental study revealed that the proposed dredging in the Outer Bar area of Pussur Channel will not result in any long-term significant adverse environmental impacts. Simultaneously the Social survey findings from FGDs, KIIs, public consultations and observations concluded that the dredging intervention has no direct negative impact to the local community. It was reported that the proposed dredging area is within fishing ground and dredging will ultimately enhance the capacity of catching fish, which would be a kind of livelihood augmentation. However, the likely



negative impacts can be avoided through implementation of EMP to an acceptable level. Environmental and social benefits of the Project outweigh the negative impacts. Therefore, it is strongly recommended that DoE authority may accord necessary environmental clearance to such a project of national importance.

### **9.3 Recommendations**

Following recommendations are made for consideration by the project proponent and the Contractor during project cycle:

- The EIA reveals that the dredging project will have no serious environmental concern provided that the EMP suggested is followed by the all concerned;
- Both MPA and the contractor shall abide by relevant environmental rules, regulations including workers' health and safety aspect, prevention of air and water pollution, protection of aquatic fauna and flora, etc.;
- During implementation phase every attempt should be made to contain noise level within allowable limit, ensure minimal obstruction to cargo vessels, restrict indiscriminate movement of dredger to control nuisance (air pollution and possible accident);
- Maintain all equipment and accessories in good working condition;
- Spoils shall be dumped in designated location following environmental code of practice.
- Spoil shall be dumped in the deep sea during ebb tide only;
- MPA has to engage monitoring Consultant to supervise and monitor dredging operation and to ensure that the EMP recommendations are implemented properly;
- To control emission level, the dredger shall be in good working condition;
- Dredging works are to be implemented during lean season only;
- To schedule dredging operation in such a way so that minimal and/or no obstruction to fishing community occurs during peak fishing periods of October to February, and
- No spoil shall be dumped in the ecologically sensitive area of the deep sea (i.e. fish breeding and spawning ground).

Figure 3.2: Sundarban Mangrove Forest and the proposed Dredging location at Outer Bar Area of Pussur Channel

