

## Annual Monitoring Report of 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

*February 2015*



Annual Monitoring Report of First year  
Monitoring Period: February 2014 – February 2015  
Combined Report of Monitoring in Four Quarters



**Bangladesh – India Friendship Power Company  
(Pvt.) Limited**  
*(A joint Venture of NTPC Ltd and BPDB)*



Center for Environmental and Geographic Information Services

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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, the second quarter monitoring was submitted in August 2014 and the third quarter monitoring was submitted in November 2014. Following the monitoring schedule, the fourth quarter monitoring activities were carried out in the field from 3 January 2015 to 17 January 2015. The fourth 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 fisheries resources covering fish habitats, biodiversity, migration and production
- Monitoring of ecosystem and biodiversity
- Monitoring of Sundarbans Forest Health

Apart from the results of fourth quarter monitoring, this annual report compiles all the monitoring data of earlier three quarters. 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 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***

Monitoring of ambient air quality has been carrying out quarterly at 11 locations that includes three locations in Sundarbans as well. Monitoring parameters covers SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>2.5</sub>, and PM<sub>10</sub>, O<sub>3</sub> and CO. Each time the prevailing wind direction and weather was recorded.

Respiratory particulate matters i.e. PM<sub>10</sub> PM<sub>2.5</sub> was found always within the standard at all location. The Suspended Particulate Matter (SPM) was found exceeding at different location in different monitoring period. SO<sub>2</sub> and NO<sub>2</sub> were also found much below the highest allowable concentration. In project site and its surrounding area, SO<sub>2</sub> varies from 18 µg/m<sup>3</sup> to 28 µg/m<sup>3</sup> where as in Sundarbans the concentration varies from 7 µg/m<sup>3</sup> to 14 µg/m<sup>3</sup>. The NO<sub>2</sub> varies in between 26 µg/m<sup>3</sup> and 41 µg/m<sup>3</sup> in project site and its adjoining area, whereas in Sundarbans the concentration ranges in between 17 µg/m<sup>3</sup> and 28 µg/m<sup>3</sup>. The CO and O<sub>3</sub> were also found much below the standard of maximum concentration. Therefore, from the first year monitoring it can be concluded that the air shed in the project site and its adjoining area including the Sundarbans is not degraded but the concentration of SPM is alarming.

***Noise Monitoring***

Unlike air quality monitoring, noise was found exceeding the standard in most of the monitoring locations even in Sundarbans. In Sundarbans the monitoring locations area were 100m inside the forest from the river bank. The sources of noise are mostly natural e.g wind action on trees, river wave, bird's chirping, etc. In Herbaria region of Sundarbans, Ship are major source of Noise. In the locations other than Sundarbans, noise sources are mostly human crowd and traffic. The locally made mechanized vehicles e.g. Nasimon, engine van, etc are very common there that generate high noise.

***Water Quality Monitoring***

Water samples from 12 locations in Passur river, one location in Shibsa river, two locations in Maidara river have been collected and tested quarterly. Similarly, ground water samples have been collected from four handpump tubewells located in project site and its surrounding unions. Surface water quality parameters considered for this monitoring include pH, Temperature, Salinity, DO, BOD, TDS, TH, TSS, COD, Nitrate, Sulphate, Phosphate, Arsenic, Lead, Mercury, and Oil & Grease. For gound water, pH, Temperature, Salinity, DO, COD, As, Hg, Total hardness, Nitrate, TS, TDS, TSS, Nitrate, Sulphate, Phosphate have been tested quarterly.

***Transportation Monitoring***

Traffic volume in Khulna – Mongla highway and Baburbari to project site which is an access road road to Project site has been carried out quarterly. The survey was carried out at five locations.

***Land Resources Monitoring***

Land resources have been monitored twice in a year. This includes monitoring of soil fertility and chemical properties Laboratory analysis of samples has been done by SRDI.

***Agricultural Resources Monitoring***

Similar to land resources monitoring, agricultural resources monitoring has been carried out twice in a year. The monitoring indicators include cropping pattern, production and damage.

***Fisheries Monitoring***

The fisheries monitoring survey has been quarterly devised and conducted in different sampling sites comprising of both capture and culture fisheries to assess the fish habitat

status, fish diversity, fish migration, shrimp/fish farm and fish production. The estimated total area of capture and culture fish habitat is about 183 ha and 164 ha respectively. The monitoring survey observed change in Fish habitat type, species richness, evenness and migration. It has also been found that fish species especially juveniles and adults of maximum species were more randomly distributed among the Passur River system. Among these Banspata, Bele, Phessa, Poma and Datina fish were widely distributed. In all the monitoring phase these species except Poma showed long extent migration for meet up their feeding, breeding, spawning and nursing purposes. The growth rate remained same in first and second monitoring phase, though mortality has increased in second monitoring phase. The growth rate of Bagda has decreased in case of Chhoto Charer Gher in Rajnagar, but increased in Gher in Kapashdanga-Muralia. However, growth rate remained same in Gher of Chunkuri-2 between second and third monitoring phase. The mortality could not be assessed in the fourth monitoring phase. Highest catch (kg) has been found in first monitoring phase followed by fourth, third and second monitoring phase. In fourth monitoring phase, the highest productivity has been found in Haldikhali, and lowest in the Mongla Point. Moreover, in shrimp/fish farm highest production has been found in third monitoring phase followed by first and second phase. No production has been found in fourth monitoring phase.

### **Ecosystem and Biodiversity Monitoring**

Ecosystem and biodiversity have been monitored quarterly. In fourth quarter, Plant health, plant canopy cover, migratory bird habitat, butterfly occurrence and dolphin occurrence have been monitored. Plant health of studied homesteads remains unchanged from previous monitoring status. Coverage of canopy followed slightly decrease for two of studied homesteads. Out of 8 important wetlands, 6 are found local migratory waterfowl and 2 (Boro Charargher and Golbunia Gher) are reported both local and overseas migratory birds. No bird nest was found at examined homesteads.

Occurrence of butterfly species observed low number of species and population too. A total of 28 butterfly species have been recorded from the study area. Evening brown (*Melanitis leda*) and Small Grass-yellow (*Eurema smilax*) is the commonest of all the recorded species.

A total of 5 individuals of Ganges River dolphin has sighted during transect survey at three confluence points of Passur-Mungla, Passur-Maidara and Maidara-Ichamoti River. Beside this, Ganges River Dolphin were also found at Passur River near Karamjal and Harbaria. 2 individuals of Irrawaddy Dolphin were also sighted at Akram point.

### **Sundarbans Forest Health Monitoring**

Sundarbans, the world largest mangrove forest provides a multiple ecosystem services ranging from protection against natural calamities, rearing unique biodiversity, livelihoods and carbon sequestration. Considering these ecosystem values, the monitoring study incorporated the Forest health survey with varying indicators such as species diversity, richness, regeneration, recruitment, seedling survival, canopy cover, growth and biomass, and disease and damage at five locations – Karamjal, Harbaria, Akrampoint, Hiron Point and Sutarkhali. Plot locations and number were selected based on distance from the proposed Project site, coal transportation route, and protection of the permanent sample plot and cover the maximum vegetation types, resources support. A transect sampling method was followed where three circular plots were laid out at 100 m intervals.

During the second quarter (baseline) the overall forest health was found well. However, in case of regeneration status, the Akram point site was less healthy than other four sites. The third quarter monitoring 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. In Harbaria, site tree height was highest, while it was lowest in Akram point and the other sites had similar tree height. We did not find any significant difference of canopy cover percentage, crab hole, pneumatophores and seedlings density among the three monitoring quarters in the five monitoring sites. However, in case of Lichen cover percentage was significantly decreased in Karamjol, Harbaria and Hiron Point. Seasonal effect, Low humidity, etc could be responsible for these changes. The seedlings survival percentage was highest in Akram point, lowest in Hiron point and other three sites shows similar survival percentage of seedling. Ecosystem carbon stocks were not included in this report as soil carbon and nutrient s analysis are under laboratory processing. From the finding of the current study it can be concluded that except lichen cover percentage, all other indicators were in good conduction.

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

Socio-economic condition has been monitored twice in a year. The results of the monitoring have been summerized below:

#### *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 (gucchho gram).

#### *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 third 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.

### ***Hydro-morphological Monitoring***

Hydromorphological monitoring included monitoring of drainage network, erosion, accretion and river bed material quality. A detail drainage network has been prepared from the analysis of satellite image (Acquired on 7 and 30 May 2014). Location of present eroding and accreting areas were identified on the basis of satellite image analysis and field observation. River bed sediments collected during first quarter monitoring were tested in the SRDI laboratory. The result of laboratory test has been provided in this second quarter monitoring report.

### ***Land use and Land Cover Monitoring***

The landcover and Land use of the study area have been identified from analyzing multispectral Rapid Eye satellite image of 5m resolution acquired on 7 and 3 May 2014. The image extracted data were further verified through ground truthing. Agricultural land is the dominating landcover that represents 59% of the study area. Agricultural land includes Current fallow and Agricultural Land Area, Seasonal Gher and Shrimp Aquaculture Pond/Gher. Shrimp aquaculture pond represents 21% of the study area.



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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

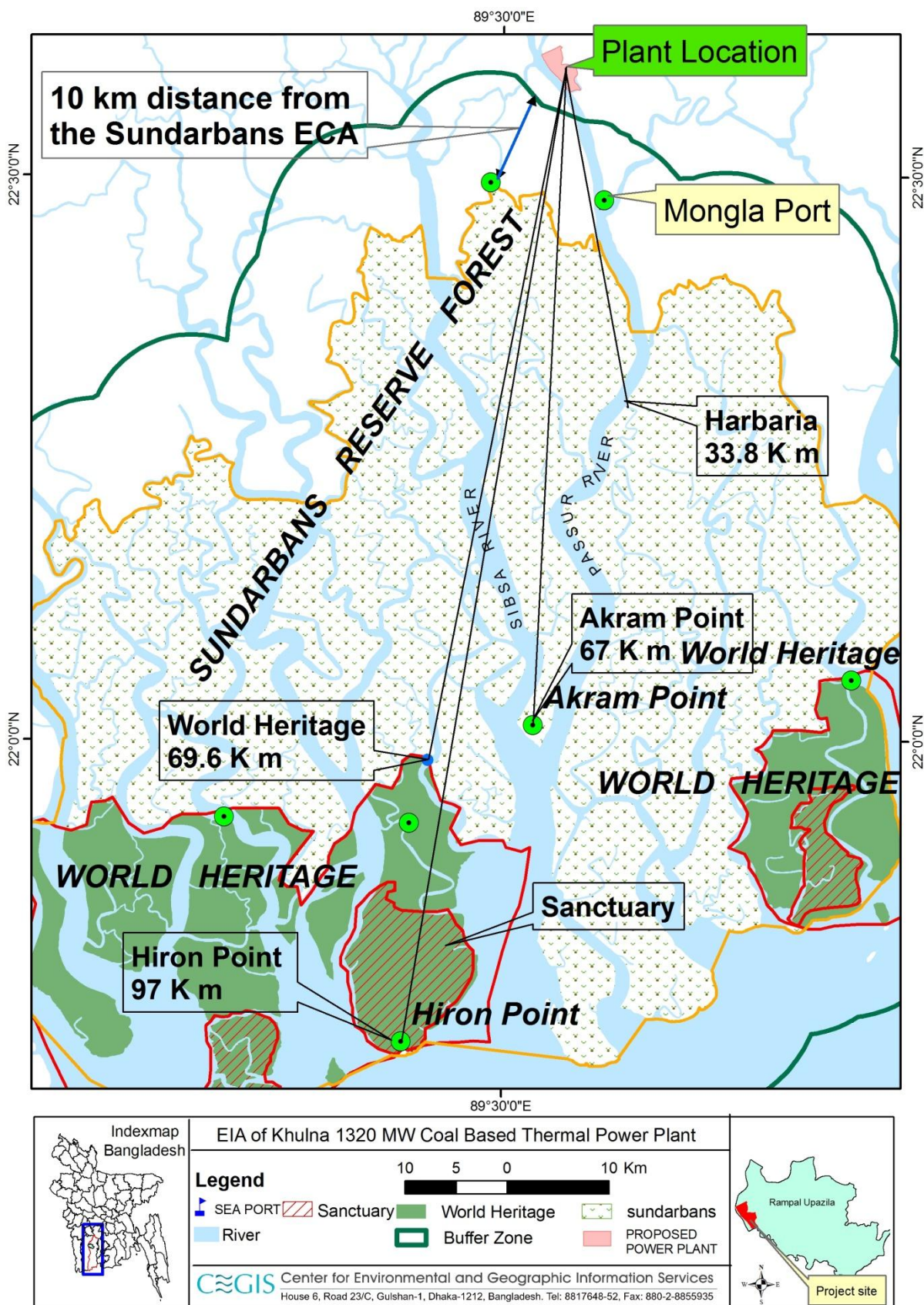
1. The Project proponent (BIFPCL) has entrusted CEGIS with the responsibility for conducting the environmental and social monitoring relevant to the pre-construction and construction activities of Khulna 1320 MW Coal Based Thermal Power Plant under the caption “Monitoring of environment parameters and 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, second and third quarter were carried out during the period in February 2014 - April 2014, May 2014 – July 2014 and August 2014 – October 2014. The Monitoring Reports were submitted in May 2014 (First Quarter), August 2014 (Second Quarter) and November 2014 (third Quarter). Followed by the third quarter monitoring, the fourth quarter monitoring period was November 2014 – January 2015. The field monitoring activities have been carried out from 3<sup>rd</sup> January to 17<sup>th</sup> January 2015.

## 1.2 Objectives of fourth 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 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 fourth quarter monitoring activities also include monitoring of environmental compliance of power plant pre-construction activities.

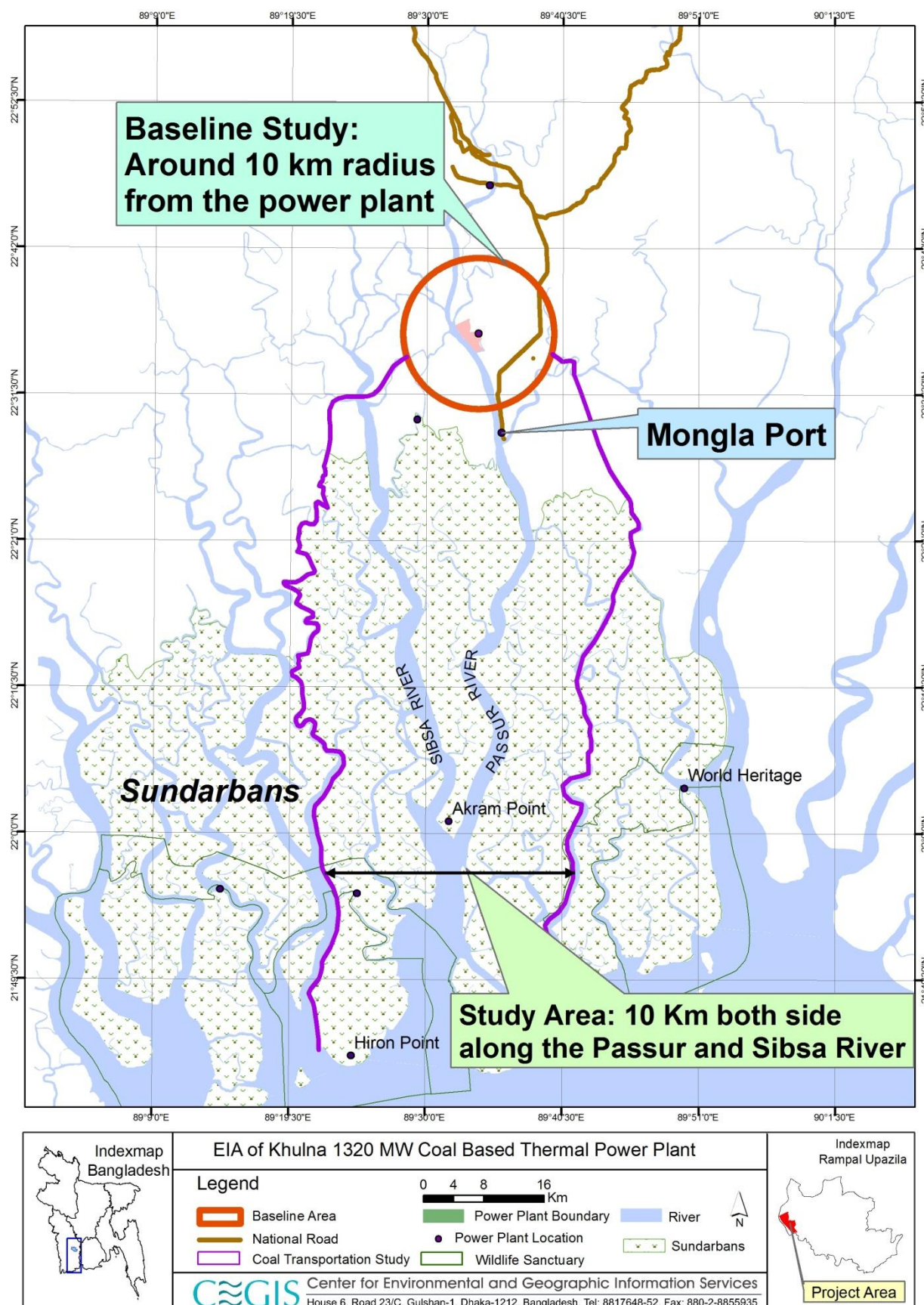
## 1.3 Project Location and Study Area

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 of the 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, Ingrowths (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 earlier quarter monitoring report to the Chief Conservator of Forest, Bangladesh Forest Department, Agargaon, Dhaka and Conservator of Forest, Khulna Circle, Boyra, Khulna. Similarly this fourth quarter monitoring report will also be forwarded to the Forest Department.

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

### **2.1 Background**

9. Environmental Compliance monitoring has been carried out at two phases – third quarter (October 14) and fourth quarter (January 15). 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 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 Diligence
1	Generation of Dust from <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	Generation of Noise (moderate) from <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	Generation of Greenhouse gases, SO <sub>x</sub> , NO <sub>x</sub> from Generators, dredgers, sand carrying vessels	<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>



SI No	Impacts	Mitigation Measures	Remarks on Due Diligence
		<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 not 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>On site toilet facilities</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**

SI 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 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</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> </ul>

SI No	Issue	Measures	Remarks on Due Dilligence
		and equal opportunity <ul style="list-style-type: none"> <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>• 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 Dilligence
	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 to community if the project posses any health</li> </ul>	<ul style="list-style-type: none"> <li>• Complied. The BIFPCL has initiated weekly health camp. Each time roughly 150 plus people</li> </ul>

		risk like sexually transmitted disease, communicable disease, vector-related	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 thorough 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 Diligence
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 or other equipment to deal with 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>• Floating Oil (of approximately 5m x 5m area) was observed at jetty front</li> <li>• No facilities to deal with the spilled oil (e.g. Oil boom, oil absorbent, Peristaltic Pump, boom accessories, boom reels, etc) was found</li> <li>• Construction of boundary wall is in progress</li> <li>• Proper run on-run off drains</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 encroachment 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 Sundarbasn 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



Donating in different religious and social programme under CSR program



Construction of alternative Access Road by LGED



### 3 Air Quality Monitoring

13. The ambient air quality has been monitored for four times in a year at 11 locations within the study area of monitoring interest. The details of the monitoring plan have been provided in the Table 3.1.

#### 3.1 Methodology

14. 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

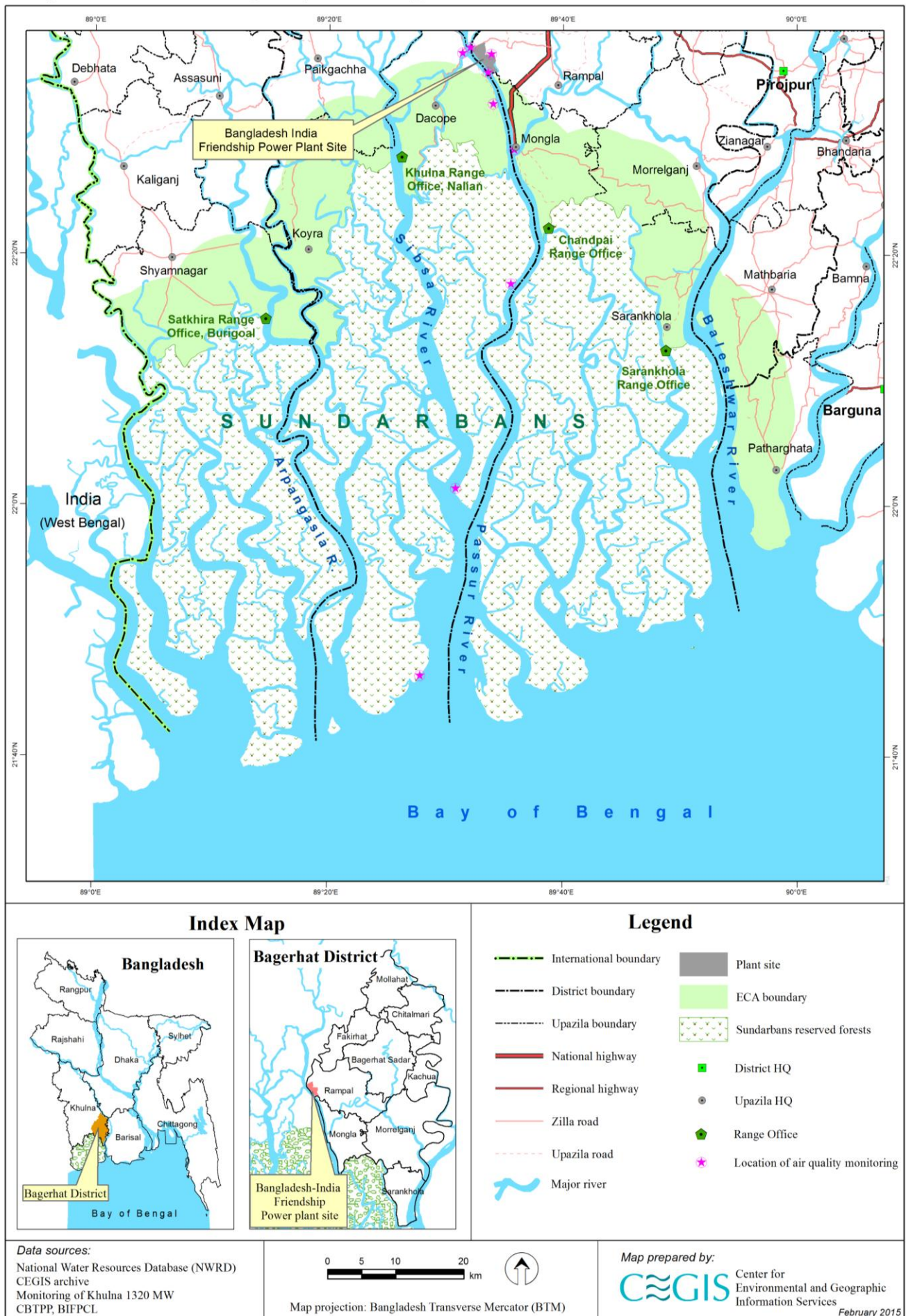
15. Respirable Dust Sampler (Model-Envirotech India APM-460BL) and Fine Particulate Sampler (Model-Envirotech India APM-550) have been used to collect the air sample. The  $PM_{2.5}$ ,  $PM_{10}$ , and SPM have been tested by gravimetric method. The  $SO_2$  has been absorbed and tested by West-Gaeke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

##### 3.1.2 Locations of air quality monitoring

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

Table 3.1 Air Quality Monitoring Plan

Sl no	Monitoring Indicators	Locations	GPS	Frequency	Methods/Tools/Techniques
1	SO <sub>x</sub> , NO <sub>x</sub> , PM <sub>10</sub> , PM <sub>2.5</sub>	South West corner of the project boundary	89°33'34.5"E, 22°34'33.8"N	Quarterly (April, July, October, January)	In situ field measurement provided with the facilities of outsourced laboratory. Method of testing SO <sub>x</sub> : USEPA (2000) Method 6 or 6A or 6B or ISO (1998) Method 11632 (as appropriate) Method of testing NO <sub>x</sub> : USEPA (2000) Method 7 or 7A or 7B or 7C or 7D or ISO (1993) Method 10396 (as appropriate). Method of testing PM <sub>2.5</sub> : Gravimetric Method of testing PM <sub>10</sub> : USEPA (1997) Method 201 or 201A (as appropriate)
2		Proposed township area	89°32'3.8"E, 22°36'32.5"N		
3		North West corner of the project boundary (Kaigardas Kati)	89°33'51.8"E, 22°36'1.06"N		
4		Barni, Gauramba union (4km North East from the chimney location)	89°34'37.7"E, 22°38'51.8"N		
5		Chunkuri-2, Bazua Union (4km South West from the chimney location)	89°34'01.1"E, 22°32'3.3"N		
6		Pankhali, Dacope, (4km North West from the Chimney location)	89°31'24.2"E, 22°36'6.7"N		
7		Mongla Port Area	89°35'50.4"E, 22°28'24.8"N		
8		Harbaria, Sundarbans	89°35'34.2"E, 22°17'43.1"N		
9		Akram point, Sundarbans	89°30'54.1"E, 22°1'23.50"N		
10		Hiron Point, Sundarbans	89°27'53.2"E, 21°46'27.60"N		
11		Khulna city near Khan Jahan Ali Bridge	89°35'35.5"E, 22°46'36.8"N		



Map 3.1: Air Quality Monitoring Location

## 3.2 Results of air quality monitoring

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

17. 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 Kaigar Daskati, Gauramva and the township which are 310, 277 and 274 respectively. In Mongla port area and in the Khan Jahan Ali Bridge, SPM was found slightly higher than the standard; high traffic might be the source of SPM there. Industries especially Cement Industries, road traffic and ongoing 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 3.2**.

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

18. 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 18 µg/m<sup>3</sup> to 28 µg/m<sup>3</sup>. All the monitoring data of ambient air quality are given in **Table 3.2**.

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

19. Similar to SO<sub>2</sub>, NO<sub>2</sub> concentration in the ambient air of Sundarbans was found very low, varying from 17 - 22 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, 36 µg/m<sup>3</sup>, at Khan Jahan Ali Bridge. The monitoring results are shown in **Table 3.2**.

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

20. CO and O<sub>3</sub> concentrations are also very low. CO concentration ranges from 150 µg/m<sup>3</sup> to 296 µg/m<sup>3</sup> in Project area and its adjoining areas, while in Sundarbans the concentration ranges 46 µg/m<sup>3</sup> to 64 µg/m<sup>3</sup>.

**Table 3.2: 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	Sunny										
Wind Direction		SE	SE	SE	NW										
		Concentrations are in µg/m <sup>3</sup>													
SW Corner of the PP area	PM <sub>2.5</sub>	33	37	25	33									65	75
	PM <sub>10</sub>	78	77	53	79									150	150
	SPM	207	239	190	200									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)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny										
Wind Direction		SE	SE	SE	NW										
		Concentrations are in $\mu\text{g}/\text{m}^3$													
	SO <sub>2</sub>	21	24	19	23									365	125
	NO <sub>x</sub>	26	29	27	31									100	200
	CO	120	188	140	190									40000*	NF
	O <sub>3</sub>	27	26	19	22									160*	160
Proposed Township area of the PP	PM <sub>2.5</sub>	39	48	48	39									65	75
	PM <sub>10</sub>	89	90	74	102									150	150
	SPM	217	263	217	274									200	NF
	SO <sub>2</sub>	19	28	22	21									365	125
	NO <sub>x</sub>	29	39	27	26									100	200
	CO	165	210	230	164									40000*	NF
	O <sub>3</sub>	33	26	26	23									160*	160
NW Corner of the PP area	PM <sub>2.5</sub>	37	44	19	42									65	75
	PM <sub>10</sub>	67	78	56	98									150	150
	SPM	234	217	157	310									200	NF
	SO <sub>2</sub>	19	22	18	27									365	125
	NO <sub>x</sub>	23	28	22	32									100	200
	CO	110	178	110	210									40000*	NF
	O <sub>3</sub>	25	19	17	36									160*	160
Barni, Gaurambha	PM <sub>2.5</sub>	39	47	57	39									65	75
	PM <sub>10</sub>	103	122	67	97									150	150
	SPM	233	244	183	277									200	NF
	SO <sub>2</sub>	21	23	17	22									365	125
	NO <sub>x</sub>	25	28	22	26									100	200
	CO	175	210	190	150									40000*	NF
	O <sub>3</sub>	26	29	22	19									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	Sunny										
Wind Direction		SE	SE	SE	NW										
Concentrations are in $\mu\text{g}/\text{m}^3$															
Chunkuri-2, Dacope	PM <sub>2.5</sub>	35	39	46	37									65	75
	PM <sub>10</sub>	77	86	69	68									150	150
	SPM	117	113	162	183									200	NF
	SO <sub>2</sub>	19	24	21	18									365	125
	NO <sub>x</sub>	23	26	27	24									100	200
	CO	190	205	170	170									40000*	NF
	O <sub>3</sub>	27	24	18	22									160*	160
Pankhali, Dacope	PM <sub>2.5</sub>	47	49	57	41									65	75
	PM <sub>10</sub>	119	127	139	101									150	150
	SPM	297	266	254	208									200	NF
	SO <sub>2</sub>	28	31	31	24									365	125
	NO <sub>x</sub>	41	39	36	26									100	200
	CO	230	217	250	188									40000*	NF
	O <sub>3</sub>	49	38	36	27									160*	160
Mongla Port area	PM <sub>2.5</sub>	47	55	39	41									65	75
	PM <sub>10</sub>	139	174	77	82									150	150
	SPM	288	303	197	217									200	NF
	SO <sub>2</sub>	27	28	26	24									365	125
	NO <sub>x</sub>	44	39	33	27									100	200
	CO	230	320	220	211									40000*	NF
	O <sub>3</sub>	57	52	37	26									160*	160
Harbaria, Sundarbans	PM <sub>2.5</sub>	19	22	33	27									65	75
	PM <sub>10</sub>	41	39	59	56									150	150
	SPM	111	117	129	139									200	NF
	SO <sub>2</sub>	9	10	14	12									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)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny										
Wind Direction		SE	SE	SE	NW										
		Concentrations are in $\mu\text{g}/\text{m}^3$													
	NO <sub>x</sub>	19	22	27	18									100	200
	CO	65	58	70	64									40000*	NF
	O <sub>3</sub>	13	12	13	11									160*	160
Akram Point Sundarbans	PM <sub>2.5</sub>	17	19	23	18									65	75
	PM <sub>10</sub>	39	44	32	39									150	150
	SPM	114	133	97	88									200	NF
	SO <sub>2</sub>	7	9	12	13									365	125
	NO <sub>x</sub>	17	19	22	17									100	200
	CO	49	60	50	46									40000*	NF
	O <sub>3</sub>	11	14	9	10									160*	160
Hiron Point Sundarbans	PM <sub>2.5</sub>	15	23	19	17									65	75
	PM <sub>10</sub>	44	38	34	41									150	150
	SPM	101	119	107	97									200	NF
	SO <sub>2</sub>	8	7	13	14									365	125
	NO <sub>x</sub>	18	18	19	22									100	200
	CO	52	62	65	60									40000*	NF
	O <sub>3</sub>	14	13	11	9									160*	160
Khulna City, near Khan Jahan Ali Bridge	PM <sub>2.5</sub>	54	39	52	42									65	75
	PM <sub>10</sub>	139	117	91	84									150	150
	SPM	301	287	239	219									200	NF
	SO <sub>2</sub>	33	29	33	28									365	125
	NO <sub>x</sub>	49	41	39	36									100	200
	CO	330	370	330	296									40000*	NF
	O <sub>3</sub>	59	67	57	39									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**

21. 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**

22. Mostly river traffics of Mongla Port area travelling 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 3.3**.



Table 3.3: Baseline Emission Inventory

		Cement Industry	Petroleum Industry	Brick Field	Road Traffic	Small vessels, engine boat	Inland Water Cargo vessel	Sea going Mother Vessel (MV)	Fly ash Carrier	Clinkers Carrier	Clinker, Fly Ash Handling	Coal Carrier (MV)	Coal Ash Carrier (MV)	Coal Carrier (Lighter Vessel)	Coal Ash Carrier (Lighter Vessel)	Coal Loading and Unloading	Coal Handling (Stock Yard, Conveyor belt, etc)	BIF Power Plant (PP)	Other Coal Based PP	Other Fuel Based PP	Dredging and Land Filling	Earth excavation	Other Construction Activities	Residential sources
SW Corner of the PP area	PM	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	✓	✓
	SOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	NOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
Proposed Township area of the PP	PM	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓
	SOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	NOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
NW Corner of the PP area	PM	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓
	SOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	NOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
Barni, Gaurambha	PM	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓
	SOx	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	NOx	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
Chunkuri-2, Dacope	PM	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	SOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	NOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
Pankhali, Dacope	PM	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	✓
	SOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓

			Cement Industry	Petroleum Industry	Brick Field	Road Traffic	Small vessels, engine boat	Inland Water Cargo vessel	Sea going Mother Vessel (MV)	Fly ash Carrier	Clinkers Carrier	Clinker, Fly Ash Handling	Coal Carrier (MV)	Coal Ash Carrier (MV)	Coal Carrier (Lighter Vessel)	Coal Ash Carrier (Lighter Vessel)	Coal Loading and Unloading	Coal Handling (Stock Yard, Conveyor belt, etc)	BIF Power Plant (PP)	Other Coal Based PP	Other Fuel Based PP	Dredging and Land Filling	Earth excavation	Other Construction Activities	Residential sources
	NOx	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
Mongla Port area	PM	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	✓	×	×	×	✓
	SOx	×	✓	×	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓
	NOx	×	✓	×	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	✓	×	×	×	✓
	GHGs	×	✓	×	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	✓	×	×	×	✓
Harbaria, Sundarbans	PM	×	×	×	×	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
	SOx	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	NOx	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	GHGs	×	×	×	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Akram Point Sundarbans	PM	×	×	×	×	✓	✓	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	SOx	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	NOx	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	GHGs	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Hiron Point Sundarbans	PM	×	×	×	×	✓	✓	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	SOx	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	NOx	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	GHGs	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Khulna City, near Khan Jahan Ali Bridge	PM	✓	×	✓	✓	✓	✓	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	✓	✓
	SOx	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	✓
	NOx	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	✓
	GHGs	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	✓

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

## 4 Noise Monitoring

23. Ambient noise levels were monitored quarterly at eleven locations. Monitoring activities were carried out in March-14, July-14, October-14 and January-15. The detail of the monitoring plan is described in Table 4.1.

### 4.1 Methodology

24. 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 interval 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

25. 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 Khan Jahan Ali Bridge and one is at Mongla Port (Map 4.1).

