Monitoring Report of Second Quarter, Second year (2015)

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

August 2015

Second Quarter Monitoring Report of

Second year (2015)

Monitoring Period:

June 2015 – August 2015

Bangladesh – India Friendship Power Company (Pvt.) Limited

(A joint Venture of NTPC Ltd and BPDB)

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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

Executive Summary

With the aim of ensuring safeguarding to Sundarbans Mangrove Forest, environment as a whole and surrounding communities, the 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 of the proposed Power Plant at Rampal, Bagerhat. 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 environmental compliance monitoring of pre-construction activities. The results of the monitoring are reported quarterly to BIFPCL through Monitoring Report of each quarter. Eventually, the BIFPCL submits these reports to DoE and Forest Department.

CEGIS has initiated the monitoring activities since February 2014. So far five quarterly monitoring reports have been submitted. In this process **2nd** quarter of the **2nd** year (2015), monitoring activities were carried out in July/August, 2015. The monitoring activities involved:

- Monitoring of Implementation of EMP and Environmental Compliance
- Monitoring of ambient air quality
- Monitoring of ambient noise condition
- Monitoring of ambient water quality
- Monitoring of fisheries resources covering fish habitats, biodiversity, migration and production
- Monitoring of ecosystem and biodiversity
- Monitoring of Sundarbans Forest Health

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

Monitoring of EMP during Pre-construction Activities

Land development for theBIFPCL's site has been completed. Construction of embankments and slope protection works are about to complete. Site office construction is yet to start. At present, due to monsoon, no physical work except minor maintenance work of land development, slope, embankments, etc. is ongoing. However, as per the EMP approved by DoE, there are some measures that should be adopted during this stage.

In general, in this quarter, 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 BIFPCL is in the process of complying the EMP as suggested in the EIA report. Being the Environmental Monitoring Consultant of the Project, CEGIS makes

few Site Specific Measure(s) that should be complied for ensuring environmental and social safeguarding of the Project, which are:

- Demark traffic way and enforce all the vehicles are using the demarked way only
- Temporary drainage and for rain fall runoff should be constructed and sediment fences/traps needs to be maintained to prevent sediment wash load to Maidara river
- Stockpile of construction material should be placed at safe distance from river bank as it has been done earlier
- More waste disposal bins need to be installed at labor shed, and working area
- Install few more toilets (mobile) near work place
- The HR policies which is under preparation should include: Working Conditions and Management of Worker Relationship, Child labor policy, Occupational Health and Safety Policies, and , Worker well beings
- Initiated establishing a grievance redress mechanism
- Assign responsibility of enforcing and monitoring safety procedure to a officer
- The EPC contractors should prepare site specific ESMP
- Arrange safety training Program for the project personnel and labor force

Air Quality Monitoring

Ambient air quality has been monitored at 9 locations in the present second year's 2nd quarterly monitoring. Wind direction was also identified and it headed to North-East from the South-West. It should also be noted that the weather condition was really not favorable for monitoring activities this time because it was hampered by the rainy, gloomy and sometimes by the stormy weather. However, in this quarter the concentration of SO_2, NO_2, $PM_{2.5}$, and PM_{10} were found within the standard level in all of the locations. But SPM concentration was found above the standard in Pankhali, Dacope and North-western corner from the PP area. Newley developed land for industrial activities along the Passur rivers, rain droplets, cement industries are the known sources of SPM in this area.

Noise Monitoring

This time, ambient noise was monitored at 9 locations among the pre-selected 11 points. Around the Project area the ambient noise levels were found in between 40.66 dB to 49.77 dB. Maximum noise level was found at Khulna-Mongla highway near the Khan Jahan Ali Bridge and lowest was found within the Project site. In Sundarbans, Noise level was only monitored in Harbaria which was 35.03 dB. Wind action on trees, splashing waves, bird's chirping, ship and fishing boats, etc are the source of noise observed in Sundarbans.

Water Quality Monitoring

Since April 2014, CEGIS have been monitoring 17 water quality parameters (plus 10 extra parameters) at 15 locations in Passur-Shibsa river system. In continuation, this time in July-August, 2015 water samples were collected from all the earlier location except Akram Point and Hiron Point of Sundarbans due to unfavourable weather condition and river condition. The samples have been submitted to DPHE for laboratory analysis. This monitoring report contains laboratory reports of last monitoring and in-situ monitoring results of this quarter.

The analyzed results of all parameters are within the standard and natural condition except oil and grease and EC. Due to incident of oil tanker accident in Sundarbans, Oil and Grease concentrations are found to be above the standard. Higher concentration of Oil and Grease also causes increase of EC. However, similar to the earlier year, seasonal variation is still

present. For example, salinity was found zero in August 2015 whereas in 2014 little salinity was present. Month long heavy rainfall, and heavy upstream flow suppressed the salinity this time.

Land Resources Monitoring

In this 2nd Quarter Monitoring report of the 2nd year (2015), soil samples were collected from 3/4/15 to 6/4/15 for dry season to determine pH, OM, EC, N, P, K, S, Ca, Mg, Na, Fe, Mn, Zn, B and heavy metal like Pb, in addition Cd analysis has been taken into account from this monitoring phase and it will continue. It was found from the laboratory analysis report of dry season of 2014-15 that the status of EC, pH, OM, N, P, K, S, Ca, Na, B, Fe, Zn, Mn and Pb concentration is higher than the previous dry season, in contrary to that the Mg level decreases from the aforementioned period.

The concentration of Cadmium (Cd) is observed 2.21-2.86(µg/gm) in 0-15 cm depth, 2.12-2.42 (µg/gm) in 15-30 cm depth and 2.11-2.55(µg/gm) in 30-45 cm depth.

Fisheries Monitoring

Fisheries resources have been monitored at the same locations for five sampling sites as of earlier quarter monitoring. The following are the key finding of the monitoring in second quarter second year:

- Habitat uses are observed to be changed yearly (2014-2015). Moreover, through analyzing the type of habitat uses by different ages of different fish species (based on the length-based community structure model) such four types of habitats have been found as the breeding, spawning, nursery and grazing ground.

- Shannon-Weiner index has also been observed to vary between 2nd quarter of 2014 and that of 2015. The highest index has been found at Chalna Point (0.95). On the contrary, lowest evenness has been found at Maidara Point (0.39). Moreover, maximum Fish Species Richness (FSR) was recorded in Sheola khal at Chandpai (n=8), while very low FSR in Passur river at Maidara point (n=2).

- Juveniles for fin fish species were more randomly distributed among the middle and lower stretches of the Passur River.

- Fish species like Bagda attains the maximum abundance among the migratory fish species. Moreover, six species like Bagda, Bele, Paissa, Gulsha Tengra, Golda and Poma showed long range of distribution.

- For the entire selected shrimp/fish farm seeds for Bagda stock were collected from the wild sources, Passur River, some were collected from hatcheries at Rampal. The highest stocking rate has been observed in case of gher in Rajnagar and mortality rate in case of gher in Chunkuri-2 mainly due to river flood.

- The highest productivity has been found in Sheola Khal at Chandpai, and lowest in the Mongla Point and Harbaria Khal because of the abundance of fries which are not considered as the production. Moreover, as expected lower productivity was observed in this second quarter of 2015 as compared to that in second monitoring year of 2014.The total catch through most frequently used Bahundi and Charpata Jal in lower stretches of Passur River are 3.25 kg and 8.75 kg respectively. And total catch through

most frequently used Net Jal in upper stretches of Passur Rive is 0.5 kg However, the total catch is lower in this monitoring year than that found in the first monitoring year.

- Highest fish production from Shrimp/fish farm (Gher) has been found in case of gher at Rajnagar attaining 3.06 kg of Bagda, Horina and Chali Chingri, Bele and Paissa as their catch within the month of July-August.

Ecosystem and Biodiversity Monitoring

Plant health, plant canopy cover, bird habitat, butterfly occurrence and dolphin occurrence have been monitored in this monitoring season. Trees look livelier in all the monitoring locations than previous season. Coconut and Date Palm showed remarkable improvement of plant health in all the monitoring locations than other plants. Plant canopy coverage was observed to be slightly improved in all the monitoring locations. Out of 4 studied locations, six nests of two bird species have been sighted at Rajnagar site. Occurrence of butterfly has reduced in this monitoring period and a total 4 species of butterflies have been recorded from three monitoring locations.