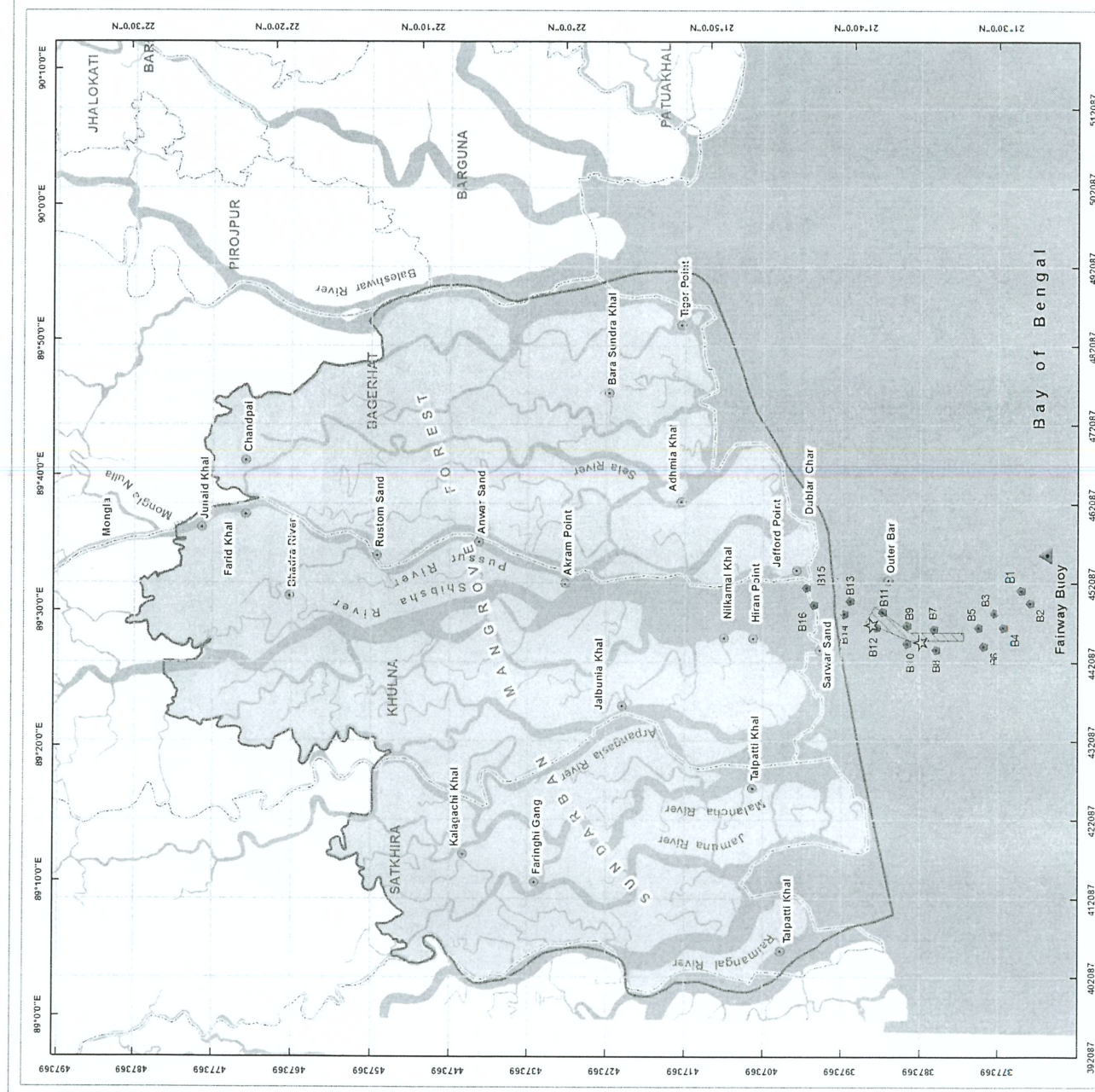




Figure 3.4: Designated Location for Dumping Dredged Spoil

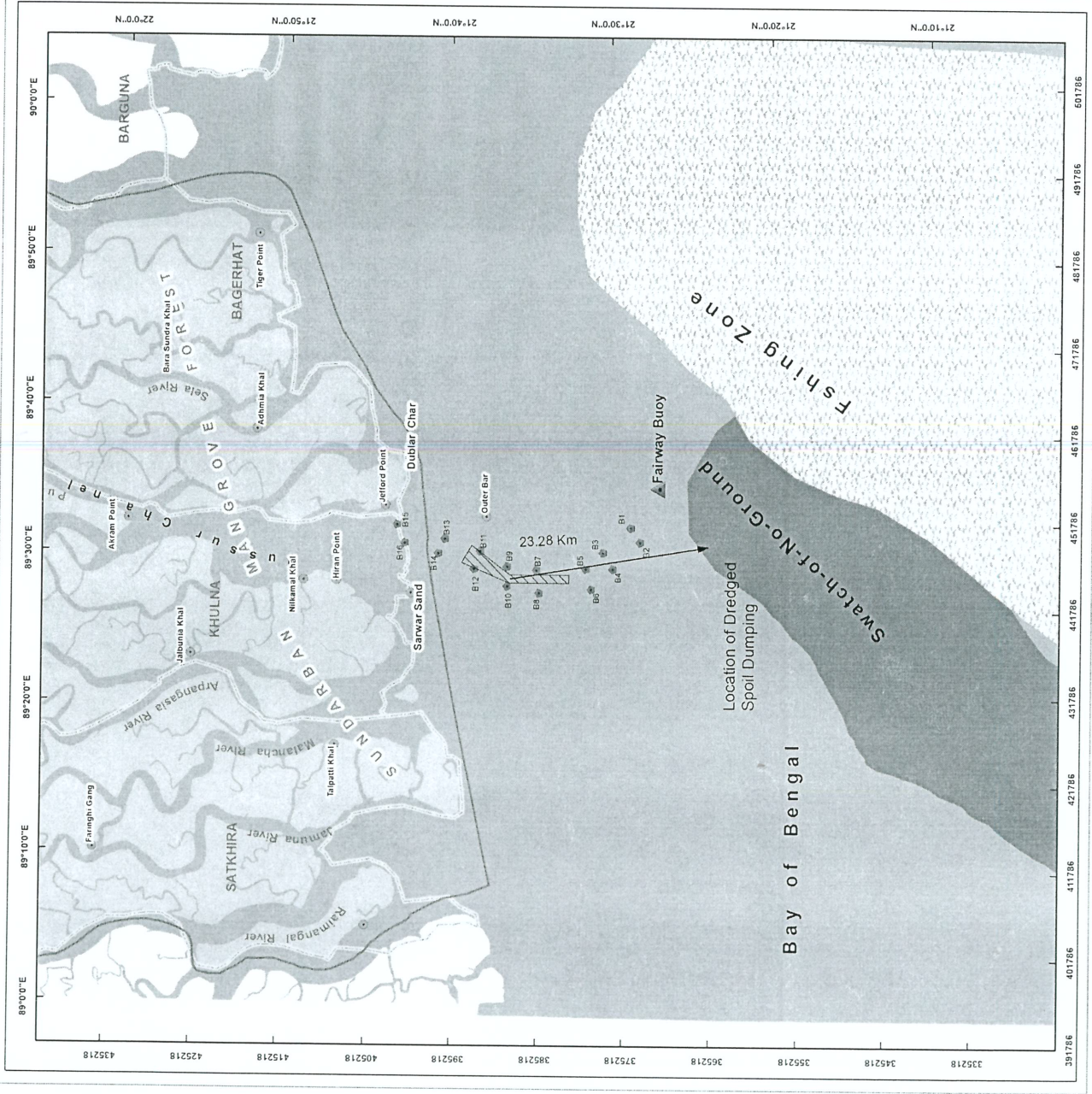
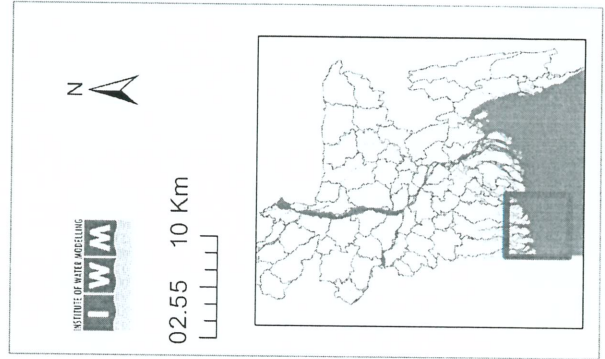
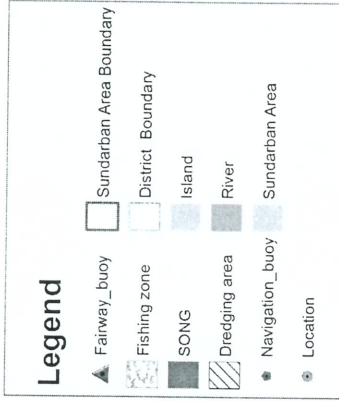
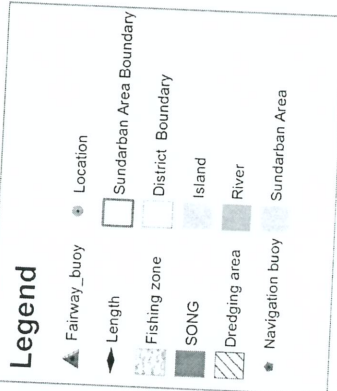
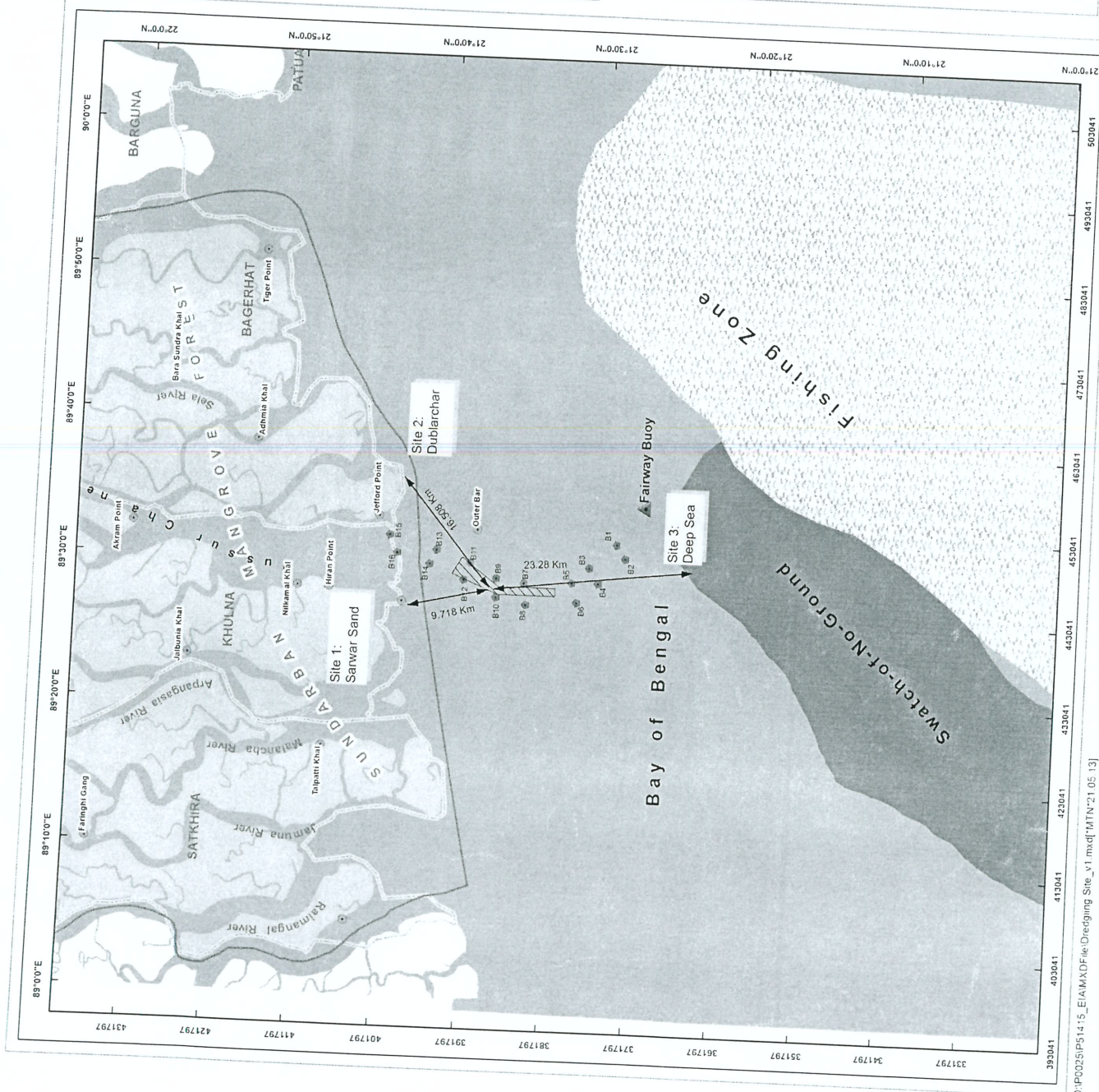
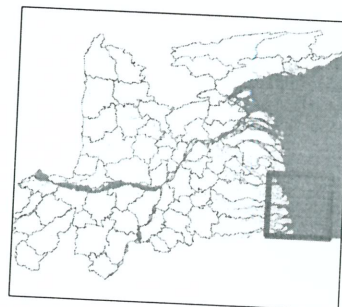




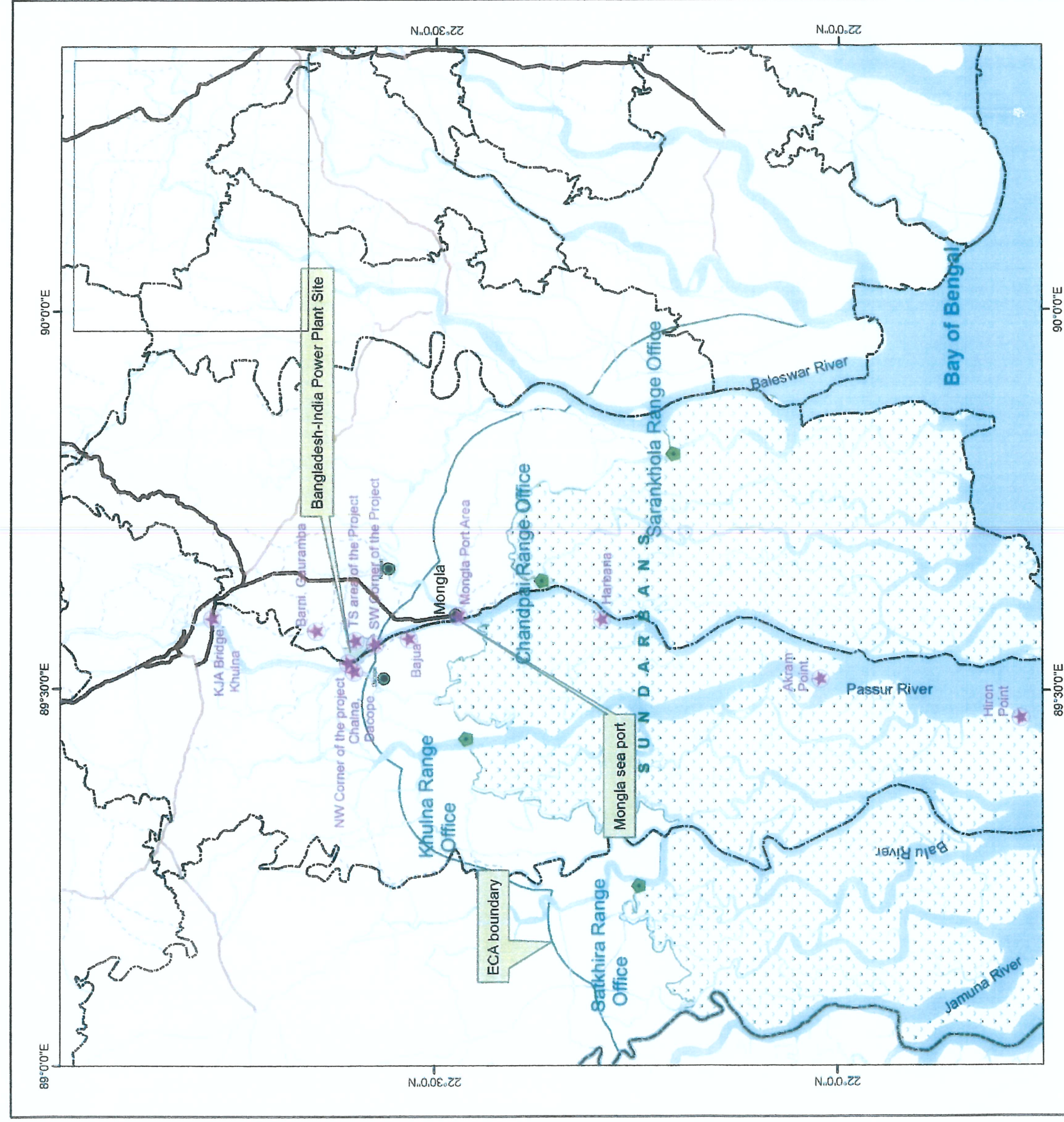
Figure 6.1: Alternative Sites for Dumping Dredged Spoil