**Table 4.1: Noise Monitoring Plan**

Sl no	Monitoring Indicators	Locations	GPS (Decimal Degree)	Frequency	Methods/Tools/Techniques
1	Ambient Sound Pressure Level	South West corner of the project boundary	89.5601 ° E, 22.5761 ° N	Quarterly (April, July, October, January)	In situ field measurement by CEGIS Team using portable Noise Level (Sound Pressure Level) Meter
2		Proposed township area	89.5644 ° E, 22.6005 ° N		
3		North West corner of the project boundary (Kaigardas Kati)	89.5334 ° E, 22.6093 ° N		
4		Barni, Gauramba union (4km North East from the chimney location)	89.5772 ° E, 22.6477 ° N		
5		Chunkuri-2, Bazua Union (4km South West from the chimney location)	89.5669 ° E, 22.5342 ° N		
6		Pankhali, Dacope, (4km North West from the Chimney location)	89.5234 ° E, 22.6046°N		
7		Mongla Port Area	89.5936 ° E, 22.4916 ° N		
8		Harbaria, Sundarbans	89.5926 ° E, 22.2968 ° N		
9		Akram point, Sundarbans	89.5152 ° E, 22.0219 ° N		
10		Hiron Point, Sundarbans	89.4614 ° E, 21.7755 ° N		
11		Khulna city near Khan Jahan Ali Bridge	89.5935 ° E, 22.7779 ° N		



Map 4.1: Noise Monitoring Locations



### 4.3 Results of Noise Monitoring

#### 4.3.1 Noise at Dacope Upazila Parishad

26. 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 data shows that noise level of fourth quarter monitoring are closer to the noise level of second and third quarter but still are within the standard (Table 4.1).
27. 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 that eventually resulted in less noise.

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

28. The North West (NW) corner of the Project area falls in Kaigar Daskati mouza of Gaurambha union. The monitoring location was nearby Gucchha gram (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 the noise level has been monitored well within the standard.

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

29. 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 and third quarter monitoring were also found exceeding the standard limit (**Table 4.1**) but this time at the fourth quarter monitoring, it was found just within the standard. 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

30. The South West corner of the Project area falls in Sapmari Katakali 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

31. 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 too (**Table 4.2**).

#### **4.3.6 Noise at Barni, Gaurambha**

32. 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**

33. 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 4<sup>th</sup> quarter 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. 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**

34. 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 4<sup>th</sup> quarter monitoring noise levels were found within the standard level.
35. 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**

36. 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 less than the standard. Ships movement, Ship Salvage operation, engines of anchored ships, wind, birds, wave, and wind action on tree leaves were the main sources of noise in this location.

#### **4.3.10 Noise at Akram point, Sundarbans**

37. 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 within 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**

38. 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 below the standard limit. Birds, stormy wind, wave breaking on the sandy shore and tree leaves are the main sources of noise here.



Table 4.2: 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))				QM4 (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	Morning (9:00)	Afternoon (13:00)	Evening (18:00)	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	51.92	53.70	54.21	53.28	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	33.87	36.42	35.46	35.25	50.00
3	Chunkuri-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	55.08	46.29	46.49	49.29	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	36.57	34.24	37.27	36.03	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	41.49	39.55	43.37	41.47	50.00
6	Barni, Gaurambha	64.95	50.93	60.65	58.84	48.73	50.37	50.75	49.95	50.18	50.89	48.27	49.78	43.36	38.56	48.86	43.60	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	61.34	63.40	60.41	61.72	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	40.26	35.04	40.76	38.69	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	36.36	32.40	-	34.38	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	37.90	30.75		34.32	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	42.82	31.93		37.37	45.00

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



## 5 Water Quality Monitoring

39. Water quality monitoring has been scheduled in each quarter of a year as per the contract. So, in the first year of monitoring, this component has been monitored four (4) times during each field visit. The details of the monitoring plan is shown in Table 5.1. Data usually are acquired from field and collected samples are brought into laboratory for various analyses. In this report, both types of data from 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> quarterly monitoring have been enumerated; but for 4<sup>th</sup> quarterly monitoring, data recorded in situ condition has been illustrated only as because of the laboratory results for the specific samples are still awaiting analysis.

### 5.1 Methodology

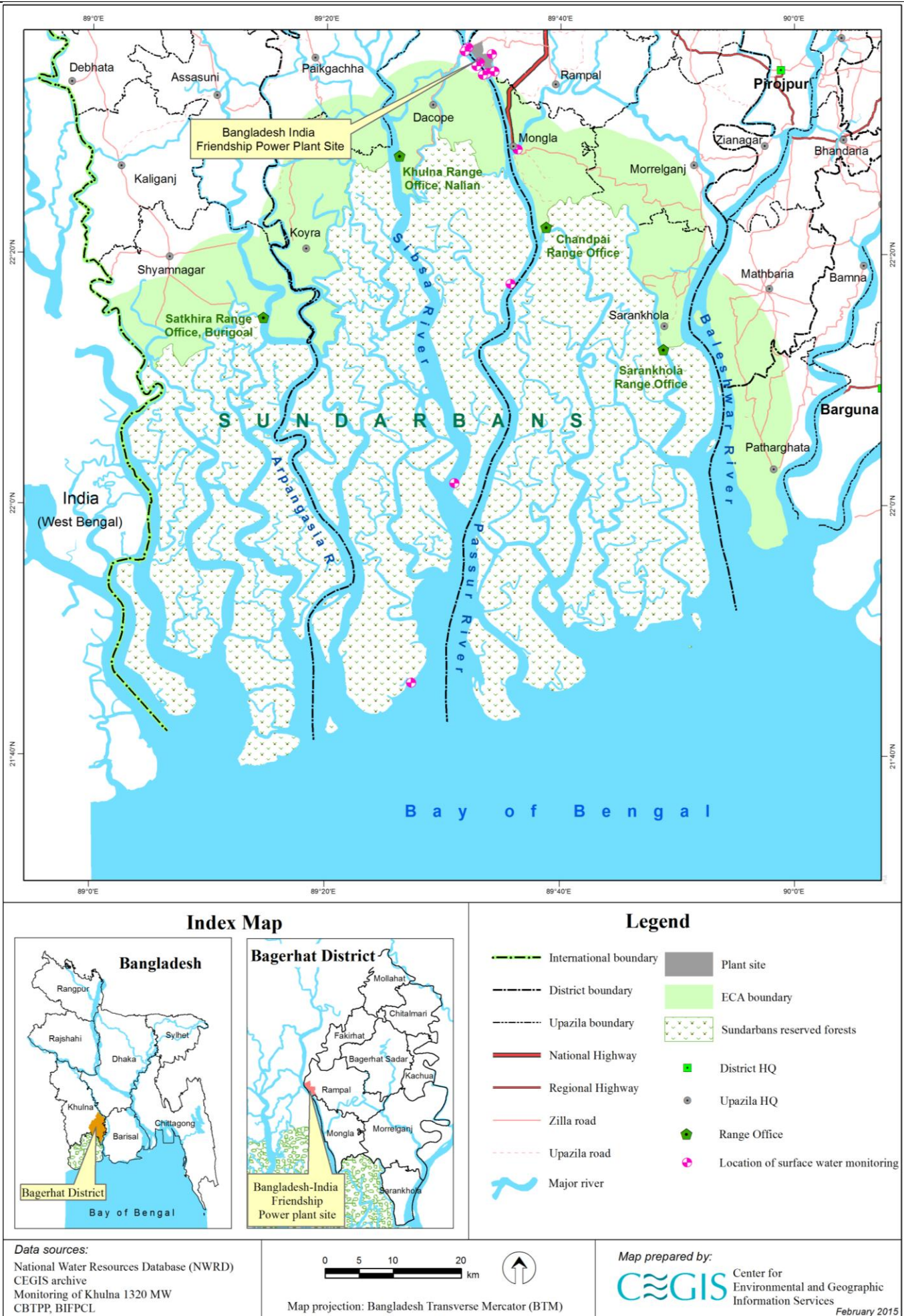
40. Monitoring of water quality directly depends on selection of water quality parameters, sampling points, sampling frequency, evaluation criteria etc. Standard practices have been followed for monitoring of water quality of Passur Sibsha River System (RS). This study is measuring both surface and ground 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, third and fourth monitoring was performed in April, July and October in 2014 and January 2015 respectively. As a part of entire monitoring activities, sample collection for fourth monitoring schedule was started from 9<sup>th</sup> to 17<sup>th</sup> January 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 have not only been presented but also been compared with the national and international standards.

### 5.2 Sampling Location

41. Similar to the first, second and third 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.

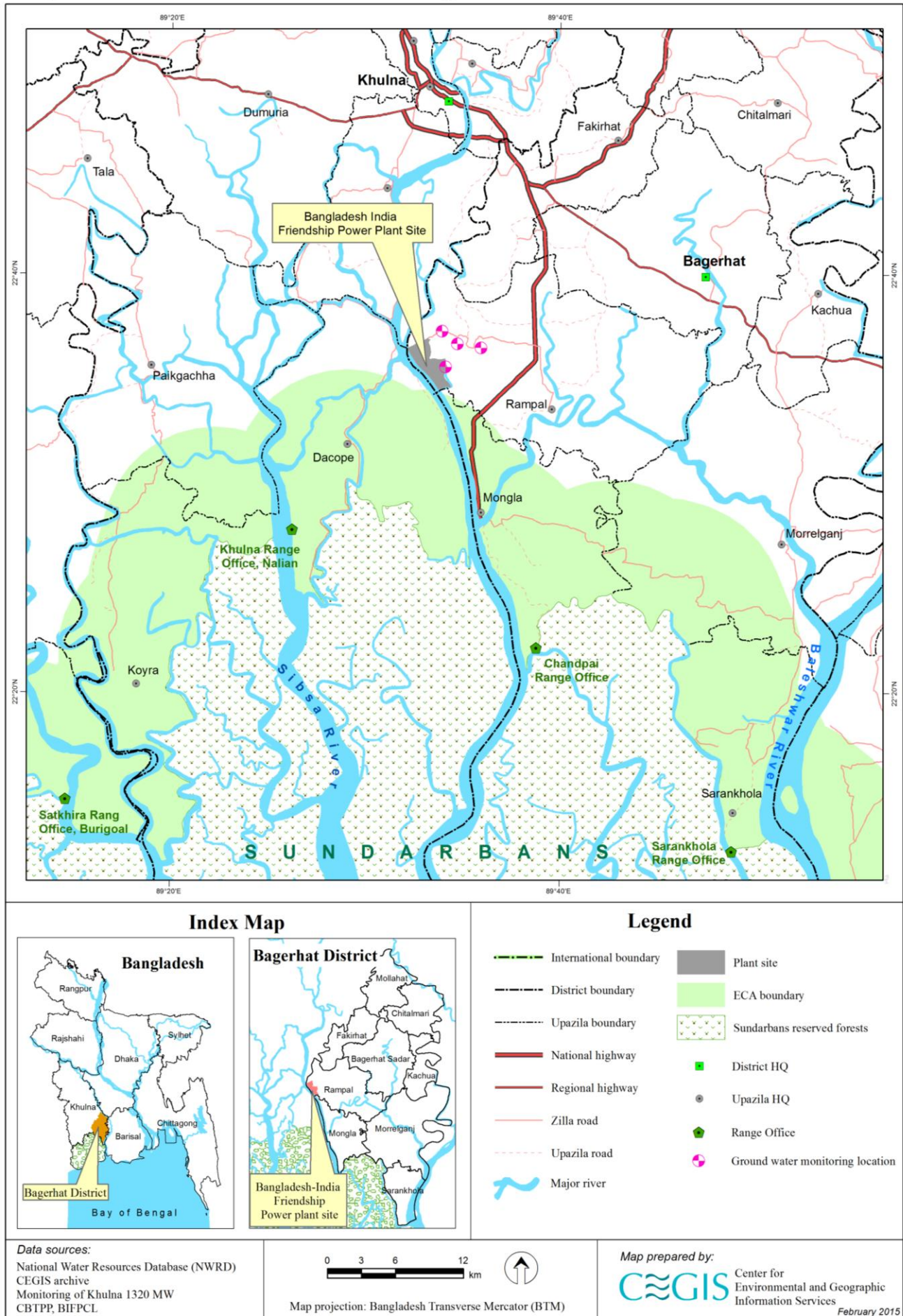
**Table 5.1: Surface Water Quality Monitoring Parameters, Locations and Plan**

SI no	Monitoring Indicators	Locations	GPS (Decimal Degree)		Frequency	Methods/Tools/ Techniques
			Easting	Northing		
1	pH, Temperature, Salinity, DO, BOD, TDS, TH, TSS, COD, Nitrate, Sulphate, Phosphate, Arsenic, Lead, Mercury, Oil & Grease	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	22.604167	89.527222	Quarterly (April, July, October, January)	Insitu measurement and Laboratory analysis
2		Middle of Passur River at 100m u/s of North West corner from the Project boundary	22.607222	89.528889		
3		Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	22.609361	89.531417		
4		Left Bank of Passur River at Project site-Jetty	22.584833	89.543583		
5		Middle Passur River at Project site-Jetty	22.587667	89.546472		
6		Right Bank of Passur River at Project site-Jetty	22.589333	89.548222		
7		Left Bank of Passur River at South West corner from the Project boundary	22.572889	89.552583		
8		Middle of Passur River at South West corner from the Project boundary	22.574611	89.557500		
9		Right Bank of Passur River at South West corner from the Project boundary	22.575667	89.559861		
10		Maidara river at the South East corner of the project at Ichamoti-Maidara confluence	22.600639	89.565611		
11		Maidara river near proposed township area	22.577472	89.569250		
12		Passur river at Passur - Mongla confluence	22.473861	89.602361		
13		Passur river at Harbaria of Sundarbans	22.295250	89.593139		



Map 5.1: Surfacewater Quality Monitoring Locations





Map 5.2: Groundwater Quality Monitoring Locations

### 5.3 Sampling Procedure

42. 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 which will reduce the error as well as increase the level of confidence of the results.
43. 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 samples were collected from the river surface.
44. 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 with sample water. Acidified sampling bottles were used for heavy metals (As, Pb, Hg) sampling and wrinkle bottles were used for BOD5 sampling. Samples were preserved as per standard practices.
45. 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

46. The selected parameters for water quality monitoring includes Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Heavy Metals (As, Pb, Hg), pH, Salinity, Hardness, Nitrate ( $\text{NO}_3$ ), Total Dissolve Solids (TDS), Total Hardness (TH), Turbidity, Temperature and 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.

#### 5.3.2 Ground water quality

47. 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 Engineering (DPHE). The selected parameters are presented in Table 5.2.

**Table 5.2: Ground Water Quality Monitoring Parameters, Locations and Plan**

Sl no	Monitoring Indicators	Locations	GPS (Decimal Degree)		Frequency	Methods/Tools/ Techniques
			Easting	Northing		
1	pH, Temperature, Salinity, DO, COD, As, Hg, Total hardness, Nitrate, TS, TDS, TSS, Nitrate, Sulphate, Phosphate	Near Proposed Township Area of the Project	22.594167	89.566139	Quarterly (April, July, October, January)	Insitu measurement and Laboratory analysis
2		Rajnagar Union	22.612528	89.576056		
3		Kalekerber Union	22.609306	89.596278		
4		Kapasdanga Union	22.622528	89.563000		



### 5.3.3 Water quality analysis procedure

48. 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 Methodology of Water Quality Parameter**

Parameters	Unit	Methods
Temperature	$^{\circ}\text{C}$	TDS meter
pH		Microprocessor pH meter
TDS	ppm	TDS meter
TSS	ppm	Drying and Filtration
Salinity	ppt	Salinity Refractometer (Master- S/MillM Cal. No. 2493, ATAGO)
DO	ppm	Dissolved Oxygen meter DO-5509
BOD	ppm	5-Day BOD Test at $20^{\circ}\text{C}$
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)
Pb	ppm	Atomic Absorption Spectrophotometers–Graphite Furnace (AAS-GF)
Hg	ppm	Mercury Analyzer

49. 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
- (iv) Heavy metals i.e. As, Pb and Hg

## 5.4 Results of surface water quality monitoring

### 5.4.1 In-situ parameters

#### (a) pH

50. In January (winter season), pH values in the Passur-Sibsha River System (RS) varied from 7.3 to 8.1 that are within the standard limit (6.5 – 8.5) of ECR'97 for inland surface waters. Highest (8.2) pH value was found at Passur river at Passur-Mongla Confluence. In rest of the places, it varies from 7.3 to 8.1 where second highest pH value (8.1) was found at most of the sampling points in this fourth quarterly monitoring study.

51. The monitoring results show that there is a seasonal variation in pH of the Passur-Sibsha RS. This time (January, 2015), the pH values were found to be slightly lower than the third quarterly monitoring study which was conducted in October 2014 (Post-monsoon) but comparatively higher than the first (pre-monsoon) and second (monsoon) quarterly monitoring. During post monsoon and winter seasons river water level normally goes down because of less rainfall and less upstream flow of Passur-Sibsha RS and make pH values little bit higher than pre-monsoon and monsoon seasons. In contrary, comparatively lower pH values in post monsoon and monsoon periods mainly for the high up stream flow and rain fall runoff.
52. After all, compare to first, second and third quarter monitoring results, the pH value found in the fourth quarter monitoring has been slight alkaline in nature. The measured pH values of selected monitoring locations during first, second, third and fourth quarterly monitoring of Passur-Sibsha RS are presented in **Table 5.4**.

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

SI	Sampling Locations	pH Values				
		1QM	2QM	3QM	4QM	BD 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	7.9	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	8.0	
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	7.2	6.9	8.0	8.1	
4	Left Bank of Passur River at Project site-Jetty	7.9	7.1	8.1	7.9	
5	Middle Passur River at Project site-Jetty	7.1	6.9	8.1	7.9	
6	Right Bank of Passur River at Project site-Jetty	7.1	6.9	8.2	7.9	
7	Left Bank of Passur River at South West corner from the Project boundary	7.4	7.0	8.1	7.6	
8	Middle of Passur River at South West corner from the Project boundary	7.4	6.9	8.0	7.5	
9	Right Bank of Passur River at South West corner from the Project boundary	7.3	6.8	8.0	7.8	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	7.4	6.9	8.1	7.7	
11	Maidara river near proposed township area	7.4	6.8	8.1	7.3	
12	Passur river at Passur-Mongla confluence	7.3	6.8	7.4	8.2	
13	Passur river at Harbaria of Sundarbans	7.9	6.9	8.0	8.1	
14	Passur river at Akram point of Sundarbans	7.2	6.9	7.9	8.1	
15	Passur river at Hiron point of Sundarbans	7.2	7.0	7.0	8.1	

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

#### (b) Temperature

53. The surface water temperature observed during fourth quarterly monitoring varies from 19°C to 22°C, which is very common in winter season. 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 fourth quarter monitoring and found

lower than the first, second and third as January is cooler period than April, July and October according to the seasonal weather pattern exists in Bangladesh. The measured temperature values of selected monitoring locations during first, second, third and fourth quarterly monitoring of Passur-Sibsha RS are presented in **Table 5.5**.

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

SI	Sampling Locations	Temperature (°C)				
		1QM	2QM	3QM	4QM	BD Standard
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	31	33	31	19	20 – 30 °C
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	31	33	31	20	
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	31	33	30	20	
4	Left Bank of Passur River at Project site-Jetty	31	33	31	19	
5	Middle Passur River at Project site-Jetty	30	32	31	19	
6	Right Left Bank of Passur River at Project site-Jetty	30	32	31	19	
7	Left Bank of Passur River at South West corner from the Project boundary	31	32	30	20	
8	Middle of Passur River at South West corner from the Project boundary	31	31	29	19	
9	Right Bank of Passur River at South West corner from the Project boundary	31	31	29	19	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	30	31	28	19	
11	Maidara river near proposed township area	30	32	27	20	
12	Passur river at Passur-Mongla confluence	29	30	32	19	
13	Passur river at Harbaria of Sundarbans	30	30	27	22	
14	Passur river at Akram point of Sundarbans	29	29	30	21	
15	Passur river at Hiron point of Sundarbans	29	30	29	21	

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

### (c) Salinity

54. Water salinity at the selected sampling stations of Passur-Sibsha RS of consecutive four seasons is presented in **Table 5.6**. In this fourth quarter monitoring (January 2015), salinity ranged was found from 4.1 to 23.0 ppt in river water. High salinity was observed in the river section from Akram point to further downstream. In January, freshwater flow from the upstream sources is insufficient to dilute the salinity intrusion from the sea.
55. Observing complete four seasons, salinity was found higher in winter and pre-monsoon seasons in the river system. High fresh water from upstream and rainfall in monsoon and post monsoon seasons, made river water saline almost zero.

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

SI	Sampling Locations	Salinity (ppt)			
		1 QM	2 QM	3 QM	4QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	11.5	2.5	0.0	4.5

SI	Sampling Locations	Salinity (ppt)			
		1 QM	2 QM	3 QM	4QM
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	11.5	0.3	0.0	4.1
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	11.5	0.2	0.0	4.5
4	Left Bank of Passur River at Project site-Jetty	12.0	2.2	0.0	4.7
5	Middle Passur River at Project site-Jetty	12.0	0.3	0.0	5.1
6	Right Bank of Passur River at Project site-Jetty	12.0	0.5	0.0	5.0
7	Left Bank of Passur River at South West corner from the Project boundary	9.5	4.0	0.0	5.2
8	Middle of Passur River at South West corner from the Project boundary	9.0	0.0	0.0	5.2
9	Right Bank of Passur River at South West corner from the Project boundary	10.0	2.5	0.0	5.1
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	10.0	0.5	0.0	5.2
11	Maidara river near proposed township area	9.0	4.5	0.0	4.5
12	Passur river at Passur-Mongla confluence	10.0	9.5	0.0	5.0
13	Passur river at Harbaria of Sundarbans	12.0	10.0	0.0	6.0
14	Passur river at Akram point of Sundarbans	19.0	15.0	1.0	16.0
15	Passur river at Hiron point of Sundarbans	23.0	19.5	2.0	23.0

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

#### (d) Dissolved Oxygen

56. Passur-Shibsha 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 while at Winter (January 2015) it ranged 5.5-6.9 mg/L. Maximum and minimum concentration of DO was measured in post monsoon and pre-monsoon periods respectively.
57. 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.
58. Seasonal variations of DO at the monitoring sites of Passur-Shibsha RS are shown in **Table 5.7**.

**Table 5.7: Dissolve Oxygen in Passur River**

SL	Sampling Locations	Dissolve Oxygen (mg/L)				
		1QM	2QM	3QM	4QM	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	5.5	5 or more (standard for sustaining
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	4.9	6.8	7.7	6.6	

SL	Sampling Locations	Dissolve Oxygen (mg/L)				
		1QM	2QM	3QM	4QM	BD Standard
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	5.2	6.7	7.7	6.7	fisheries)
4	Left Bank of Passur River at Project site-Jetty	5.7	6.8	7.6	5.8	
5	Middle Passur River at Project site-Jetty	5.9	6.9	7.2	5.9	
6	Right Bank of Passur River at Project site-Jetty	5.8	6.6	8.0	6.8	
7	Left Bank of Passur River at South West corner from the Project boundary	6.6	7.3	5.6	6.1	
8	Middle of Passur River at South West corner from the Project boundary	6.5	7.1	5.6	6.9	
9	Right Bank of Passur River at South West corner from the Project boundary	6.5	7.2	5.8	6.6	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	6.0	6.5	8.0	6.0	
11	Maidara river near proposed township area	6.7	6.8	8.0	6.2	
12	Passur river at Passur-Mongla confluence	5.3	6.2	7.0	6.5	
13	Passur river at Harbaria of Sundarbans	5.4	5.9	7.0	6.6	
14	Passur river at Akram point of Sundarbans	7.9	6.4	7.7	6.7	
15	Passur river at Hiron point of Sundarbans	7.5	6.5	7.8	6.5	

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

#### (e) Biochemical Oxygen Demand

59. During fourth quarterly monitoring, BOD<sub>5</sub> values varied from 0.8 to 2.7 mg/L. The highest BOD<sub>5</sub> was found at Right Bank of Passur River at 100m u/s of North West corner from the Project boundary (2.7 mg/L) while lowest (0.8 mg/L) BOD<sub>5</sub> observed at Left Bank of Passur River at Project site-Jetty. BOD<sub>5</sub> of Winter season of the Passur-Shibsha RS fully complies with the BD standard (6 or less for sustaining fisheries).
60. In general, among the four seasons, BOD<sub>5</sub> was found to be very low in winter season while high BOD<sub>5</sub> was observed in pre-monsoon season. The water temperatures was lower in winter season than those of pre-monsoon, monsoon and post monsoon seasons, which intern decreases the bacterial and microbial activities and contributes a low level of BOD<sub>5</sub>, in winter season. The measured BOD<sub>5</sub> values at different monitoring locations during first, second, third and fourth quarterly monitoring of Passur-Shibsha RS are presented in **Table 5.8**.

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

SL	Sampling Locations	Biochemical Oxygen Demand (mg/L)				
		1Q M	2Q M	3Q M	4Q M	BD 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	1.6	6 or less (for sustaining fisheries)
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	4.9	3.3	4.1	2.3	
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	2.2	2.8	3.4	2.7	
4	Left Bank of Passur River at Project site-Jetty	3.2	3.1	4.0	0.8	
5	Middle Passur River at Project site-Jetty	3.0	2.5	3.5	1.4	
6	Right Left Bank of Passur River at Project site-Jetty	5.8	3.5	3.6	2.0	

SL	Sampling Locations	Biochemical Oxygen Demand (mg/L)				
		1Q M	2Q M	3Q M	4Q M	BD Standard
7	Left Bank of Passur River at South West corner from the Project boundary	3.9	2.8	2.6	1.0	
8	Middle of Passur River at South West corner from the Project boundary	3.8	3.3	2.8	2.6	
9	Right Bank of Passur River at South West corner from the Project boundary	6.5	3.8	2.9	2.1	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	3.2	3.3	5.5	1.5	
11	Maidara river near proposed township area	4.1	3.7	4.0	2.0	
12	Passur river at Passur-Mongla confluence	2.3	2.2	1.7	2.0	
13	Passur river at Harbaria of Sundarbans	2.2	2.5	2.6	1.9	
14	Passur river at Akram point of Sundarbans	5.0	2.9	3.7	2.2	
15	Passur river at Hiron point of Sundarbans	4.3	2.7	3.9	2.3	

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

## 5.4.2 Laboratory tested parameters

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

61. 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 to 21,500 mg/L in pre-monsoon season. On the other hand, in monsoon and post monsoon seasons, TDS concentration in observed locations found to be in between 251 to 15,960 mg/L and 152 to 5,720 mg/L respectively.
62. 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 post monsoon while very high in pre-monsoon season in Passur and Shibsha rivers. In monsoon and post monsoon period the Passur-Shibsha river system receives large volume of fresh water compare to pre-monsoon period which reduced TDS drastically by mixing up with upstream freshwater (rainfall and surface runoff).
63. During pre-monsoon, monsoon and post 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 (Ca<sup>2+</sup>, Mg<sup>2+</sup>, Sr<sup>2+</sup> etc) of the water more than the upstream monitoring points.
64. During pre-monsoon period, the water hardness in the sampling stations of Passur River was found to be ranged 2,500-13,060 mg/L, whereas it remarkably decreased and ranged 251–13,625 mg/L in monsoon and 216-1440 mg/L in post 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 the three seasons of Passur-Shibsha RS.
65. Total Suspended Solid (TSS) includes solid materials of organic and inorganic origins that are suspended in the water. Suspended matters in Passur and Shibsha Rivers are comprised by 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. On the other hand, TSS concentration was found much higher in post monsoon season than the previous two seasons at most of the observed locations except Akram point (28 mg/L) of Passur river. Due to less rainfall and upstream flow, TSS was found much higher in dry season mainly.

66. The TDS, TH and TSS of pre-monsoon, monsoon and post 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	3QM	1QM	2QM	3QM	1QM	2QM	3QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	13060	251	176	2900	250	216	598	126	234
2	Middle of Passur River at 100m u/s of North West corner from the Project boundary	12630	246	162	2500	180	218	45	92	193
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	12900	383	153	2650	170	335	53	112	174
4	Left Bank of Passur River at Project site-Jetty	13190	445	169	2550	175	390	54	99	227
5	Middle Passur River at Project site-Jetty	13330	353	156	2600	275	340	60	100	232
6	Right Bank of Passur River at Project site-Jetty	13380	402	152	2625	350	355	55	105	186
7	Left Bank of Passur River at South West corner from the Project boundary	13180	655	162	2550	325	330	24	116	185
8	Middle of Passur River at South West corner from the Project boundary	13390	587	153	2800	350	345	27	112	536
9	Right Bank of Passur River at South West corner from the Project boundary	13240	916	154	2500	475	325	67	37	459
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	12400	455	214	2500	450	350	7	65	798
11	Maidara river near proposed township area	10970	2510	257	2400	725	330	9	24	389
12	Passur river at Passur - Mongla confluence	12800	6410	209	3150	1400	377	50	310	203
13	Passur river at Harbaria of Sundarbans	12280	9360	285	2625	2150	345	65	90	869
14	Passur river at Akram point of Sundarbans	21500	15960	3400	4500	3625	980	115	99	28
15	Passur river at Hiron point of Sundarbans	21500	14050	5720	4850	3050	1440	91	72	267

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) Chemical Oxygen Demand

67. In general, COD found to be higher in Passur-Shibsha RS. The river contain high load of organic content. Total Organic Content (TOC), 6.25 -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.

68. The COD concentration of pre-monsoon, monsoon and post monsoon seasons at different monitoring locations are presented in **Table 5.10**. In monsoon (July) and post monsoon (October), COD was found lower than the pre-monsoon (April). In July, higher discharge diluted the COD load in the river which also influenced to reduce COD concentration in October.

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

SI	Sampling Locations	COD (mg/L)		
		1QM	2QM	3QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	288	24	26
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	284	20	30
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	328	56	14
4	Left Bank of Passur River at Project site-Jetty	376	28	18
5	Middle Passur River at Project site-Jetty	400	60	14
6	Right Bank of Passur River at Project site-Jetty	364	496	18
7	Left Bank of Passur River at South West corner from the Project boundary	364	108	10
8	Middle of Passur River at South West corner from the Project boundary	400	40	22
9	Right Bank of Passur River at South West corner from the Project boundary	408	120	10
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	276	32	10
11	Maidara river near proposed township area	284	96	26
12	Passur river at Passur - Mongla confluence	408	172	14
13	Passur river at Harbaria of Sundarbans	372	216	14
14	Passur river at Akram point of Sundarbans	536	520	54
15	Passur river at Hiron point of Sundarbans	540	416	122

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) Nitrate, Sulphate and Phosphate



69. Nitrate concentrations as  $\text{NO}_3\text{-N}$  in the Passur-Shibsha RS observed generally low and varied from 0.10 to 2.70 mg/L, 0.76 to 3.32 mg/L and 0.32 to 2.26 mg/L in pre-monsoon, monsoon and post monsoon seasons respectively. Nitrate concentration in monsoon season is comparatively little bit higher than the pre-monsoon and post monsoon seasons but these three seasons fully complied with the BD standards (10.0 mg/L). Generally, over the whole river system the nitrate is showing low concentration and irregular spatial variation in all observed points over these three seasons.
70. Naturally,  $\text{SO}_4^{2-}$  is higher in sea water as well as river in coastal region. From the observed dataset, it is seen that  $\text{SO}_4^{2-}$  is very high in pre-monsoon season which ranged in between 1,120-2,600 mg/L during the monitoring period. In contrary,  $\text{SO}_4^{2-}$  concentration found to be low in monsoon (ranged 20-1,400 mg/L) and post monsoon (ranged 27-2,360 mg/L) seasons except Akram and Hiron points of Sundarbans. At Akram and Hiron points,  $\text{SO}_4^{2-}$  concentrated in a range of 1160-1400 mg/L and 1390-2360 mg/L at monsoon and post monsoon seasons respectively. Usually,  $\text{SO}_4^{2-}$  concentration of Passur-Shibsha RS increases from upstream to downstream of the rivers. Comparatively lower  $\text{SO}_4^{2-}$  in monsoon and post monsoon seasons is the dilution effect of upstream fresh water.
71. Due to similar reason,  $\text{PO}_4^{2-}$  concentration was found higher in pre-monsoon (ranged 0.52-7.51 mg/L) compare to monsoon (ranged 0.45-2.55 mg/L) and post monsoon (ranged 0.67-1.27 mg/L) seasons in observed locations.
72. The observed  $\text{NO}_3^{2-}$ ,  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentration at different monitoring locations during pre-monsoon, monsoon and post 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**

Sl	Sampling Locations	$\text{NO}_3^{2-}$ (mg/L)			$\text{SO}_4^{2-}$ (mg/L)			$\text{PO}_4^{2-}$ (mg/L)		
		1QM	2QM	3QM	1QM	2QM	3QM	1QM	2QM	3QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	0.90	2.89	0.32	1840	20	26	0.52	2.23	0.67
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	0.70	2.40	1.57	1320	23	28	0.50	1.99	1.12
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	0.10	3.20	1.84	1280	36	34	1.10	2.55	0.95
4	Left Bank of Passur River at Project site-Jetty	1.30	0.76	1.64	1360	45	33	2.10	0.45	0.92
5	Middle Passur River at Project site-Jetty	1.40	2.69	1.42	1040	32	30	2.20	2.13	1.11
6	Right Bank of Passur River at Project site-Jetty	1.10	2.98	1.33	1320	20	27	2.00	2.42	0.99
7	Left Bank of Passur River at South West corner from the Project boundary	0.75	2.13	1.85	1640	60	40	0.57	1.25	1.18
8	Middle of Passur River at South West corner from the Project boundary	1.10	2.43	2.09	1520	40	35	1.20	1.51	1.25
9	Right Bank of Passur River at South West corner from the Project boundary	1.20	2.05	2.21	1280	80	64	1.50	1.10	1
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	0.30	2.18	2.26	1120	20	63	0.55	2.10	1.27
11	Maidara river near proposed township area	0.50	0.88	1.98	1320	210	63	1.10	0.53	1.04

12	Passur river at Passur - Mongla confluence	0.60	1.52	1.64	1360	620	44	1.30	0.35	0.86
13	Passur river at Harbaria of Sundarbans	1.40	1.75	1.67	1560	860	69	1.10	0.56	1.22
14	Passur river at Akram point of Sundarbans	2.70	3.32	0.59	2600	1400	1390	1.30	0.29	0.8
15	Passur river at Hiron point of Sundarbans	0.80	2.84	0.4	2080	1160	2360	7.51	0.29	1.09

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) Heavy Metals

73. As, Pb and Hg concentrations were found to be very low in river water during all three seasons of pre-monsoon, monsoon and post monsoon. The observed As, Pb and Hg concentrations during the three seasons are presented in **Table 5.12**.