Dolphin occurrence has increased in Passur River than previous monitoring season. All the sighted individuals are Ganges River Dolphin and reduction of river water salinity favor their abundance in the rivers along the project site.

Sundarbans Forest Health Monitoring

Forest health was monitored in the three sites (Sutar Khali, Karamjol and Harbaria) among the five sites (Akram Point and Hiron Point were not visited due to adverse weather condition). In this monitoring we investigated canopy cover, pneumatophore, crab hole density, seedling density, net canopy photosynthesis rate and tree tag numbers. In the three monitoring sites, all the forest health parameters were sound except lichen coverage. Lichen coverage was reduced from first to fifth monitoring in the three monitoring sites. However, in Sutar Khali and Karamjol this parameter was good but in Harbaria, site this figure is extremely lower than that of level of good condition. Several factors may be responsible for this condition such as temperature and air pollutants etc as in this site larger ships unload their goods to lighter ships.

The carbon stocks and soil properties that were measured during January 2015, also included in this report. The highest ESC was found in Akram Point followed by Karamjol, Harbaria, Sutar Khali, and Hiron Point, where the ESC varied depending on species and tree size. Soil salinity was found highest at Akram Point, while this figure was lowest at Sutar Khali. The soil pH, P and bulk density were found almost similar in the five monitoring sites.

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, CEGIS has been carrying out the monitoring activities since February 2014. So far five monitoring reports have been submitted. This time, monitoring activities in second quarter of second year has been carried out in between May 2015 to August 2015.

1.2 Objectives of 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 bein operation phase. The 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 22^0 37' 0''N to $22^0$34'30''N and longitude $89^0$32'0''E to $89^0$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 Shibsha rivers starting from Plant site to Hiron point (**Map 1.2**).

1.4 Limitations of Monitoring in this Quarter

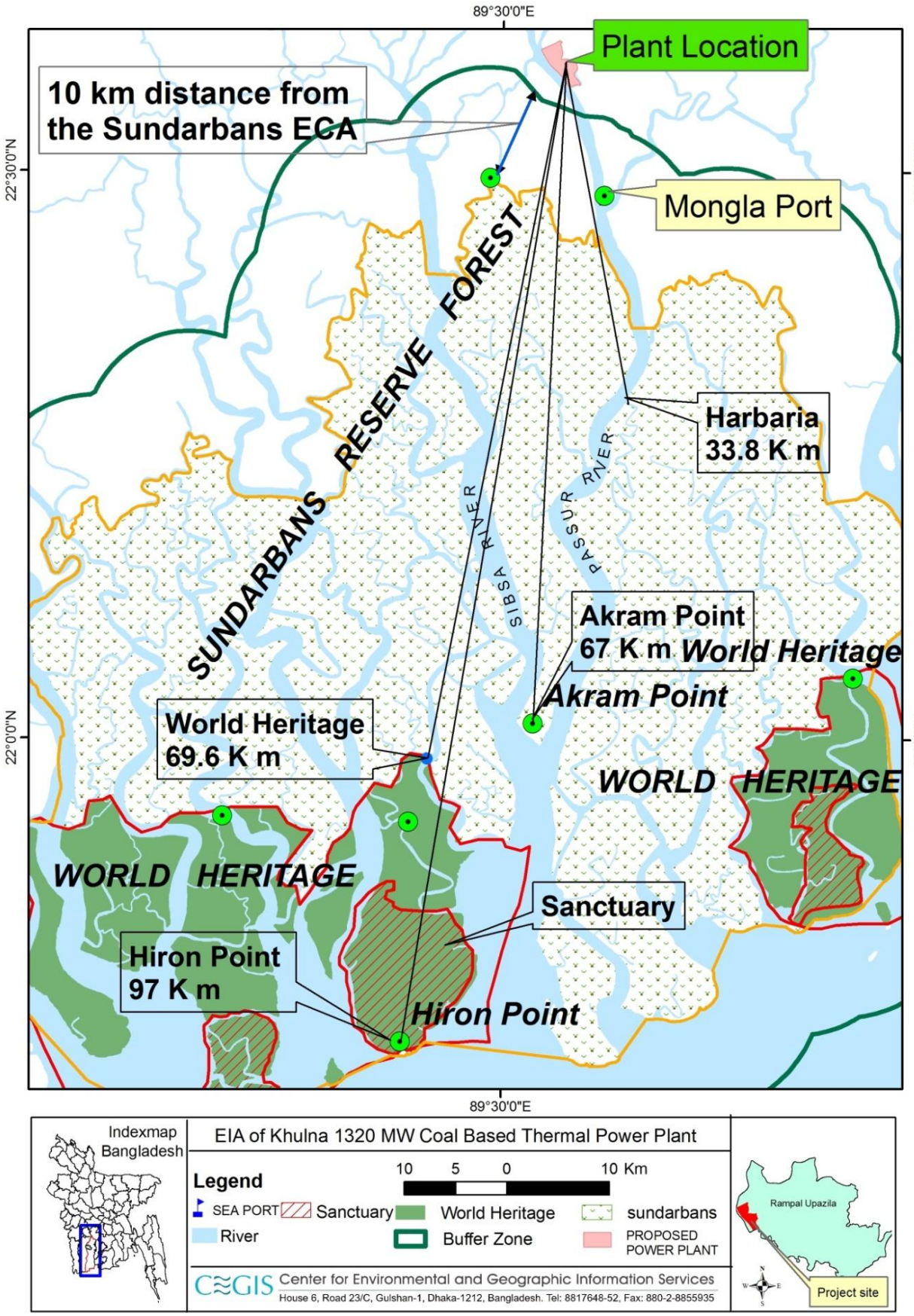
6. Generally, in June to September, river condition becomes very rough. Strong current, high wave, gusty wind and frequent storms hinder the access to the survey points near Akram Point and Hiron Point. In the last year's visit, severe storm and high wave made the survey team's experience very bitter.

7. The issue will not be solved even by hiring sea-going vessel of Mongla port Authority. The vessel anchors at the middle of the river where draft is suitable but then a small country boat/speed boat will be required to reach the shore line which is not safe during this rough weather condition.

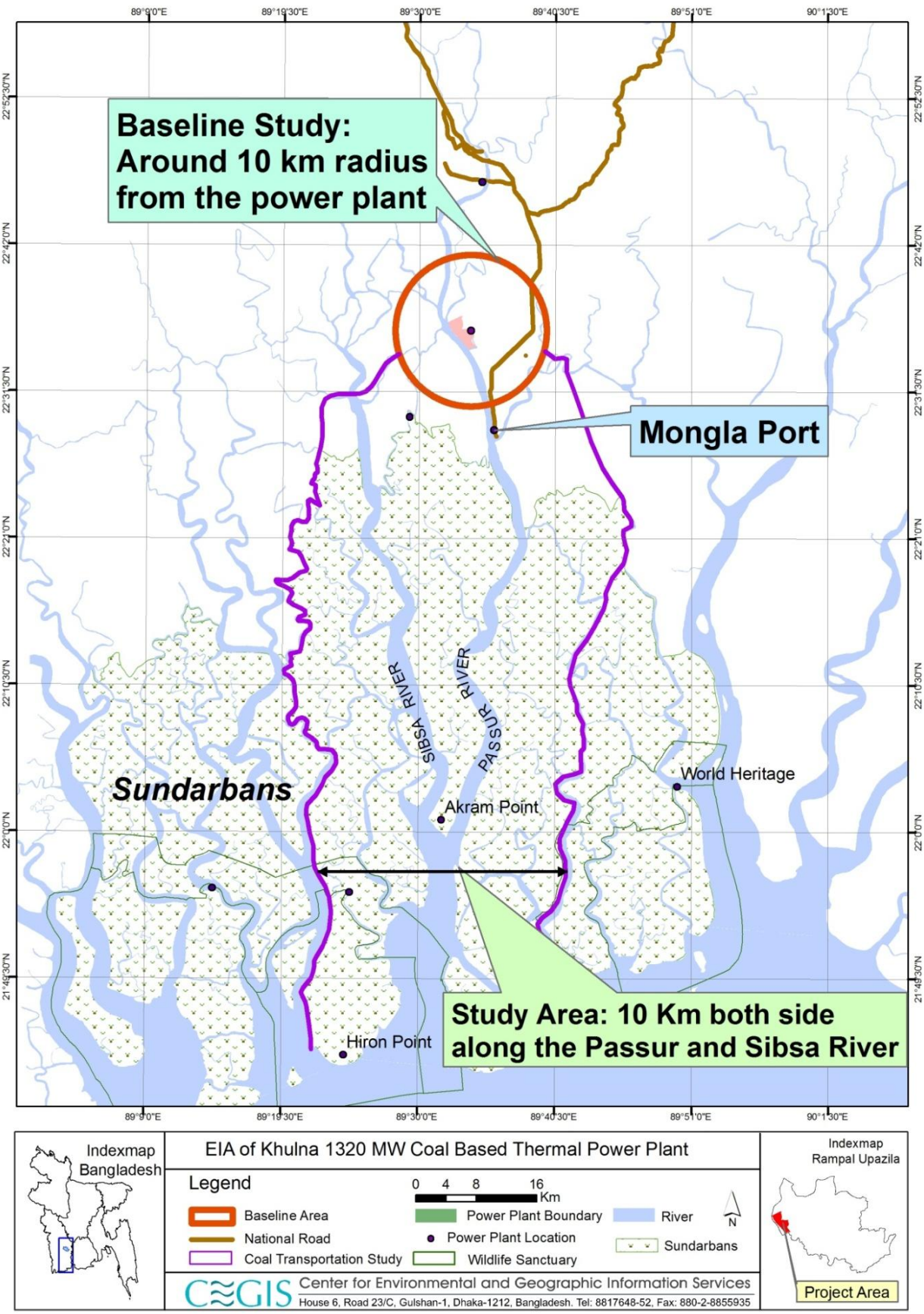
8. Even DoE and Forest Department do not collect data at Hiron Point and Akram Point region during this season.