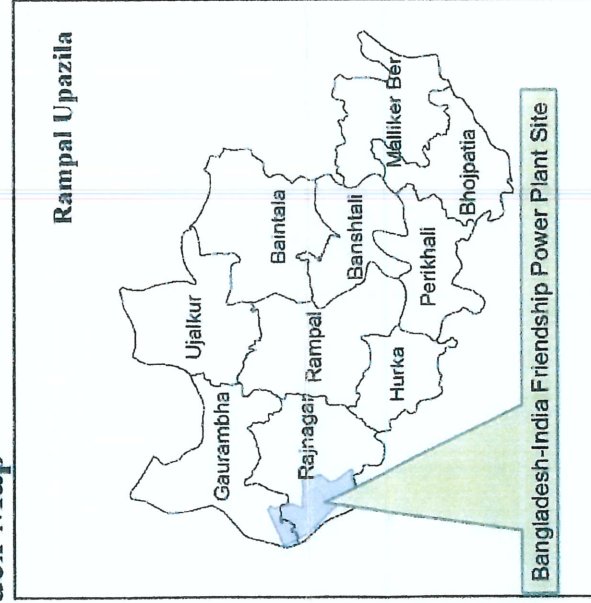
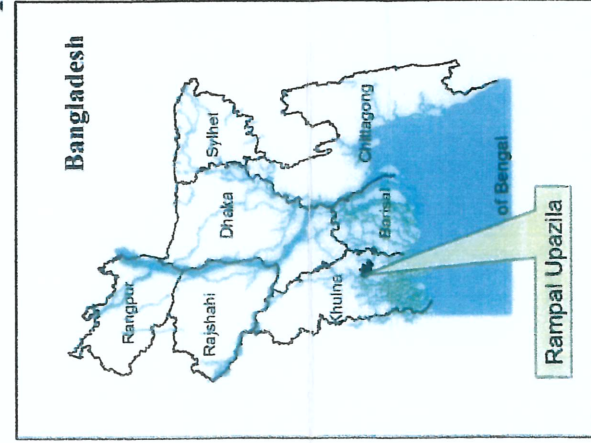
02.55 10 Km







## Index Map



## Legend

- ★ Location of air quality monitoring
- Range Office
- Upazila head quarter
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



Projection:  
Bangladesh Transverse Mercator (BTM)  
Datum - Gulshan 303

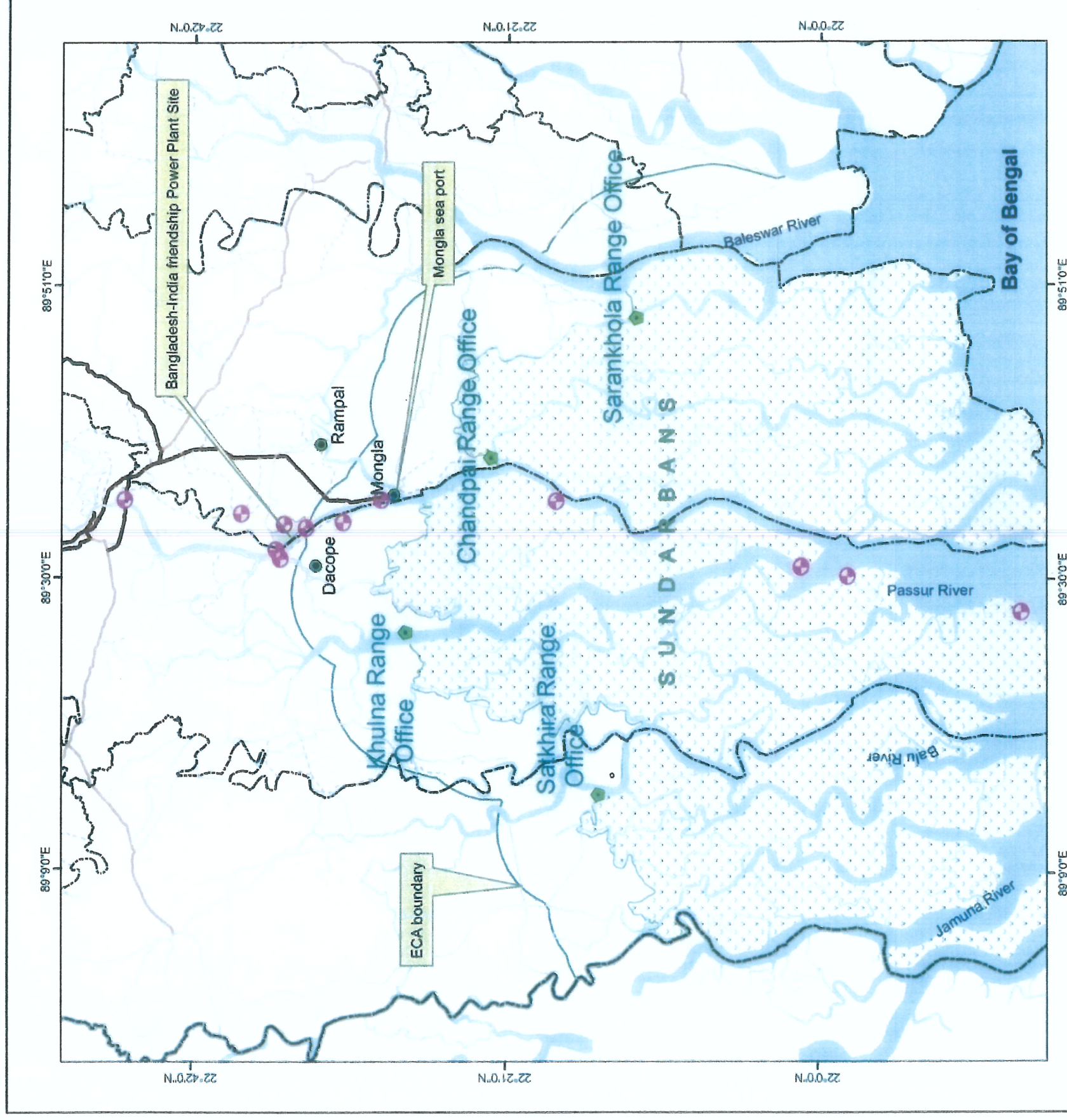
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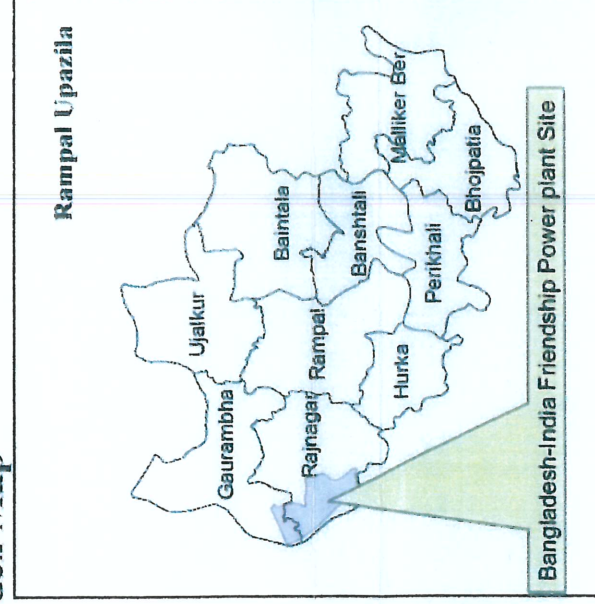
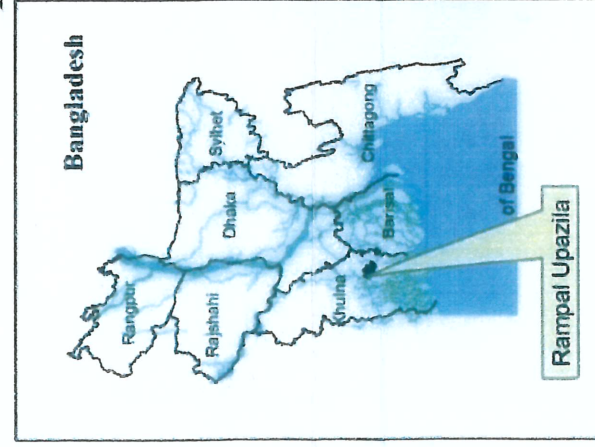
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Map 3.1: Air Quality Monitoring Locations





### Index Map



### Legend

- Location of noise monitoring
- Range Office
  - Upazila head quarter
  - International boundary
  - District boundary
  - Upazila boundary
  - District road
  - Upazila road
  - National highway
  - Regional highway
  - Rampal boundary
  - Major River
  - ECA boundary
  - Sundarbans Reserved Forests