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

SI	Sampling Locations	As (mg/L)			Pb (mg/L)			Hg (mg/L)		
		1QM	2QM	3QM	1QM	2QM	3QM	1QM	2QM	3QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	0.002	0.003	0.004	0.053	0.004	0.002	<0.00015	<0.00015	<0.00015
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	0.002	0.003	0.004	0.055	0.002	0.003	<0.00015	<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	0.004	0.055	0.005	0.002	<0.00015	<0.00015	<0.00015
4	Left Bank of Passur River at Project site-Jetty	0.002	0.004	0.004	0.057	0.002	0.003	<0.00015	<0.00015	<0.00015
5	Middle Passur River at Project site-Jetty	0.002	0.004	0.004	0.060	0.002	0.002	<0.00015	<0.00015	<0.00015
6	Right Bank of Passur River at Project site-Jetty	0.002	0.003	0.003	0.058	0.002	0.002	<0.00015	<0.00015	<0.00015
7	Left Bank of Passur River at South West corner from the Project boundary	<0.001	0.003	0.006	0.053	0.002	0.003	<0.00015	<0.00015	<0.00015
8	Middle of Passur River at South West corner from the Project boundary	<0.002	0.004	0.004	0.054	0.003	0.004	<0.00015	<0.00015	<0.00015
9	Right Bank of Passur River at South West corner from the Project boundary	0.002	0.003	0.006	0.056	0.005	0.004	<0.00015	<0.00015	<0.00015
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	<0.001	0.003	0.006	0.053	0.004	0.004	<0.00015	<0.00015	<0.00015
11	Maidara river near proposed township area	0.002	0.002	0.003	0.048	0.004	<0.002	<0.00015	<0.00015	<0.00015
12	Passur river at Passur - Mongla confluence	0.002	0.004	0.003	0.050	0.032	<0.002	<0.00015	<0.00015	<0.00015
13	Passur river at Harbaria of Sundarbans	0.004	0.003	0.004	0.043	0.044	0.004	<0.00015	<0.00015	<0.00015
14	Passur river at Akram point of Sundarbans	0.004	0.002	0.002	0.194	0.071	0.032	0.0020	<0.00015	<0.00015
15	Passur river at Hiron point of Sundarbans	0.003	0.002	0.003	0.224	0.050	0.07	0.0023	<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), 3QM = Third Quarterly Monitoring (October, 2014)

### (e) Oil and Grease

74. 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, monsoon and post monsoon periods, the concentration of oil and grease was found negligible and all of the monitoring locations fully comply with the ECR' 1997 Standard. 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**

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

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

## 5.5 Ground water quality monitoring

### 5.5.1 In-situ parameters

#### (a) pH and Temperature

75. Physical parameter pH and temperature in observed locations fully comply with the drinking water quality standards of ECR, 1997 for the consecutive four seasons. The pH values of fourth quarter monitoring (January 2015) found to be varying from 8.0 to 8.2 while temperature was found to be in between 22.5.0°C to 25.1°C (Table 6.14). The first, second, third and fourth monitoring results of pH and temperatures of four selected locations are presented in **Table 5.14**.

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

SI	Locations	Tube Well Type	pH value					Temperature (°C)				
			1 QM	2 QM	3 QM	4 QM	BD Standard*	1 QM	2 QM	3 QM	4 QM	BD Standard*
1	Near Proposed Township	Deep (>600 ft)	7.6	7.7	7.9	8.0	6.5-8.5	27.3	28.5	26.0	24.5	20 – 30° C

2	Rajnagar	Deep (>600 ft)	7.6	7.8	8.0	8.2		29.6	29.9	28.0	22.5	
3	Kalekharber	Shallow (<250 ft)	6.3	6.5	NF	NF		27.5	28.7	NF	NF	
4	Kapasdanga	Deep (>600 ft)	7.6	7.7	8.0	8.1		29.2	28.9	28.0	25.1	

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

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

\*\*Non-functional tube well

### (b) Salinity and Dissolved Oxygen

76. The hand pump tube wells, the samples were collected in the consecutive four seasons (pre-monsoon to winter), found fully free from salinity except one point in winter period. Sampling site which is located near proposed township area was found to be affected by salinity (1ppt) in this fourth quarterly monitoring study. In case of dissolved oxygen, observed DO levels were found to be in between 6.3 - 6.7 mg/L in this last monitoring study. ECR 1997 defines DO standard as 6 mg/L but it is not clearly mentioned whether it is maximum or minimum concentration. Actually, World Health Organization (WHO) does not consider DO as a 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)				
			1 QM	2 QM	3 QM	4 QM	BD Standard*	1 QM	2 QM	3 QM	4 QM	BD Standard*
1	Near Proposed Township	Deep (>600 ft)	0	0	0	1	N/A***	4.4	5.2	6.5	6.7	6 mg/L
2	Rajnagar	Deep (>600 ft)	0	0	0	0		6.0	6.2	7.7	6.3	
3	Kalekharber	Shallow (<250 ft)	0	0	NF*	NF*		4.4	6.0	NF**	NF**	
4	Kapasdanga	Deep (>600 ft)	0	0	0	0		6.4	6.5	6.1	6.5	

Source: Field Survey- April, July and October 2014 and January 2015

Note: 1QM= First Quarterly Monitoring (April, 2014), 2QM = Second Quarterly Monitoring (July, 2014), 3QM = Third Quarterly Monitoring (October, 2014), 4QM = Fourth Quarterly Monitoring (January 2015)

\*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

77. Ground water TDS, TSS and TH value of first, second and third quarter monitoring have been presented in **Table 5.16**.

78. 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 actually within the drinking water quality standard. In case of

third (October 2014) quarter monitoring, it was not possible to monitor TDS concentrations timely.

79. TSS was found within the standard limit in this second quarter except on point. TSS was found very higher (48 mg/L) in the tube well in Kalekharber. This tube well was installed at shallow depth which might be a reason of higher TSS. On the other hand, TSS was found higher (19 mg/L) than the standard limit (10 mg/L) in another point of near township area of the proposed project during post monsoon monitoring period.

**Table 5.16: TDS, TSS 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*
			1 QM	2 QM	3 QM		1 QM	2 QM	3 QM		1 QM	2 QM	3 QM	
1	Township near project site	Deep (>600 ft)	1113	999	-	1000 mg/L	-	6	19	10 mg/L	425	250	300	200-500 mg/L
2	Rajnagar	Deep (>600 ft)	4090	371	-		-	6	2		220	175	180	
3	Kalekharber	Shallow (<250 ft)	1055	970	-		-	48	NF*		780	450	NF*	
4	Kapasdanga	Deep (>600 ft)	643	635	-		-	8	6		190	140	180	

Source: Field Survey- April, July and October 2014

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

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

80. 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

81. 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 pre-monsoon, monsoon and post monsoon seasons. In pre-monsoon season, the concentration found in between 28-48 mg/L whereas in monsoon and post monsoon it was observed in ranges of 28-36 mg/L and 8-34 mg/L respectively. The COD concentrations of first, second and third quarter monitoring are presented in **Table 5.17**.

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

SI	Locations	Tube Well Type	COD (mg/L)			
			1QM	2QM	3QM	BD standard
1	Township near project site	Deep (>600 ft)	32	32	34	4
2	Rajnagar	Deep (>600 ft)	28	28	18	
3	Kalekharber	Shallow (<250 ft)	32	36	NF*	
4	Kapasdanga	Deep (>600 ft)	48	32	34	

Source: Field Survey- April, July and October 2014

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

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

\*Non Functional Hand Pump

### (c) Nitrate, Sulphate and Phosphate

82. 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**

SI	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 *
			1 QM	2 QM	3 QM		1 QM	2 QM	3 QM		1 QM	2 QM	3 QM	
1	Township near project site	Deep (>600 ft)	0.20	0.48	<0.10	10.0	-	3	-	400	-	2.2	-	6.0
2	Rajnagar	Deep (>600 ft)	0.60	0.68	0.31		-	2	-		-	2.5	-	
3	Kalekharber	Shallow (<250 ft)	0.40	0.56	NF		-	3	NF		-	1.2	NF	
4	Kapasdanga	Deep (>600 ft)	0.80	0.40	0.80		-	10	-		-	6.2	-	

Source: Field Survey- April, July and October 2014

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

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

83.  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentrations monitoring of Passur-Shibsha RS have been appended in this study since second quarterly monitoring.  $\text{SO}_4^{2-}$  and  $\text{PO}_4^{2-}$  concentrations were found within the safe limit of drinking water quality standard. It is here to be mentioned that concentrations monitoring of these two parameters was not possible in third quarter monitoring study.

### (d) Arsenic, Lead and Mercury

84. As per the Bangladesh Standard, the maximum acceptable concentration of Arsenic in groundwater is 0.05 mg/L. Among the four tube wells, Kalekharber tube well, which is installed at shallower depth, was found arsenic contaminated. All other tube wells were found to be free from arsenic contamination. In case of Pb and Hg concentration, very low concentrations were found and which were much below the highest acceptable limit of 0.05 mg/L and 0.001 mg/L respectively (**Table 5.19**).

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

S I	Location s	As (mg/L)				Pb (mg/L)				Hg (mg/L)			
		Tested results			BD stand ard*	Tested results			BD stand ard*	Tested results			BD stand ard *
		1 QM	2 QM	3 QM		1 QM	2 QM	3 QM		1 QM	2 QM	3 QM	
1	Townshi p near project site	0.013	0.020	0.012	0.05	0.002	<0.002	0.004	0.05	<0.00015	<0.00015	<0.0005	0.001
2	Rajnagar	0.006	0.009	0.006		<0.002	<0.002	<0.002		<0.00015	<0.00015	<0.0005	
3	Kalekhar ber	0.376	0.407	NF		0.002	0.008	NF		<0.00015	<0.00015	NF	
4	Kapasda nga	0.036	0.033	0.020		<0.002	0.004	<0.002		<0.00015	<0.00015	<0.0005	

Source: Field Survey- April, July and October 2014

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

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





## 6 Transportation Monitoring

85. Transportation monitoring was supposed to be carried out quarterly as per the monitoring schedule provided in Table 6.1. But, during the fourth quarter, the survey was possible to carry out due to prevailing political situation. The usual traffic situation was obstructed by the road blockade campaign.

### 6.1 Location of Traffic Survey

86. The 4<sup>th</sup> quarter of first year traffic volume computation survey was duly scheduled on the first week of January, 2015 at five pre-selected monitoring locations which are shown in **Map 7.1**.

87. The selected sites were Babur Bazar, Rupsha Bridge, Bagha Bazar, Babu Bari (access road) and Katakhal. The day on which the survey is supposed to be conducted, is usually sunny which ensure normal movement of vehicles on the roads.

### 6.2 Traffic Volume Calculation

88. The survey results are 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 6.2**.

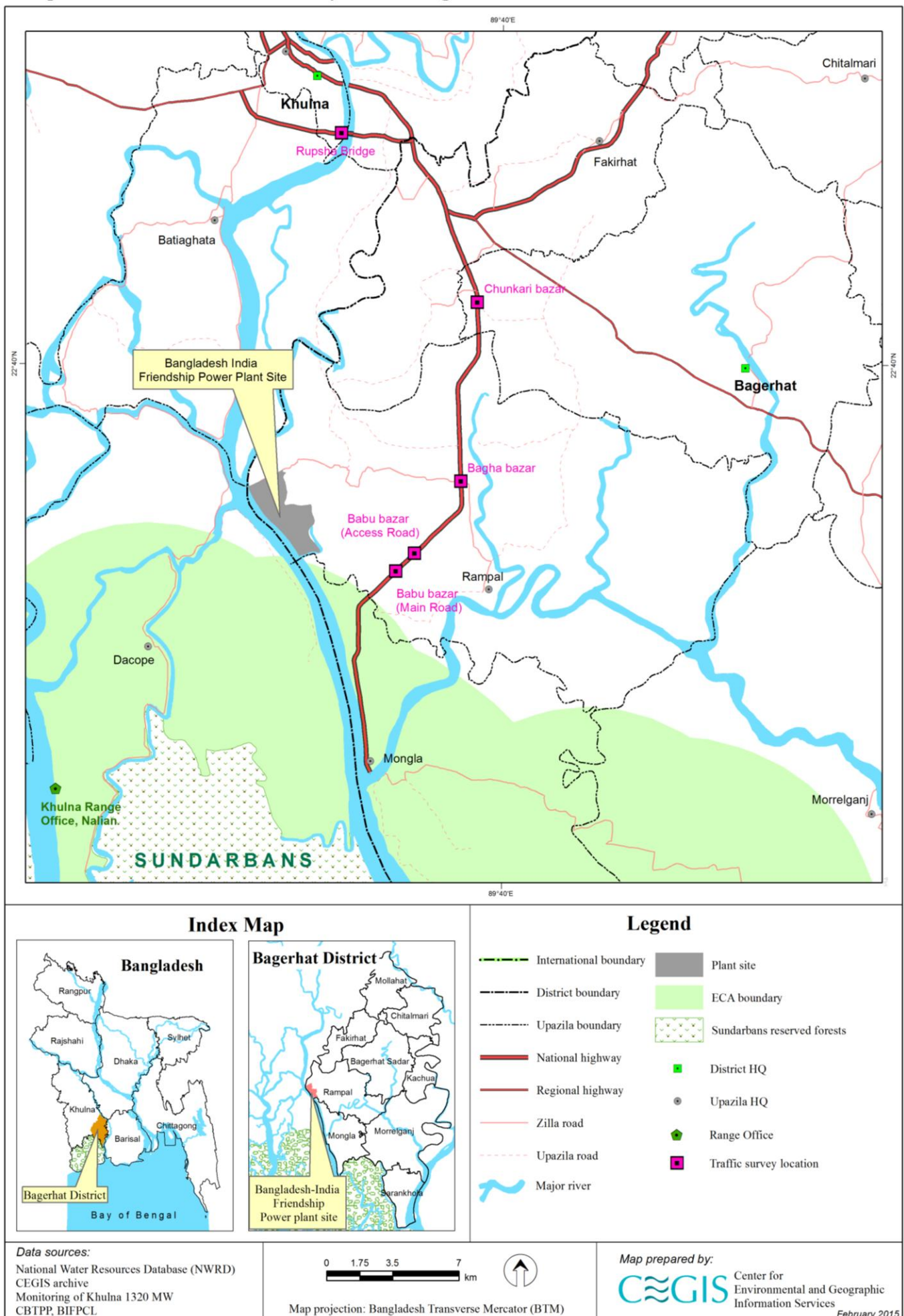
**Table 6.1: Monitoring Plan of Transportation Survey**

Sl no	Monitoring Indicators	Locations	GPS (Decimal Degree)		Frequency	Methods/Tools/ Techniques
			Easting	Northing		
1	Traffic Volume	Khan Jahan Ali Bridge	22.778194	89.580722	Quarterly (April, July, October, January)	Traffic Survey
2		Khulna Mongla Highway at Chunkuri Bazar	22.697389	89.651000		
3		Khulna Mongla Highway at Bagha bazar	22.715139	89.551500		
4		Khulna Mongla Highway at Babu bazar	22.568694	89.609278		
5		Access road to Project at Babu bazar	22.568694	89.609278		

**Table 6.2: 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*



**Map 6.1: Traffic Monitoring Locations**

### 6.3 Results of Monitoring

89. The summary results of vehicular movements at five different locations are shown in **Table 6.3** 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).
90. Briefly, the vehicular movements observed during each quarterly survey 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 survey datasheet regarding the traffic volume survey is attached in **Annex - II (Table A)**.

**Table 6.3: Results of Transportation monitoring**

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	4th QM	1st QM	2nd QM	3rd QM	4th QM	1st QM	2nd QM	3rd QM	4th QM
Babur Bazar (Access Road)	30	13	41.5	-	23	21	34.25	-	24	25	46	-
Khan Jahan Ali Bridge	700	566	655.25	-	836	829	637.25	-	841	719	801	-
Babur Bazar (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	-
Chulkatthi	445	523	680.5	-	501	634	692	-	508	733	715.25	-

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

\*n/a: not applicable (data not collected)



## **7 Land Resources Monitoring**

91. Land Resources monitoring has been scheduled twice a year as per the monitoring plan provided in Table 7.1. Hence, in the first year of monitoring, survey has been conducted in April and in October.
92. During field visit in April 2014, baseline information on land and agriculture resources was collected. From the field, soil samples were collected for determining soil quality and fertility. pH, OM, EC, N, P, K, S, Ca, Mg, Na, Fe, Mn, Zn, B, Cl<sup>-</sup> and Pb were considered as soil quality and fertility parameters.

### **7.1 Methodology**

#### **7.1.1 Monitoring Indicators**

93. Land use, soil fertility/nutrient, status of soil contamination with heavy metals is the major monitoring indicators for land resources under this study. During the operation phase of Power Plant, it is assumed that ash may be deposited in the surrounding agriculture land and plants on the homestead area which will impact the crop production and fruit bearing in the coconut plants. Therefore, monitoring of the selected indicators is very crucial for land resources monitoring in the study area.

#### **7.1.2 Frequency**

94. Land use monitoring data were collected in October, 2014. Soil samples for monitoring of soil fertility/nutrient status of soil contamination with heavy metals, samples of wet season were also collected in the month of October, 2014. Next dry season soil samples will be collected in March, 2015.

#### **7.1.3 Location**

95. Five mouzas within the 10 Km radius of the Power Plant were selected for monitoring of land use, soil fertility/nutrient, status of soil contamination with heavy metals. The selected mouzas are Baranpara, Chunkuri-2, Kapalirmet, Chakgona and Basherhula.

### **7.2 Process of soil samples collection**

#### **7.2.1 Land selection**

96. Group discussion was held during collection of the soil samples, especially with the land owners. Monitoring locations have been selected considering the potential locations of dry/wet deposition of ash, SO<sub>x</sub> and NO<sub>x</sub> to be emitted from the Plant. The GPS readings were recorded on each location to facilitate the collection of soil samples from the exact locations in future.

#### **7.2.2 Soil sample collection**

97. Soil samples were collected following the standard practices of composite method. At each plot, soil samples were collected from three dug pit. From each pit, three soil samples were extracted from three different depths. Top soil from 0-15 cm depth, subsoil from 15-30 cm depth and sub stratum from 30-45 cm depth were collected using augur. The three top soil samples collected from three different pits were then mixed properly to

**Table 7.1: Land and Agricultural Resources Monitoring Plan**

SI no	Monitoring Indicators	Locations	GPS (Decimal Degree)		Frequency	Methods/Tools/ Techniques
			Easting	Northing		
1	Landuse, Soil fertility and Nutrient, Chemical Properties of Soil (pH, As, and Hg), Crop production, damage, Coconut plants/fruits damage	Mouza - Bashurhula, Union-Rajnagar, Upazila-Rampal	89.516417	22.632500	Twice crop season (May and October)	In situ field sampling and Laboratory Testing in SRDI,
2		Mouza - Chunkuri-2, Union – Bajua, Upazila - Dacope	89.538889	22.580833		
3		Mouza - Bidyarbon, Union – urirdanga, Upazila – Mongla	89.602444	22.538583		
4		Mouza: Kapalirmet , Buridmial, Union – Burirdanga, Upazila- Mongla	89.573694	22.571750		
			89.573611	22.603889		



### **7.2.3 Soil sample collection**

98. Soil samples were collected following the standard practices of composite method. At each plot, soil samples were collected from three dug pit. From each pit, three soil samples were extracted from three different depths. Top soil from 0-15 cm depth, subsoil from 15-30 cm depth and sub stratum from 30-45 cm depth were collected using augur. The three top soil samples collected from three different pits were then mixed properly to make a composite sample and 500g of soil mass was taken and stored in an air tight protective poly bag for laboratory analysis. Similar approach was followed in collecting sub soil and sub stratum soil sample collection. To have more accurate results, it was ensured that the top, subsoil and substratum are taken from the same pit.
99. In the right hand picture at Kapalirmet, last year T.aman was cultivated. Farmers decided that this year he will go for shrimp or fish culture.



**Photo 7.1: View of soil sample collection from monitoring land at Basherhula**

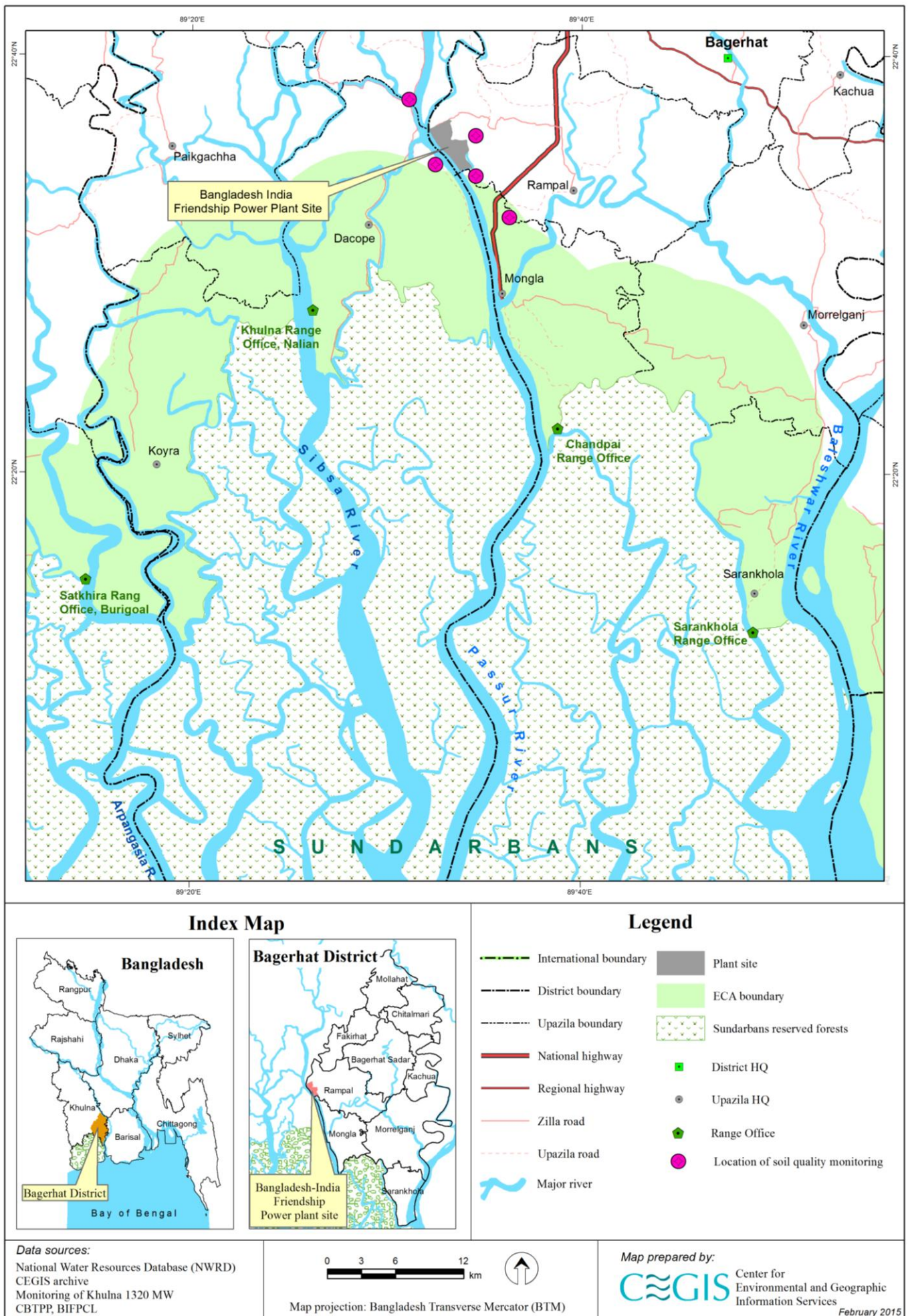


**Photo 7.2: View of soil sample collection from monitoring land at Kapalirmet**

### **7.2.4 Laboratory analysis**

100. The collected soil samples have been handed over to the Soil Resource Development Institute (SRDI), Dhaka for laboratory analysis. Results will be presented in the next monitoring report after obtaining the same from SRDI.





Map 7.1: Soil Quality Monitoring Locations

### **7.3 Results of Monitoring**

101. 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 7.2** again for use in future.

Table 7.3: Chemical Properties of Soil

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
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	*										

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
		Substratum(30-45cm)												
		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)	490.9	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 <sup>-</sup> )(µg/gm)	692.9	*										
2.	Chunkuri-2	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 <sup>-</sup> )(µg/gm)	1957.6	*										
		Subsurface soil(15-30cm)												
		EC(ds/m)	9.1	Moderately saline										
		pH	6.7	Neutral										
		OM (%)	1.8	Low										
		N (%)	0.09	Very low										

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
		K (%)	1.6	Very high										
		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										
	Kapalimet													

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
		Mn(µg/gm)	3.8	Very high										
		Zn(µg/gm)	2.0	High										
		Lead(Pb) (µg/gm)	12.5	*										
		Chloride (Cl <sup>-</sup> )(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 <sup>-</sup> ) (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 <sup>-</sup> ) (µg/gm)	1801.6	*										
4	Chakgona	Top soil(0-15cm)												
		EC(ds/m)	11.5	Moderately										



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
				saline										
		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 <sup>-</sup> )(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 <sup>-</sup> )(µg/gm)	2113.5	*										
		Substratum(30-45cm)												
		EC(ds/m)	10.9 saline	Moderately										
		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										

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
5.	Basherhula	Na(meq/100g)	8.5	*										
		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 <sup>-</sup> )(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 <sup>-</sup> )(µg/gm)	2442.6	*										
		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										

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
		Lead(Pb) (µg/gm)	18.8	*										
		Chloride (Cl <sup>-</sup> ) (µg/gm)	1611.1	*										
		<b>Substratum(30-45cm)</b>												
		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 <sup>-</sup> )(µg/gm)	1489.8	*										



## 8 Agriculture Resources Monitoring

Monitoring of Agriculture Resources has been scheduled twice a year as per the contract. Hence, in the first year of monitoring, survey has been conducted in April and in October.

### 8.1 Methodology

#### 8.1.1 Monitoring Indicators

102. 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

103. 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

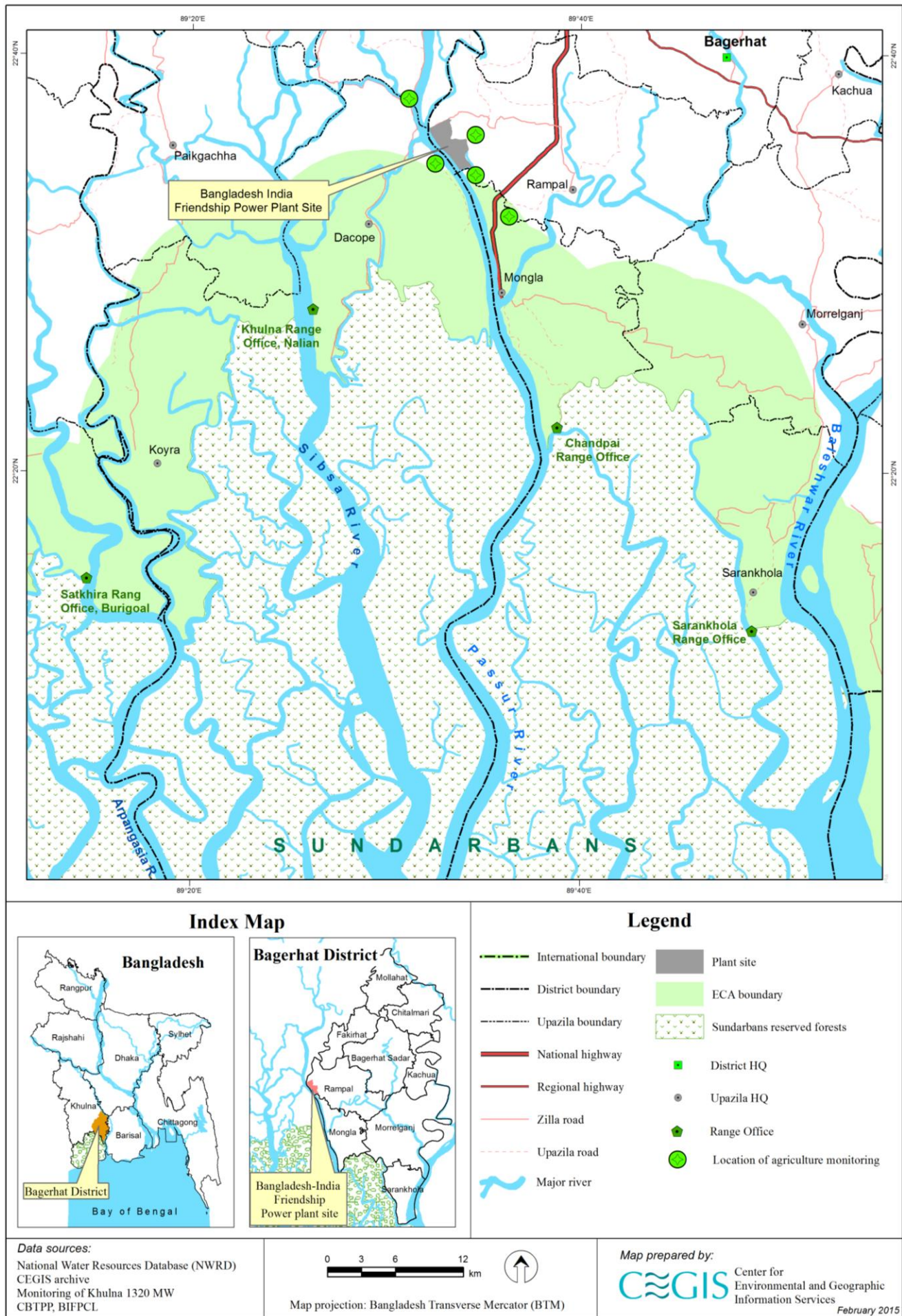
104. Land use, major crops area, major crop production and damage are monitored quarterly in a year. For the cropping season 2013-14, these data were collected in April, 2014. Crop production and damage information's were also collected from the same land. Samples were collected in October for Kharif-II (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

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

**Table 8.1: Agriculture Resources Monitoring Monitoring Plan**

Sl no	Monitoring Indicators	Locations	GPS (Decimal Degree)		Frequency	Methods/Tools/ Techniques
			Easting	Northing		
1	Landuse, Soil fertility and Nutrient, Chemical Properties of Soil (pH, As, and Hg), Crop production, damage, Coconut plants/fruits damage	Mouza - Bashurhula, Union-Rajnagar, Upazila-Rampal	89.516417	22.632500	Three crop season (May, July, October)	In situ field sampling and Laboratory Testing in SRDI,
2		Mouza - Chunkuri-2, Union – Bajua, Upazila - Dacope	89.538889	22.580833		
3		Mouza - Bidyarbon, Union – urirdanga, Upazila – Mongla	89.602444	22.538583		
4		Mouza: Kapalirmet , Buridmial, Union – Burirdanga, Upazila- Mongla	89.573694	22.571750		



Map 8.1: Agricultural Resources Monitoring Locations

## 8.2 Agricultural Resources

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

106. 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 Union:Gongarampur Upazila-Batiaghata District:Khulna	E-89° 30'59.1" N-22° 37'57.0"	About 3.5	About 0.4	Name: Anil Krishna Roy Father: Keshab Lal Roy
2	Mouza:Chunkuri-2 Union:Bajua Upazila:Dacope District:Khulna	E-89° 32'20.0" N-22° 34'51.0"	About 1.0	About 0.93	Name: Md.Abul Sheikh Father: Md.Jamir Sheikh
3	Mouza:Kapalirmet Buridmial Union: Burirdanaga Upazila:Mongla District:Bagerhat	E-89° 36'8.8" N-22° 32'18.9"	About 5.5	About 0.14	Name: Panesh Biswas Father: Nishikanto Biswas
4	Mouza: Chakgona Union:Rajnagar Upazila:Rampal District:Bagerhat	E-89° 34'25.3" N-22° 34'18.3"	About 1.0	About 0.28	Name: Manoj Das Father: Mahendra Nath Das
5	Mouza: Basherhula Union:Rajnagar Upazila:Rampal District: Bagerhat	E-89° 34'25.0" N-22° 36'14.0"	About 1.0	About 0.47	Name: Amjad Hajra Father: Chirman Ali Hajra

Source: Field survey, 2014

### 8.2.2 Present cropping patterns

107. 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

108. 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.

109. 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 Kapalimet (\*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**

110. 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**

111. 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**

112. 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**

113. 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

114. 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 (Kapalirmet 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

115. Fisheries resources have been monitored quarterly in a year. After completion of first three quarters, the fourth quarter monitoring, has been conducted during the period of 4 to 15 January, 2015. This chapter contains the results of fourth quarter monitoring along with the results of earlier three quarters.

### 9.1 Monitoring Location

116. 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/ 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

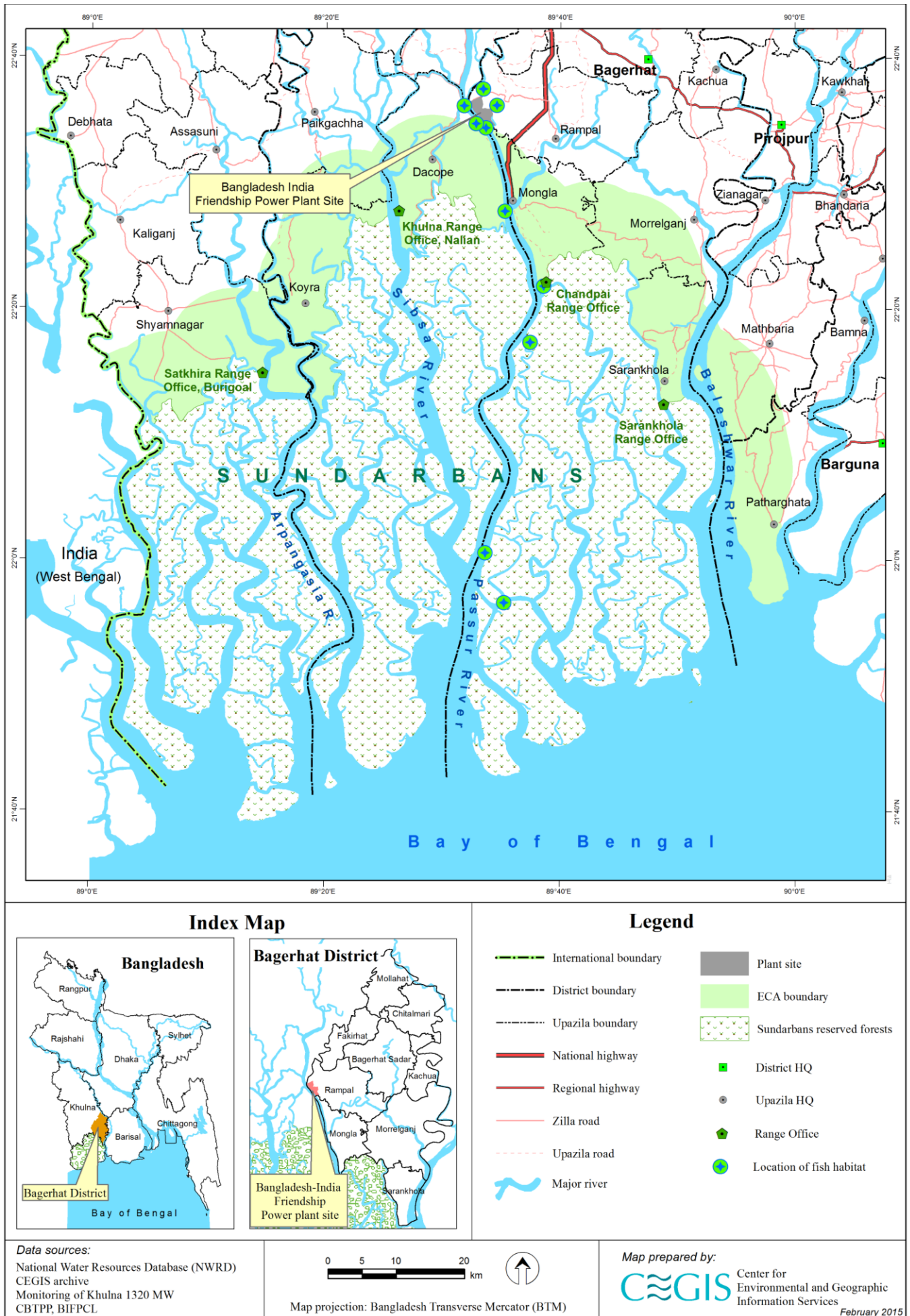
117. The following indicators have been monitored to understand the fish habitat status and quality: (i) water quality; (ii) bed material; (iii) hydrological condition; (iv) morphological aspects; (v) vegetation cover etc. These indicators would present the maximum natural capability of habitats to produce 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.