9. Specifically, during this **2nd Quarter** monitoring of the **2nd year**, a depression was prevailing over the entire area resulting extreme rainfall, exacerbated by Tropical Cyclone "Komen" (The heavy rain developed as a slow-moving monsoon depression formed over Bangladesh during the last week of July and eventually organized itself into a tropical cyclone over the northern Bay of Bengal).

10. Due to stormy condition and probability of surges, farthest two locations inside the Sundarbans (near the open sea) had been discarded from the itinerary of the trip to avoid any life risk.Then again, in this monsoon season, the pollution loads are insignificant in general; so missing data in only two points will have very minimal effect on the overall assessment. However, we still have the data collected in the upstream location(s) of Akram point and Hiron Point to depict the scenario persisting over the region in this monitoring period.



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



Map 1.2: Area under the Interest of Environmental and Socio-economic Monitoring

1.5 Collaboration with Forest Department

11. 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.

12. 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

13. 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 monitoring report will also be forwarded to the Forest Department.

1.6 Collaboration with Department of Environment

14. The monitoring plan including indicators, location and schedule were prepared incorporating the suggestion of the department of Environment. Before initiating the monitoring study, a discussion meeting was held with experts of DoE to finalize the monitoring plan at CEGIS office.

15. The BIFPCL forwarded the submitted monitoring report and data to the DoE regularly. In addition, the BIFPCL officials along with the study team members of the monitoring study mak visit to DoE office to inform them the progress of the study. The monitoring report will also be presented to the EC committee of the DoE during renewing of the EIA approval.

2 Monitoring of Environmental Compliance during Pre-construction Activities

2.1 Background

16. At present, no construction or preconstruction activities is going at site due weather condition. Land development, site office construction, slope protection, etc will be resumed after rainy season. However, there are some environmental compliance measures and measures in environmental management plan that should be at place during this time.

2.2 Monitoring of Environmental Compliance

17. 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

18. 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 checklist are attached in Annex I. 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

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
1	Generation of Noise within the BIFPCL's Plant Premise	• Conduct noise survey around and inside the site boundary • Reducing Noise and Vibrations to country's ambient standards, and occupational health and safety standards • Introducing vehicle speed limit and speed limit monitoring system • Green Plantation around the project boundary • Switching off/throttled downing of machines/equipments/ generators which are not in use	• CEGIS is carrying out noise survey in ambient environment under environmental monitoring study. • Reducing Noise and Vibrations to country's ambient standards, and occupational health and safety standards • BFD has initiated green plantation as a depository work of BIFPCL • Switching off/throttled downing of machines/equipments/ generators which are not in use	• Introducing vehicle speed limit and speed limit monitoring system • Provide Noise Muffler for heavy noise generating equipment operators (e.g. stone/brick crusher)	Complied at this stage but few measures (as recommended) need to be adopted during construction phase
2	Dust Generation from Land development activities and other construction works	• Conducting dust monitoring and visual inspection around the site boundary • 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 • If yes, do they monitor vehicle speed regularly? • Construction of boundary wall	• CEGIS is quarterly monitoring dust. • Construction of boundary wall	• Construct brick road within the project site for traffic movement (if possible) • Otherwise, demark traffic way and enforce all the vehicles are using the demarked way only. • Spray water along the road and road side to suppress dust generation	BIFPCL agrees to take such more measures
3	Water Quality	• 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 waste water to river or canal.	• Construction of boundary wall • Arrangement of runoff run on drainage at some places • No disposal of waste and waste water to river or canal.	• Temporary drainage for rain fall runoff should be constructed • Stockpile of construction material should be placed at safe distance from river bank	BIFPCL agrees to take such more measures
4	Waste	• Provision of onsite waste management system	• Conventional way of waste	• Waste disposal bin also	Complied

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
	Management System		collection and disposal system at plant office and kitchen	should be installed at labor shed, and working area	
5	Compensation and Resettlement	• Prepare Proper resettlement action plant 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 • Has a resettlement plan been developed which includes compensation, restoration, livelihood, living standards etc. based on proper socio economic studies? • Human Provide/ take extra care/caution for the disadvantaged/ vulnerable group/s (i.e. women, children, ethnic minorities, indigenous people etc.) • Provision of monitoring the compensation and resettlement process	• Compensation to the right full owners of the land as per the laws of Bangladesh • Compensation made by local DC office • Local DC office facilitates un authorized occupants of the acquired land to get home in the Government's shelter homes or cluster villages • BIFPCL gives priority to affected people in project related employment • BPDB is communicating to the Government of Bangladesh for taking some further initiatives for resettlement of the people who do not onwed the land but dependent on it for their livelihoods	• Government of Bangladesh should take initiatives for resettlement of the people who do not onwed the land but dependent on it for their livelihoods	Partially Complied
6	Livelihood and living	• Does the project pose any threat to the livelihood/living standards of the local people?If yes, are adequate steps taken to reduce the impacts • Has the company developed any policy which prioritizes the local laborers in employment opportunities? • Is there any possibility that large vehicle related	• Construction of boundary wall to mitigate dust generation • Creating a position and recruiting a social officer responsible for maintaining social liaison • Engagement of Human Resources consultant for	• Construct toilets near working place	Complied

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
		to the project will cause traffic induced disturbance/s to the local dwellers? • If yes, are there any mitigative steps taken to decrease the disturbance/s? • Has the road network been developed after the project was proposed and during the construction phase? • Are there separate water and sanitation facilities for the construction workers in the project area?	preparing HR policies, Labor recruitment Policies, Manpower set up, etc. • Construction of toilets for labor near labor shed • Provision of first aid box • Setting up medical unit capable of dealing emergency situation like injury, accident, etc.		
7	Green House Gas Controlling Measures	• Use of efficient generator 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	• Informing the bidders for EPC of main plants about measures to be followed • Making IFC guidelines, EIA approval of DoE, and EMP of the EIA, etc as a part of the bid document	• Prepare a checklist on equipments and condition of the equipments that should be owned by the contractors	The Project is in preliminary pre-consruction stage . To be complied during construction stage

Table 2.2: Monitoring Labour and Working Condition

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
1	Working Conditions and Management of Worker Relationship	• Preparation of Human Resources Policies and Procedures for Direct workers • Defined Working condition and Terms of Employment for direct worker • Sustainably equivalent terms and condition for migrant workers • Compliance to national law of forming worker organization • No discrimination and equal opportunity for all • Measures for protecting past discrimination • Grievance Mechanism	• Engagement of HR consultant to prepare relevant policies	• The proposed EMP measures should be addressed in the HR policies which is under preparation	The Project is in preliminary pre-consruction stage. BIFPCL agrees to comply all the measures
2	Protecting Workforce	• The client will not employ children in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • No Force Labor	• No child labor is employed	The HR policy should covers child labor policy	Complied