### Data sources:

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CBTPP, BIFPCL



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Datum - Gulshan 303

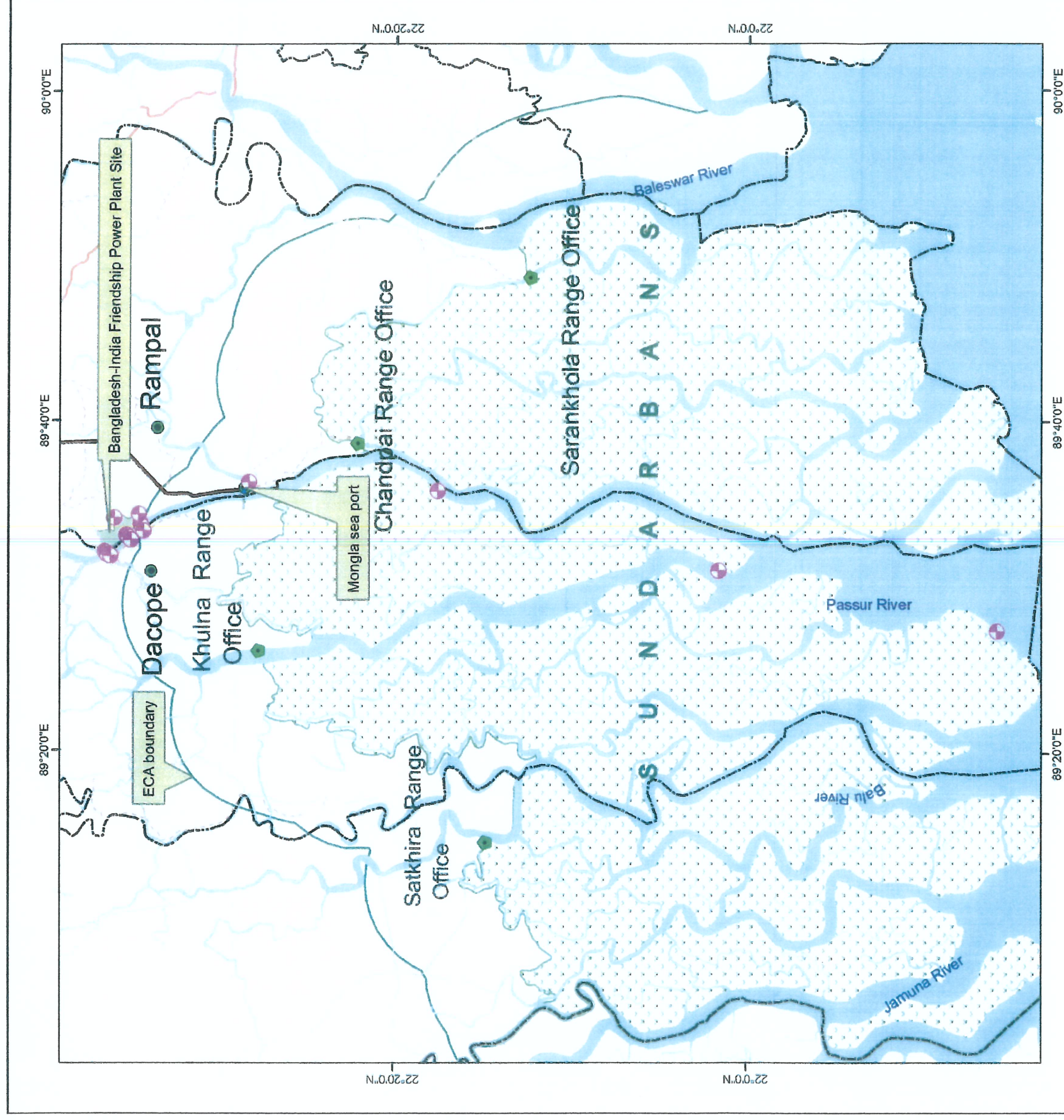
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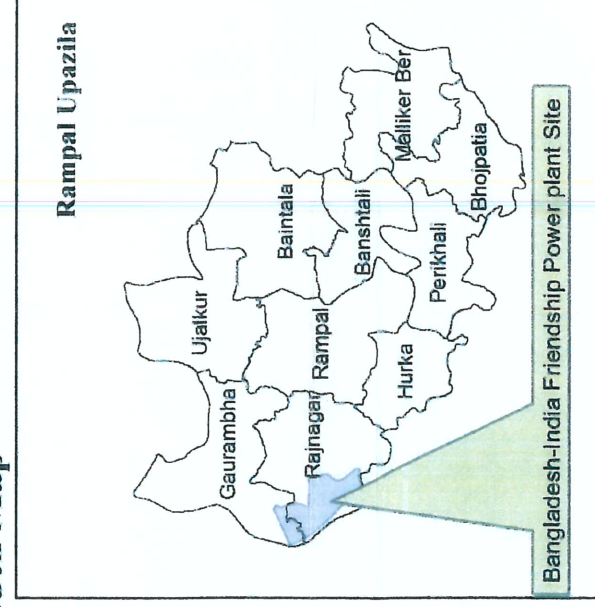
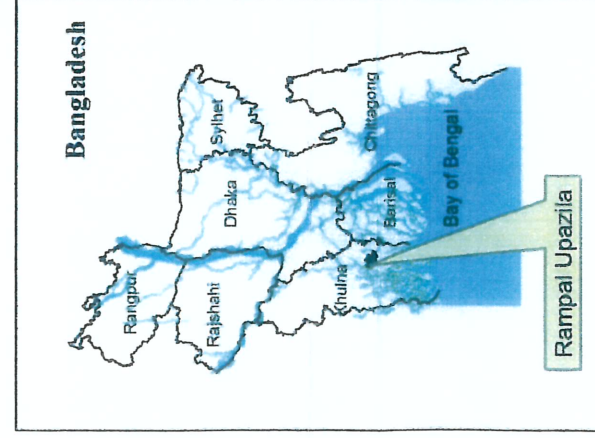
May 2014

Map 4.1: Noise Monitoring Locations







## Index Map



## Legend

- Legend
- Location of surface water monitoring
  - Upazila head quarter
  - Range Office
  - International boundary
  - District boundary
  - Upazila boundary
  - District road
  - Upazila road
  - National highway
  - Regional highway
  - Rampal boundary
  - Major River
  - ECA boundary
  - Sundarbans Reserved Forests