118. 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  $j$ .



Map 9.1: Fisheries Resources Monitoring Locations

**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
<b>2014-2015</b>									
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							
Reproduction ( $C_R$ )	V1	Phytoplankton (%)							
	V2	Zooplankton (%)							
	V3	Turbidity							
	V4	TDS							
	V5	Surface water temperature							
	V6	Dissolved Oxygen (DO)							
	V7	pH							
	V8	Salinity							
<b>2015-2016</b>									
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							
Reproduction ( $C_R$ )	V1	Phytoplankton (%)							
	V2	Zooplankton (%)							
	V3	Turbidity							
	V4	TDS							
	V5	Surface water temperature							
	V6	Dissolved Oxygen (DO)							
	V7	pH							
	V8	Salinity							



Life Requirements	Variable SI.	Habitat Variables	A	B	C	D	E	F	G
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							
Reproduction ( $C_R$ )	V1	Phytoplankton (%)							
	V2	Zooplankton (%)							
	V3	Turbidity							
	V4	TDS							
	V5	Surface water temperature							
	V6	Dissolved Oxygen (DO)							
	V7	pH							
	V8	Salinity							

119. 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

120. 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

121. 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)

122. 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

123. 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

124. 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.

### 9.3 Results of 4<sup>th</sup> Monitoring

125. Followed by the first, second and third quarter monitoring, the fourth quarter monitoring has been conducted during the period of 4 to 15 January, 2015.

#### 9.3.1 Fisheries Resources

126. Fisheries resources for the monitoring study are identified as riverine fisheries, 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 fisheries. 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

<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).

selected for monitoring on the basis of the probable dispersion of fly ash from the Plant in its operation stage. 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.

127. Fishes are generally become less abundant 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.

### 9.3.2 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 stake 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)
- Low water depth and flow velocity found in fourth monitoring phase as compared to other phases
- Fish diversity is highly dominated during lunar phase and tide condition.

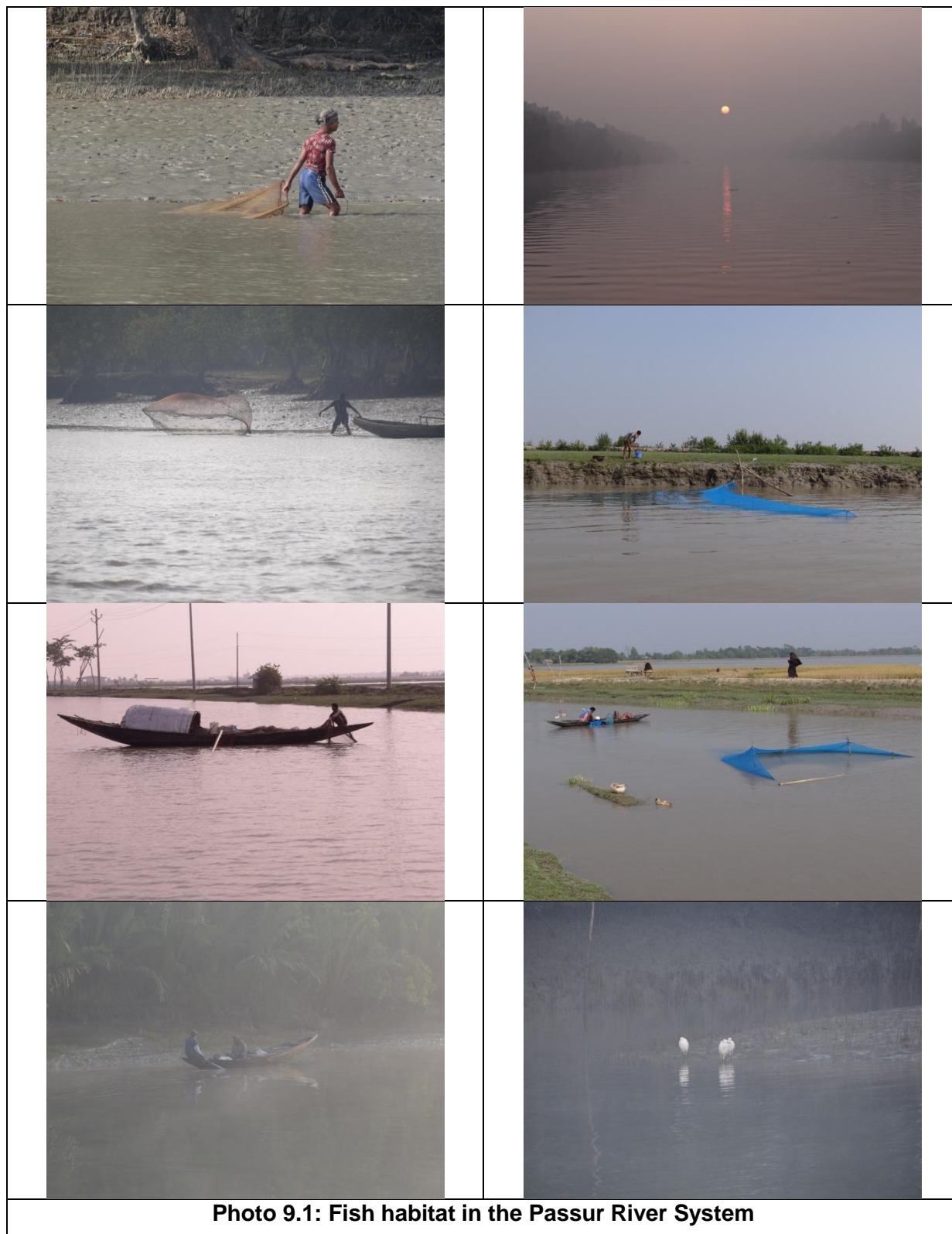
### 9.3.3 Fish Habitat Status

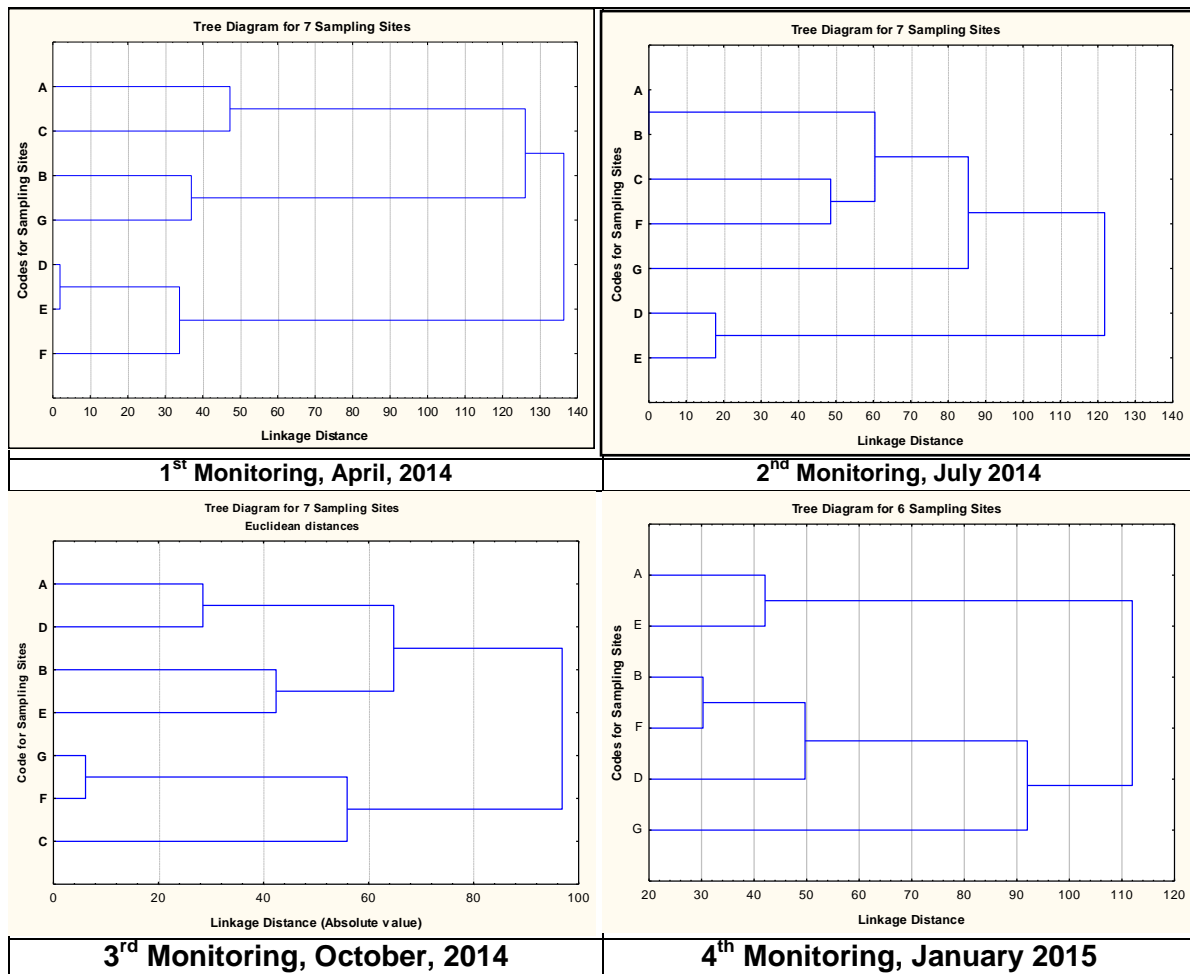
#### (a) Habitat Classification

128. 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 behavioural 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.
129. 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 the habitats has been found to beshifted to some extent. However, in fourth monitoring phase in the month of January 2015 the similarity of size group distribution of fish species among the habitats has also been shifted to some extent.
130. 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**.

131. **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.
132. **Nursery and Grazing Ground:** Among the sampling sites, the Haldikhali Khal (B) Sheola Khal at Chandpai (D), Maidara-Passur confluence (F) respectively are similar in the distribution of life stages from Juveniles to adult aged fish. These habitats are classified as the nursery and grazing ground. Moreover, in spite of low similarity with the mentioned sites Chalna point of the Passur River (G) is also identified as a habitat.

133.

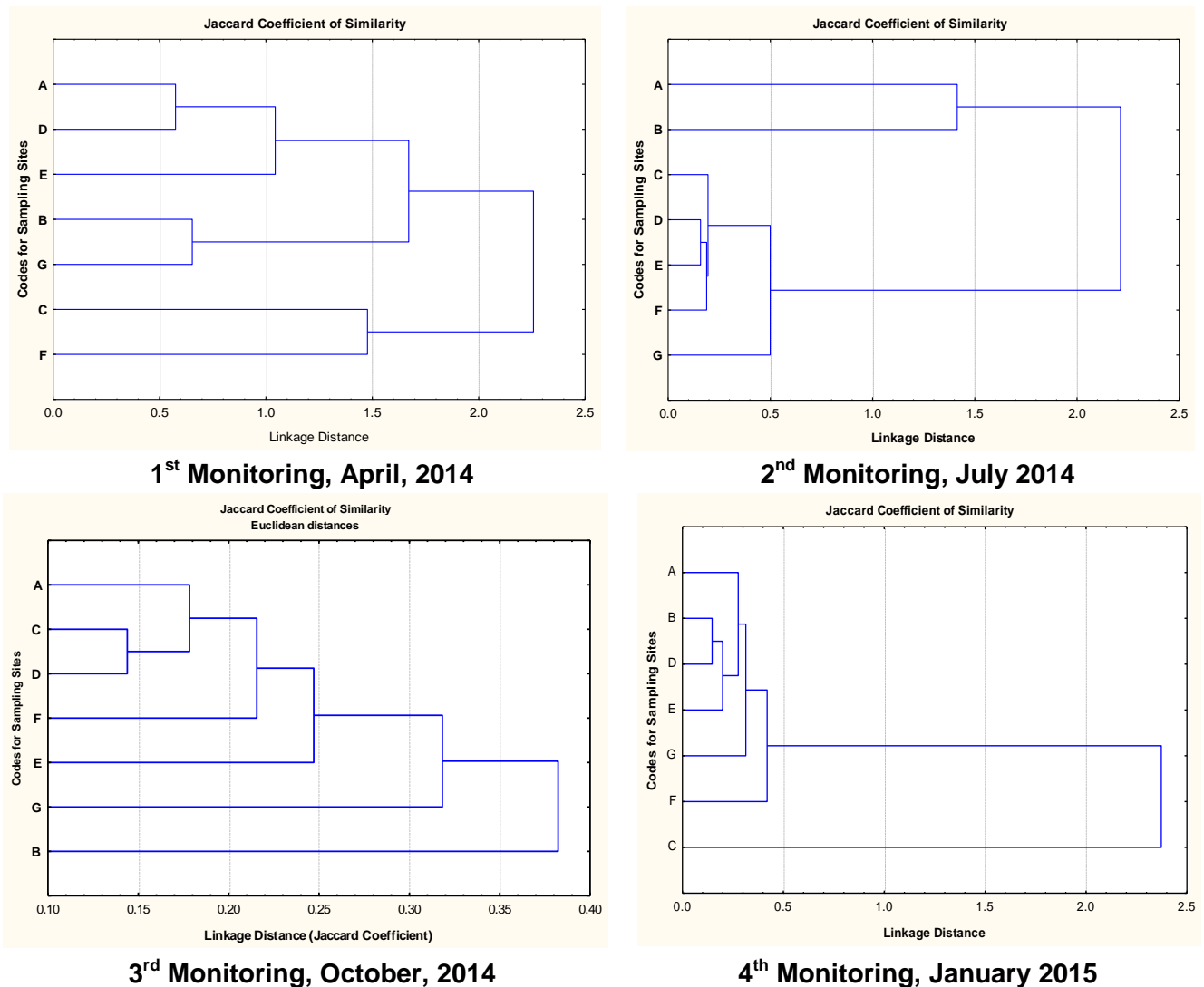




**Figure 9.1: Habitat Classification on the basis of Different Life Stages of Fish Species**

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

134. This figure analyses the distances among the 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 monitorings. For example, 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. In third quarter monitoring highest JI value was found between C and D sampling sites. On the other hand, the JI value between B and D sampling sites was the highest in fourth monitoring phase in the month of January, 2015. 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)**

135. 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. The 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				
D				
E				
F				

Sampling Sites	Location	HSI* (2014-2015)	HSI (2015-2016)	HSI (2016-2017)
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

### 9.3.4 Fish Bio-diversity

136. 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 based on the length of each species from the samples. Diversity has been calculated by analyzing Shannon-Weiner Index.

#### a) Shannon-Weiner Index

137. 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 Herbaria (shown in the **Table 9.4**). In first monitoring, however, very high diversity in species composition was found in the Haldikhali and the 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	7									0.49	0	0.73	0.57								
B	12	0	24	14									0.85	0	0.57	0.39								
C	2	12	9	0									0.29	0.77	0.40	0.00								
D	12	22	15	26									0.31	0.78	0.73	0.51								
E	7	13	10	11									0.38	0.60	0.76	0.77								
F	3	13	6	4									0.82	0.77	0.54	0.60								
G	6	3	5	7									0.68	0.82	0.72	0.66								

\*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)



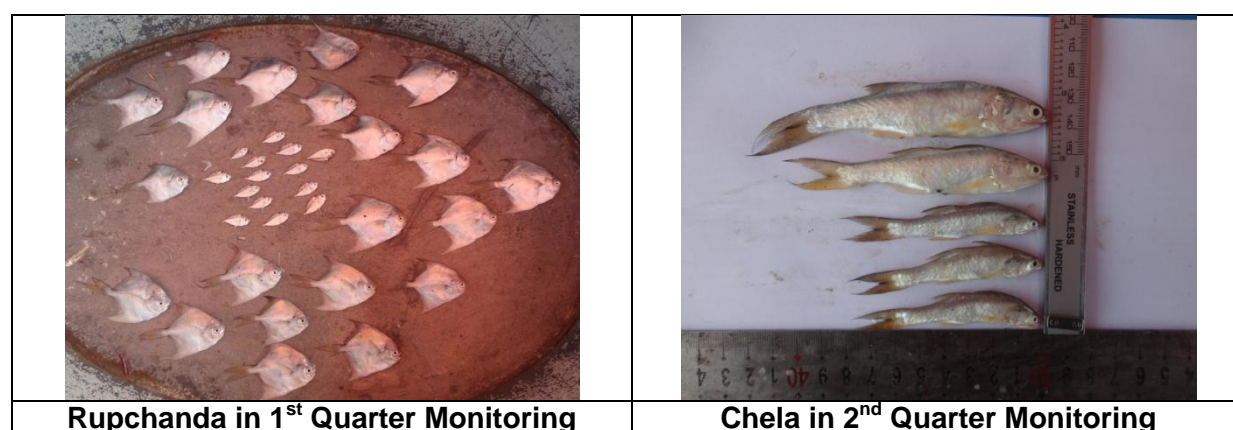
### b) Fish Species Richness (FSR)

138. 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**).









139. In fourth monitoring phase, maximum FSR was obtained in Mongla-Passur confluence point (n=5), while very low FSR was recorded in Maidara River at Baro Durgapur and in Haldikhali (n=2). Moderate FSR was observed at Akram point and Passur river at Chalna point (n=3). Among habitats in upstream portions of the Passur river, Mongla Point was home to a rich assemblage of Banspata, Phessa, Poma and Tigar shrimp; Maidara River at Baro Durgapur and Chalna point were rich in Bagda, Bele, Poma, Tiger Chingri and Poma. Among habitats in lower stream portions, Chandpai was rich in Boiragi Chela, Motka Chingri, Potka and Horina Chingri and Akram point in Boiragi Chela, Motka Chingri, Potka and Horina 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	3								
B	Haldikhali	7	0	4	2								
C	Harbaria	1	5	2	0								
D	Chandpai	2	2	5	4								
E	Mongla Point	1	10	4	5								
F	Maidara at Baro Durgapur	3	6	2	2								
G	Botiaghata, Chalna Point	3	3	2	3								

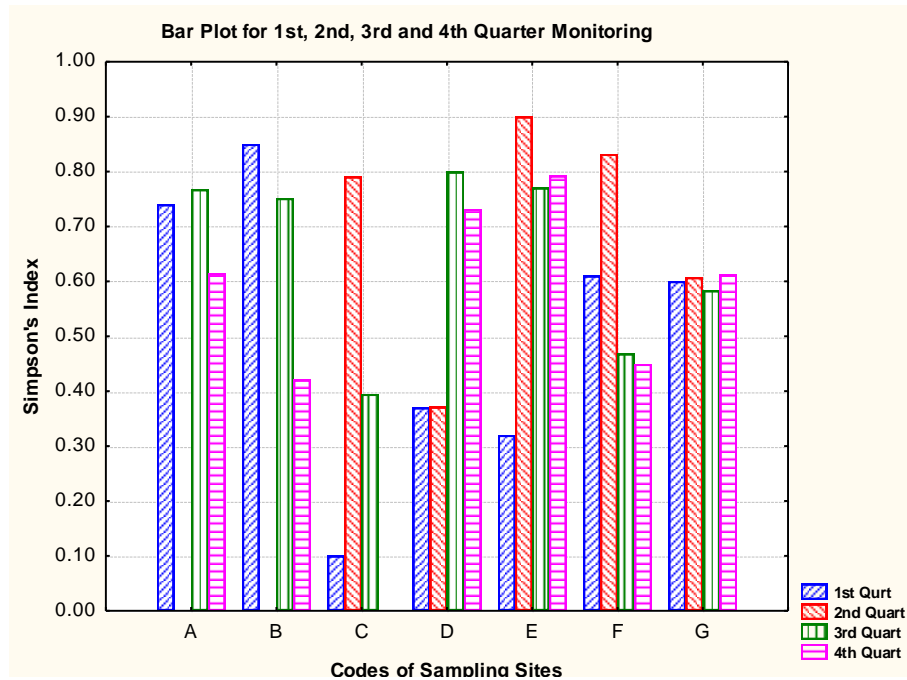


<sup>3</sup> Simpson's index is a method to calculate the community characteristics of fish in a particular habitat. It is mainly used to know about the species richness of a particular habitat to tell how many species are rich in their abundance. The value of this index ranges from 0 to 1. There is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

	
<p>Phesa, Chela, Hilsa, Gagla Tengra</p>	<p>Harina Chingri</p>
	
<p>Lal Chewa</p>	<p>Crab</p>
	
<p>Poma, Rita, Tengra</p>	<p>Poma, Rita, Tengra</p>
	
<p>Phessa</p>	<p>Poma, Phesa</p>
	
<p>Tapse</p>	<p>Phesa</p>
<p>Fish Species at 3<sup>rd</sup> Quarter Monitoring</p>	



	
Amadi Chela	Banspata
	
Chata Bele	Poma
	
PL of Bagda	Phessa, Poma and Horina Chingri
Fish Species in Upstream of Passur River at 4 <sup>th</sup> Quarter Monitoring	
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

140. Fish community structure has been analyzed through counting the length-wise fish individuals (**Photo 11.2**). The following table 9.6, -9.7 and figure 9.4 for fourth monitoring shows that juveniles and adults of maximum species were more randomly distributed among the upper, middle and lower stretches of the Passur River. Among these Banspata, Bele, Phessa, Poma and Datina fish were widely distributed among the sampling sites. However, Tiger shrimp was restricted in upper and Gang Tengra in lower stretches of the Passur River system. No brood fish, except Gura Chingri, has been observed in the fourth monitoring phase in the month of January.

**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	<i>Anguilla bengalensis</i>		+	-	-	-								
Bacha	<i>Eutropichthys 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			-	+	+	-											
Chitra			+	-	-	+											
Khayra Chela			-	+	-	-											
Sada Chewa	<i>Trepachen 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	+	-	+	-											
Paira 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>	-	+	+	+	-											
Datina			-	-	-	+											
Jaba			-	-	-	+											
Shol	<i>Channa striatus</i>		-	-	-	+											
Magur	<i>Clarias batrachus</i>		-	-	-	+											
Koi	<i>Anabas testudineus</i>		-	-	-	+											
Vetki			-	-	-	+											
Gangania			-	-	-	+											

\*Local Status Source: IUCN Red List

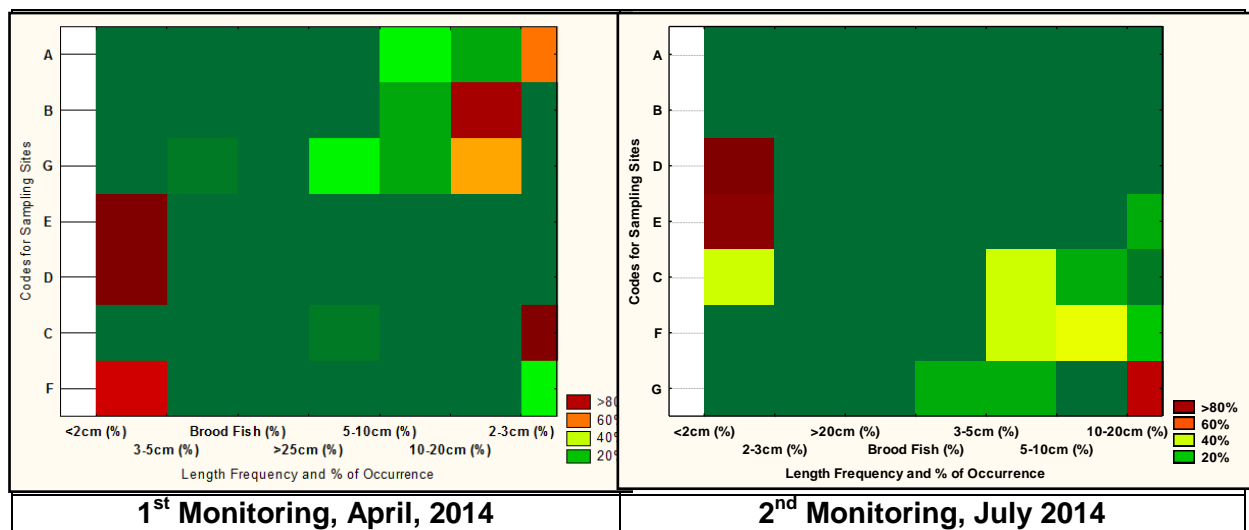
**Table 9.7: Length-wise species distribution in sampling sites**

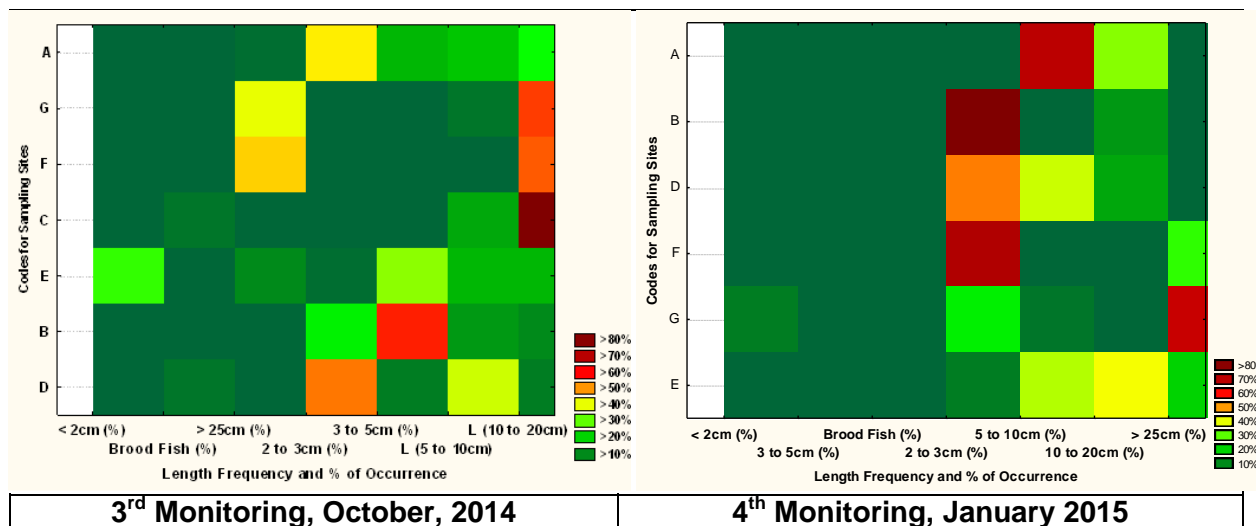
Fish Species	Site	L (< 2cm)	L (2 to 3cm)	L (3 to 5cm)	L (5 to 10cm)	L (10 to 20cm)	L (> 25cm)	Brood Fish
Bagda	Chalna Point	0	100	0	0	0	0	0
	Chandpai	0	0	0	0	100	0	0
	Mongla Point	0	0	0	0	100	0	0
Banspata	Chalna Point	0	0	0	0	0	100	0
	Chandpai	0	0	0	0	0	100	0
	Haldikhali	0	0	0	0	71	29	0

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
	Maidara	0	0	0	0	0	100	0
	Mongla Point	0	0	0	0	0	100	0
Bele	Akram Point	0	0	0	0	100	0	0
	Chalna Point	0	0	0	0	0	100	0
	Chandpai	0	0	0	0	50	50	0
	Haldikhali	0	0	0	0	100	0	0
	Mongla Point	0	0	0	100	0	0	0
Boiragi Chela	Chandpai	0	0	0	100	0	0	0
	Mongla Point	0	0	0	0	100	0	0
Chaka Chingri	Akram Point	0	0	0	90	9	0	0
	Haldikhali	0	100	0	0	0	0	0
Chanda	Haldikhali	0	0	0	100	0	0	0
Chata Baila	Chandpai	0	0	0	0	75	25	0
	Haldikhali	0	0	0	0	56	44	0
	Mongla Point	0	0	0	0	100	0	0
Chitra	Chandpai	0	0	0	100	0	0	0
Datina	Chalna Point	100	0	0	0	0	0	0
	Chandpai	0	0	0	0	100	0	0
	Haldikhali	0	0	0	0	73	27	0
Dogri	Chandpai	0	0	0	0	100	0	0
Gangania	Chandpai	0	0	0	57	43	0	0
	Haldikhali	0	0	0	0	100	0	0
Goda Chingri	Chandpai	0	100	0	0	0	0	0
	Chandpai	0	0	0	94	6	0	0
	Haldikhali	0	0	0	0	40	60	0
Gulsha Tengra	Chandpai	0	0	0	0	100	0	0
	Mongla Point	0	0	0	100	0	0	0
Gusha Chingri	Haldikhali	0	100	0	0	0	0	0
Horina Chingri	Chalna Point	100	0	0	0	0	0	0
	Chandpai	0	100	0	0	0	0	0
Jaba	Akram Point	0	0	0	0	0	100	0
	Chandpai	0	0	0	0	0	100	0
Kain Magur	Chandpai	0	0	0	0	0	100	0
Kalo Chewa	Mongla Point	0	0	0	0	0	100	0
Katali Chingri	Chandpai	0	100	0	0	0	0	0
Koi	Chandpai	0	0	0	100	0	0	0
Kuchia	Chandpai	0	0	0	0	0	100	0
Lal Chewa	Chandpai	0	0	0	0	0	100	0
Magur	Chandpai	0	0	0	0	0	100	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
Meth Tengra	Akram Point	0	0	0	0	0	100	0
Motka Chingri	Chandpai	0	100	0	0	0	0	0
Paissa	Akram Point	0	0	0	57	43	0	0
	Haldikhali	0	0	0	0	100	0	0
Phessa	Chalna Point	0	0	0	0	0	100	0
	Haldikhali	0	0	0	0	80	20	0
	Maidara	0	0	0	0	0	100	0
	Mongla Point	0	0	0	0	100	0	0
Poma	Chalna Point	0	0	0	9	0	91	0
	Chandpai	0	0	0	57	19	24	0
	Haldikhali	0	0	0	0	76	24	0
	Maidara	0	0	0	4	7	89	0
	Mongla Point	0	0	0	67	26	7	0
Potka	Chandpai	0	0	0	58	42	0	0
Shoul	Chandpai	0	0	0	0	40	60	0
Sylon	Mongla Point	0	0	0	0	100	0	0
Gang Tengra	Akram Point	0	0	0	44	56	0	0
	Chandpai	0	0	0	0	100	0	0
	Haldikhali	0	0	0	0	100	0	0
Tigar Chingri	Maidara	0	100	0	0	0	0	0
	Mongla Point	0	100	0	0	0	0	0
Vetki	Akram Point	0	0	0	0	0	100	0
	Chandpai	0	0	0	0	80	20	0
	Haldikhali	0	0	0	0	40	60	0

Source: CEGIS field survey, 2015





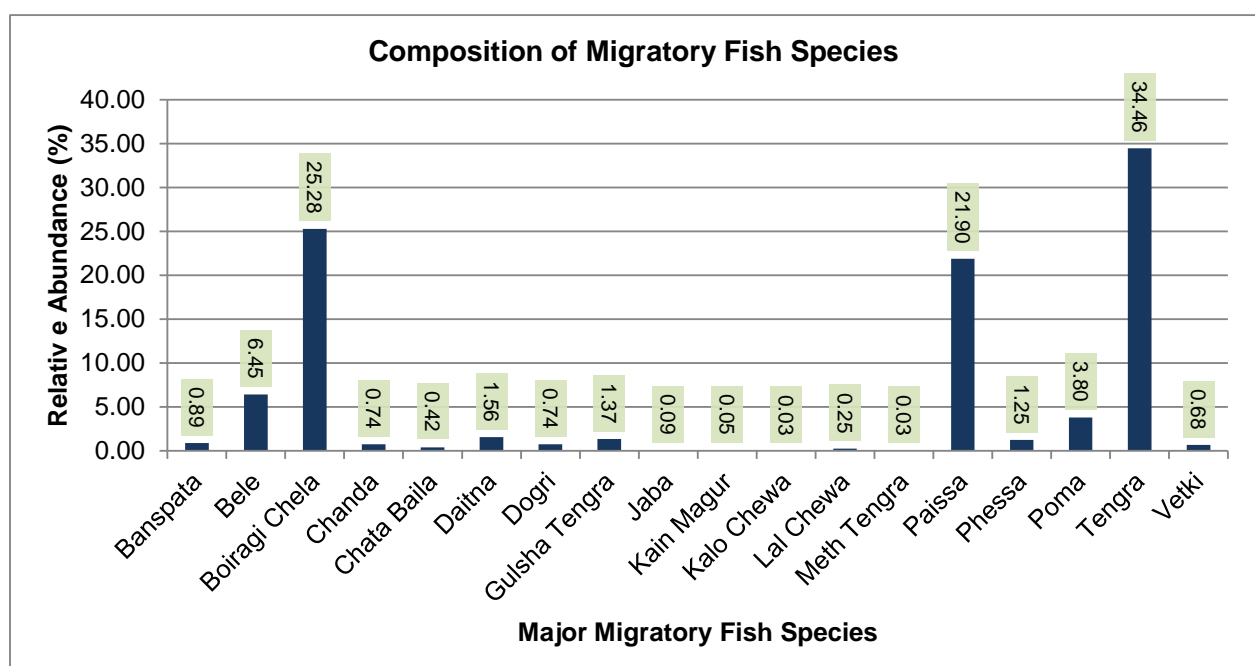
**Figure 9.4: Habitat Distribution of Different Life Stages of Fish Species**

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

### 9.3.5 Fish Migration

#### (a) Migratory Species Diversity

141. Migratory species have been identified by analyzing the common species available in the regular catch from the sampling sites. Fish species like Boiragi Chela, Paissa and Gang Tengra attain the maximum abundance among the migratory fish species observed in fourth monitoring phase. The availability of all other species was very low as compare as found in other monitoring phases. The relative abundance of the migratory species is give below in the **figure 9.5**.