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
3	Safety at site	• 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.) • 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 • Availability of First Aid at work place • Preparation and Follow of Emergency Response Plan • adequate fire precautions in place (for example, fire • 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	• Construction of boundary wall • Aware labor and project personnel to use PPEs • Safety Policy of DoE and IFC, Safety measures proposed in EIA report have been incorporated in the bid document of EPC of main plant to aware the potential bidders • The basic design of the plant and the bid document of the EPC contraction includes	• The EPC contractor should prepare Health and Safety Plan and safety procedure to follow that should covers the EMP measures mentioned here	The Project is in preliminary pre-consruction stage. BIFPCL agrees to comply all the measures

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
4	Occupational Health and Safety Procedure	• Provision of complete EHS division in the Human Resources Planning/Organogram • Preparation of Safety Policy to be adopted during plant operation	• Engagement of HR consultant to develop HR policy and Organogram	• Provision of complete EHS division in the Human Resources • The EPC contractor should prepare a safety policy for plant operation	The Project is in preliminary pre-consruction stage. BIFPCL agrees to comply all the measures
5	Workers Well Being	• Establishment Grievance Mechanisms • 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	Engagement of HR consultant to develop HR policy and Organogram	The workers well being should protected in the HR policy	The Project is in preliminary pre-consruction stage. BIFPCL agrees to comply all the measures

Table 2.3: Monitoring Community Health, Safety and Security

Sl no	Potential Impacts	Proposed EMP	Actual measures already Implemented	Recommended Action	Compliance Status
1	Disturbance to nearby community due to Dust from newly developed land and Noise from construction activities	• Construction of boundary wall around the project area • Installation of water spraying system to control dusts • Conducting dust monitoring and visual inspection around the site boundary • Adoption of Noise management plan	• Construction of boundary wall around the project area • Water spray around the plant office	• Water spray along the road way/walk way, major working area, labor sheds	BIFPCL agrees to take more such measures
2	Grievance of local people	• Availability and operation of Grievance Redress Mechanism • Maintaining open communication channel with the local community	• Recruiting a Social officer to maintain close relation with nearby community	• Establish a grievance Redress Mechanism	BIFPCL agrees to establish a grievance redress mechanism during the construction period
3	Risk of breaching Community Safety	• Construction of boundary wall/safety fence around the project area • Practicing Risk Assessment and Evaluation Process • Practicing safe management for hazardous materials which may pose threat to the community • Availability and operation of Emergency Response Plan • Maintaining open communication channel with the local community • Training and instruction to the security personnel about their behaviour and communication with the local people • Aware the security personnel about the	• Construction of boundary wall around the project area • Incorporating safety policies to be followed in the bid documents of the contractors/EPC contractors/etc • Preparing a safety checklist to be followed during selecting construction contractors • Keeping a good communication with community • Negotiation with local DC office and Bangladesh Ansar	• Assign responsibility of enforcing and monitoring safety procedure to a officer • Aware labors and all employee about the safety procedure • The EPC contractors should prepare site specific ESMP • Arrange a safety training program for project personnel and labors • Training and instruction to the security personnel	BIFPCL agrees to comply all the measures during constrction.

Sl no	Potential Impacts	Proposed EMP	Actual measures already Implemented	Recommended Action	Compliance Status
		right of the community people	and VDP (who are made responsible for security)	about their behaviour and communication with the local people • Aware the security personnel about the safeguarding environment and community	
	Community Health Risk	• Provision of providing health service facilities to community if the project posses any health risk like sexually transmitted disease, communicable disease, vector-related Implement all pollution mitigation measures to ensure safeguarding to community	• Establishing a medical unit (consisting medical officer, medical assistant, office assistant) at plant site • Arranging weekly health service program (medical consultation and free medicine) for the local community • Providing health services to around 1100 people during May 2015- July 2015		Complied
	Youth Employment	• Providing training/awareness program for the local youth to let them aware about the required qualification to get involved in the project related activities	• Informal sitting with the community	• Initiate awareness program for the local youth to let them aware about the required qualification to get involved in the project related activities	• The Project is in preliminary pre-consructio n stage. To be complied during constructio n stage
	Public Communication, Consultation and	• Arranging public communication/consultation meeting • Sharing of project information with local	• Informal sitting with the community • Display project related	• Arrange dissemination workshop in Dhaka and Khulna to aware the	Complied

Sl no	Potential Impacts	Proposed EMP	Actual measures already Implemented	Recommended Action	Compliance Status
	Awareness	people • Organizing environmental and social awareness programs/meetings	information on a display board at project site • Recruitment of a Public Relation Officer at head office • Preparing an video documentation on project related information • Published project related discussion/article in different print media	community, civil society, environmentalist about the environmental safeguarding measures considered in basic design.	

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

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
1	Runoff (contain mostly sediment load) from newly developed land falls into nearby river and channel.	• Installation of proper run on/runoff drains • Use of sediment fences, traps and basins for trapping the sediment, if required	• Temporary installation of runoff drains • Construction of sediment traps is mentioned in the Bid documents to instruct the bidders	• Use sediment fences/traps to prevent sediment wash load to Maidara river	• To be complied during the construction stage
2	Disturbance to nearby ecosystem due to different construction activities	• No cutting/ felling of trees existing along the river bed • Implementation of on-site waste and air quality management plan • Limiting soil extraction activities limited within the defined area • Limiting the vegetation clearance and base stripping process within the project boundary • Safety fence around the construction site • Limiting the use of night light	• No cutting/ felling of trees existing along the river bed • Limiting soil extraction activities limited within the defined area • Limiting the vegetation clearance and base stripping process within the project boundary • Construction of Boundary wall • Installation of few numbers of night light • Provision of cut-off time to switch off unnecessary lights at	• Using shade (directed downwards) around the outdoor lights	Complied

Sl no	Potential Impacts	EMP measures as proposed in the EIA	Actual measures already Implemented	Recommended Action	Compliance Status
		• Using shade (directed downwards) around the outdoor lights • Provision of cut-off time to switch off unnecessary lights at night • Initiate Green plantation • No plantation of non-native species • Retaining top soil for future habitat restoration • No degradation of critical habitat?	night • Selection of local plant species for green plantation • No degradation of critical habitat?		
3	Occupation of river, inter-tidal areas and wetlands	• No encroachment of inter-tidal flood plain area • No disturbance to Dolphin community • Monitoring of Ecosystem Health and Monitoring of Sundarbans Forest Health • If required, embankment should be constructed considering a set back distance from river/canal bank • Slope protection work along the Maidara River should be completed on an urgent basis before rainy season come and • BIFPCL may take initiatives of excavating of silted reach of Maidara river near proposed township area to facilitate proper functioning of River for maintaining tidal dynamics	• Monitoring of forest health and ecosystem health in Sundarbans and around the project site by CEGIS • Maintaining a good set back distance from Passur river • Completion of slope protection work • Revising the drawing of embankment/slope protection works along the Maidara river keeping necessary set back distance from Maidara river	• Install sediment traps/fence in the area close to Maidara river to prevent trap sediment from rainfall run off • BIFPCL may take initiatives of excavating of silted reach of Maidara river near proposed township area to facilitate proper functioning of River for maintaining tidal dynamics	Complied