*Data sources:*  
CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL

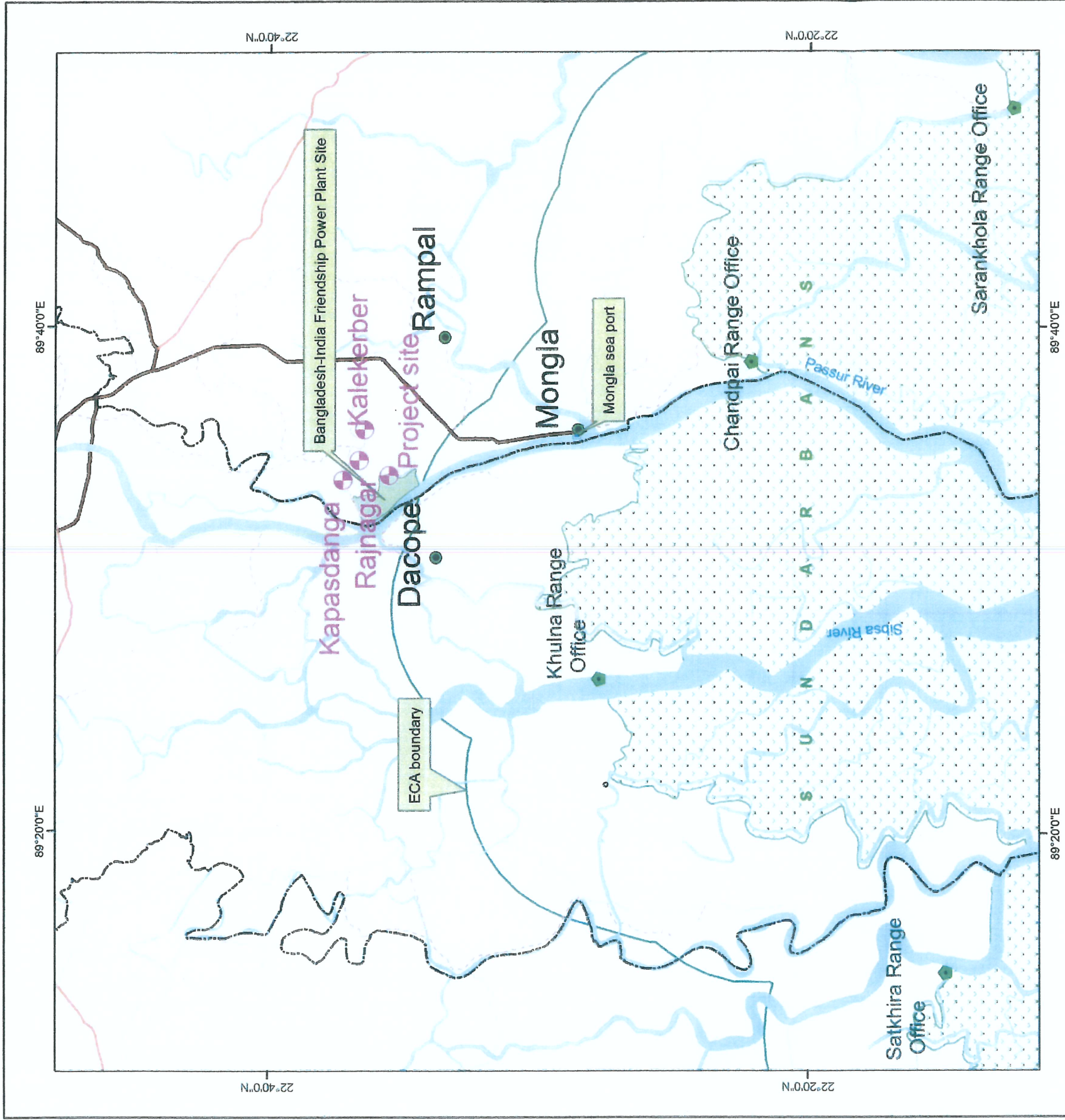



**Projection:**  
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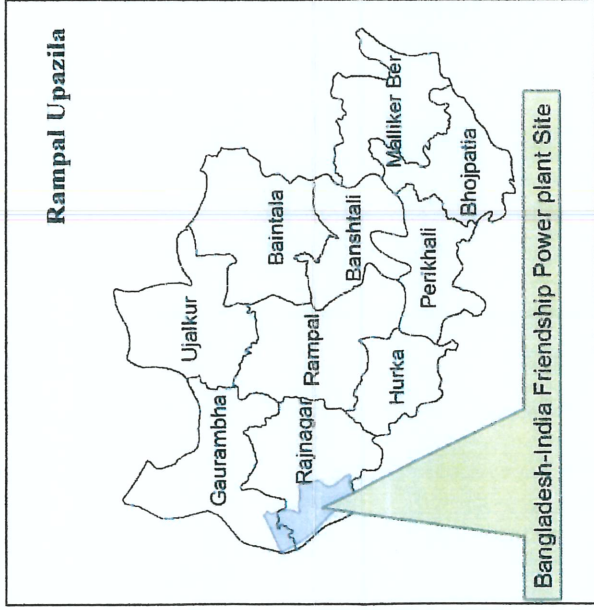
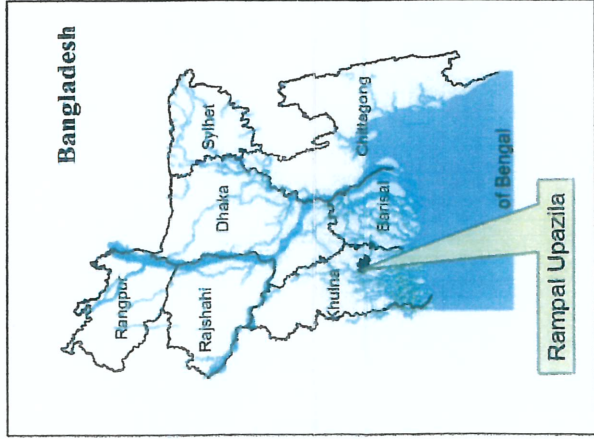
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**C&GIS**  
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### Map 5.1: Surfacewater Quality Monitoring Locations





### Index Map



### Legend

- Ground water monitoring location
- Upazila head quarter
- Range Office
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- Buffer Zone (10 km)
- Sundarbans Reserved Forests

#### Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



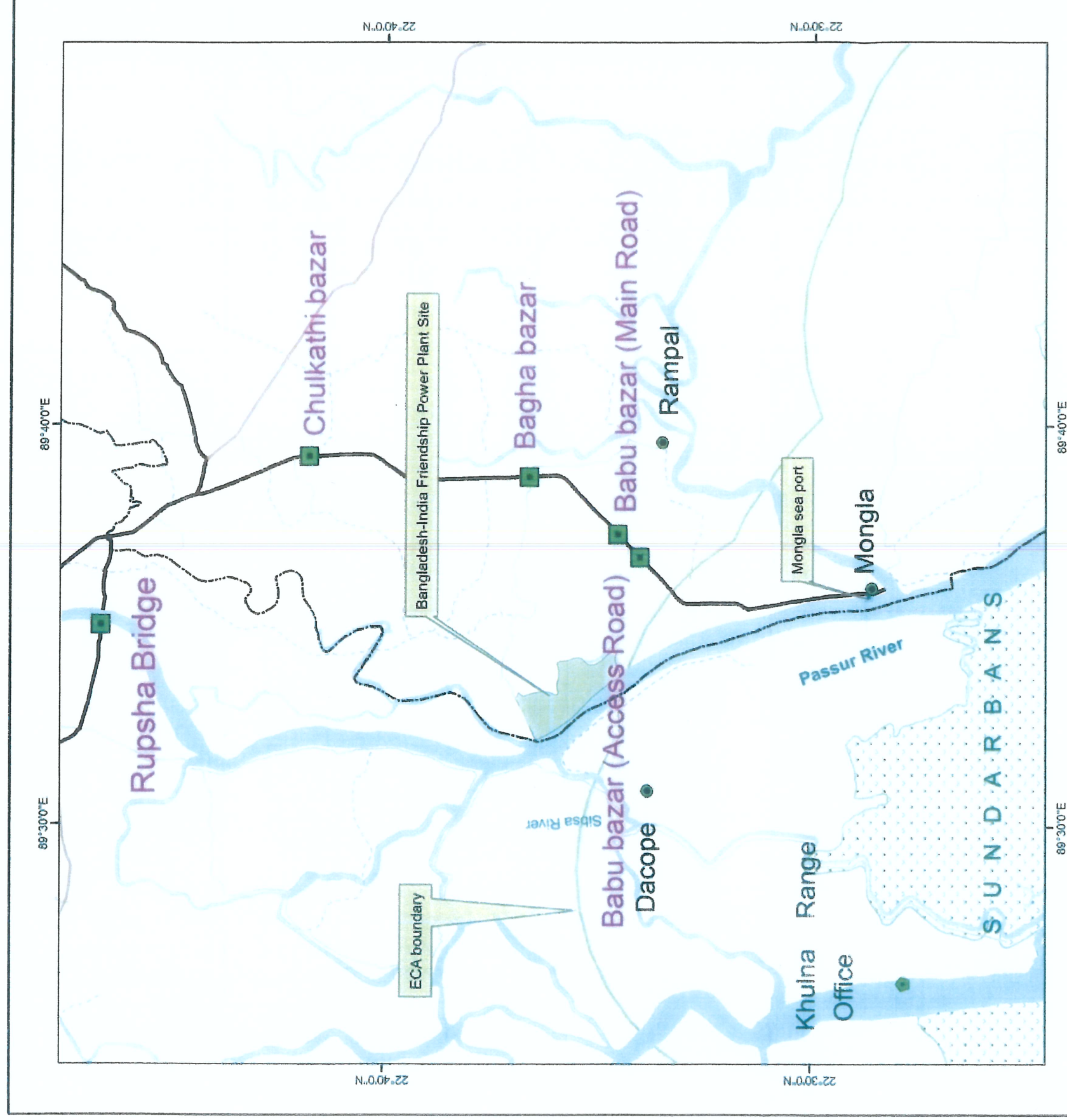
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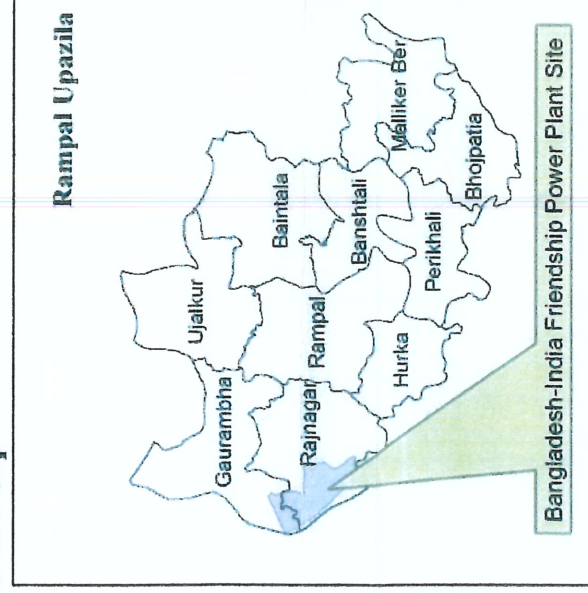
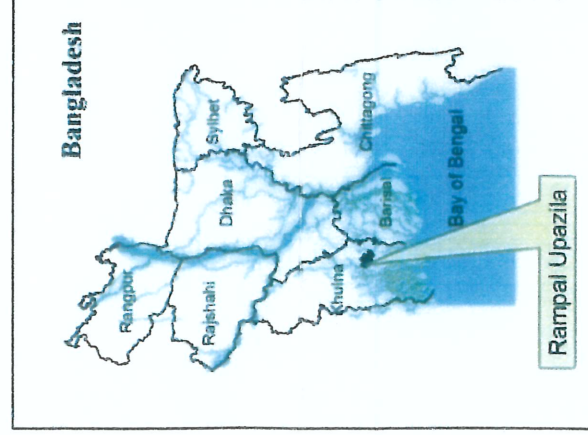
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Map 5.2: Groundwater Quality Monitoring Locations





### Index Map



### Legend

- Location of traffic survey monitoring
- Upazila head quarter
- Range Office
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

#### Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



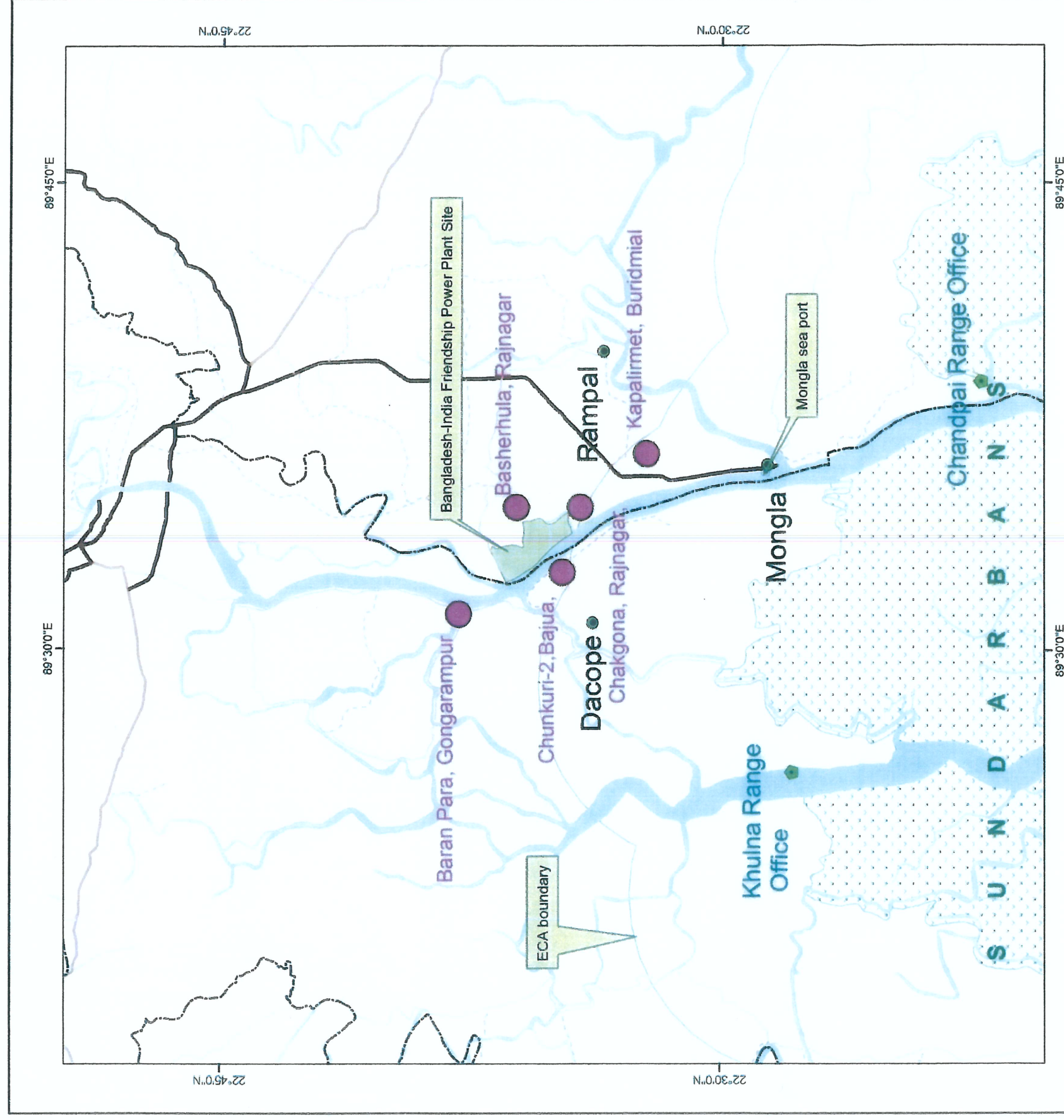
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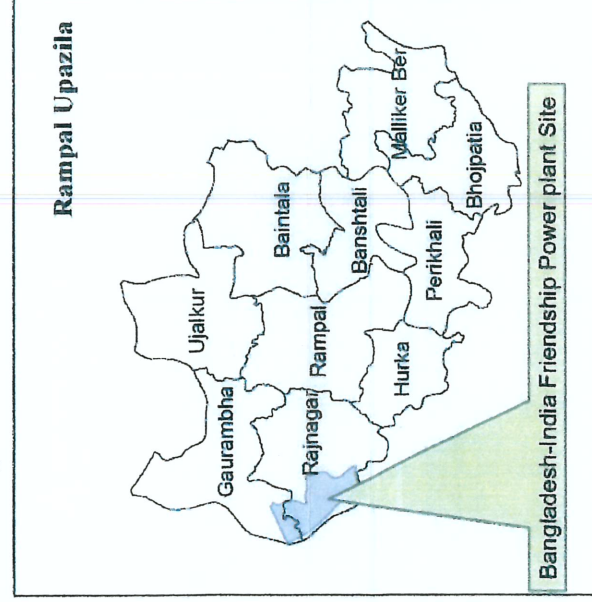
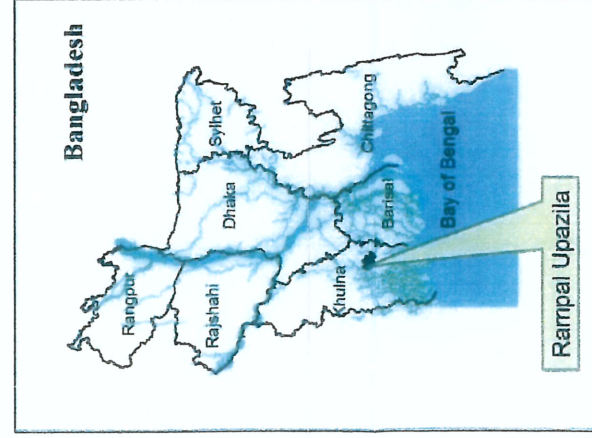
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May 2014

Map 6.1: Traffic Monitoring Locations





### Index Map



### Legend

- Location of soil quality monitoring
- Upazila head quarter
- Range Office
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

#### Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



#### Projection:

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Datum - Gulshan 303

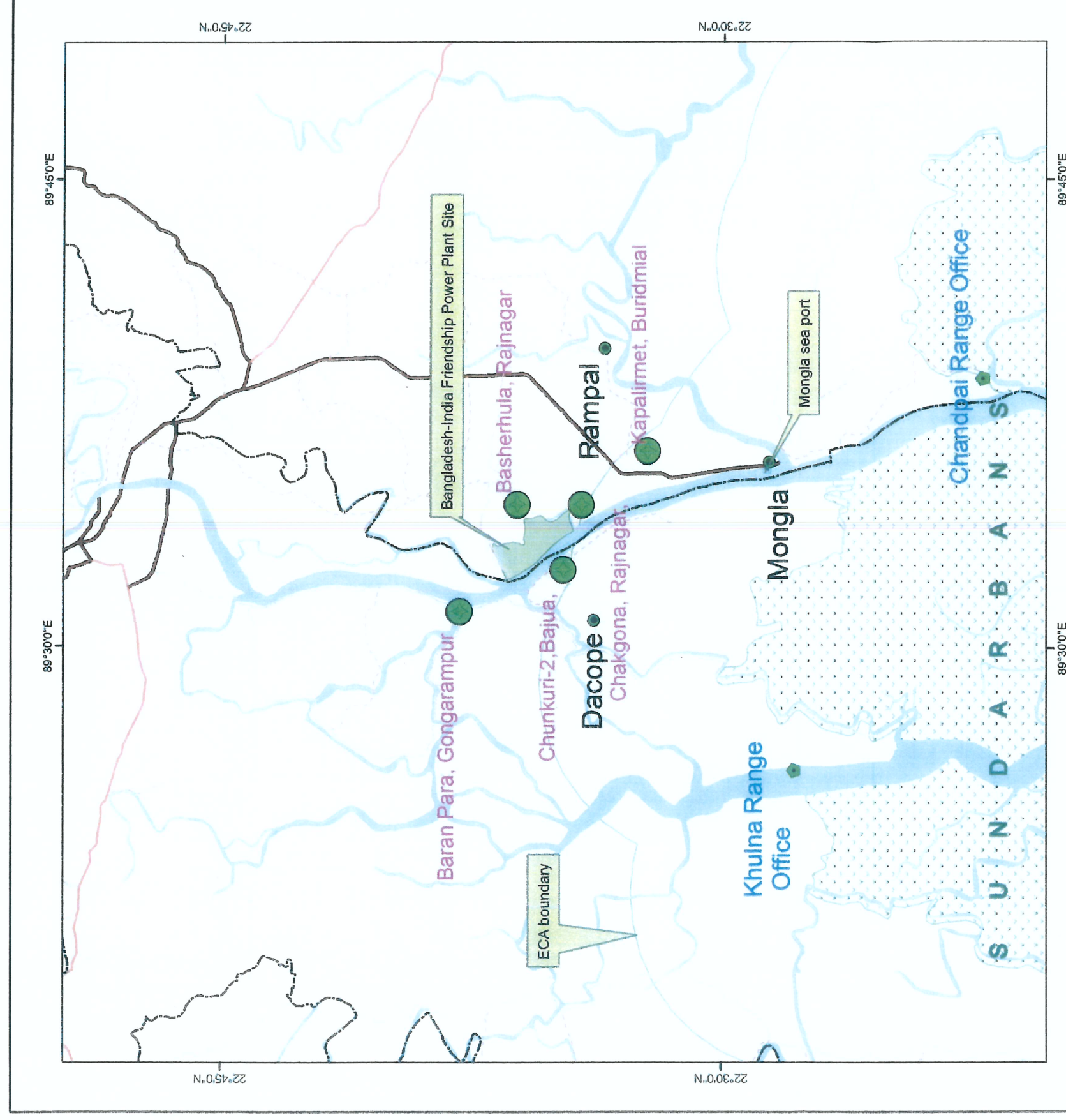


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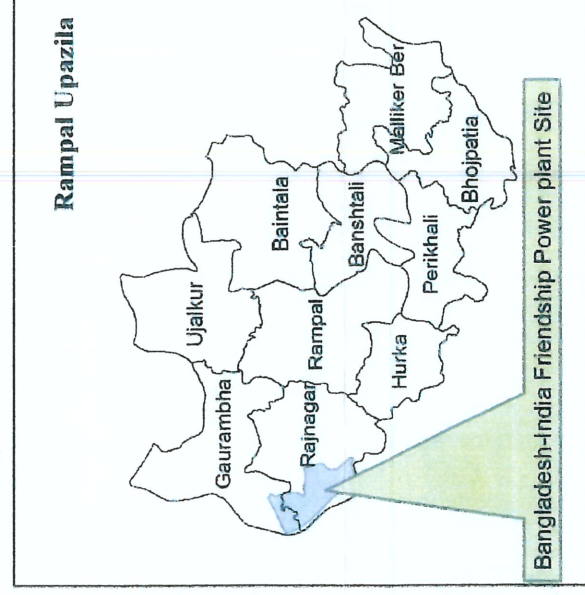
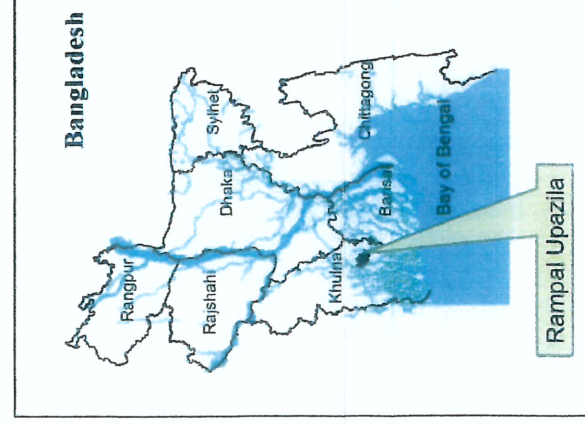
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Map 7.1: Soil Quality Monitoring Locations