**Figure 9.5: Relative abundance of migratory fish species in sampling sites****(b)      *Migration Extent, Time and Purpose***

142. Major fish species showed interesting pattern in distribution for exploiting different purposes mentioned in the following table all along the sampling sites. This means such fish species are migratory in nature. Five (5) fish species were found common in most of the sites. The longest distance from site to site is the distance from the Akram Point to the Chalna Point in the study reach. Only four species have been observed in this range like Banspata, Bele, Phessa and Poma indicating long range of distribution (Table 9.8.

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											
			1st Monitoring (April, 2014)	2nd Monitoring (July, 2014)	3rd Monitoring (Oct, 2014)	4th Monitoring (Dec, 2014)	5th Monitoring (April, 2015)	6th Monitoring (July, 2015)	7th Monitoring (Oct, 2015)	8th Monitoring (Dec, 2015)	9th Monitoring (April, 2016)	10th Monitoring (July, 2016)	11th Monitoring (Oct, 2016)	12th Monitoring (Dec, 2016)
Tapsi	Haldikhali	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	Haldikhali	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	Feeding								
	Chalna Point	Juvenile and Age-1 adult	Feeding and Growing	-	-	-								
	Harbaria	Juvenile	Feeding and Growing	-	-	-								
	Mongla Point	Fry	-	Nursing	-	Feeding								
	South-west of the Project	Juvenile	-	Feeding and Growing	-	-								
Chapila	Haldikhali	Juvenile	Feeding and Growing	-	-	-								
	Akram Point	Juvenile	Feeding and Growing	-	-	-								

Migratory Fish Species	Sampling Sites	Year Class*	Migration Purpose											
			1st Monitoring (April, 2014)	2nd Monitoring (July, 2014)	3rd Monitoring (Oct, 2014)	4th Monitoring (Dec, 2014)	5th Monitoring (April, 2015)	6th Monitoring (July, 2015)	7th Monitoring (Oct, 2015)	8th Monitoring (Dec, 2015)	9th Monitoring (April, 2016)	10th Monitoring (July, 2016)	11th Monitoring (Oct, 2016)	12th Monitoring (Dec, 2016)
	Mongla Point	Fry	-	Nursing	-	-								
	South-west of the Project	Age-1 adult	-	Feeding and Growing	-	-								
Loitta	Haldikhali	Juvenile and Age-1 adult	Feeding and Growing	-	Feeding 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	-	-	Feeding								
	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	Feeding								
	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	-								
	Mongla Point	Adult	-	-		Feeding								
	South-west of the Project	Adult	-	-	Feeding	Feeding								
	Chalna Point	Juvenile, Adult and Brood Fish	Breeding and Spawning	-	-	-								
	Chalna Point	Juvenile and Adult	-	-	Feeding and Growing	Feeding								

Migratory Fish Species	Sampling Sites	Year Class*	Migration Purpose											
			1st Monitoring (April, 2014)	2nd Monitoring (July, 2014)	3rd Monitoring (Oct, 2014)	4th Monitoring (Dec, 2014)	5th Monitoring (April, 2015)	6th Monitoring (July, 2015)	7th Monitoring (Oct, 2015)	8th Monitoring (Dec, 2015)	9th Monitoring (April, 2016)	10th Monitoring (July, 2016)	11th Monitoring (Oct, 2016)	12th Monitoring (Dec, 2016)
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	-	-								
Gang Tengra	Haldikhali	Adult	Feeding	-	Feeding	Feeding								
	Akram Point	Adult	Feeding and Breeding	-	-	Feeding								
	Harbaria	Adult	-	-	Feeding	-								
	Chandpai	Adult	-	-	Feeding	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	-	-	-								
	Chandpai	Age-1 adult	-	-	-	Feeding								
	Mongla Point	Age-1 adult	-	Feeding and Growing	-	Feeding								
Potka	Haldikhali	Adult	Feeding and Breeding	-	-	-								
	Chandpai	Fry	Spawning	Spawning and Nursing	-	-								
	Chandpai	Adult	-	-	-	Feeding								
	Mongla Point	Fry	Spawning	-	-	-								
Paira Chanda	Akram Point	Adult	Feeding	-	-	-								
	Chandpai	Fry	Breeding and Spawning	-	-	-								

Migratory Fish Species	Sampling Sites	Year Class*	Migration Purpose											
			1st Monitoring (April, 2014)	2nd Monitoring (July, 2014)	3rd Monitoring (Oct, 2014)	4th Monitoring (Dec, 2014)	5th Monitoring (April, 2015)	6th Monitoring (July, 2015)	7th Monitoring (Oct, 2015)	8th Monitoring (Dec, 2015)	9th Monitoring (April, 2016)	10th Monitoring (July, 2016)	11th Monitoring (Oct, 2016)	12th Monitoring (Dec, 2016)
			g											
Chewa	Akram Point	Juvenile and Adult	Feeding	-	Feeding and Growing	-								
	Chandpai	Fry and Juvenile	Spawning	-	Feeding and Growing	-								
	Chandpai	Adult	-	-	-	Feeding								
	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	Feeding								
	Haldikhali	Juvenile-1, Juvenile and Adult	-	-	Nursing and Growing	Feeding								
	Harbaria	Juvenile and Adult	-	-	Feeding and Growing	-								
	Chandpai	Fry	Breeding and Spawning	Nursing	-	-								
	Chandpai	Juvenile and Adult	-	-	Feeding and Growing	Feeding								
	Mongla Point	Fry	Breeding and Spawning	-	-	-								
	Mongla Point	Fry, Juvenile-1 and Juvenile			Nursing and Growing	-								
	Mongla Point	Juvenile and Adult	-	-	-	Feeding								
	Chalna Point	Fry	Breeding and Spawning	Nursing	-	-								
	Chalna Point	Adult	-	-	-	Feeding								
	South-west of the Project	Juvenile and Age-1 adult	-	Feeding and Growing	Feeding and Growing	Feeding								
Tular Dandi (Nona bele)	Akram Point	Adult	Feeding	-	-	-								
	South-west of the Project	Adult	-	-	Feeding	-								
	Chalna Point	Adult	Feeding	-	Feeding	-								

Migratory Fish Species	Sampling Sites	Year Class*	Migration Purpose											
			1st Monitoring (April, 2014)	2nd Monitoring (July, 2014)	3rd Monitoring (Oct, 2014)	4th Monitoring (Dec, 2014)	5th Monitoring (April, 2015)	6th Monitoring (July, 2015)	7th Monitoring (Oct, 2015)	8th Monitoring (Dec, 2015)	9th Monitoring (April, 2016)	10th Monitoring (July, 2016)	11th Monitoring (Oct, 2016)	12th Monitoring (Dec, 2016)
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	-								
	Haldikhali	Adult	-	-	-	Feeding								
	Chalna Point	Juvenile and Adult	Feeding	Feeding and Growing	-	-								
	Chalna Point	Adult	-	-	Feeding	Feeding								
	Mongla Point	Adult	-	-	Feeding	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	Feeding								
Paissa	Akram Point	Juvenile and Adult	Feeding	-	Feeding and Growing	Feeding								
	Haldikhali	Juvenile and Adult	Feeding	-	Feeding and Growing	Feeding								
	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	-	-	-								
	Chandpai	Adult	-	-	-	Feeding								
	Haldikhali	Juvnile and adult	-	-	Feeding and Growing	Feeding								
	Mongla Point	Fry and Adult	Feeding	Nursing	-	-								

Migratory Fish Species	Sampling Sites	Year Class*	Migration Purpose											
			1st Monitoring (April, 2014)	2nd Monitoring (July, 2014)	3rd Monitoring (Oct, 2014)	4th Monitoring (Dec, 2014)	5th Monitoring (April, 2015)	6th Monitoring (July, 2015)	7th Monitoring (Oct, 2015)	8th Monitoring (Dec, 2015)	9th Monitoring (April, 2016)	10th Monitoring (July, 2016)	11th Monitoring (Oct, 2016)	12th Monitoring (Dec, 2016)
	Mongla Point	Adult	-	-	-	Feeding								
	South-west of the Project	Adult	-	-	Feeding	Feeding								
	Chalna Point	Adult	-	-	Feeding	Feeding								
Hilsa	Haldikhali	Juvenile	-	-	Feeding and Growing	-								
	Mongla Point	Adult	-	-	Feeding	-								
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

143. It is interpreted from the findings that in the month of January fish species migrate to the upper reaches of the Passur river for feeding purpose.

### **9.3.6 Shrimp/Fish Farm**

144. For monitoring shrimp/fish farm, three farms situated in the direct impact zone of Power Plant have been surveyed. 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 getting more economical output from the farms. So, stocking pattern, growth rate and mortality rate and its causes have been surveyed intensively.

#### **(a) Stocking Pattern**

145. It is reported by the farmers of the shrimp farms that availability of wild seed (PL) has been declining over the years. For this reason, 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 the stocks are still collected from wild source of the Passur River in the third monitoring phase too. However, there was no stocking found in this monitoring phase.

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

146. The following Table 9.10 shows that the growth rate of Bagda has decreased in case of Chhoto Charer Gher in Rajnagar, increased in Gher in Kapashdanga-Muralia but remained same in Gher of Chunkuri-2 between second and third monitoring phase when the mortality rate was highest in Gher of Chunkuri-2 and lowest in Gher in Kapashdanga-Muralia. The mortality has not been assessed in the fourth monitoring phase.



Table 9.10: Growth Rate and Mortality of Fish/Shrimp

Gher No.	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	
	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)	Rate (cm/day)	Mortalit y (%)
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

### 9.3.7 Fish Production

#### (a) Capture Fish Production

147. In fourth monitoring phase, the highest productivity has been found in Haldikhali, and lowest in the Mongla Point (**Table 9.11**). Moreover, as expected higher productivity was observed in the fourth monitoring phase as compared to that of the second and third monitoring. However, during the month of January the lower reach of the river (Haldikhali and Akram point) has mainly been observed as the ideal home of adult fish as the over-wintering refuges.

148. The present study observed that Ber, Behundi, Charpata and Khepla Jal are frequently used to catch fish. The total catch through Ber and Charpata Jal is 11.4 and 45 kg respectively (**Table 9.11**). The following table also expresses that Ber Jal is used in lower reach and upper reach of the Passur River. Moreover, lining spear has been found in lower reaches of the Passur River. However, the total catch is higher in fourth monitoring phase than that found in the third and second monitoring (**Table-9.12**).

**Table 9.11: Total Catch in Different Gears in the Sampling Sites**

Sl. No	Site	Habitat	Gear Name/Type	Haul Duration (hr)	No of Haul	Total Catch (kg)	kg/haul
A	Akram Point	Kukilmoni Khal	Khepla Jal	1	40	6	0.15
			Lining Spear	7	1	40	40
B	Haldikhali	Haldekhal Khal	Charpata Jal	8	1	30	30
C	Harbaria	Harbaria Khal	Not Found	0	0	0	0
D	Chandpai	Sheola Khal	Baundi Jal	4	1	5.5	6
			Charpata Jal	10	1	15	15
E	Mongla Point	Passur River	Ber Jal	2.3	2	1.2	0.6
			Khepla Jal	3	10	0.1	0.01
F	Maidara	Mouth of Muidhara River	Poa/Ber Jal	6.3	4	3.7	0.93
G	Chalna Point	Passur River	Net Jal	6	1	0	0
			Poa/Ber Jal	7	6	6.5	1.08

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

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	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	28.7								
B	65	0	1	3.3								
C	1,559	0.5	8	8.7								
D	**	12	3	30.0								
E	**	0.6	5	0								
F	**	1.2	13	3.7								

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	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
G	**	1.6	4	0.7								

\*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*

149. The present study on shrimp/fish farm in the fourth quarter monitoring phase showed that there was no production found in shrimp/fish culture pond in three selected ghers (**Table 9.13**).

Table 9.13: 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		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	
	Species	ton	Species	ton	Species	ton	Species	ton	Species	ton	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	HarinaHarina 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																		
	-	-	-		Gulsha Tengra	0.2																		
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																		
	-	-	-	-	Bele	20																		

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		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	22																		
	-	-	-	-	Rui	28																		
	-	-	-	-	Vetki	-																		
	-	-	-	-	Harina Chingri	-																		
	-	-	-	-	Chami Chingri	-																		
	-	-	-	-	Catla	56																		
	-	-	-	-	Mrigel	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**

150. Ecosystem and biodiversity of the study area have been monitored quarterly as per the monitoring schedule. Followed by the first three quarter monitoring, the fourth quarter monitoring has been carried out in January 2015. This report compiles all the monitoring data up to fourth quarter monitoring.

### **10.1 Indicators of Monitoring**

151. 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.

152. 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.

153. 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.

154. 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.

155. 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 after year will be considered to observe migratory bird habitat suitability.

156. 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.

157. 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.

158. 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.

159. 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**

160. 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.

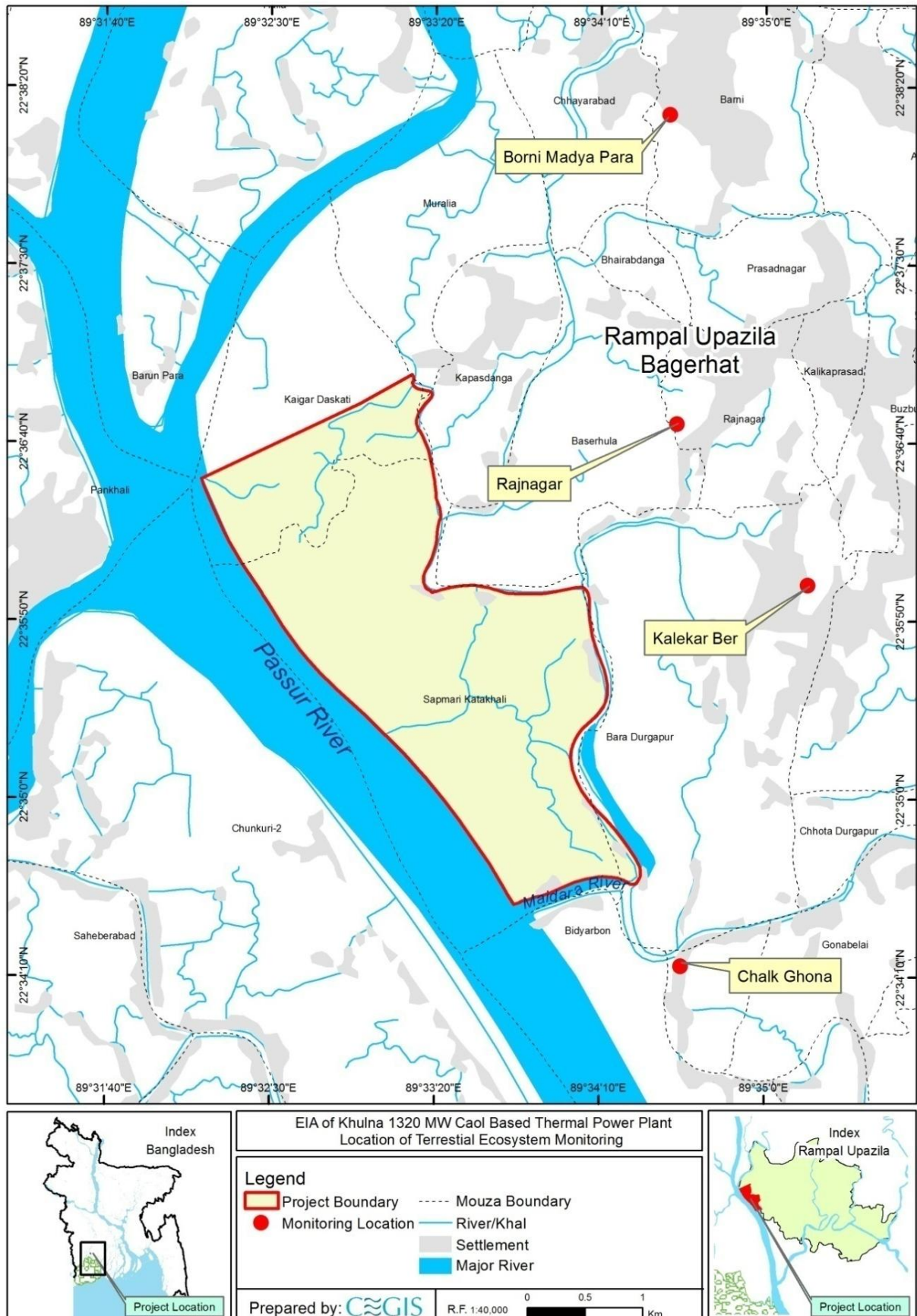
**Table 10.1: Locations of Terrestrial Ecosystem Monitoring**

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



Sl. No.	Homestead Location	Owner's Name	Homestead area in Decimal	Special direction from the Project boundary	GPS Coordinates
	Madyapara, Union: Gaurambha, Upazila: Rampal			north from north-east boundary	89°34'31"E

Source; Field Survey, 2014



Map 10.1: Terrestrial Ecosystem Monitoring Locations

**(b) Aquatic Ecosystems**

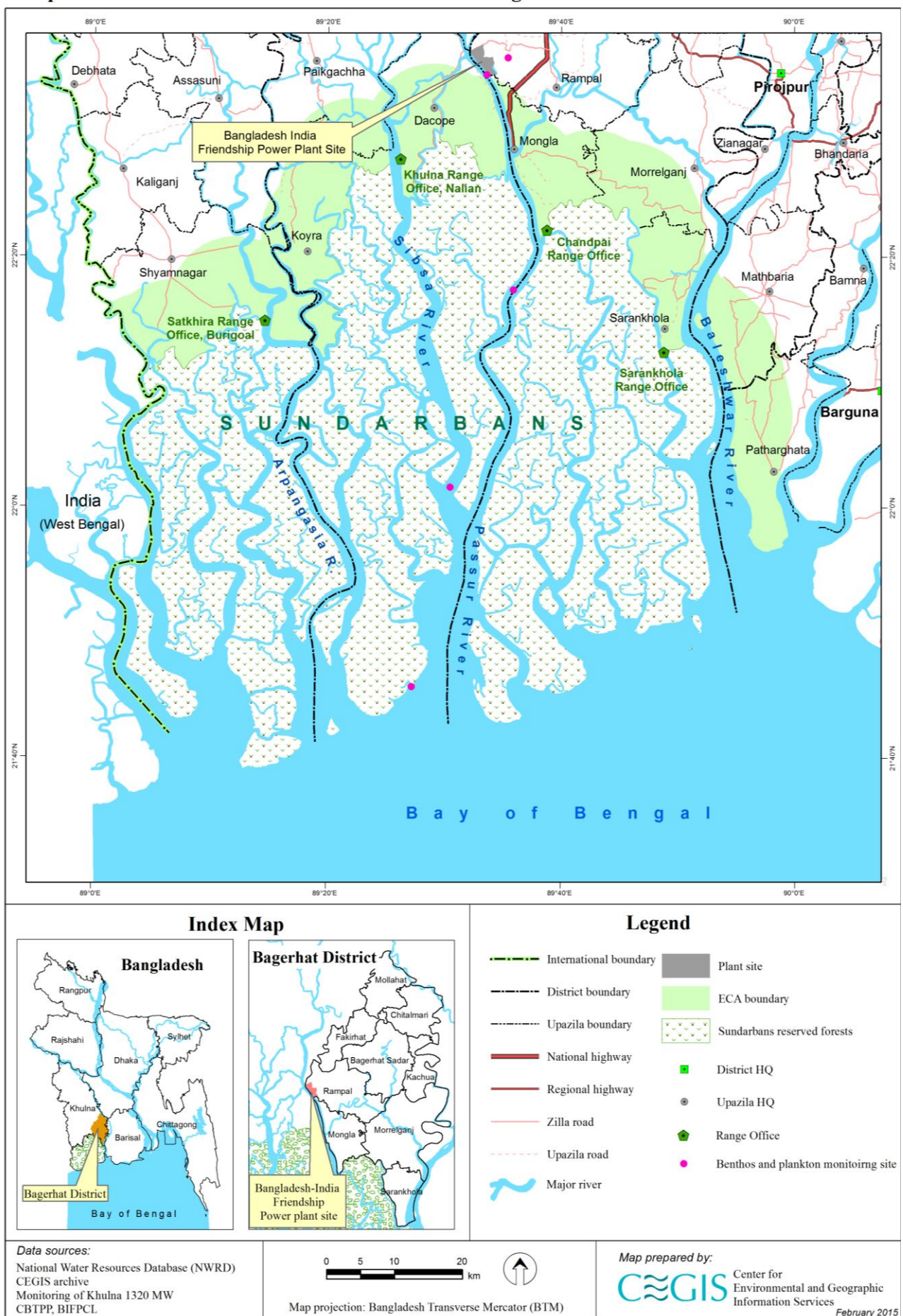
161. Different locations of river systems as well as lentic waterbodies have been selected to observe the changes in the three selected indicators: benthos, plankton and Dolphin occurrence for aquatic ecosystem monitoring. In addition, to monitor the stagnant water ecosystem condition, two ponds have 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 89°33'37"E
	Project Jettyghat at Passur river	22°35'21"N 89° 32'51"E
	Passur River near Harbaria	
	Passur River near Akram Point	21°59'33"N 89°31'54"E
Benthos and Plankton species composition in stagnant waterbody	Kalekherber Dighi	22°36'00"N 89° 35'13"E
	Kaigardaskanthi Gucchagram Pond	22°36'35"N 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 89° 32'00"E
	Along Maidara River from Passur-Maidara confluence point to upstream reach	From 22°34'34"N 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





Map 10.2: Benthos and Plankton Monitoring Locations

## 10.3 Monitoring of Ecosystem and Bio-diversity

### 10.3.1 Terrestrial Ecosystem

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

#### a. Description of the selected homestead

The homestead in Rajnagar is located at 2.5 km. east from upper North-east boundary of the project site. This is situated inside the damp area as numerous small swamps exist inside and surround the homesteads. Water retention capacity of surface soil of this homestead is very low and for this reason very little number of grasses and other herbs are present. Land elevation of selected homestead at Kalekar Ber dighi village is comparatively flood free. This is located at about 1.8 km. east from Middle-east boundary of the project. Chalkghona village is located 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. Borni village is located at about 3.0 km north from north-east boundary. Sampled homestead at Borni is situated at the middle part of the village. This homestead is also dominated by planted tree species and soil condition is similar to Rajnagar site. Vegetation of this homestead have been severely been damaged by past Cyclone Aila.

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

##### *Homestead at Rajnagar*

Among the trees, Gewa (*Excocharia 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 Boro ( *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. In addition three Bola (*Hibiscus tiliaceus*) and one Sundari (*Heritiera fomes*) also found to exist. The homestead has no grasses or undergrowth vegetation.

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

Narikel (*Cocos nucifera*) and Khejur (*Phoenix sylvestris*) occupies the top canopy. Aam (*Mangifera indica*), Safeda (*Manilkara zapota*), Peyara (*Psidium guajava*) and Boro ( *Zizyphus* sp) are common trees height about 3-5 m. Rendi Koro ( *Albizia saman*) and Raj Koro ( *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, Swarnalata (*Cuscuta reflexa*) and Durba (*Cynodon* sp) are found.

##### *Homestead at Chalkghona*

Similar to the above homesteads, in the selected homestead at Chalkghona, Narikel is the dominating tree species as well as occupying the top canopy. As the homestead is near the peripheries of river and shrimp gher, soil salinity supports luxurious growth of mangrove plant Gewa (*Excocharia agallocha*). This homestead has two shallow ditches which contain brackish water throughout the year and 2 Gol (*Nipa fruticans*) bushes are 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 10.3.



**Photo 10.1: A part of homestead vegetation at Barni**

#### *Homestead at Barni*

This homestead contains 21 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. Then the house owner planted many timber and fruit yielding trees throughout 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			
			Borni	Kalekar Ber Dighi	Chalk ghona	Rajna gar
<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	Leguminosae	6	7	3	2

Species Name	Local Name	Family	No. of Plants			
			Borni	Kalekar Ber Dighi	Chalk ghona	Rajna gar
	Koroi					
<i>Anona squamosa</i>	Ata	Anonaceae	-	1	-	-
<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>Phylanthus acidus</i>	Naul/Orboroi	Euphorbiaceae	-	-	2	-
<i>Pongamia sp</i>	Koroj	Leguminosae	-	-	2	3
<i>Psidium guajava</i>	Peyara	Myrtaceae	2	8	17	2
<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 mehogoni</i>	Mehogani	Meliaceae	11	17	1	2

Species Name	Local Name	Family	No. of Plants			
			Borni	Kalekar Ber Dighi	Chalkghona	Rajna gar
<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

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 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
Borni	1	<i>Swietenia mahagoni</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
	5	<i>Phoenix sylvestris</i>	Khejur	Palmae	12	2.4	240
Kalekar Ber Dighi	1	<i>Cocos nucifera</i>	Narikel	Palmae	56	11.2	1120
	2	<i>Excoecaria 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
	5	<i>Dyospyros blancoi</i>	Bilati Gab	Ebnaceae	12	2.4	300



Location	Sl. No.	Species Name	Local Name	Family	Total Number of individuals	Density	Abundance	
Rajnagar	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	-
	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

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

Plant health of this area is not satisfactory. Vegetation structure of this area is tree dominant. Random saline shrimp farming is a big 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*

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.

Symptoms of plant diseases are same like previous monitoring condition. Leaf spot, leaf blast, nut fall, spot canker on fruits are common diseases of the plants in the study area. A brief discussion was held with home owners about diseases of selected economic plants which exist in their homesteads. Most symptoms for 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 all location. Infection of fungal disease is not remarkable all the homesteads.



**Photo 10.2: Unhealthy coconut and date palm plant at studied homesteads in Chalkghona.**

#### *Number of disease affected trees*

There is no significant change in number of disease affected plants than last monitoring in October, 2014. Nevertheless, all disease affected plants mostly for Coconut and Date Palm in Rajnagar and Chalkghona village followed unhealthier in this monitoring. No new plant has recorded as disease affected.

Following table represent 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 (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4 <sup>th</sup> QM (Jan 2015)	1st QM (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4 <sup>th</sup> QM (Jan 2015)
Rajnagar	<i>Cocos nucifera</i>	17	NS	7	11*	11	NS	10	5	5
	<i>Phoenix sylvestris</i>	25	NS	10	21	21	NS	15	4	4

Location	Plant Name	Total No. of Plant	No. of Healthy Plant				No. of Unhealthy Plant			
			1st QM (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4 <sup>th</sup> QM (Jan 2015)	1st QM (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4 <sup>th</sup> QM (Jan 2015)
	<i>Manilkara zapota</i>	1	NS	1	1	1	NS	0	0	0
	<i>Albizia saman</i>	2	NS	2	2	2	NS	0	0	0
	<i>Excoecaria agallocha</i>	100	NS	100	98*	98	NS	0	1	1
	<i>Mangifera indica</i>	3	NS	2	3	3	NS	1	0	0
	<i>Psidium guajava</i>	2	NS	0	2	2	NS	2	0	0
Borni	<i>Cocos nucifera</i>	10	3	7	10	10	7	3	0	0
	<i>Phoenix sylvestris</i>	12	12	7	8	8	0	5	4	4
	<i>Borassus flabellifer</i>	6	3	5	6	6	3	1	0	0
	<i>Mangifera indica</i>	6	3	3	5	5	3	3	1	1
	<i>Excoecaria agallocha</i>	18	18	18	18	18	0	0	0	0
	<i>Swietenia mehogani</i>	11	11	11	11	11	0	0	0	0
	<i>Areca catechu</i>	10	10	4	8	8	0	6	2	2
	<i>Manilkara zapota</i>	1	1	1	1	1	0	0	0	0
	<i>Psidium guajava</i>	2	0	1	2	2	2	1	0	0
Kalekarber Dighi	<i>Cocos nucifera</i>	56	21	50	55	55	35	5	1	1
	<i>Phoenix sylvestris</i>	10	10	7	10	10	0	3	0	0
	<i>Mangifera indica</i>	5	3	5	5	5	1	1	0	0
	<i>Manilkara zapota</i>	1	1	1	1	1	0	0	0	0
	<i>Borassus flabellifer</i>	8	8	8	8	8	0	0	0	0
	<i>Zizyphus sp</i>	1	1	1	1	1	0	0	0	0
	<i>Psidium guajava</i>	8	7	8	8	8	0	0	0	0
	<i>Tamarindus indica</i>	2	2	2	2	2	0	0	0	0
Chalkghona	<i>Cocos nucifera</i>	39	35	20	34	34	25	19	5	5
	<i>Phoenix sylvestris</i>	24	24	14	23	23	0	10	1	1
	<i>Albizia saman</i>	3	1	3	3	3	0	0	0	0
	<i>Excoecaria agallocha</i>	36	36	36	35	35	0	0	1	1
	<i>Manilkara zapota</i>	1	1	1	1	1	0	0	0	0
	<i>Psidium guajava</i>	17	16	10	17	17	1	7	0	0
	<i>Mangifera indica</i>	7	5	6	7	7	2	1	0	0
	<i>Borassus flabellifer</i>	2	2	2	2	2	0	0	0	0

Note: NS = Not Surveyed

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

#### f. Vegetation canopy status

Canopy status of terrestrial vegetation indicates plant health and biomass properties of an area. Vegetation canopy structure may be changed for the change in plant growth rate due to soil properties change, 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 is monitoring in different time intervals.

*Species representation in different canopy layers of homestead vegetation*

*Cocos nucifera* occupied top canopy of all the studied homestead vegetation. *Phoenix sylvestris* is prevalent as second top layer followed by *Excochcaria 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 followed at studied homesteads.

*Estimated Canopy cover in homestead vegetation of sampling sites*

Canopy cover is followed decrease in Rajnagar and Chalkghona village. Seasonal effect on plant life cycle slow foliage growth rate during winter. As a result, vegetation of sample homesteads showed low canopy coverage than previous monitoring. In the case of Kalekarber village, canopy coverage is estimated about 25% which is 1% more from previous monitoring. Coconut leaves are contribute staple coverage of canopy in this homestead which was in pruning form during last monitoring. Canopy coverage of the studied homesteads have been represent in following table.

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

Location	% of canopy Coverage			
	1st QM (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4 <sup>th</sup> QM (Jan 2015)
Rajnagar	NS	19	19	17
Borni	NS	26	18	18
Kalekarber	NS	20	24	25
Chalkghona	NS	13	24	22

Note: NS = Not Surveyed

**g. Lichen cover**

Lichen coverage on plant bark have not monitored in this phase. However, this indicator will be observed in next monitoring season.

**h. Bird Habitat**

*Local birds and their nesting behavior*

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 boundaries, 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 10.8.

**Table 10.8: 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
<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>Larus 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

Scientific Name	Common Name	Local Name
<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 Swamphe	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>Sturnus 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>Vanellus indicus</i>	Red-wattled Lapwing	Lal Hotiti

Source: Field Monitoring, April 2014

#### *Migratory birds and their habitats*

Migratory and local migratory winter birds are followed at large shrimp gher along the study area. Bar Headed Goose, Red Crested Pochard, Ruddy Shelduck, Common Coot, Common Snipe, Black Winged Stilt etc are common winter visitor of this area. In addition, local Ruddy Breasted Crake, Common Sandpiper, Great Egret, Pond Heron, Little Cormorant are also found at Borocharar Gher and Golbunia Gher at Borodurgapur Mouza.

Out of eight locations/ wetlands, Borocharar Gher and Golbunia Gher are in top abundance of migratory birds which have been observed during last field visit in January 2015. According to local knowledgeable persons, population of migratory birds are reducing day by day from these wetlands for hunting, re-starting shrimp culture within short intervals from shrimp harvesting in past year and indiscriminate use of pesticides in agriculture field and shrimp ghers.

Following table show the presence of migratory birds at the important wetlands inside the study area.

**Table 10.9: Presence of migratory birds at different wetland inside the study area**

Wetland Name	Wetland type	Approximate distance from project Boundary (Km.)	Presence of Birds	
			Local Migratory	Migratory
Choto Charargher	Saline Water Shrimp Farm	0.10	Yes	No
Boro Charargher	"	0.10	Yes	Yes
Putimari Gher	"	1.10	Yes	No

Golbunia Gher	'	0.1	Yes	Yes
Shukariar Gher	'	1.25	Yes	No
Koigar Daskati Gher	'	0.25	No	No
Badyamari Gher	'	1.00	No	No
Chalkghonar Beel	'	1.50	Yes	No

Source: Field Monitoring, January 2015

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

No bird nest has been observed at 4 studied homesteads during this monitoring season.

**Table 10.10: Bird nest monitoring datasheet**

Bird Name	No. of Bird Nest observed															
	1st QM (Apr 2014)				2nd QM (Jun 2014)				3rd QM (Oct 2014)				4th QM (Jan 2015)			
	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

From the last monitoring period (October 2015) a total of 28 butterfly species have been recorded from the study area. Among which, 5 species are not directly observed during field visit at this monitoring period and those are identified through public discussion. Rice Swift, Common Crow, Grass-yellow, Common Emigrant, Blue Tiger are the common butterflies of the study area frequently found along the flowering plants, near marshes and bushes. Recorded butterfly species and their occurrences are listed in Table 10.11 below.

**Table 10.11: Occurrences of Butterflies in the study area**

Common Name	Scientific Name	Occurrence of Butterfly species															
		1st QM (Apr 2014)				2nd QM (Jun 2014)				3rd QM (Oct 2014)				4 <sup>th</sup> QM (Jan 2015)			
		R	B	K	C	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>					-	*	-	-	-	-	-	-	-	*	*	-
Danaid Eggfly	<i>Hypolimnas 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'=Borni, 'K'=Kalekarber, 'C'=Chalkghona

Occurrence of butterflies observed lower than previous monitoring. However, 10 species of butterflies have been recorded from studied homesteads and its peripheral areas. Evening brown (*Melanitis leda*) and Small Grass-yellow (*Eurema smilax*) is the commonest of all the recorded species.



## 10.4 Aquatic Ecosystem Monitoring

Rivers, canals, ponds and saline water shrimp farms are main wetland forms in the study area. Of which, river bear the flowing/ lotic and ponds bear the stagnant/lentic water systems. Canals of this area have merged with shrimp farms. Shrimp farms extend a large proportion of total watershed of the study area those are intervene by human. Therefore, canals are not a actual flowing or stagnant water system.

### 10.4.1 Monitoring Locations

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 Saitakhali 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.

### 10.4.2 Dolphin Occurrence

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

Two dolphin species (Ganges River Dolphin and Irrawaddi Dolphin) travel throughout the Passur river for whole of the year. The Ganges river dolphin migrate 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 mainly during high tide. Siltation and narrowing of upstream branches is limiting the length of migration area of this river day by day.

#### *Dolphin occurrence in Passur River*

Occurrence of dolphin have been monitored by boat transect along about 20 km length of Passur River surround the project area. A total of 5 Ganges River Dolphins were recorded at different locations of the surveyed transect. All of which are diving and occurrence concentrated at the confluence of the Mungla-Passur and the Maidara-Passur points.

Detail survey result is presented in following figure (Figure 10.3).

Another short survey was conducted Karomjal, Harbaria and Akram Point while passing the river. In Karamjal and Harbaria, evidence of Ganges Dolphin was found at both locations. 2 individuals of Irrawaddy Dolphin were also sighted at Akram point. However, the survey result is included in Table: 10.12.