2.3 Compliance to Conditions of DoE

sl no	Condition of DoE	Compliance	Remarks
1	This EIA Report is approved only for 1320 MW Khulna Coal Based Power Plant. Any expansion or extension of this power plant will require obtaining further Environmental Clearance with additional EIA Study.	Not applicable now	**BPDB will comply with the condition prior to initiation of any extension/ expansion.**
2	The Coal Specification and power plant technology should be maintained as per EIA report. In case any change in design the proponent must obtain consent from DoE.	BIFPCL has engaged PWC as coal consultant. Once coal specification is fixed, the technical report will be sent to DoE. Power Plant Technology has been maintained as per EIA report	**BIFPCL will comply with the condition**
3	Project Proponent may undertake activities for land development and infrastructural development of the project.	BIFPCL has started only land and infrastructure development activities	**Complied**
4	Project Proponent may open L/C (Letter of Credit) for importing machineries for the project which shall also include machineries relating to waste treatment plant and other pollution control devices.	BIFPCL will open L/C after finalizing the EPC contractor	**To be Complied**
5	The activity under Proposed Khulna 3120 MW Coal based Thermal Power Plant Construction and operation shall not release any pollutant that affect human health or will have damaging impact on the environment or natural resources.	At present the Plant is in preliminary stage. BIFPCL engaged CEGIS for monitoring pre-construction and construction activities for examining environmental impacts. No impact has been reported yet.	**In the process of compliance**
6	Proper and adequate mitigation measures shall be ensured throughout preparation, construction and operation period of the proposed Khulna 1320 MW Coal based Thermal Power Plant Project activities.	BIFPCL is monitoring adoption of mitigation measures through CEGIS, as an environmental consultant. At present preliminary site preparation (pre-construction) activities are going on. Mitigation measures appropriate at this stage have been taken.	**In the process of compliance**
7	Any heritage sight, ecologically critical area, and other environmentally, religious and archaeologically sensitive places shall be kept protected during project construction phase.	Sundarbans is the only critical area of concern here. There is no religious, archaeological place in and around the site. The pre-construction activities has been carrying out ensuring safeguarding to Sundarbans and ECA	**Complied**

sl no	Condition of DoE	Compliance	Remarks
8	Environment friendly construction and development practices shall be followed that minimize loss of habitats and fish breeding, feeding & nursery sites.	The pre-construction activity is being carrying out keeping all the mitigation measures in order.	***In the process of compliance.*** **BIFPCL will ensure all the mitigation measures that required to be adopted during construction stage as well.**
9	Construction works shall be restricted to daytime hours so as to avoid/mitigate the disturbance of local lives as well as implementation schedules of the works shall be notified in advance to nearby residents.	The local communities are notably far from the project site and the present activities are limited to daytime only. BIFPCL is keeping close communication with local people to receive the grievance .	***Complied***
10	Proper and adequate sanitation facilities shall be ensured in labor camps throughout the proposed project period.	At present the Plant is in preliminary site preparation (pre-construction) phase Adequate and hygienic sanitation facilities are being ensured before starting of major construction works	***Complied***
11	In order to control noise pollution, vehicles & equipment shall undergo regular maintenance; working during sensitive hours and locating machinery close to sensitive receptor shall be avoided.	All vehicle & equipment used at site are under regular maintenance.	***Complied***
12	No solid waste can be burnt in the project area. An environment friendly solid waste management should be in place during the whole period of the project in the field.	At present the Plant is in preliminary site preparation (pre-construction) phase. Insignificant amount of solid waste (mostly papers, construction waste, etc) is generated at site. No waste is burnt. Wastes are managed in conventional way. However, a proper system of waste collection and disposal system will be maintained at site when the major construction work will be started.	***Complied***
13	Proper and adequate on-site precautionary measures and safety measures shall be ensured so that no habitat of any flora and fauna would be endangered or destructed.	Pre-construction activities are being taken up with adequate on-site precautionary measures and safety measures to safeguard flora and fauna.	***Complied***

sl no	Condition of DoE	Compliance	Remarks
14	All the required mitigation measures suggested in the EIA report along with the emergency response plan are to be strictly implemented and kept operative/functioning on a continuous basis.	At present the Plant is in preliminary site preparation (pre-construction) phase. BIFPCL has appointed a doctor for regular health check up of the workers and villagers surrounding area are also availing the health facilities. Emergency response plan shall be strictly implemented and kept operative/ functioning on a continuous basis.	***Complied.***
15	To control dust, spraying of water over the earthen materials should be carried out from time to time.	Water is sprayed in the area around the premises of site office to control dust. A boundary wall is around the plant have been constructed, that will control dust within the project boundary.	***Complied***
16	Storage area for soils and other construction materials shall be carefully selected to avoid disturbance of the natural drainage.	Construction materials have been stocked and piled far away from river bank and other water bodies	***Complied***
17	Adequate considerations should be given to facilitate drainage system for run off water from rain/tidal surge.	At present the Plant is in preliminary site preparation (pre-construction) phase. Run off drainage are being constructed, as required at this stage. Adequate drainage shall be ensured during construction nad operation phase.	***Complied***
18	Adequate facilities should be ensured for silt trap to avoid clogging of drain/canal /water bodies	Run off/ storm water drainagesystem shall have silt trap.	***Are being Complied***
19	The entire coal handling system should be designed as an enclosed (and not only covered) conveyor system. There should be integrated dust control system with dust extraction and bag filters at unloading areas and at each transfer points on the conveyor system.	Entire coal handling system are being designed as an enclosed conveyor system as per DoE requirement. Integrated dust control system with dust extraction system / bag filter and dust suppression system at crusher house, unloading points, transfer points has been specified in the technical specification of Main Plant EPC contract package.	***Complied***
20	Coal plant should have high-efficiency bag filter for arresting dust emissions.	All these stipulations have been included in the technical specification of EPC contract package	***Complied***
21	Coal should be stored in a covered storage yard.	All these stipulations have been included in the technical specification of EPC contract package	***Complied***
22	The entire coal stockyard should be covered with water sprinkler provide with automated moisture sensor to	All these stipulations have been included in the technical specification of EPC contract package	***Complied***

sl no	Condition of DoE	Compliance	Remarks
	control self-combustion.		
23	100% utilization of fly ash and bottom ash should be planned and implemented throughout the operation of the plant. There should only be a provision of small ash dyke that will not exceed 25 (twenty five) acres of land to store residual ash.	100% utilization of fly ash are being planned and shall be implemented throughout the operation of the plant.	***Complied***
24	Integrated dry ash handling, loading, unloading and transportation system should be established.	Integrated dry ash handling, loading,unloading and transportation system are being provided.	***Complied***
25	There should be adequate and properly sized and designed dry ash silo with appropriate conveyor system.	adequate and properly sized dry ash silo with appropriate conveying system have been specified in technical specification of EPC contract package.	***Complied***
26	Bottom ash should be extracted, crashed and stored in silos for utilization with proper collection and conveyor system.	Bottom ash shall be extracted, crushed and stored in silos for utilization with proper collection and conveying system. Same have been included in the technical Specification of EPC contract package.	**Complied**
27	Resettlement and rehabilitation of the displaced population (including those who do not own land) should be done properly.	Resettlement and rehabilitation action was taken as per the law of the Bangladesh BPDB has approached to GoB for suitable resettlement and rehabilitation as per requirements of the DoE	**In the process of compliance**
28	Resettlement plan should be properly implemented and people should be adequately compensated.	Mentioned above	**In the process of compliance**
29	Construction material should be properly disposed off after construction work is over.	At present the Plant is in preliminary site preparation (pre-construction) phase. Construction wastes are being reused at this stage	***Complied***
30	As described in the report environmental monitoring should be strictly followed and monitoring report should be shared with DoE to ensure the environmental management properly.	BIFPCL has engaged CEGIS for environmental monitoring in February 2014. CEGIS has completed first year of monitoring activities, and submitted five quarterly monitoring reports, which are available at BIFPCL web page.	**Complied**
31	All activities (pre-construction, construction and post-construction stage) should be implemented according to EMP clearly listed in the EIA report.	BIFPCL has adopted all of the EMP applicable at this stages. CEGIS, as an environmental consultant of BIFPCL is monitoring implementation of EMP. BIFPCL is taking all possible actions	**Complied**