### Index Map



### Legend

- Location of agriculture monitoring
- Upazila head quarter
- Range Office
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

### Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



### Projection:

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Datum - Gulshan 303

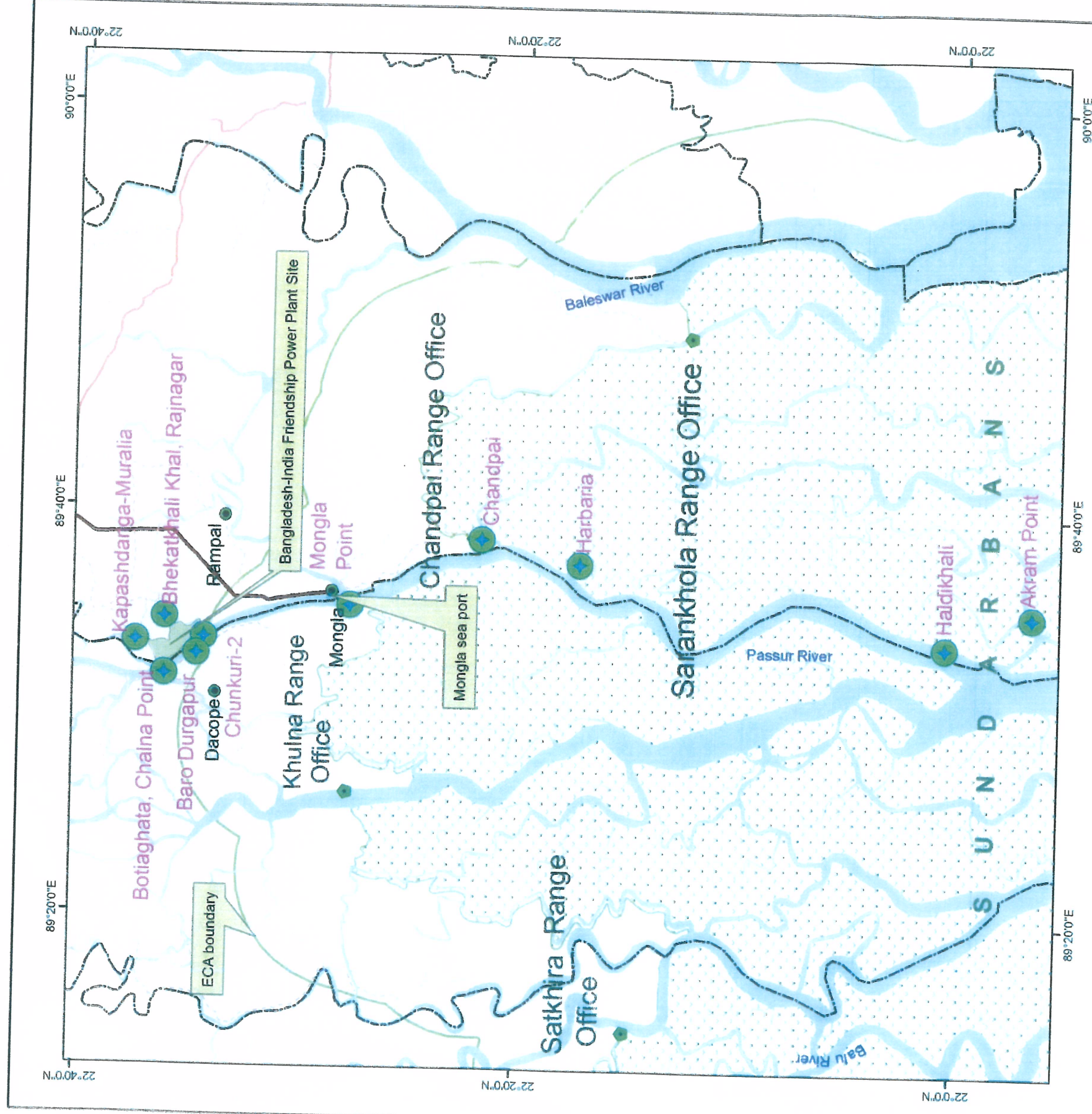


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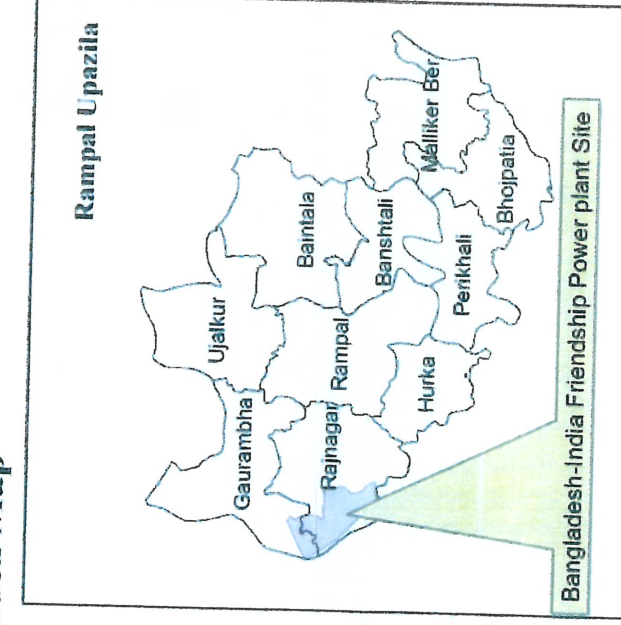
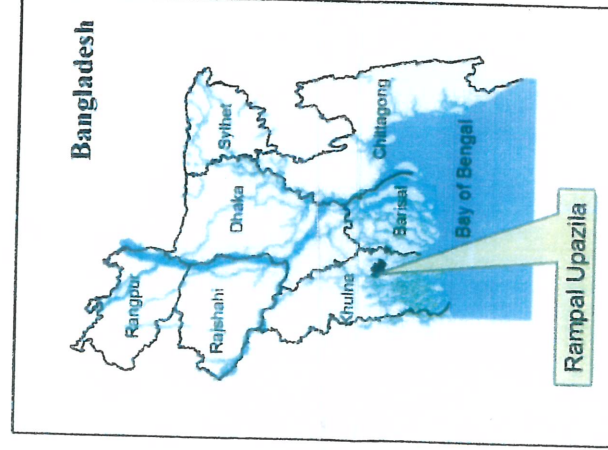
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May 2014

Map 8.1: Agricultural Resources Monitoring Locations





## Index Map



## Legend

- Location of fish habitat monitoring
- Upazila head quarter
- Range Office
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

### Data sources:

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Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