#### *Dolphin occurrence in Maidara River*

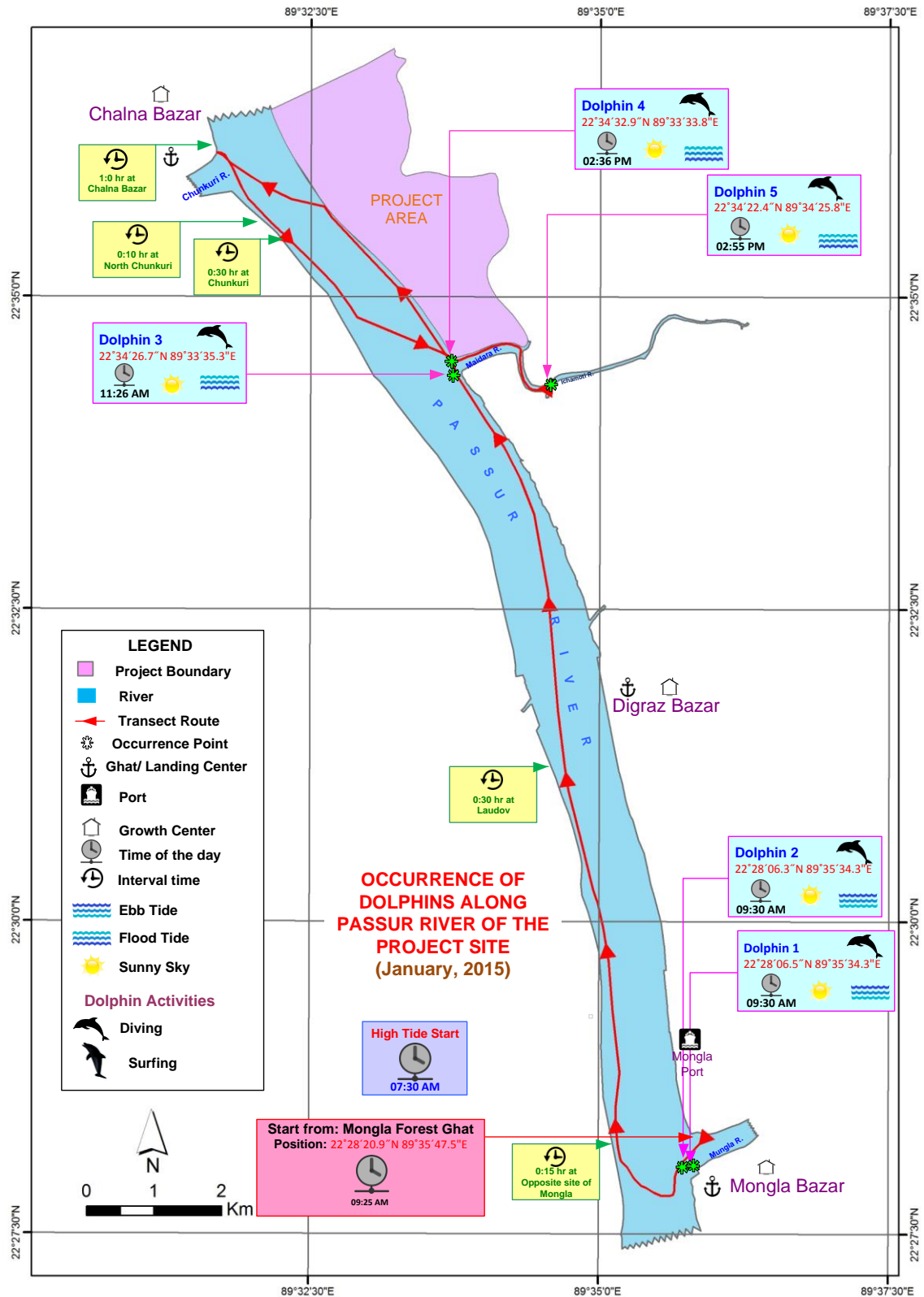
Dolphin occurrence also have observed inside Maidara and Ichamoti River in parallel survey with project site Passur river during full-flood tide. At the mouth of Maidara River (Passur-Maidara confluence point), 2 Ganges River Dolphins were recorded which is already mentioned earlier. Beside this, one individual was found at Ichamoti-Maidara confluence point a distance about 2 km inner from Passur-Maidara confluence point.

**Table 10.12: Dolphin observation Datasheet**

Location of River systems	Occurrence Status							
	1 <sup>st</sup> QM (Apr 2014)		2 <sup>nd</sup> QM (Jun 2014)		3 <sup>rd</sup> QM (Oct 2014)		4 <sup>th</sup> QM (Oct 2014)	
	FT	NT	FT	NT	FT	NT	FT	NT
Passur River Near Project Side	Y	Y	Y	Y	Y	Y	Y	Y
Karamjal	NS	NS	NS	N	NS	Y	Y	Y
Harbaria	NS	NS	NS	N	NS	Y	Y	N
Akram Point	NS	NS	NS	N	NS	N	NS	Y
Sarankhola	NS	NS	NS	N	NS	NS	N	N
Moidara River	Y	N	N	N	Y	Y	Y	N

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

Occurrence Status: Y = Occurred, N = Not occurred



**Map 10.3: Occurrence of Dolphin at Passur and Maidara River along the project site (January 2015)**



## 11 Sundarbans Forest Health Monitoring

### 11.1 Monitoring Indicator

162. The following indicators have been selected for the monitoring of Sundarbans Forest health:
- i. Species richness, diversity, evenness, dominance
  - 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
163. Monitoring frequency for different indicators is different. In this quarter, the following indicators were observed
- Regeneration and survival percentage
  - Canopy cover, pneumatophore
  - Crab hole density
  - tree height,
  - lichen presence and
  - Ecosystem carbon stocks.
    - i. Bulk density, organic carbon
    - ii. Soil pH, salinity
    - iii. N and P

### 11.2 Monitoring location

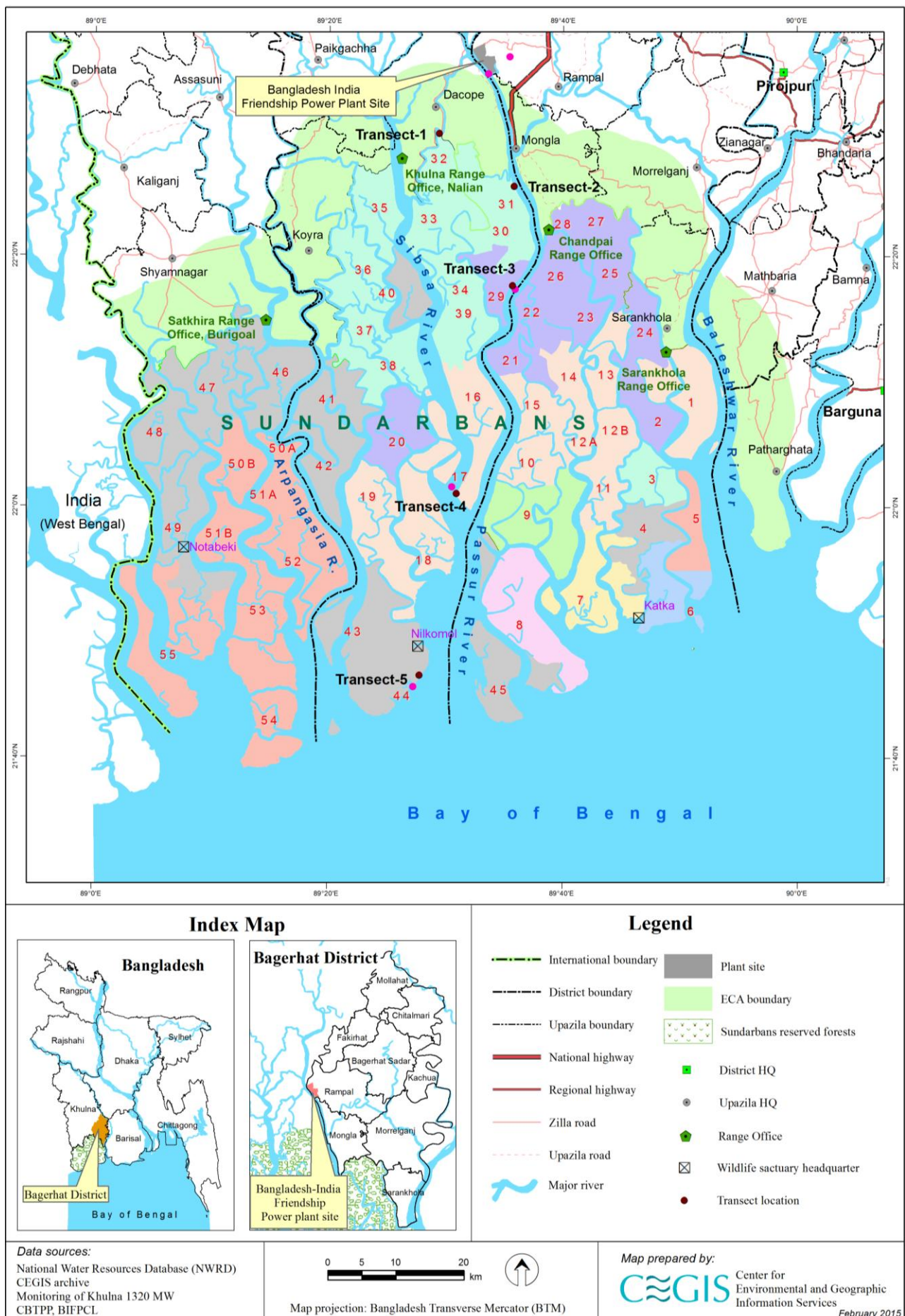
164. Five sites were selected on the basis of the survey conducted from April 3 to 6, 2014 (Map 11.1). Among them, four sites along the Passur River at Karomjol, Harbaria, Akram point and Hiron point and another near Sutarkhali forest office. Distance from the proposed Project site, coal transportation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

### 11.3 Method

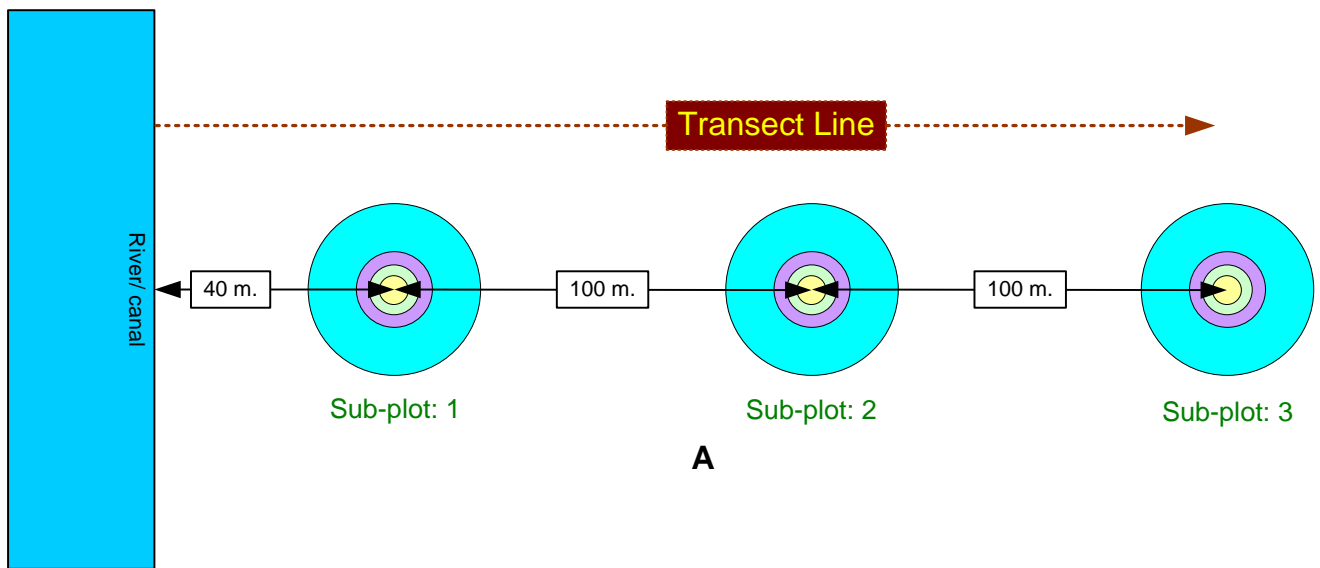
#### 11.3.1 Sampling design

165. 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.

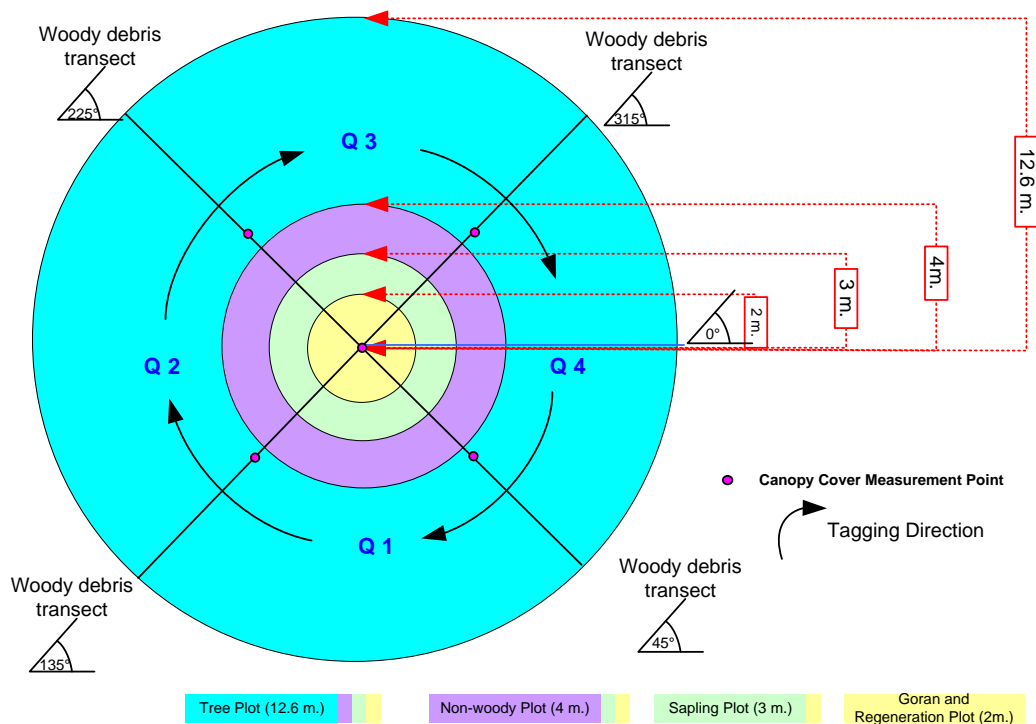




Map 11.1 : Location Map of Sundarbans Forest health Monitoring Plots



**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

167. Trees (DBH  $\geq 5$ cm and lean angle greater than 450) were measured within 12.62 m radius circle. All species tagged numbers were rechecked and rewrote if any number observed as fade.



The diameter of all trees was measured at breast height (1.37 m) and height was measured using Hoga Altimeter (Photo. 11.1) measured. Also, tree living status, damage and disease (top dying, canker) condition were also observed.



**Photo 11.1: Surveyor measuring tree height using Hoga Altimeter in January 2015 monitoring**



**Photo 11.2: Surveyor measuring stump' base diameter in January 2015 monitoring**

### ***Sapling and seedling***

168. 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***

169. 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***

170. Pneumatophores, 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 Pneumatophores 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 pneumatophores 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***

171. 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 an area of 2 m radius circle in each subplot.





**Photo 11.4: Crab hole with Pneumatophore at Akram point site in SRF**

### ***Canopy cover***

172. 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 levelling the instrument using the level bubble, the dots not occupied by canopy was systematically counted. In each subplot, the readings were taken at five points facing at north, south, east, and west direction including subplot centre point. First one was taken standing at subplot centre and other four were taken at the middle point of the four transects between centre and periphery. The canopy cover was estimated by taking the average of these five readings.

### ***Lichen***

173. The presence and absence of Lichen in tree species is an important indicator of forest health because it is very sensitive to air pollution such as sulfur dioxide, fluoride etc. The lichen cover percentage on tree was measured visually at breast height from 0-100 %. The plot average percentage was calculated and status was evaluated following Path Finder Science standard (2006)



**Photo 11.5: Lichen (white circle) on Gewa tree in Hiron Point site.**

### ***Soil sampling***

174. An open face feat augur (1m long) was used to pull out one meter long soil core. Soil core will be taken around the centre of the each plot. From the 100 cm soil core, a 5 cm long subsample was taken from the middle point of 0-15, 15-30, 30-50 and 50-100 cm intervals for bulk density, soil pH, salinity, soil nutrients (Ca, Mg, Al , K, N and P ) and organic carbon assessment.

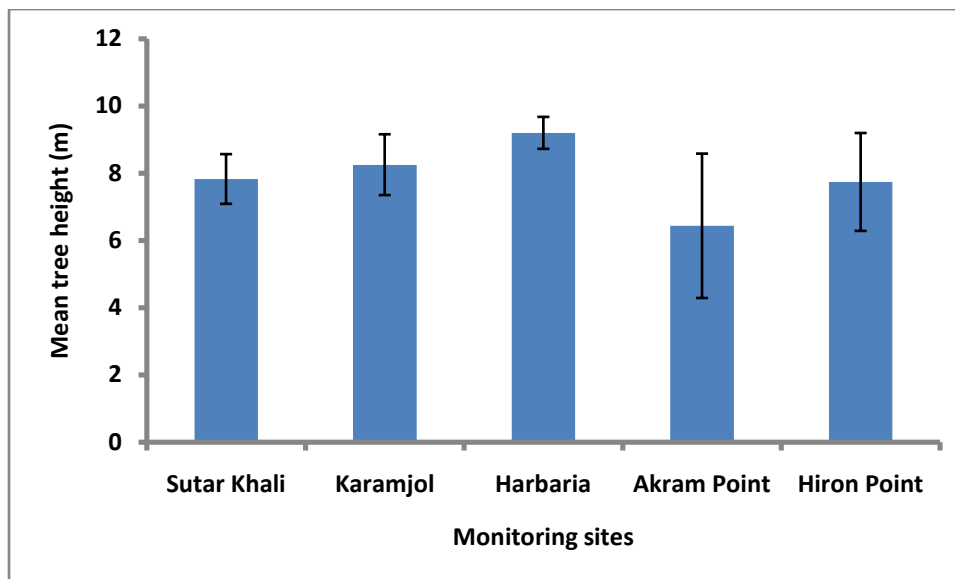
### **11.4 Statistical analysis**

175. Different statistical analyzes were preformed for different indicators. A one way ANOVA analysis was tested for canopy cover, pneumatophores and seedling density in order to find out whether any difference was made. For crab hole and lichen change, we performed paired sample t test in order to find out the difference between the two monitoring quarters.

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

#### **11.5.1 Tree height**

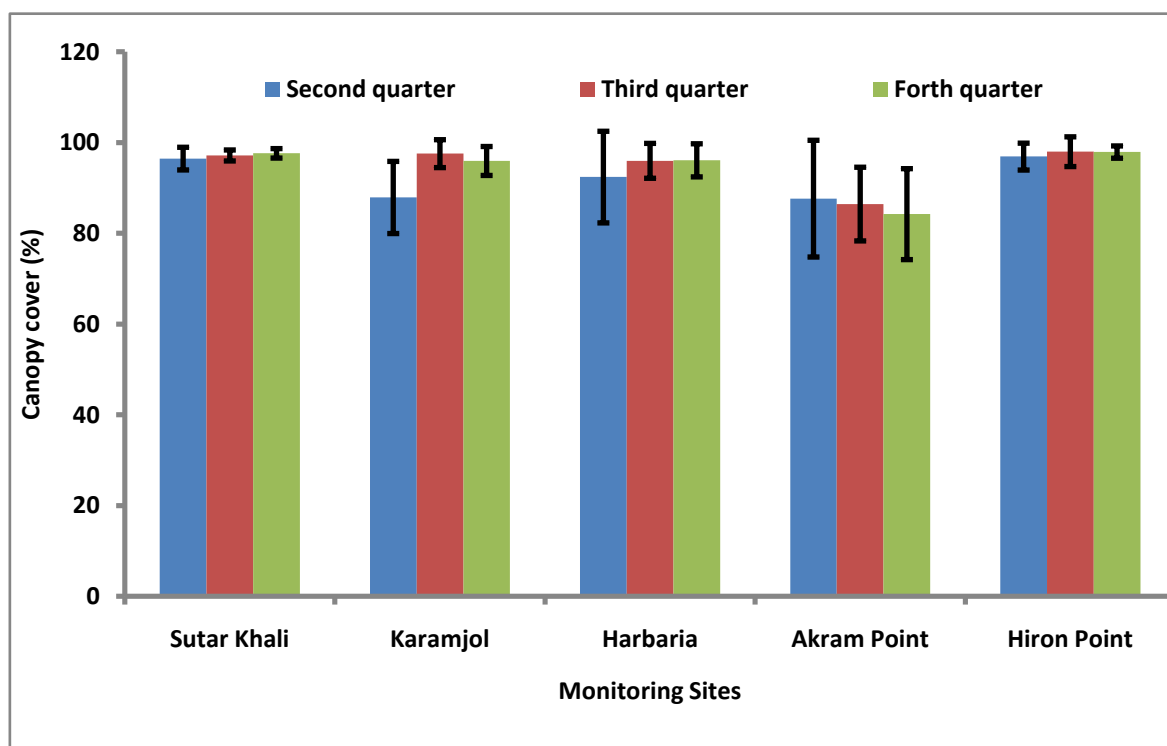
176. In the current monitoring, firstly the height was measured. The mean tree height in Sutarkhali, Karamjal and Hiron Point was similar. In herbaria, site tree height was highest, while it was lowest in Akram point.



**Figure 11.3: Mean ( $\pm$  95% CI) tree height in fourth quarter survey in five monitoring sites of the SRF.**

#### 11.5.2 Canopy cover

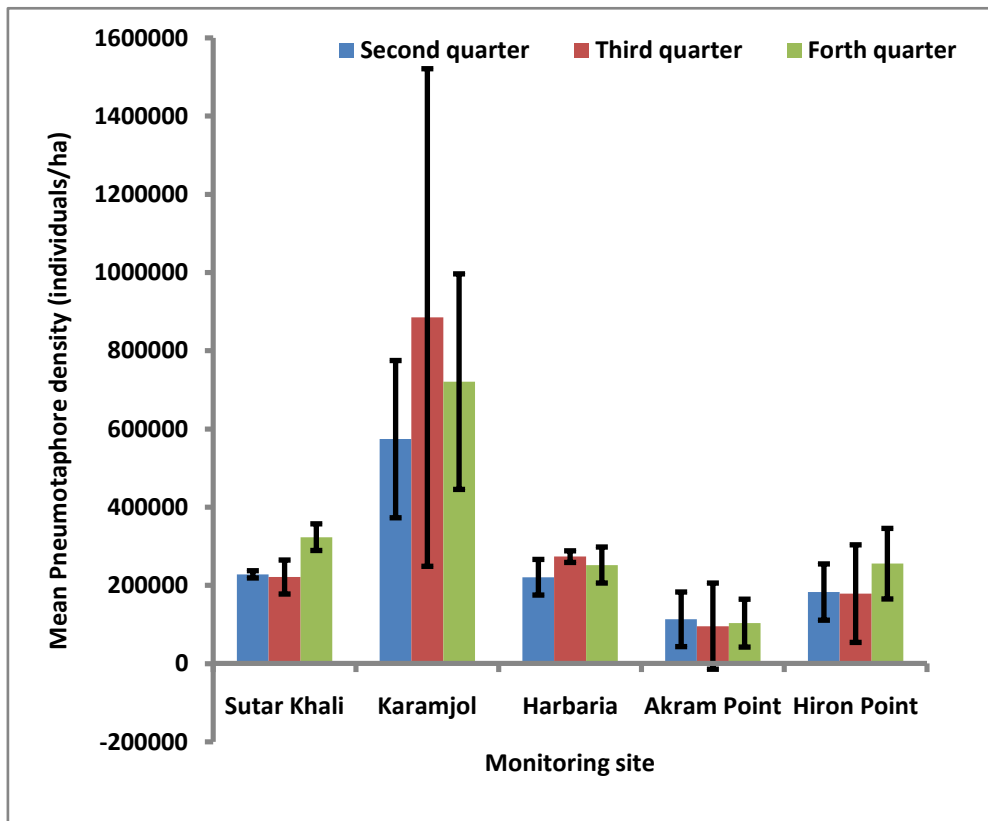
177. The canopy cover percentage in the five monitoring sites was not significantly varied during the three monitoring periods ( $P < 0.05$ ; Figure 11.4). These findings indicate that the foliage health condition across the five monitoring sites was good with no or less insect damage.



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

### 11.5.3 Pneumatophore

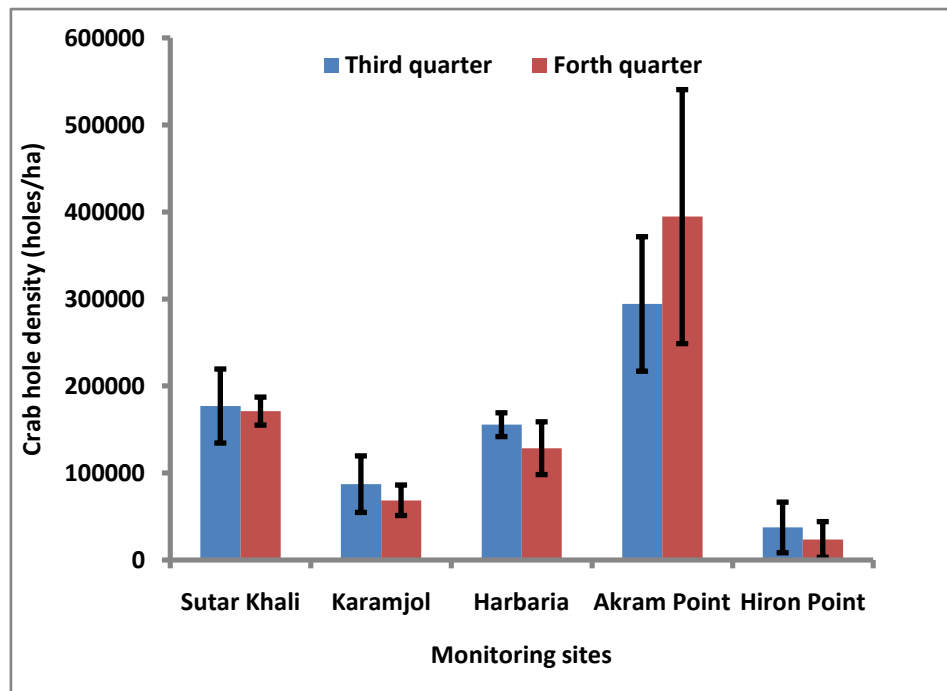
178. The mean density of pneumatophores was varied significantly in Sutarkhali monitoring site ( $P < 0.05$ ). This was because it is a Sundori dominated stand where new pneumatophores grow up the course of time. However, no significant difference was found in pneumatophores density of the four other monitoring sites ( $P > 0.05$ ). A similar trend was found at Harbaria, and Akram point site, while in Karamjal and Hiron Point, though it was observed decrease and increase trend in Pneumatophores density, in ANOVA analysis, these change were not significant during the three time periods. This could be due to the large variation among the subplot (replication). As for example, in the third subplot in Karamjal site mainly dominated by Baen tree and it has numerous tender pneumatophores that usually dry up and die during dry season.



**Figure 11.5: Average ( $\pm$  95% CI) number of pneumatophores density among the quarter suervy in five monitoring sites of the SRF.**

### 11.5.4 Crab hole

179. According to paired t-test analysis, the crab hole density was not varied between the second and fourth quarter monitoring in the five monitoring sites- Sutarkhali, Harbaria, Karamjal, Akram Point and Hiron Point ( $P > 0.05$ ; figure 11.6). In the all the all the sites (except Akram point), the crab hole density decrease from the third quarter monitoring. As the crab density is related to water availability that means regular inundation, the fourth quarter monitoring that was conducted during the dry season, experienced with lower crab density.



**Figure 11.6: Mean ( $\pm$  95% CI) crab hole density between first and second quarter suervy in five monitoring sites of the SRF.**

#### 11.5.5 Seedling regeneration

180. The seedlings density across the five monitoring sites was not significantly varied in ANOVA analysis ( $P > 0.05$ ; Figure. 11.8). However, a decreasing trend of seedling recruitment was found in all sites except Akram Point (Table 11.2). This declination of seedling density is due to natural motility of seedling which is a common in mangrove at the early stage of seedling development.

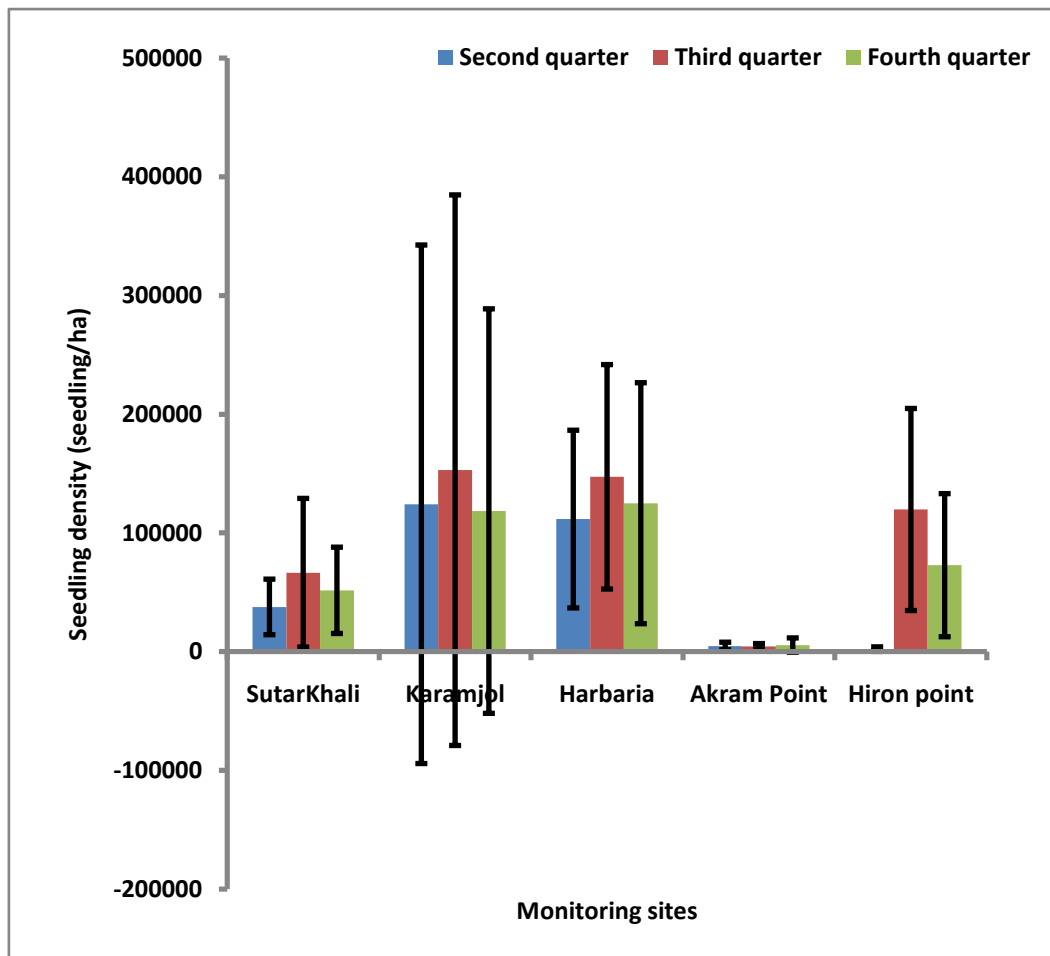
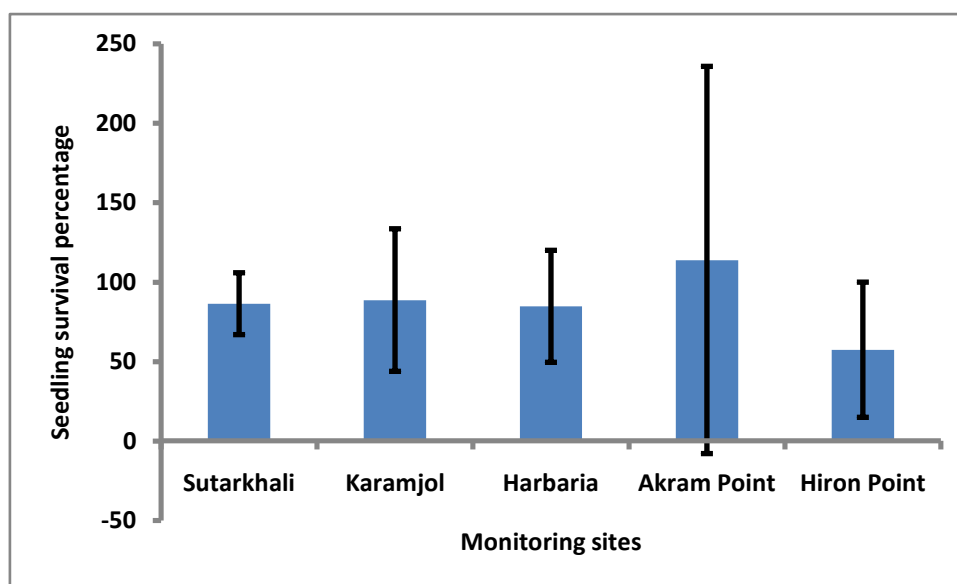


Figure 11.7: Mean ( $\pm$  95% CI) seedlings density among second, third and fourth quarter survey in five monitoring sites of the SRF.

#### 11.5.6 Seedling Survival

181. The seedlings survival percentage that were calculate from number of live seedlings present from the third quarter to fourth quarter monitoring across the five monitoring sites. The percentage of seedlings survival was found similar in Sutarkhali, Karamjal and Harbaria monitoring sites. In Akram point site, the survival percentage of seedling attained higher because during this time interval new seedling appeared in the fourth quarter monitoring, while in Hiron Point seedling survival percentage was lower (Figure 11.8).





**Figure 11.8: Mean ( $\pm$  95 % CI) seedling survival percentage between third and fourth quarter survey in five monitoring sites of the SRF.**

### 11.5.7 Pest and insect

#### *Lichen*

182. The lichen coverage (percentage at DBH) on tree was satisfactory in all the monitoring site except Hiron Point (Table 11.9) according to the Pathfinder Science (2006) standard (community with 5 % is assumed that the ecosystem has abundant lichen). However, the percentage of lichen presence on tree was reduced from second to fourth quarter monitoring except Sutarkhali (Table. 11.9). From the paired t test analysis it was found that these changes were significant in Karamjal, Harbaria and Hiron Point sites ( $P < 0.05$ ), while these figure was insignificant in Sutarkhali and Akram point sites ( $P > 0.05$ ). The presence and absence of Lichen is sensitive to air pollution. For example, it so much sensitive to sulfur dioxide as it will injure and die with increase of Air  $\text{SO}_2$  content (Smith and Thomson, 2003; Pathfinder Science, 2006). It was observed that the  $\text{SO}_2$  content in air were increased in the Karamjal (Near to Mongla Port), Harbaria, Akram point and Hiron Point which could be a causal factor for these lower presences of lichen percentage in fourth quarter monitoring (See chapter.3; Table. 3.1). Also, humidity low humidity could be another factor of these lower lichen presences (Pathfinder Science, 2006.)