sl no	Condition of DoE	Compliance	Remarks
		based on EMP monitoring report.	
32	A third party/independent monitoring bodies excluding JVC/BPDB should be engaged immediately for monitoring of all activities during pre-construction, construction and operation phases as per monitoring plan of EIA report and monitoring report must be submitted to Bagerhat District Office, Khulna Divisional Office and Headquarters of the Department of Environment simultaneously.	BIFPCL has engaged CEGIS for environmental monitoring in February 2014. CEGIS has completed first year of monitoring activities, and submitted five quarterly monitoring reports, which are available at BIFPCL web page.	***Complied***
33	Regular monitoring of the susceptible places of Sundarbans for protecting ecosystem, biodiversity and forest coverage should be made using latest high resolution image for keeping ambient environment.	The Monitoring activities of CEGIS included this part. The monitoring report contains analysis of biodiversity and forest coverage. However, in addition to this, Forest Department has also suggested some survey & analysis which have also been monitored by CEGIS	***Complied***
34	Air, water, soil, biological and social data should be monitored regularly with a network monitoring system with a view to assess the natural quality of the Sundarbans and other fragile ecosystem and report of monitoring results should be submitted to Bagerhat District Office, Khulna Divisional Office and Headquarters of the Department of Environment simultaneously.	CEGIS is monitoring air quality, soil quality, biological conditions, social conditions, etc. as suggested by DoE. The network monitoring system will be installed when the plant will be in operation.	***Complied*** The network monitoring system will be installed at operation phase.
35	There should be regularly disclosure of the report through workshops and websites and responses should be taken care accordingly.	All the reports are available on website of BIFPCL (www.bifpcl.com). CEGIS is regularly carrying out public consultation. The progress of the monitoring is regularly discussed in monthly project implementation monitoring meeting in presence of PGCB, LGED, Bangladesh Army, BPDB, CEGIS, etc. The same is being reviewed by the project steering committee, chaired by the Secretary, Power Division	***Complied***
36	Online air and water quality monitoring system should be made functional throughout the life of the Plant.	The online monitoring system would be installed when the Plant will be in operation phase and will be continued for throughout the life time of the Plant. All these stipulations have been	***Complied***

sl no	Condition of DoE	Compliance	Remarks
		included in the technical specification of Main Plant EPC contract package.	
37	Management Information System (MIS) are to be developed for this coal based power plant. The scope of MIS services will obviously include representing the real time monitored data especially environmental parameters displaying at Bagerhat District Office, Khulna Divisional Office and Headquarters of the Department of Environment, BPDB and other concern agencies/Ministries. The MIS should be web based for accessing every individual to show the real time monitored records.	The MIS will be prepared before commissioning of Plant. The consultant for developing MIS will be engaged at least one year earlier. Specification for elaborate MIS system already included in EPC contract document.	***Complied***
38	JVC should provide all sort of logistics support to DoE and other relevant agencies for monitoring environment related items/events.	BIFPCL is ready to provide all sort of logistic support as and when required by DoE for monitoring of Plant construction activities and environmental items/events.	***Complied***
39	No ground water should be allowed to use for plant purposes.	No ground water has been used so far. And the plant has been designed considering use of surface water only.	***Complied***
40	Conduct stakeholder meetings on regular basis for better performance the project as a whole.	At present the Plant is in preliminary site preparation (pre-construction) phase. BIFPCL has appointed a social worker who regularly visits nearby community to consult with the local people. Besides, CEGIS,appointed as environmental monitoring consultant is carrying out consultation with locals.	***Complied***
41	Additional Environmental baseline data to be collected as suggested in the EIA report and conveyed to DoE and other concern authorities.	In February 2014, CEGIS has been engaged for preparing Detail Environmental Baseline. CEGIS has submitted annual monitoring report along with reports of quarterly monitoring containing latest baseline data.	***Complied***
42	The Environmental Management Plan under the EIA study shall strictly be implemented and kept functioning on a continuous basis.	BIFPCL is implementing EMP phase by phases and appointed CEGIS for monitoring it.	***Being Complied*** BIFPCL will implement all the EMP as suggested in EIA report and by DoE.
43	The project authority shall submit a detail work plan with time schedule	BIFPCL shall submit detail work plan before the start of Main Plant Works.	**Agreed to Comply**

sl no	Condition of DoE	Compliance	Remarks
	of development activities at least 7 (seven) days ahead of the work commences in the field to the Bagerhat District Office, Khulna Divisional Office and Headquarters of the Department of Environment simultaneously.		
44	Environmental Monitoring Reports according to specific format specified in the EIA Report shall be made available simultaneously to DoE Bagerhat District Office, Khulna Divisional Office and Headquarters on a monthly basis during the construction period of the project.	EMP Reports as per specific format in the EIA shall be made available by BIFPCL to DOE on a monthly basis during the construction period of the project.	**Agreed to Comply**
45	The following records must be kept in respect if any samples required to be collected for the purpose of environmental monitoring activities: (a) the date(s) on which the sample was taken; (b) the time(s) at which the sample was collected; (c) the point at which the sample was taken; and (d) the name of the person who collected the sample.	The Monitoring report of CEGIS keeps records of all as suggested.	***Complied***
46	The results of any monitoring required to be conducted under this EIA report must be recorded.	CEGIS is recording all the monitoring data and submitting to BIFPCL through proper documentation. The report is being shared with DoE on regular basis.	***Complied***
47	In case of any emergency, the following information shall be immediately be reported to Bagerhat District Office, Khulna Divisional Office and Headquarters of the Department of Environment (DoE) simultaneously a) Nature of incident (oil spill, fire, accident. Collision, land slide, etc.) b) Personnel affected (injured, missing, fatalities, etc.) c) Emergency support available and its location (standby transport, medical facilities, etc.) d) Weather conditions	So far no such emergency has been happened. BIFPCL would establish a proper mechanism for recording such incident as suggested	***To be complied***

sl no	Condition of DoE	Compliance	Remarks
	e) Current operations (abandoning the site, fire fighting, etc.)		
48	The project authority or its employees must notify the department of Environment of incident s causing or threatening material harm to the environment as soon as practicable after the person becomes aware of the incident.	BIFPCL would establish a proper mechanism for recording such incident as suggested.	***Agreed to Comply***
49	All pollution incidents shall be reported immediately and simultaneously to the Bagerhat District Office, Khulna Divisional Office and Headquarters of the Department of Environment (DoE) in Dhaka.	So far no such incident has been happened. BIFPCL would establish a proper mechanism for recording such incident as suggested. CEGIS has been engaged to record such incident during pre-construction and construction period	***Complied***
50	Appropriate permission would require to be obtained from the from the Forest Department in favor of cutting/felling on any plant/tree/sapling forested by any individual or government before doing such type of activity.	There will be no need of cutting/felling down of any trees. However, in future, if any such case would arise, BIFPCL would seek for appropriate permission	***Complied***
51	Re-vegetation and replantation under green belt activities shall be undertaken in consultation with the Forest Department according to those mentioned in the EIA report.	MOU signed with Forest Deptt., Bangladesh on 24.02.2015 for implementation of Afforestation Programme. Initial target is planting of 2 lac saplings in 3 years.	***Complied***
52	Climate Change impacts and maximum storm surge height shall have to consider at the design and construction phase.	The level (elevation) of the land and earthen embankment have been fixed considering the climate change impact and maximum storm surge height.	***Complied***
53	A separate EIA/morphological study shall have to be conducted for coal transportation and river dredging to develop sound environmental management plan towards conservation of ecosystem and biodiversity.	Mongla Port Authority (MPA) is the Implementing Agency for dredging and coal transportation will be through the existing maritime route, which is Mongla port controlled waterways. M/s IWM has already been appointed by MPA for EIA for the dredging activity.	***Complied***
54	A full-fledged institutional setup for EHS and CSR must be put in place before operation of the power plant.	A full-fledged institutional setup for EHS activities shall be in place before operation of the plant project. Meanwhile, a number of CSR activities are on going at project site like free medical facilities to locals, Free potable	**Agreed to comply**

sl no	Condition of DoE	Compliance	Remarks
		water supply to the local people and BIFPCL has appointed a social worker to collect social data.	
55	The project authority shall extend active cooperation to DoE officials to facilitate their visit to the site as and when necessary.	BIFPCL is extending its all cooperation to DoE	**Complied**
56	Violation of any of the above conditions shall render this approval void.	Noted by BIFPCL	**Complied**
57	Any injunction on this project from the Honorable Supreme Court/High Court Division shall render this approval void.	Noted by BIFPCL	***Complied***
58	Without installation of 275 Meter Height Chimney, Effluent Treatment Plant (ETP), Waste Water Treatment Plant (WWTP), Settling Pond , Desalinization Plant, API Oil Water Separator, High Efficiency Electro Static Precipitator (ESP), 'closed-loop' Flue Gas Desulfurization (FGD), Low NOx Burner, online air and water quality monitoring system and other pollution control equipment and obtaining Environmental Clearance Certificate the proponent shall not start operation of the project.	At present the Plant is in preliminary site preparation (pre-construction) phase. The functional technical specification of the main plant includes 275 Meter Height Chimney, Effluent Treatment Plant (ETP), Waste Water Treatment Plant (WWTP), Setting Pond, Desalinization Plant, API, Oil Water Separator, High Efficiency Electro Static Precipitator (ESP), 'closed-loop' Flue Gas Desulfurization (FGD), Low NOx Burner, online air and water quality monitoring systematic for preventing pollution. All these stipulations have been included in the technical specification of Main Plant EPC contract package..	***Complied***
59	This EIA Approval has been issued with the approval of the appropriate authority.	BPDB and BIFPCL are thankful DoE.	**N/A**

3 Air Quality Monitoring

19. The ambient air quality has been monitored in this **2nd Quarter** of the **2nd year (2015)** at 9 (nine) specific 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

20. 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 the major parameters of monitoring. With relation to the Project related activities, model generated emission dispersion scenario and Environmental Monitoring Plan (CEGIS, 2013), nine locations have been monitored in order to analyze the aforementioned parameters. Pre selected sites have been monitored up to the last endeavors; but in this quarter, due to the rough weather, 2 of the furthest sites (Akram point & Hiron point) have been discarded from the trip plan beforehand.