### Projection:

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Datum - Gulshan 303



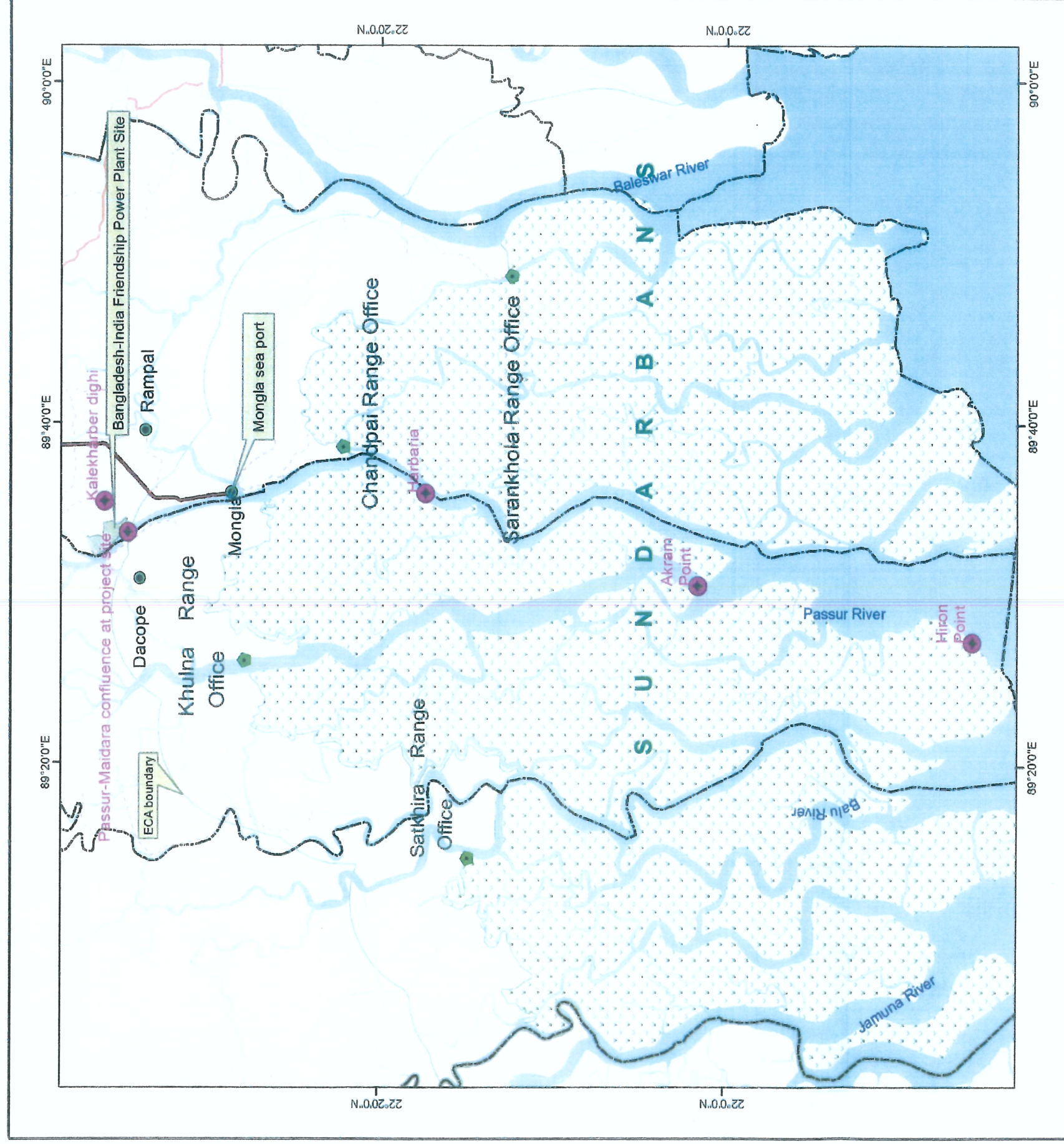
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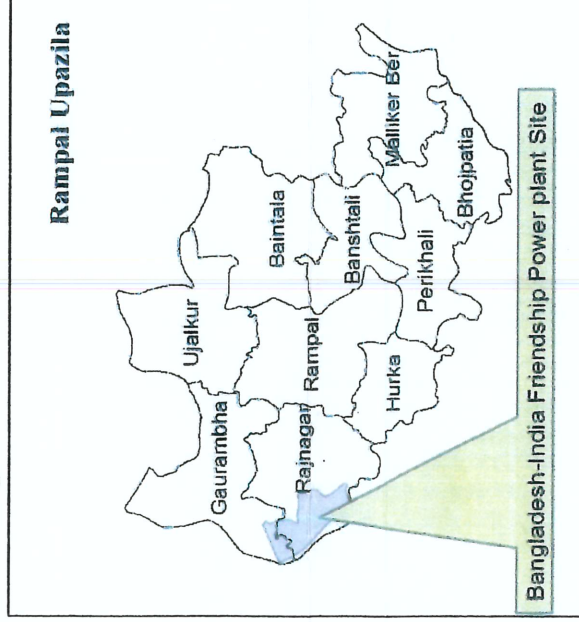
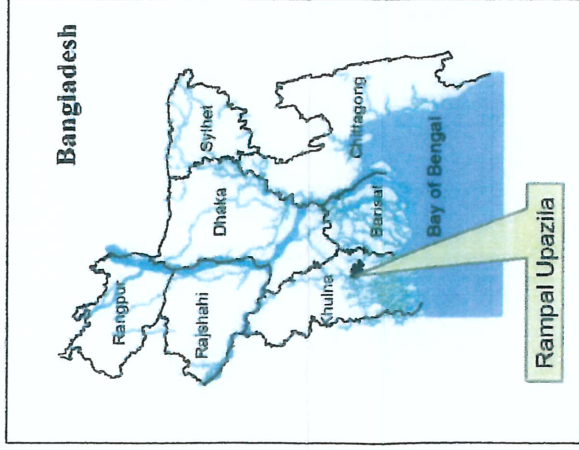
May 2014

Map 9.1: Fisheries Resources Monitoring Localtons





## Index Map



## Legend

- Benthos and plankton monitoring site
- Upazila head quarter
- Range Office
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Rampal boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

### Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



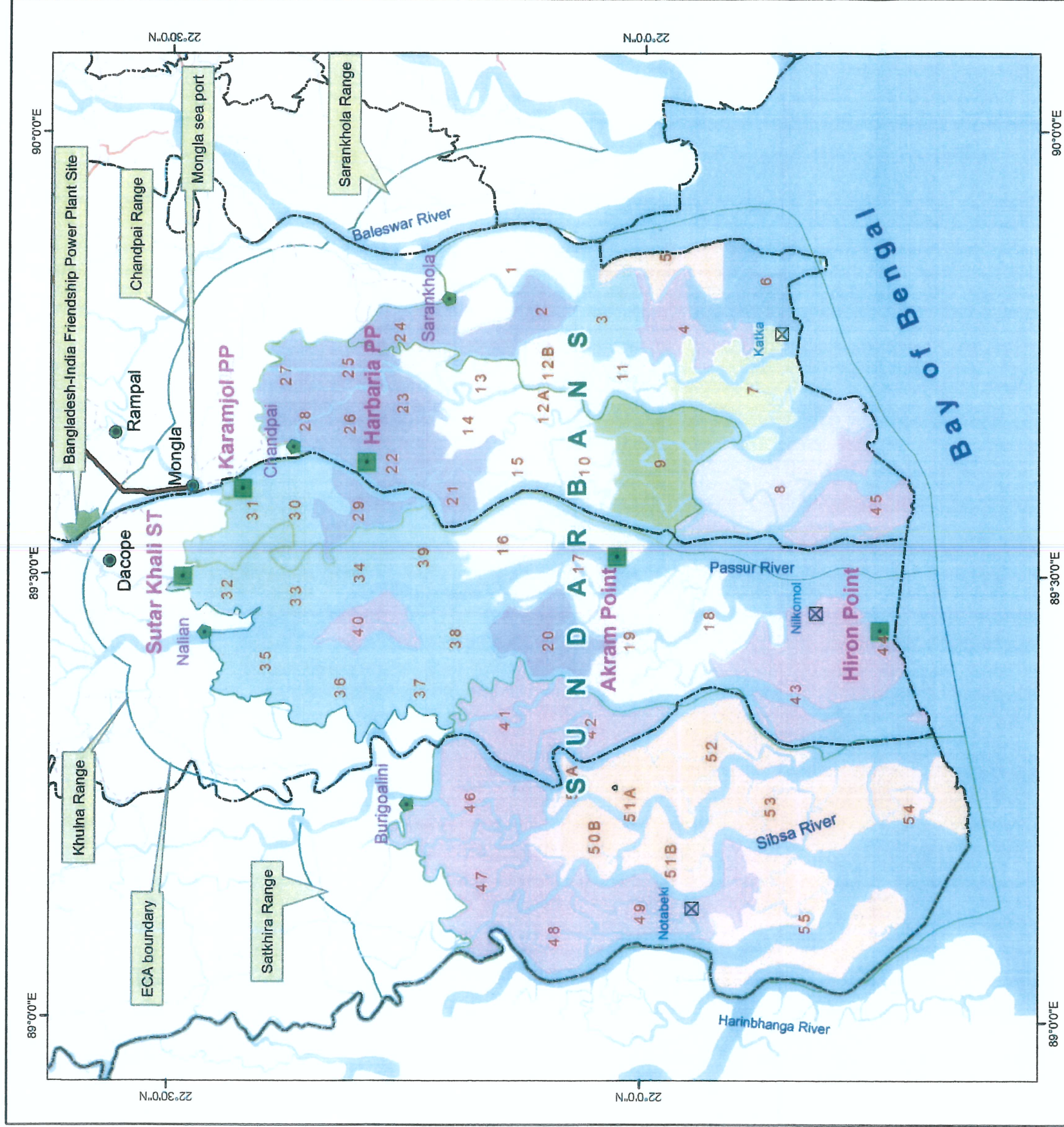
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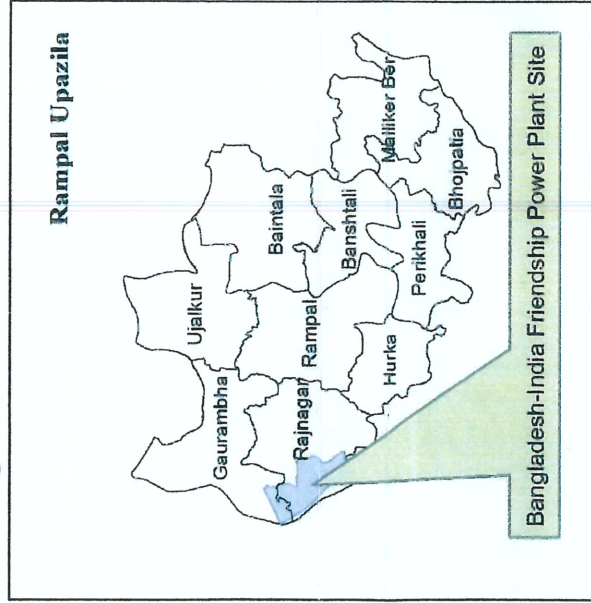
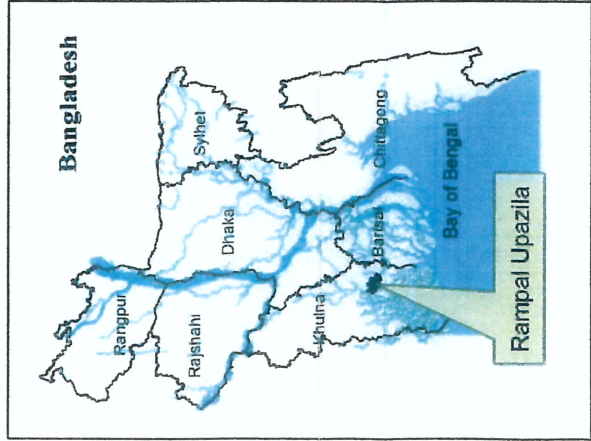
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May 2014

Map 10.2: Benthos and Plankton Monitoring Locations





Index Map



Legend

- Forest health monitoring location
- Range Office
- Wildlife Sanctuary Headquarter
- Upazila head quarter
- International boundary
- District boundary
- Upazila boundary
- District road
- Upazila road
- National highway
- Regional highway
- Project boundary
- Major River
- ECA boundary
- Sundarbans Reserved Forests

Data sources:

CEGIS Archive  
Environmental and Socio-economic  
Monitoring of Khulna 1320 MW  
CBTPP, BIFPCL



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Map 11.1 : Location Map of Sundarbans Forest health Monitoring Plots