**Table11.1: Mean ( $\pm$  95 % CI) percentage of changes in lichen availability between fourth and second quarter survey in five monitoring sites of the SRF.**

Monitoring site	Monitoring quarter		Change in Lichen %
	Fourth	Second	
Sutarkhali	27.06 $\pm$ 5.41	20.26 $\pm$ 2.64	6.81 $\pm$ 6.09
Karamjal	11.19 $\pm$ 4.34	24.45 $\pm$ 0.14	-13.26 $\pm$ 4.21
Harbaria	9.79 $\pm$ 5.15	22.91 $\pm$ 3.15	-13.12 $\pm$ 3.45

Akram Point	10.08±7.08	15.18±2.88	-4.46±4.37
Hiron Point	4.13±5.38	7.87±4.07	-3.83±1.31

### 11.5.8 Ecosystem carbon stocks

183. The ecosystem carbon stock is not included in the current in this report because the soil carbon and nutrient analysis is under laboratory. It will be updated whenever the analysis report available.

### 11.5.9 Conclusion

184. In the fourth quarter monitoring we measured tree height, canopy cover, crab hole and pneumatophores, regeneration status, seedlings survival percentage lichen presence and ecosystem carbon stocks. In herbaria, site tree height was highest, while it was lowest in Akram point and the other sites had similar tree height. We did not find any significant difference of canopy cover percentage, crab hole, pneumatophores and seedlings density among the three monitoring quarters in the five monitoring sites. However, in case of Lichen cover percentage was significantly decreased in Karamjal, Harbaria and Hiron Point. Low humidity and higher SO<sub>2</sub> could be responsible for these changes. The seedlings survival percentage was highest in Akram point, lowest in Hiron point and other three sites shows similar survival percentage of seedling. Ecosystem carbon stocks were included in this report as soil carbon and nutrient s analysis are under laboratory processing. From the finding of the current study it can be concluded that except lichen cover percentage, all other indicators were in good conduction.

## 12 Socio-economic Condition and Socio Safeguard Monitoring

### 12.1 Introduction

185. 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

186. 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.

187. 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*

188. 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: Household and population by mouza in quarters**

Name of Mouza	HHs 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>

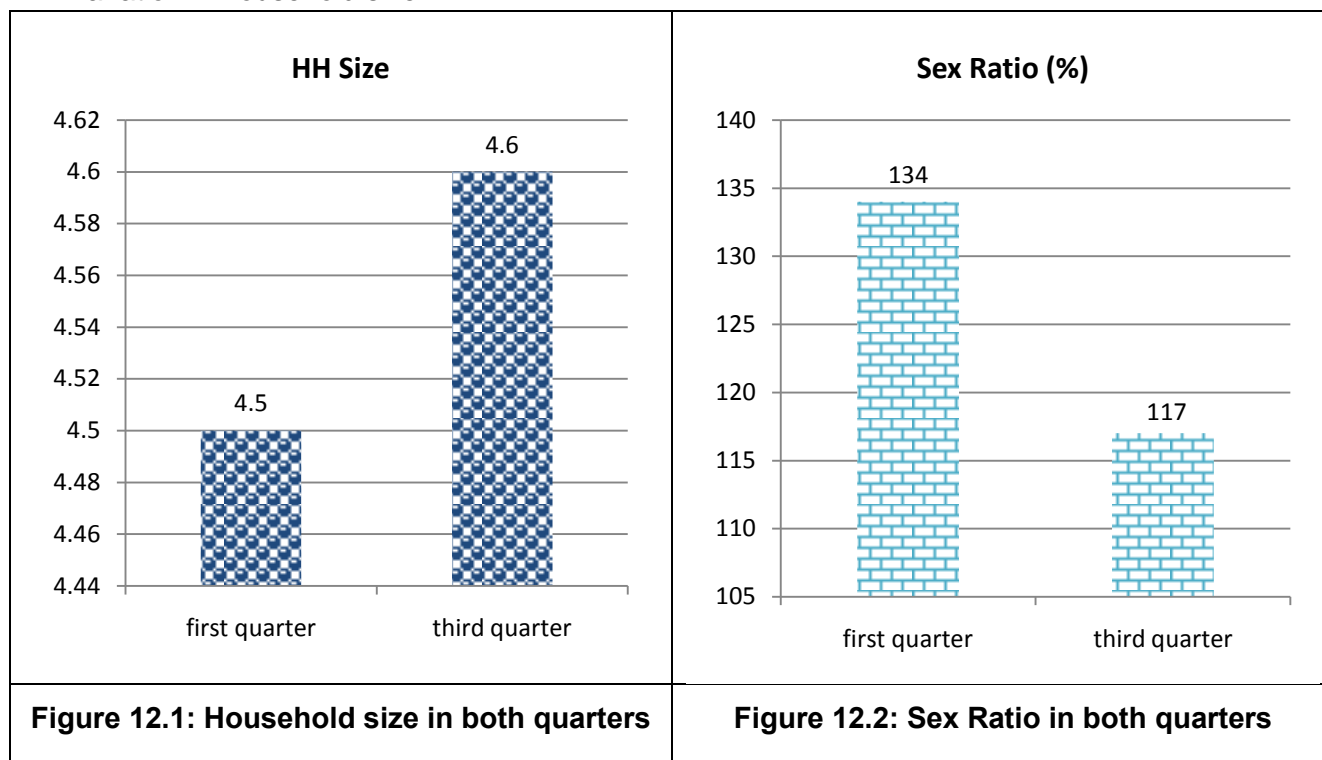
Source: HH survey, CEGIS, 2014

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

<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.

189. 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).

190. 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.

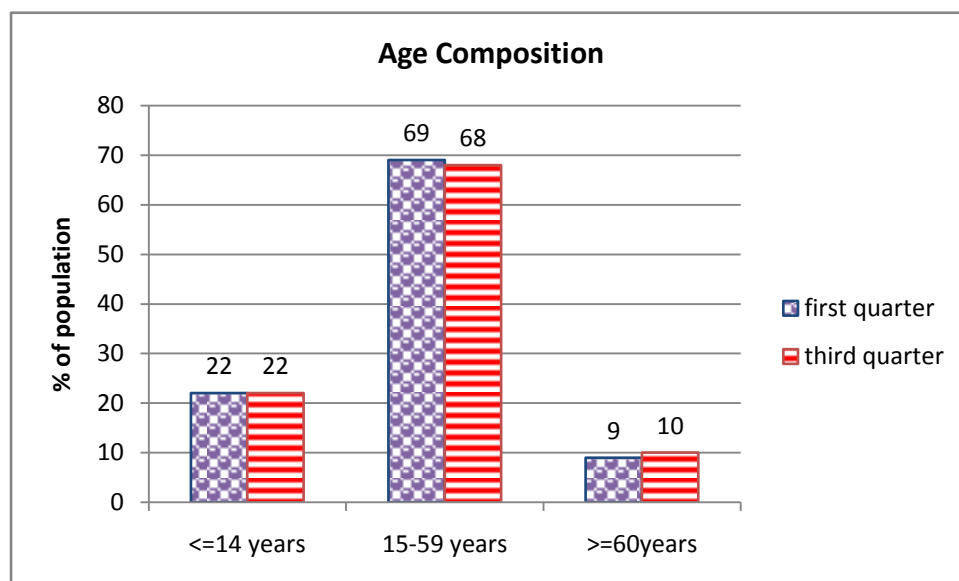


Source: HH survey, CEGIS, 2014

#### Age composition

191. 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.

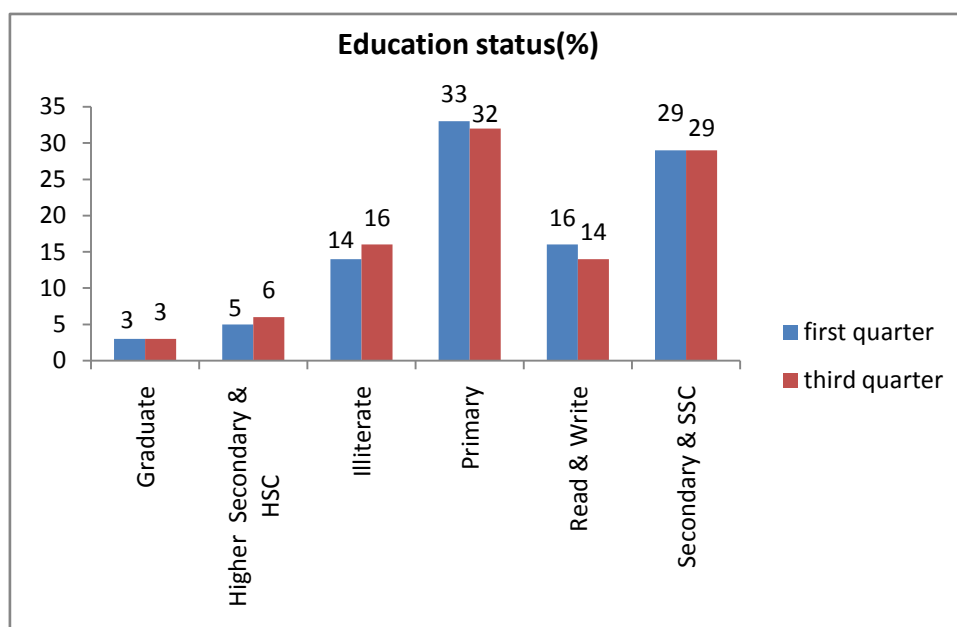


Source: HH survey, CEGIS, 2014

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

#### *Education and literacy status*

192. 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

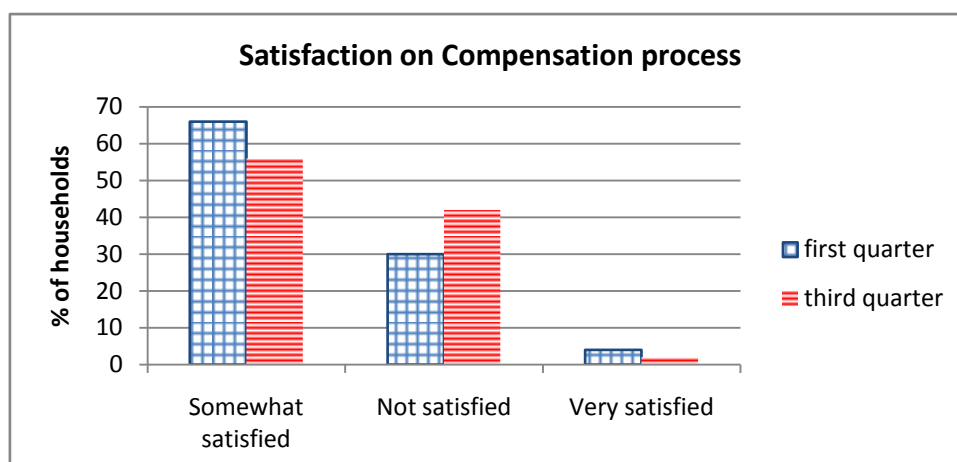
193. The DC office of Bagerhat is executing the compensation process following the government's rules and policy. As per the rule, only the land owner gets compensation. The local people informed that the compensation process has almost been finished only a few households remained to receive their compensation who are processing the documents of their land. 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)		Compensation status(%)
	1 <sup>st</sup>	3 <sup>rd</sup>	
Bara Durgapur	10	15	
Kapasdanga	20	16	
Barni	16	21	
Rajnagar	1	3	
Total	47	55	

Source: HH survey by CEGIS, 2014

194. The percentage of affected households received compensation has increased in the third quarter. The compensation amount is not satisfactory for them under present market value. The satisfactory levels of surveyed 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. The result varied due to increase of surveyed HHs and change of mind of the interviewers. Most of the newly surveyed eligible households showed dissatisfaction about the compensation process additional with the household having due of compensated money.



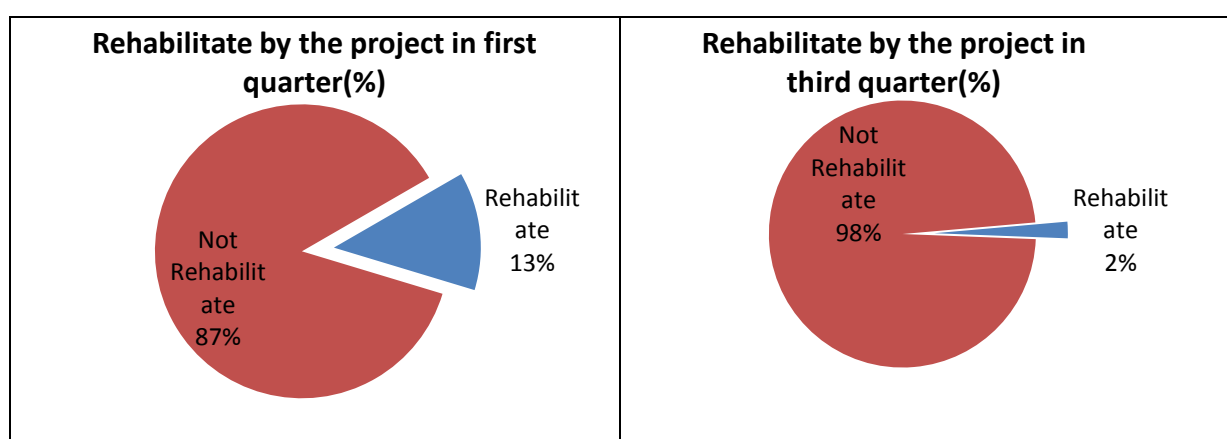
Source: HH survey by CEGIS, 2014

**Figure 12.5: Opinion of directly affected households on compensation**

#### 12.4.2 Rehabilitation

195. The land acquisition was executed by the Government following the laws of the county. There is no scope of rehabilitation program for the PAPs in the law of the country.

196. However, BIFPCL is trying to help the PAPs to recover the losses by providing employment opportunity for the directly affected people during laboring activities. Therefore, the status of generating employment opportunities for the directly affected people has been considered as the rehabilitation status of the socio economic monitoring study. The rehabilitation status has been monitored by the surveying 55 directly affected households. In this third quarter, less number of directly affected members got the employment opportunity from the BIFPCL. Local people alleged that the BIFPCL recruited a number of laborers as per the concern of local leaders. Therefore, most of the actual 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**

197. 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

198. 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.



199. 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

200. 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

201. 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.
202. 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*.
203. 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**

204. 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.

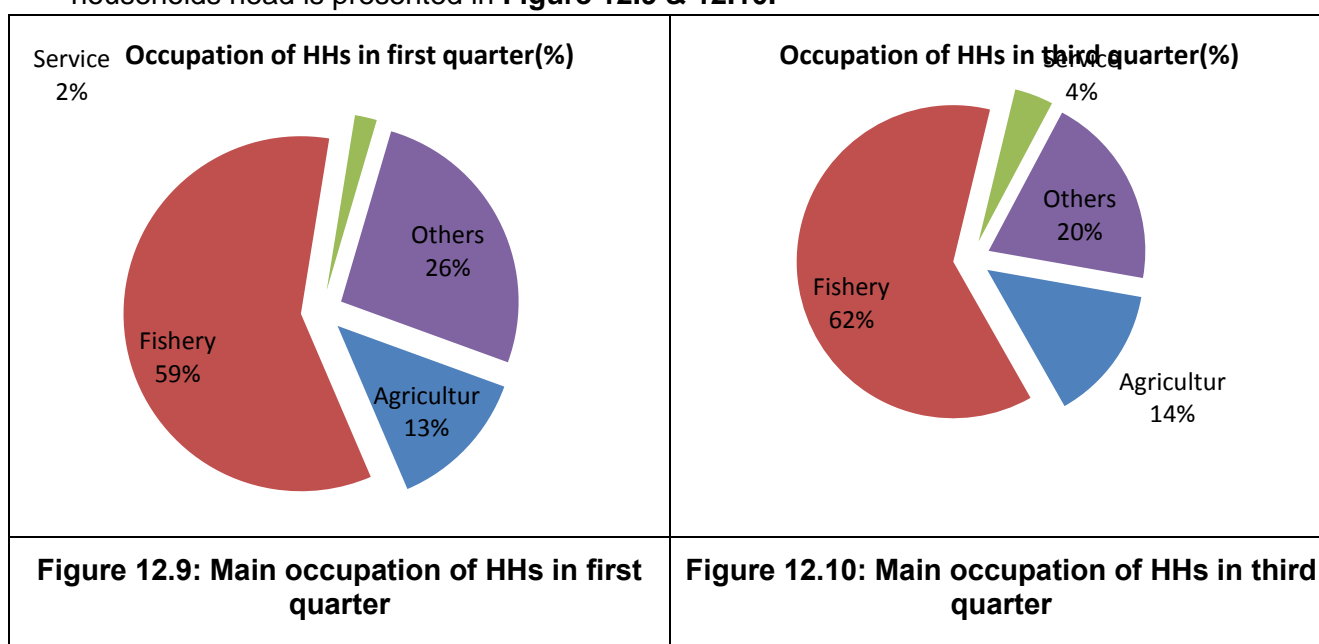
205. The project authority informed that they have opened a medical camp in the project area where they provide treatment and medical facilities to the local community as well as their labors. This camp is opened once in a week and over 150 people get treatments in each week by this camp.



**Photo 12.6 : Construction of boundary wall**

#### 12.4.7 Livelihood and occupation

206. 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

207. 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.

208. 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	Kapsadanga	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

209. 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 of Tk.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
Kapsadanga	14406	13517
Pankhali	12313	8943
Rajnagar	9773	9857
Average	10433	10775

Source: HH survey by CEGIS, 2014

#### 12.4.10 In and out migration

210. 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/ 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

211. 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*

212. 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 12.7: Free health services and facilities in the project**

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

213. 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.

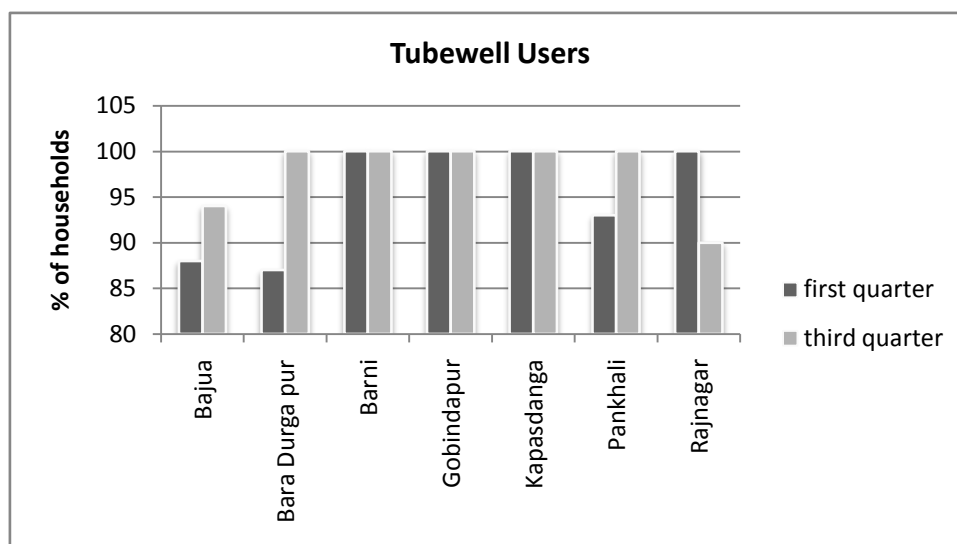


**Photo 12.8: Project authority donated for puja**

#### **12.4.12 State of Social Amenities**

##### *Drinking water*

214. 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.

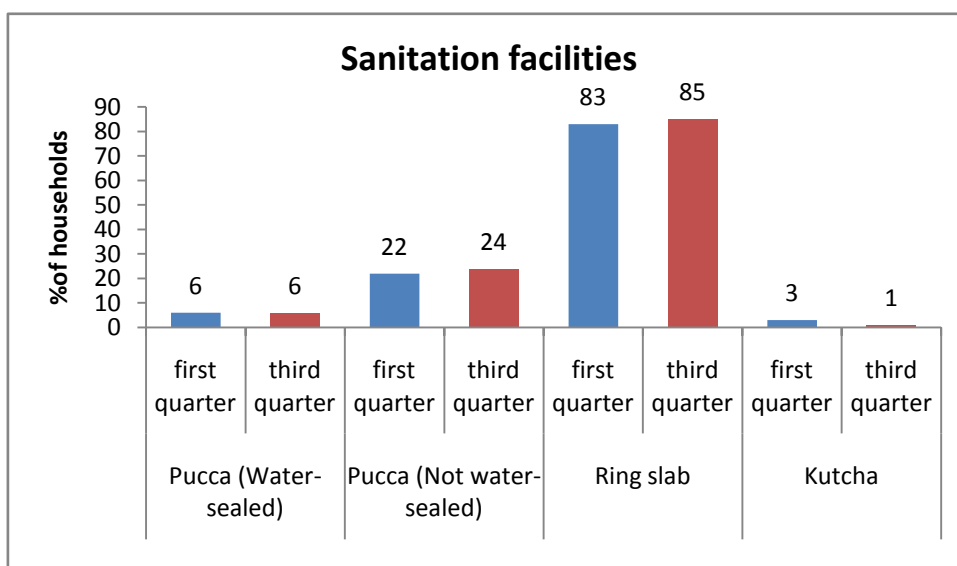


Source: HH survey by CEGIS, 2014

**Figure 12. 11: Drinking water status by using tubewell**

#### Sanitation

215. 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.

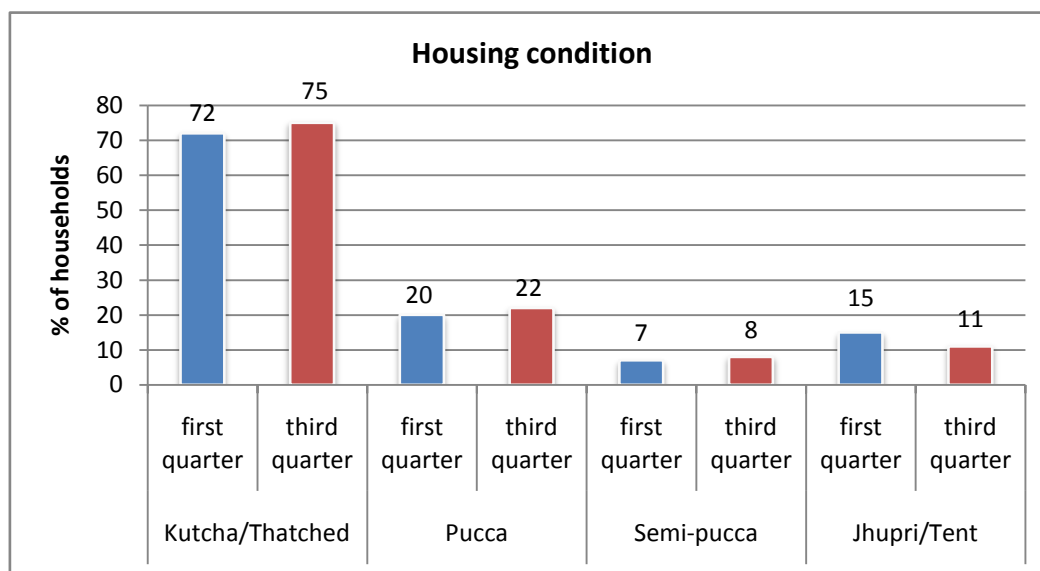


Source: HH survey by CEGIS, 2014

**Figure 12.12 Availability of Pucca and Ringslab latrines**

### Housing condition

216. 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.



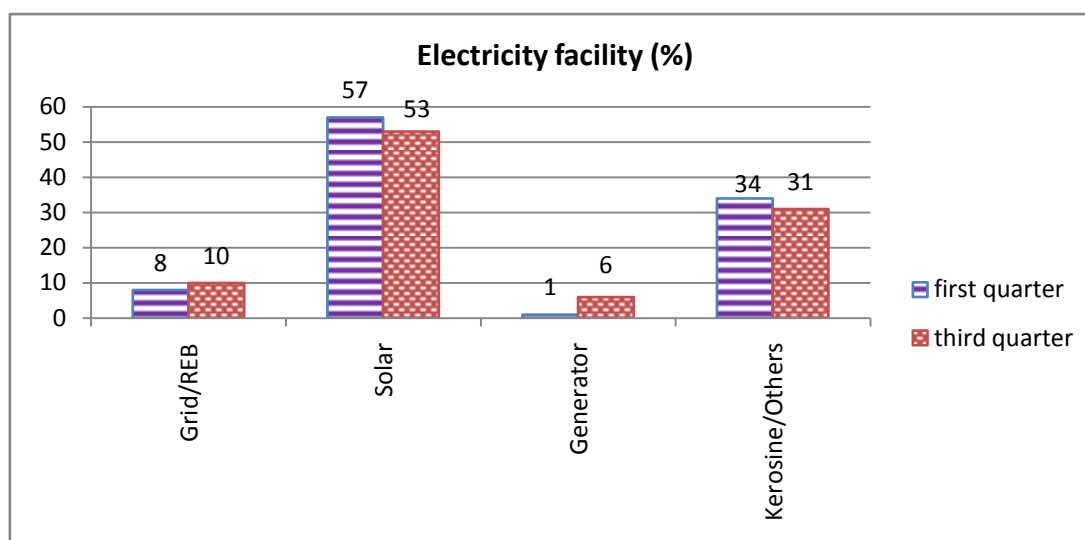
Source: HH survey by CEGIS, 2014

**Figure 12.13 Type of main dwelling house**

### Electricity coverage and fuel consumption

217. 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

218. 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 the future and are 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.



## 13 Hydro-morphological Monitoring

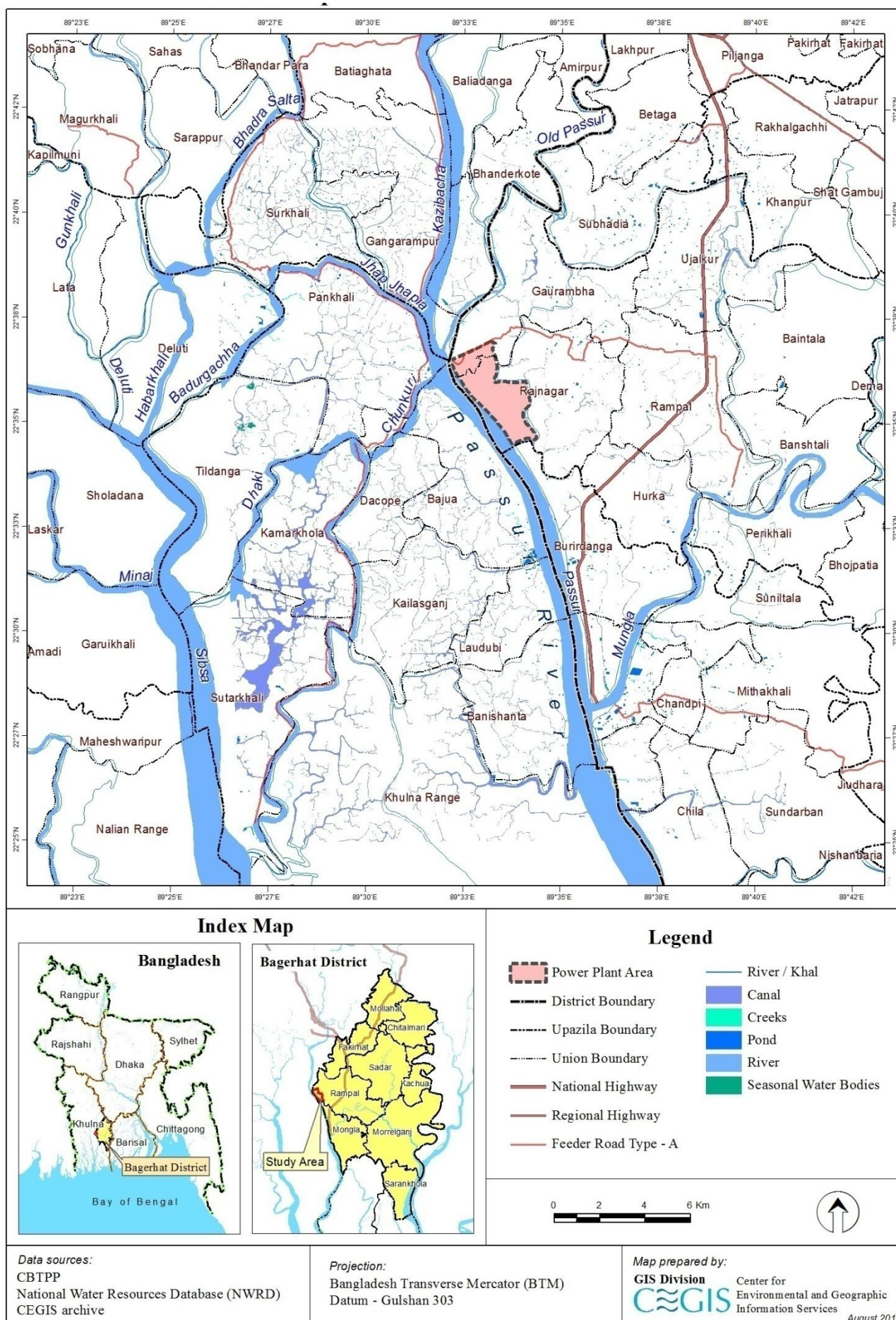
219. Hydro-morphological monitoring was carried out once in a year. The following sections briefly describe the results of first year monitoring of hydro-morphological indicators

### 13.1 Drainage Network and Connectivity

220. The monitoring study area is surrounded by a number of rivers and canals. Passur – Sibsha river system the governing river system here. The river system is hydrologically connected with numerous canals, tidal creeks and inter-tidal areas. The river receives fresh water from Ganges through Gorai, Mathabhanga, Nabaganga, Bhairab and Rupsha river, and ultimately drains to the Bay of Bengal. The tide enters from the Bay of Bengal and reaches to its tidal flood plains through numerous tidal canals, and creeks.

221. Passur River is the downstream river of the Rupsha River. Flowing alongside the Khulna city, the Bhairab-Rupsha flows further South and is renamed as Passur near Chalna and falls into the Bay of Bengal flowing to the right of Trikona and Dubla islands while from down of the Mongla port, the river flows through the Sundarbans. The maximum flow of the Gorai-Madhumati flows into this river through the Nabanganga. The Mongla canal joins the river at about 32 km south from Chalna. Flowing further south, the river meets the Sibsha at about 75 km downstream of Chalna and finally the combined river falls into the sea with its original name Passur.

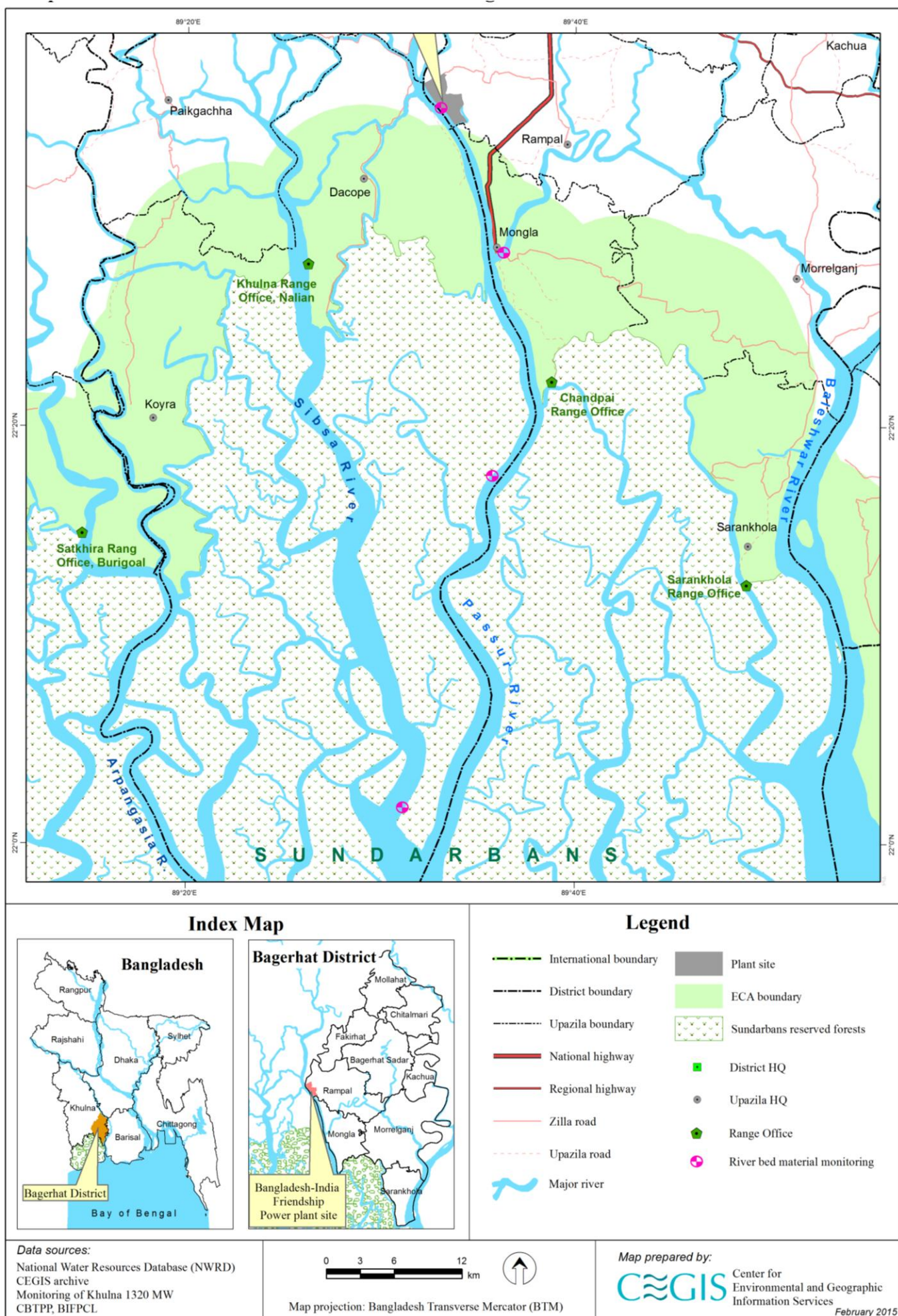
222. The flow of the Passur River is dominated by the Atai and Bhairab rivers. The wet season brings additional volume of water from the Ganges through Gorai-Nabaganga-Atai into the system.