3.1.1 Method of Sampling and Laboratory Testing

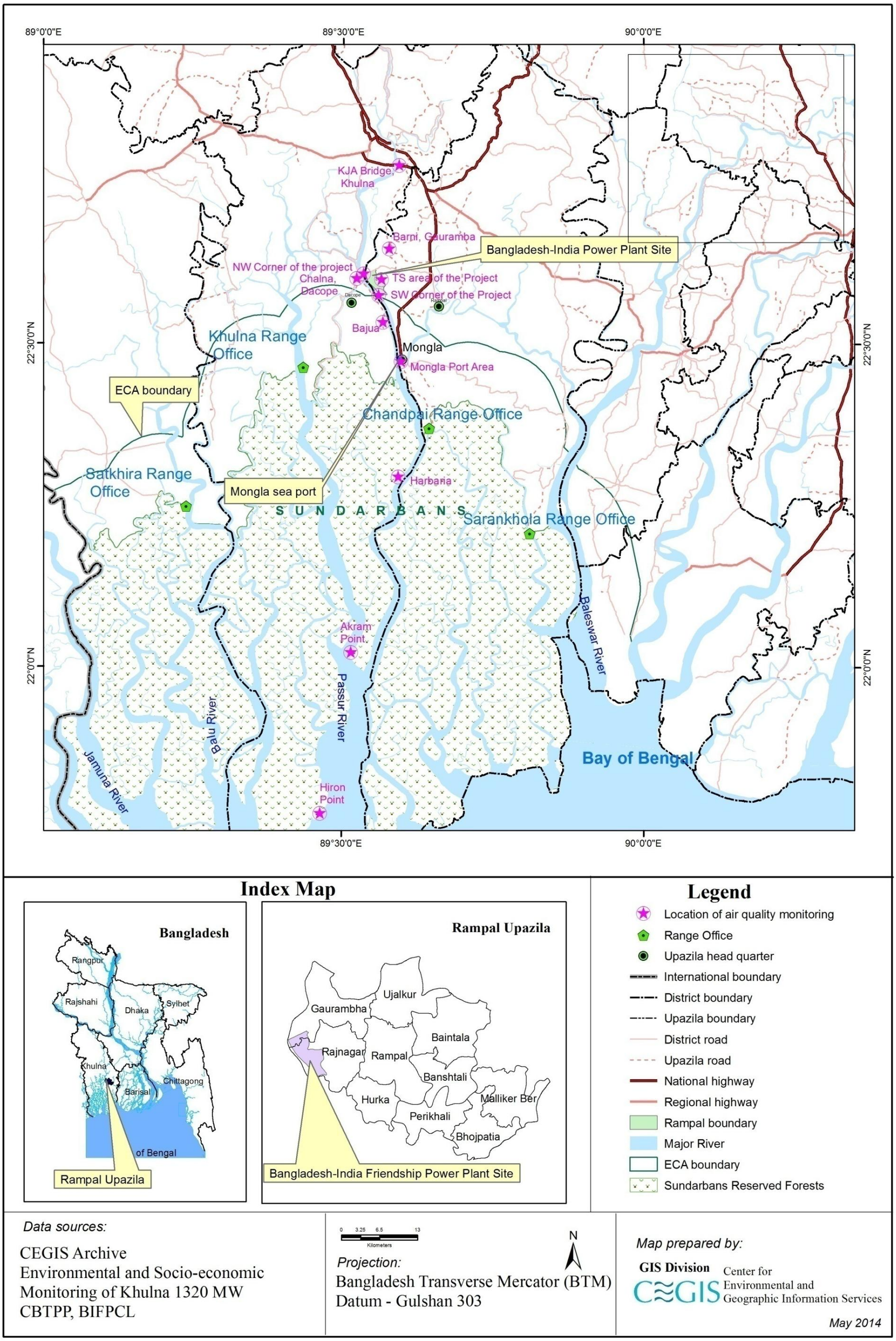
21. Respirable Dust Sampler (Model-Envirotech India APM-460BL) and Fine Particulate Sampler (Model-Envirotech India APM-550) have been used to collect the air sample. The $PM_{2.5}$, PM_{10}, and SPM have been tested by gravimetric method. The concentration of SO_2 has been tested by West-Gaeke method.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

3.1.2 Locations of air quality monitoring

22. Ambient air quality has been monitored during this quarterly (**2nd Quarter** of the **2nd year)** 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 Points	Frequency	Methods/Tools/Techniques
1	SO_X, NO_X , PM_{10}, $PM_{2.5}$	South West corner of the project boundary	89°33'34.5"E, 22°34'33.8"N	Quarterly	In situ field measurement provided with the facilities of outsourced laboratory. Method of testing SO_X: USEPA (2000) Method 6 or 6A or 6B or ISO (1998) Method 11632 (as appropriate) Method of testing NO_X: USEPA (2000) Method 7 or 7A or 7B or 7C or 7D or ISO (1993) Method 10396 (as appropriate). Method of testing $PM_{2.5}$: Gravimetric Method of testing PM_{10}: USEPA (1997) Method 201 or 201A (as appropriate)
2		Proposed township area near Chimney location, Mouza: Sapmari Katakhali	89°32'3.8"E, 22°36'32.5"N		
3		North West corner of the project boundary (Kaigar daskati)	89°33'51.8"E, 22°36'1.06"N		
4		Barni, Gaurambha union (4km North East from the chimney location)	89°34'37.7"E, 22°38'51.8"N		
5		Chunkuri-2, Bajua 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 $PM_{2.5}$, PM_{10} and SPM

23. The values of $PM_{2.5}$ and PM_{10} were found within the standard limit at each location. Among those locations, the maximum concentration of $PM_{2.5}$ and PM_{10} was 46 µg/m^3 and 144 µg/m^3 and was found in near Khan Jahan Ali Bridge and Pankhali, Dacope respectively. But, SPM was found exceeding the standard level at Pankhali, Dacope and at NW Corner of the PP area. Large number of two stroke human hauler, small engine boats and a number of anthropogenic activities 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 are given in **Table 3.2.**

3.2.2 SO_2

24. Concentration of Sulphur-di-oxide in the ambient air was found within the standard. The values of SO_2 ranged in between µg/m^3 45 to 59 µg/m^3. SO_2 concentration was also measured in the Sundarban reserve forest the result indicated a moderate condition in there. In other areas, SO_2 varies in between 11 µg/m^3 to 31 µg/m^3. All the monitoring data of ambient air quality are given in **Table 3.2.**

3.2.3 NO_2

25. NO_2 concentration in the ambient air of Sundarbans adjacent areas ranged between 34 µg/m^3 to 49 µg/m^3. NO_2 concentrations were also checked In Project site and its adjoining areas and were found a little bit higher than that of Sundarbans but still within the standard limit. The monitoring results are shown in **Table 3.2**.

3.2.4 CO and O_3

26. CO concentration ranged from 89 µg/m^3 to 146 µg/m^3 in Project area and its adjoining areas. The possible cases for the higher concentration might be the increased activity such as big ship's anchorage beside the sampling point and for the loading-unloading activity. Similarly, results of O^3 were laid between 7 µg/m^3 to 21 µg/m^3 which were found to be lower than the BD standards.