**Map 13.1: Map of the River Network**







**Map 13.2: Location of River Bed Sediment Monitoring**

### 13.2 Monitoring River bed Sediment

223. River bed sediments were collected at four locations (Map 5.2) of Passur river in between Chalna and Hiron Point.

224. The bed materials were collected during the first quarter monitoring in April 2014. River bed samples were collected at the time when the river current was relatively sluggish or calm. Otherwise, the grab could not perform well at the bottom of the river effectively. The samples were then preserved following the procedure of the Soil Resource Development Institution (SRDI) where the samples have been tested.



**Photo 13.1: Grab sampling at Akram Point**

225. Bed sediments were collected to analyze the particle size distribution and soil quality parameters i.e. Organic Matter, Heavy Metals, pH, etc.

#### **(a) Particle Size Distribution**

226. The laboratory analysis shows that bed sediments near Project site are mostly silty loam whereas in Sundarbans region bed materials are mostly silty clay loam. The particle size distribution is presented in Table 5.1.

**Table 13.1: Soil texture of riverbed sediment along the Pasur River**

Sampling location	Soil type	% distribution		
		Sand	Silt	Clay
Project site	Silty Loam	25	54	21
Mongla port	Sand	95	3	2
Harbaria	Silty Clay Loam	1	68	31
Akram point	Silty Clay Loam	3	63	34

Source: Sample collected in April 2014 and Laboratory analysis in SRDI Laboratory

**(b) River bed sediment quality**

227. In addition to the particle size distribution, the sediment quality has also been considered for monitoring. The collected samples have been tested in SRDI laboratory for sediment quality analysis of organic matter and heavy metals content, pH, etc. (Table 5.2).

**Table 13.2: Riverbed sediment quality along the Pasur River**

Sampling location	pH	Organic Matter (%)	Sulphur	Pb
			(µg/g)	
Project site	7.9	1.28	185.78	31.75
Mongla port	7.8	1.01	96.07	25.00
Harbaria	7.6	1.08	179.05	31.75
Akram point	6.5	1.61	617.70	37.75

Source: Laboratory analysis of sample collected in April 2014. Analysed in SRDI Laboratory

228. Riverbed sediments were found to be slightly alkaline in all the locations except in Akram Point. In Akram point bed sediment is slightly acidic.

229. Organic matter content was found low in all locations. Sulphur content was found very high in Sundarbans' locations. This might be from the marine sources or from the organic matter deposited from Sundarbans. It varies from 25-37.75 µg/g.

**13.3 Erosion and Accretion**

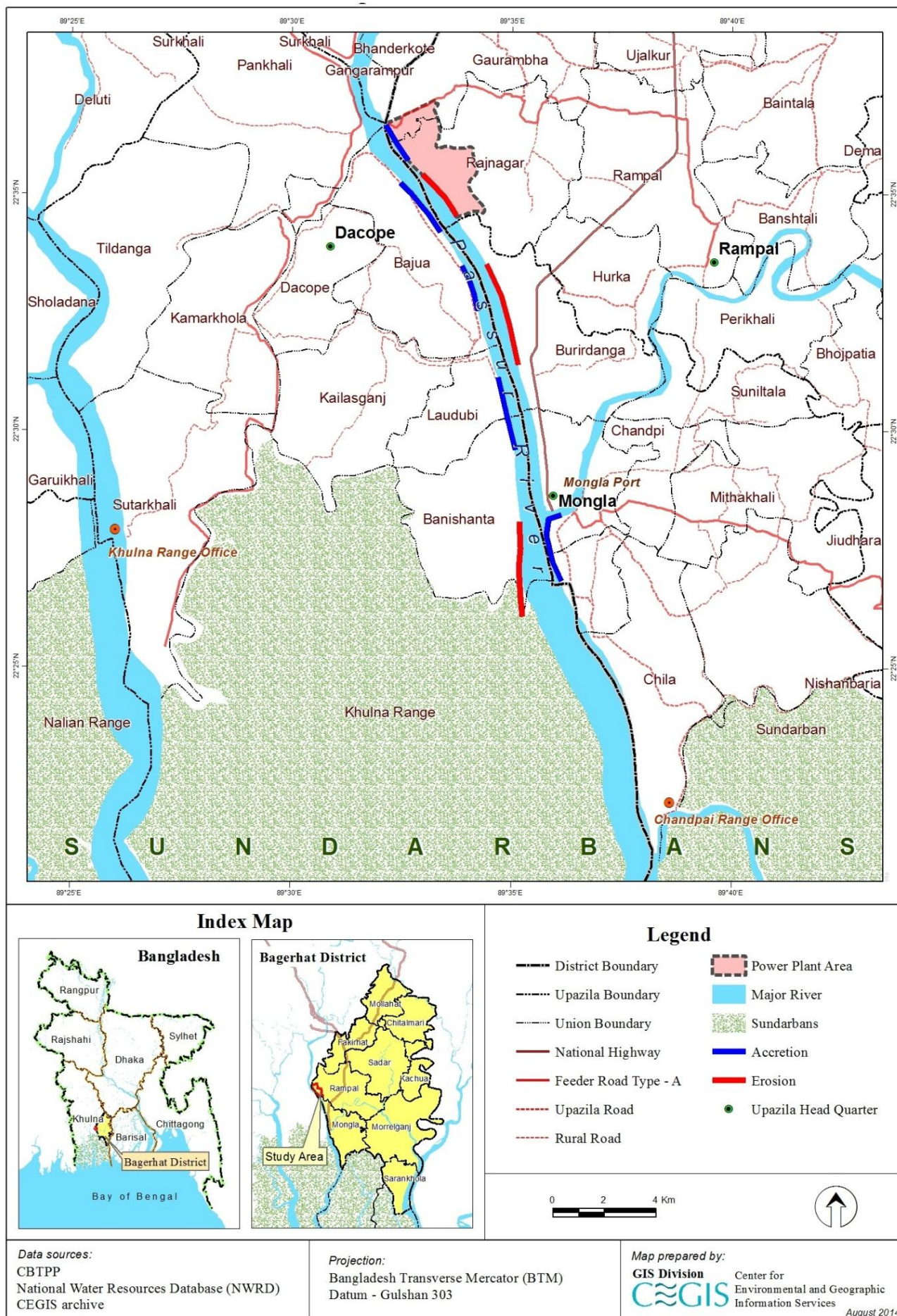
230. Erosion and accretion have been monitored quarterly within the river section from Project site to Hiron point. Mostly, erosion of river bank, formation of new char or bankline shifting has been considered as the key indicators for this monitoring study.

231. Monitoring was completely based on physical observation. The lower rate of erosion-accretion and continual tidal fluctuation made it difficult to use satellite image in this process.

**13.3.1 Erosion**

232. Erosion was seen in most of the outer bends of the river reach in between Bajua union of Dacope to Baniashanta union of Mongla (Map 5.3). Erosion was found to be continuing beside Project site (Sapmari Katakhal mouza), along left bank in Bidyarbon and Bidyarbon Digraj mouzas (Burirdanga union of Mongla upazila) and along the right bank in Banishanta union (Dacope upazila). As per the local information, lateral extent of erosion ranges from 0.4-0.5 m per year.





**Map 13.3: Location of Erosion and Accretion along the Passur River**

### **13.3.2 Accretion**

233. Accretion has also been investigated along both the banks of the Pasur River from Gaurambha union of Rampal upazila (of Bagerhat district) to Chandip union of Mongla upazila. During field visit, accretion was found at inner bends in Kaigar Daskathi union (Gaurambha union of Rampal upazila), Sapmari Katakhal mouza (Gaurambha union of Rampal upazila) and Mongla Paurashava along the left bank. In right bank, accretion was found in Chunkuri-2 mauza (Bajua union of Dacopa upazila), Laudubi which is immediately at the downstream of the confluence point of Pasur River and Bisnu-Kumarkhali River (Map 5.3).

## 14 Land Use and Land Cover Monitoring

### 14.1 Introduction

234. Landuse and landcover were also monitored once in a year. Remote sensing and GIS technology were used for land use and land cover mapping of the study area of 77,866 hectares. The Land use and land cover map of the study area were derived from multispectral color RapidEye satellite images of 2014. The major classes that were extracted from images are *Agricultural Land, Permanent Fallow Land, Forest, Industrial Area, Inter Tidal Area, Road, Rural Settlement with Homestead Vegetation, Built-up Area and Water Bodies*.

### 14.2 Description of Satellite Image

235. The multispectral RapidEye satellite images of 5 meter resolution acquired on 7th and 30th March, 2014 were used for land use and land cover map preparation. **Map 14.1** shows the area of satellite images purchased for the study area. The multispectral RapidEye satellite image is suitable for identification of general land uses and land covers mapping. The image data has five spectral bands. The name and wavelength of each band is given in the **Table-14.1**.

**Table 14.1: Information on Spectral Bands of RapidEye Satellite Images**

Band ID	Band Name	Wave length (nm)
1	Blue (B)	440-510
2	Green (G)	520-590
3	Red (R)	630-685
4	Red Edge (RE)	690-730
5	Near Infra Red (NIR)	760-850

### 14.3 Methodology

236. The image analysis was carried out using image processing software ERADAS IMAGINE. All images of the study area were georeferenced to Bangladesh Transverse Mercator coordinate system. After geo-referencing, a field survey was carried out to collect referenced data and those data was used for image classification. The field visited sites are shown in the **Map 12.2**. The following major classes: *Agricultural Land, Permanente Fallow Land, Forest, Industrial Area, Inter Tidal Area, Road, Rural Settlement with Homestead Vegetation, Built-up Area and Water Bodies* were extracted from satellite images using visual interpretation and on screen digitization technique.

#### 14.3.1 Agricultural Land

237. Three types of agricultural land were identified from analysis of satellite images: *Current fallow and Agricultural Land Area, Seasonal Shrimp Gher, and Permanent Shrimp Gher*. The agricultural land in most of the area was found fallow on the image acquisition dates were classified as *Agricultural Land*. It was found from field survey that T. Aman rice, which is the main crop in the study area, is practiced in those fields during monsoon season. It was validated using ground reference data. *Seasonal Shrimp Gher* means those areas where shrimp aquaculture (Bagdha) is practiced in the dry season and T. Aman is practiced in monsoon season. Shrimp aquaculture practiced throughout the year is classified as *Permanent Shrimp Gher* areas.

#### **14.3.2 Permanent Fallow Land**

238. The land area which remains year round fallow was classified as *Permanent fallow*.

#### **14.3.3 Rural settlement with homestead vegetation**

239. The spatial distribution of *Rural Settlements with Homestead Vegetation* in the study area is linear. The texture and tone of the settlements are more distinct than that of other land uses and land covers. The class *Rural Settlements with Homestead Vegetation* includes, rural house structures, yards, small vegetable gardens and trees and other vegetation surrounding rural settlements.

#### **14.3.4 Forest**

240. The forest area within the study area was derived from satellite image analysis. The mangroves within Sundarbans are classified as *Reserve Forest*, which grow naturally near saline water in the active delta along the coast of Bay of Bengal. Some river side mangrove areas outside of the Sundarbans are classified as *River Side Mangrove Vegetation*.

#### **14.3.5 Road and Embankment**

241. Road and embankment class was sub classified as *National road*, *Local road* and *Embankment*. The *National* and *Local road* includes all types of metal and non-metal roads visible in the satellite images. The existing road network data available in CEGIS archive was also used during identification, interpretation and digitization of roads and embankments from satellite images.

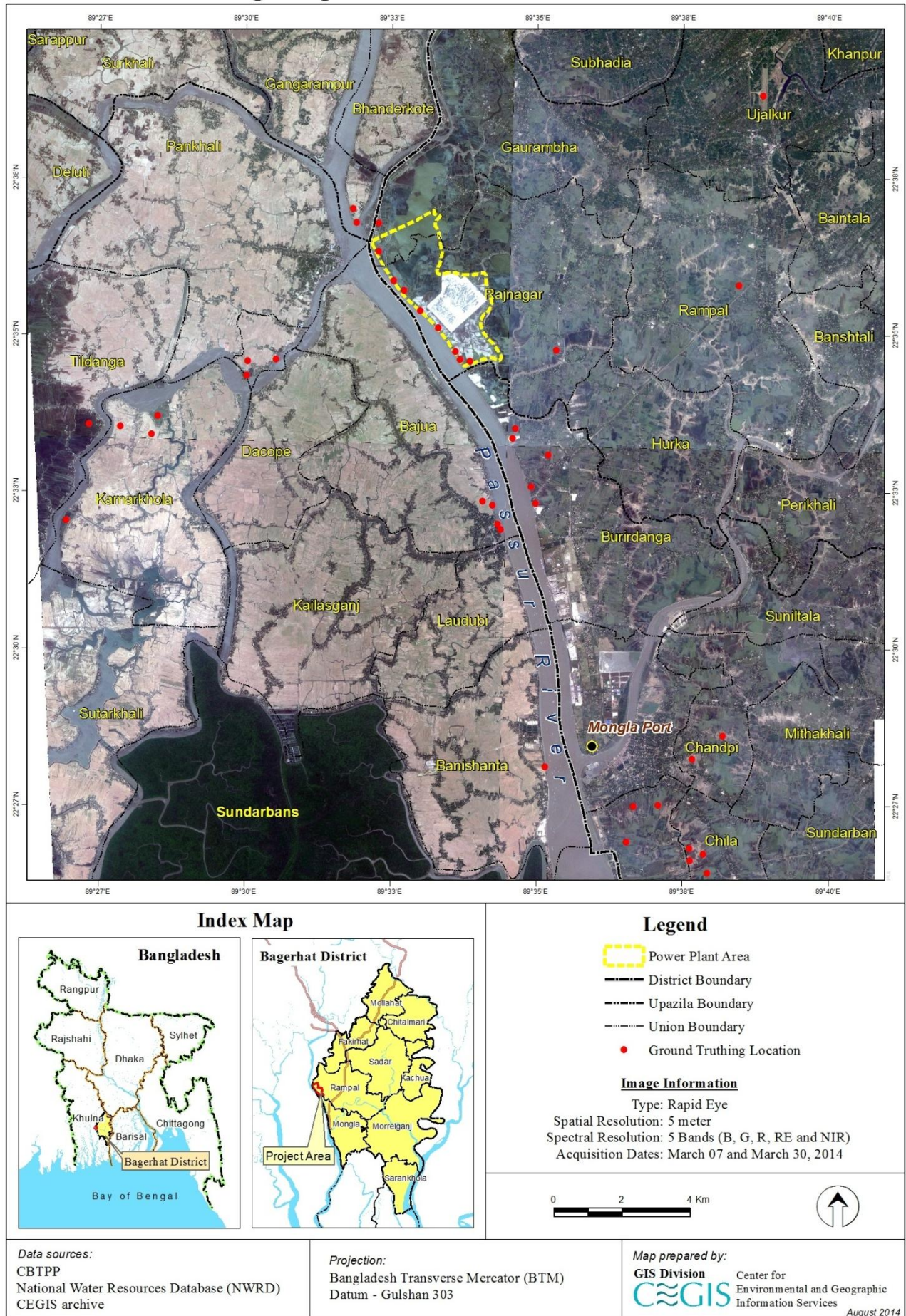
#### **14.3.6 Industrial Area**

242. The sub classes of Industrial Area include *Mongla port*, *EPZ* and *Area under development*. The Rampal Power Plant Project area is classified as *Area under development*.

#### **14.3.7 Water bodies**

243. The *Water Bodies* class was further subdivided into *River*, *Canals*, *Creeks*, *Pond* and *Seasonal Water Bodies*. Most of the water bodies and rivers were digitized by visual interpretation. Branches of the rivers are considered as *canal*.





**Map 14.1: Extend of Satellite Image Acquired for Land use Analysis and Location of Groundtruthing Points**

#### 14.4 Description of Landcover and Land use

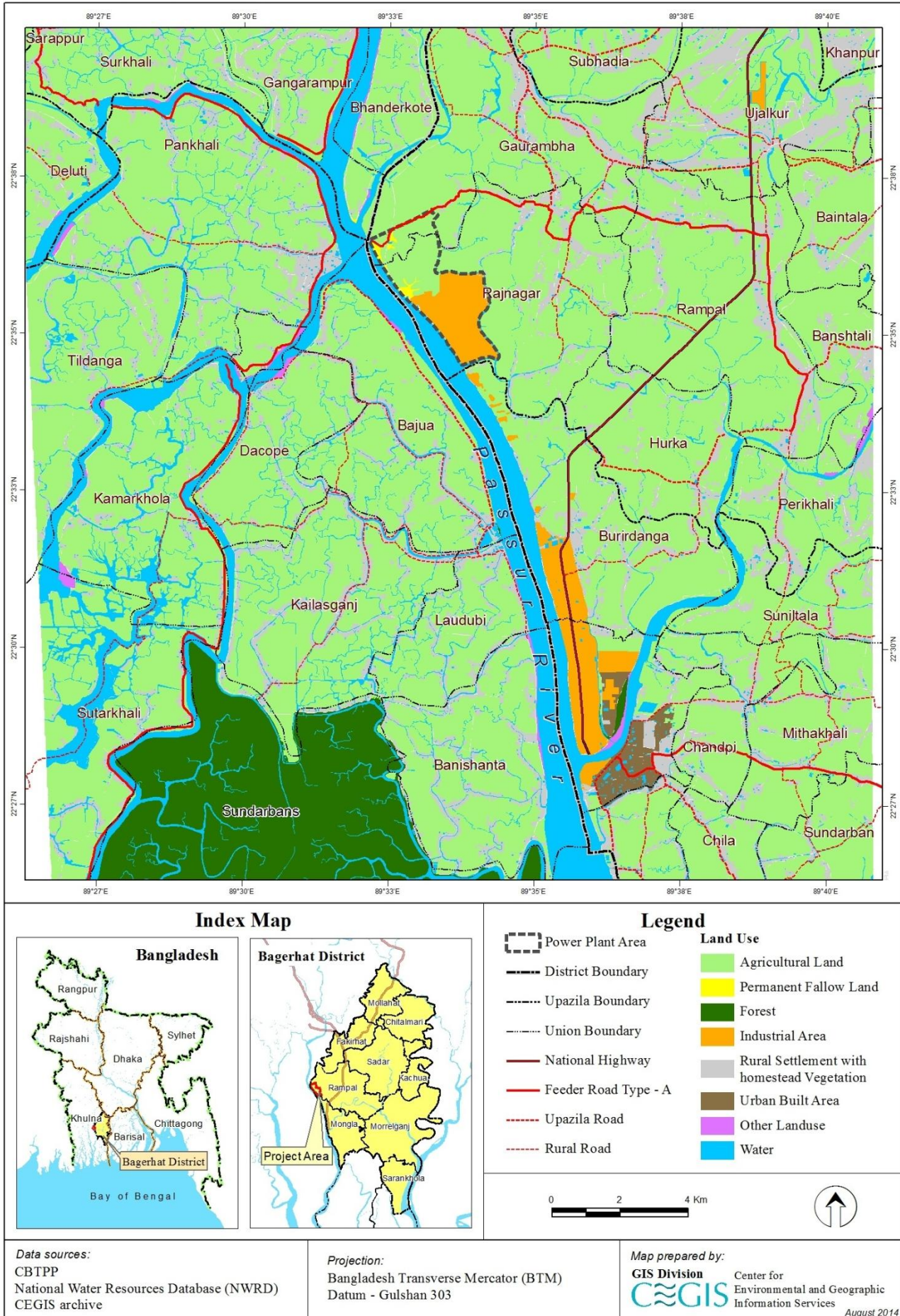
244. The **Map 14.2 and 14.3** show the Land use and Land Cover Map of the Study Area derived from analysis of satellite images. The study area is mostly surrounded by *Agriculture Land* (48,555 ha) 62.3% of the total area including *Permanent* and *Seasonal Shrimp Gher*. The rural *Settlement with Homestead Vegetation* is 13.5%, *Forest Land* is 9.1% and *Water Bodies* are 11.9%. The detail area coverage of each class and sub class is given in the **Table 14.2**.

**Table14.2: Land Cover Classification of the Study Area**

Major Class	Sub-Class	Hectare	(%)
Agricultural Land	Current fallow and Agricultural Land Area	29,695.9	38.14
	Seasonal Gher	2,448.4	3.14
	Shrimp Aquaculture Pond/Gher	16,411.2	21.08
Forest	Reserve Forest	7,010.5	9.00
	River Side Mangrove Vegetation	96.7	0.12
Industrial Area	Area under development	546.9	0.70
	EPZ	24.3	0.03
	Mongla Port Area	557.4	0.72
Other Land use	Inter tidal area	215.2	0.28
Permanent Fallow Land	Permanent Fallow Land	34.6	0.04
Road	Embankment	271.9	0.35
	Local Road	382.7	0.49
	National Road	20.3	0.03
Rural Settlement with homestead Vegetation	Rural Settlement with homestead Vegetation	10,543.5	13.54
Urban Built Area	Urban Built Area	334.4	0.43
Water Bodies	Canal	3,167.1	4.07
	Creeks	43.7	0.06
	Pond	574.9	0.74
	River	5,454.9	7.01
	Seasonal Water Bodies	30.9	0.04
<b>Grand Total</b>		<b>77,866</b>	<b>100.00</b>

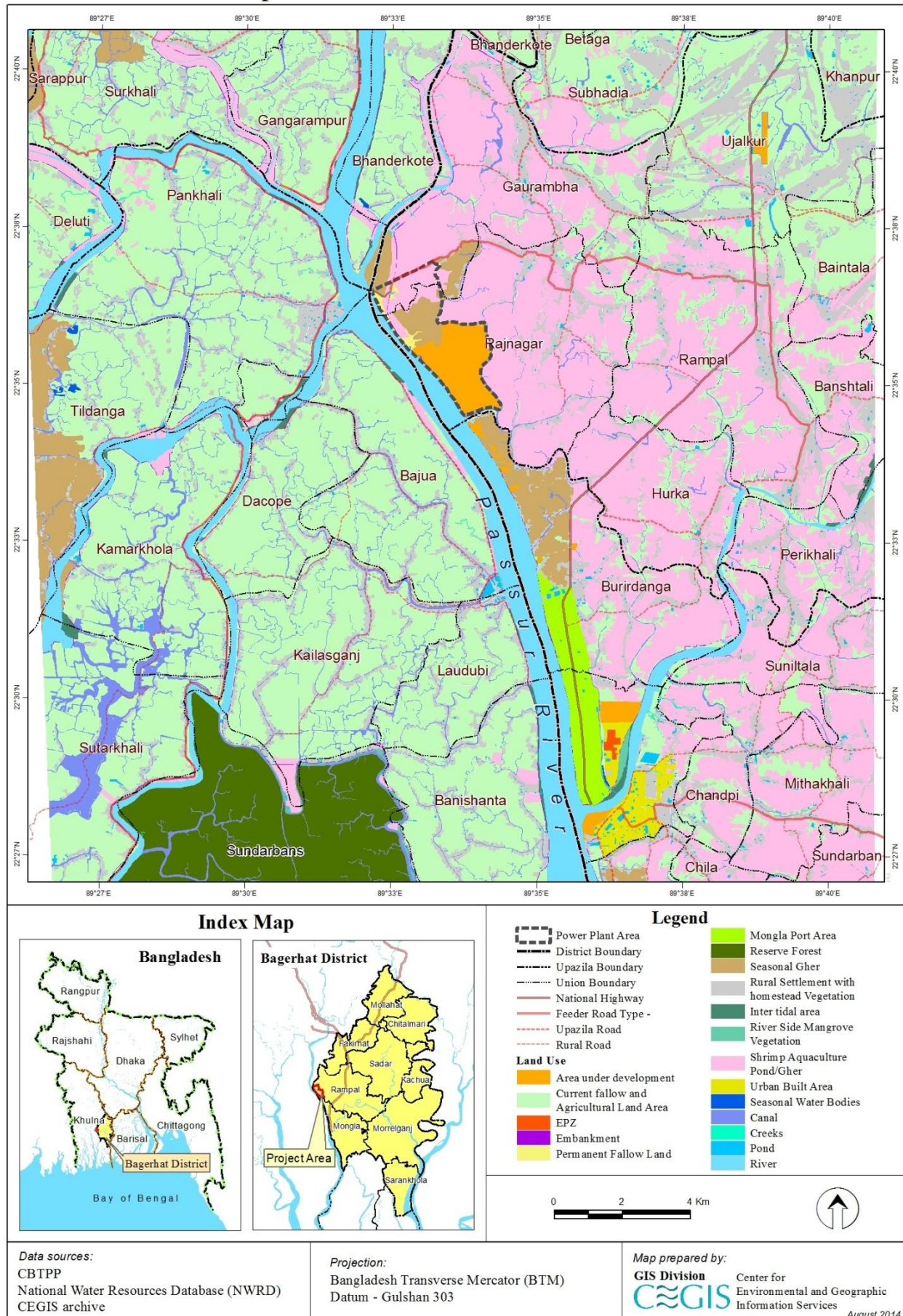
Source: Satellite image analysis





**Map 14.2: Major Land use and Land Cover Classes of the Study Area**





Map 14.3: Detail Land Use and Land Cover Classes of the Study Area



## 15 References

- BARC (Bangladesh Agricultural Research Council). 2012. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, Farmgate, Dhaka.
- Badran M (2001) Dissolved oxygen, chlorophyll a and nutrient seasonal cycles in waters of the Gulf of Aqaba, Red Sea. *Aquat Ecosys Health Manag* 4(2):139–150
- CEGIS. (2013). *Environmental Impact Assessment of 2X (500-660) MW Coal Based Thermal Plant to be Constructed at the Location of Khulna* (p. 456). Bangladesh.
- Chave J, Andalo C, Brown S, Cairns M. A., Chambers, J. Q., Eamus D et al (2005) Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia* 145: 87–99
- Donato, D.C., Kauffman, J.B., Stidham, M.A. (2009) Protocols for measuring and reporting carbon stocks in mangrove forests. Unpublished report prepared for the workshops on Global Climate Change and Carbon Financing: Opportunities for Bangladesh. Dhaka, Bangladesh, 28, October–9 November 2009.
- Eckman, J.E., (1979) Small-scale patterns and processes in a soft-substratum intertidal community. *J. Mar. Res.*37:437–457.
- Eckman, J.E., (1983) Hydrodynamic processes affecting benthic recruitment. *Limnol. Oceanogr.* 28: 241–257
- Goldman, S. 2005. Information theory. Dover, New York.
- Harmon, M. E. and J. Sexton (1996). Guidelines for measurements of woody detritus in forest ecosystems. U. S. LTER Publication No. 20.
- Hossain, M., Siddique, M. R. H., Bose, A., Limon, S.H., Chowdhury, M.R. K., • Saha, S. (2012) Allometry, above-ground biomass and nutrient distribution in *Ceriops decandra* (Griffith) Ding Hou dominated forest types of the Sundarbans mangrove forest, Bangladesh. *Wetlands Ecol Manage* DOI 10.1007/s11273-012-9274-2
- Kauffman, J.B. and Donato, D.C. (2012) Protocols for the measurement, monitoring and reporting of structure, biomass and carbon stocks in mangrove forests. Working Paper 86. CIFOR, Bogor, Indonesia.
- Komiyama A, Ong JE, Pongpan S (2008) Allometry, biomass, and productivity of mangrove forests: A review. *Aquat Bot* 89:128–137
- MacArthur, R.H. & MacArthur, J.W. (1961) On bird species diversity. *Ecology*, **42**: 594–598.
- Margalef, R. (1958) "Information theory in ecology," *General Systems Yearbook*, vol. 3, pp. 36–71,
- Moore, P.D. & Chapman, S.B. (Ed.) (1986) *Methods in Plant Ecology*. Blackwell Scientific Publications. 581.5 MET
- Odum, E. P. (1971) *Fundamentals of Ecology*, WB Saunders, Philadelphia, Pa, USA, 1971.

- Pearson T, Walker S, Brown S (2005) Sourcebook for land use, land-use changes Forestry Projects. Report from BioCF and Winrock International. Available at: <http://www.winrock.org/ecosystems/tools.asp?>
- Pielou, E.C. (1969) An Introduction to Mathematical Ecology. John Wiley & Sons, Inc., New York, 286 pp.
- Rahman, M. M. (2012) Relationship between carbon storage, vegetation type and salinity in Sundarbans Reserved Forest. M. Sc. Thesis. Forestry and Wood Technology Discipline, Khulna University, Khulna-9208, Bangladesh.
- S. A. HAQUE, 2006. Review article, salinity problems and crop production in coastal regions of Bangladesh. Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh. Pak. J. Bot., 38(5): 1359-1365.
- Schnitzer SA, DeWalt SJ, Chave J (2006) Censusing and measuring lianas: A quantitative comparison of the common methods. *Biotropica* 38(5): 581-591
- Shukla, S.R. and Chandel, S. P. (1980) Plant ecology. 4<sup>th</sup> Edn. S. Chandel and Co. Ramnagar, New Delhi –110055. 197
- Skilleteer, G.A., Warren, S. (2000) Effects of habitat modification in mangroves on the structure of mollusc and crab assemblages *Journal of Experimental Marine Biology and Ecology*, 244: 107–129
- Sukumar, R., Dattaraja, H. S., Suresh H. S. et al. 1992. "Long-term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India," *Current Science*, 62:608–616,
- Warren, J.H., (1990) Role of burrows as refuges from subtidal predators of temperate mangrove crabs. *Mar. Ecol. Prog. Ser.* 67:295–299
- Weiss R (1970) The solubility of nitrogen, oxygen and argon in water and seawater. *Deep Sea Res Oceanogr Abstr* 17(4):721–735
- WHO (World Health Organization), Guidelines for drinking water quality, 2nd Edition; 1993.
- WHO, The International Network to Promote Household Water Treatment and Safe Storage. 2007
- .

## 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/throttling down 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			
		No disposal of waste and untreated waste water to river or canal			
1.5	Waste Management System	Provision of onsite waste management system			

SL	Category	Measures	Due Diligence		Remarks
			Complied	Not complied	
1.6	Compensation and Resettlement	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			
		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			
1.7	Livelihood and living	No impacts on livelihoods living standards which has been consider in Social and Monitoring Plan			
		Developent 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.			
1.8	Others	Carry out technically and financially feasible alternative study			
		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?			
1.9	Green House Gas Controlling Measures	Use of efficient machineries in the construction activities			
		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 (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 (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 posses 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				
		<b>PS 6. Biodiversity and Sustainable Management of Living Natural Resources</b>				
<b>(Construction Phase)</b>						
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 II: Traffic Volume Survey Datasheet

**Table A: Traffic Volume Survey at (survey location)**

**Date:** \_\_\_\_\_

Vehicles	8:30 AM to 9:30AM				12:30 PM to 1:30PM				4:30 PM to 5:30PM			
Direction	To Main Road	To Project Site	Factor	PCU	To Main Road	To Project Site	Factor	PCU	To Main Road	To Project Site	Factor	PCU
Bus			3				3				3	
Truck			3				3				3	
Private Car			1				1				1	
Microbus/ Jip			1.75				1.75				1.75	
CNG			0.75				0.75				0.75	
Auto Rickshaw			0.75				0.75				0.75	
Nosimon			1				1				1	
Utility Vehicle			1				1				1	
Motor Cycle			0.75				0.75				0.75	
Rickshaw			0.5				0.5				0.5	
Bi-cycle			0.5				0.5				0.5	
Non Motorized Vehicle			0.5				0.5				0.5	
Van			0.5				0.5				0.5	
			Total									





## Annex III: Photo Album

### Monitoring Activities in Fourth Quarter, First Year



Team Composition



Organizing the Layout of sampling sites at Koromjal and Harbaria

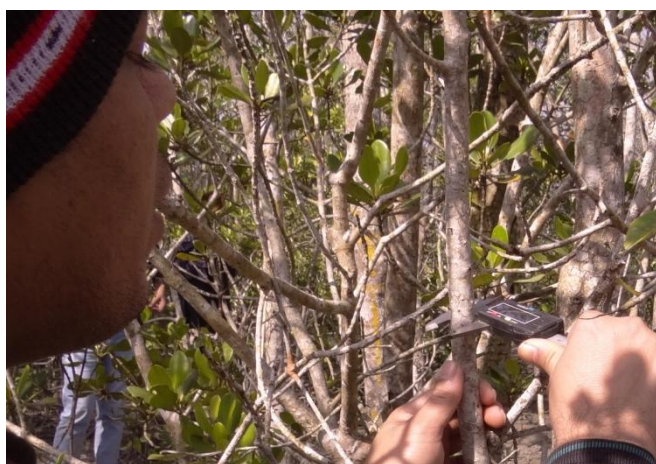




Estimating Canopy density by Densiometer



Measuring DBH of tree at Karomjal and Akram Point sites



Measuring Sapling DBH



On site Air quality sampling at Akram Point





Record tree information at Harbaria



Cheking previous data



Measuring tree height with The Haga altimeter



Taking measurement of standing dead tree stem



Counting pneumatophores and crab holes at Akram Point







Collecting of soil samples from forest ground



Observing Foliage health at Akram Point



Measuring Woody debris at Hiron Point



Fish Catch Assessment at Passur River



## Annex IV: Terms of References (ToR)

As per ECA 1995 and ECR 1997, the proposed Project “1320MW coal based thermal Power Plant at Rampal, Khulna” falls under red category; needs proper monitoring and documenting of environmental and socio-economic parameters.

Accordingly, the EIA study of the proposed plant has already been conducted. The EIA of the proposed Power Plant briefly describes the monitoring plan. The ToR has been prepared for engaging Engineering, environmental and social Contractor for monitoring the environmental and socio-economic parameters during pre-construction and construction phases along with the engineering consideration of the site development and construction of the Project so that the monitoring plan suggested in the EIA is properly followed and satisfies the requirement of ECR 1997 and ECR 2005.

The monitoring works has been divided in to two major components:

**Work A:** Monitoring of Engineering activities of site development and others.

**Work B:** Monitoring of Social and Environmental parameters for updating the baseline and Implementation of the Project.

**Work A:** The main objective of this component is to monitoring the engineering activities of site development and others during pre-construction and construction phase for installation of the Power Plant.

The specific objectives of the monitoring program are:

- To establish baseline environmental conditions;
- To detect adverse environmental impacts for river dredging and land filling activities for site development;
- To demonstrate whether the environmental control measures are operating as per designed;
- To provide data for emission inventories;
- To provide data at regular intervals for dissemination to the stakeholders
- To provide data for improvement and updating of the monitoring program;
- To assist in investigating the event of a trigger level or emission limit value being crossed.

Landfill monitoring is an interactive process of incorporating the findings of the site investigation, the environmental impact assessment, environmental monitoring results, risk assessment and the conclusions reached in the investigations.

**Work B:** The main objective of this component is to monitor the environmental parameters and implementation of environmental management plan during pre-construction and construction phase for installation of the Power Plant. The specific objectives of the monitoring program are:

- Update baseline data as per monitoring schedule and location.
- Monitor and provide the environmental parameters during pre construction activities.
- Provide technical assistance to the client for implementation of the EMP at different sector of construction activities.
- Monitor the environmental aspects during construction of the Project.
- Review the EIA document to evaluate the EMP measures incorporated in the contract to mitigate different social and environmental hazards and risks during construction of the Project
- Submit progress reports to the client.

- 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.