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	1st QM, April 2015	2nd QM, July/ August 2015	3rd QM, October 2015	4th QM, January 2016	1st QM, April 2016	2nd QM, July 2016	3rd QM, October 2016	4th QM, January 2017	Bangladesh (DoE) Standard for ambient Air (ECR 2005)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny	Sunny	Rainy/ Cloudy								
Wind Direction		SE	SE	SE	NW	SE to NW	SW to NE								
		Concentrations are in µg/m^3													
SW Corner of the PP area	$PM_{2.5}$	33	37	25	33	47	25							65	75
	PM_{10}	78	77	53	79	83	35							150	150
	SPM	207	239	190	200	177	42							200	NF
	SO_2	21	24	19	23	15	52							365	125
	NO_x	26	29	27	31	29	35							100	200
	CO	120	188	140	190	144	146							40000*	NF
	O_3	27	26	19	22	26	12							160*	160
Proposed Township area of the PP	$PM_{2.5}$	39	48	48	39	34	18							65	75
	PM_{10}	89	90	74	102	97	31							150	150
	SPM	217	263	217	274	266	47							200	NF
	SO_2	19	28	22	21	22	58							365	125
	NO_x	29	39	27	26	24	46							100	200
	CO	165	210	230	164	136	127							40000*	NF
	O_3	33	26	26	23	21	16							160*	160
NW Corner of the PP area	$PM_{2.5}$	37	44	19	42	59	28							65	75
	PM_{10}	67	78	56	98	91	96							150	150
	SPM	234	217	157	310	244	321							200	NF
	SO_2	19	22	18	27	21	56							365	125

Locations of Monitoring	Pollutants	1st QM, April 2014	2nd QM, July 2014	3rd QM, October 2014	4th QM, January 2015	1st QM, April 2015	2nd QM, July/ August 2015	3rd QM, October 2015	4th QM, January 2016	1st QM, April 2016	2nd QM, July 2016	3rd QM, October 2016	4th QM, January 2017	Bangladesh (DoE) Standard for ambient Air (ECR 2005)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny	Sunny	Rainy/ Cloudy								
Wind Direction		SE	SE	SE	NW	SE to NW	SW to NE								
		Concentrations are in µg/m^3													
	NO_x	23	28	22	32	39	43							100	200
	CO	110	178	110	210	140	133							40000*	NF
	O_3	25	19	17	36	44	11							160*	160
Barni, Gaurambha	$PM_{2.5}$	39	47	57	39	41	34							65	75
	PM_{10}	103	122	67	97	82	65							150	150
	SPM	233	244	183	277	236	79							200	NF
	SO_2	21	23	17	22	25	41							365	125
	NO_x	25	28	22	26	27	44							100	200
	CO	175	210	190	150	196	96							40000*	NF
	O_3	26	29	22	19	15	9							160*	160
Chunkuri-2, Dacope	$PM_{2.5}$	35	39	46	37	33	35							65	75
	PM_{10}	77	86	69	68	61	109							150	150
	SPM	117	113	162	183	188	175							200	NF
	SO_2	19	24	21	18	11	55							365	125
	NO_x	23	26	27	24	18	49							100	200
	CO	190	205	170	170	33	133							40000*	NF
	O_3	27	24	18	22	41	21							160*	160
Pankhali, Dacope	$PM_{2.5}$	47	49	57	41	39	-							65	75
	PM_{10}	119	127	139	101	105	144							150	150

Locations of Monitoring	Pollutants	1st QM, April 2014	2nd QM, July 2014	3rd QM, October 2014	4th QM, January 2015	1st QM, April 2015	2nd QM, July/ August 2015	3rd QM, October 2015	4th QM, January 2016	1st QM, April 2016	2nd QM, July 2016	3rd QM, October 2016	4th QM, January 2017	Bangladesh (DoE) Standard for ambient Air (ECR 2005)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny	Sunny	Rainy/ Cloudy								
Wind Direction		SE	SE	SE	NW	SE to NW	SW to NE								
		Concentrations are in µg/m^3													
	SPM	297	266	254	208	299	339							200	NF
	SO_2	28	31	31	24	30	58							365	125
	NO_x	41	39	36	26	27	47							100	200
	CO	230	217	250	188	177	125							40000*	NF
	O_3	49	38	36	27	11	13							160*	160
Mongla Port area	$PM_{2.5}$	47	55	39	41	26	33							65	75
	PM_{10}	139	174	77	82	35	52							150	150
	SPM	288	303	197	217	214	118							200	NF
	SO_2	27	28	26	24	14	45							365	125
	NO_x	44	39	33	27	17	40							100	200
	CO	230	320	220	211	24	110							40000*	NF
	O_3	57	52	37	26	09	15							160*	160
Harbaria, Sundarbans	$PM_{2.5}$	19	22	33	27	24	27							65	75
	PM_{10}	41	39	59	56	49	42							150	150
	SPM	111	117	129	139	109	70							200	NF
	SO_2	9	10	14	12	16	51							365	125
	NO_x	19	22	27	18	22	34							100	200
	CO	65	58	70	64	56	112							40000*	NF
	O_3	13	12	13	11	14	12							160*	160

Locations of Monitoring	Pollutants	1st QM, April 2014	2nd QM, July 2014	3rd QM, October 2014	4th QM, January 2015	1st QM, April 2015	2nd QM, July/ August 2015	3rd QM, October 2015	4th QM, January 2016	1st QM, April 2016	2nd QM, July 2016	3rd QM, October 2016	4th QM, January 2017	Bangladesh (DoE) Standard for ambient Air (ECR 2005)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny	Sunny	Rainy/ Cloudy								
Wind Direction		SE	SE	SE	NW	SE to NW	SW to NE								
		Concentrations are in µg/m^3													
Akram Point Sundarbans	$PM_{2.5}$	17	19	23	18	49	-							65	75
	PM_{10}	39	44	32	39	77	-							150	150
	SPM	114	133	97	88	102	-							200	NF
	SO_2	7	9	12	13	21	-							365	125
	NO_x	17	19	22	17	27	-							100	200
	CO	49	60	50	46	163	-							40000*	NF
	O_3	11	14	9	10	27	-							160*	160
Hiron Point Sundarbans	$PM_{2.5}$	15	23	19	17	28	-							65	75
	PM_{10}	44	38	34	41	60	-							150	150
	SPM	101	119	107	97	110	-							200	NF
	SO_2	8	7	13	14	15	-							365	125
	NO_x	18	18	19	22	20	-							100	200
	CO	52	62	65	60	60	-							40000*	NF
	O_3	14	13	11	9	23	-							160*	160
Khulna City, near Khan Jahan Ali Bridge	$PM_{2.5}$	54	39	52	42	55	46							65	75
	PM_{10}	139	117	91	84	75	89							150	150
	SPM	301	287	239	219	222	181							200	NF
	SO_2	33	29	33	28	31	59							365	125
	NO_x	49	41	39	36	33	38							100	200

Locations of Monitoring	Pollutants	1st QM, April 2014	2nd QM, July 2014	3rd QM, October 2014	4th QM, January 2015	1st QM, April 2015	2nd QM, July/ August 2015	3rd QM, October 2015	4th QM, January 2016	1st QM, April 2016	2nd QM, July 2016	3rd QM, October 2016	4th QM, January 2017	Bangladesh (DoE) Standard for ambient Air (ECR 2005)	IFC/WB Standard
Weather		Sunny	Rainy/ Cloudy	Sunny	Sunny	Sunny	Rainy/ Cloudy								
Wind Direction		SE	SE	SE	NW	SE to NW	SW to NE								
		Concentrations are in µg/m^3													
	CO	330	370	330	296	101	89							40000*	NF
	O_3	59	67	57	39	21	7							160*	160

Note:

- Concentrations are in µg/m^3 DoE- Department of Environment, NF – Not found
- Fine Particulate Matter ($PM_{2.5}$), Respirable Dust Content (PM_{10}), Suspended Particulate Matter (SPM), Oxides of Nitrogen (NO_X). Sulphur-Di-Oxide (SO_2), Carbone Mono-Oxide (CO). & Ozone (O_3).
- All standards are for 24hr average except CO and O_3, standards for CO and 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

27. 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

28. Mostly river traffics of Mongla Port area travelling across the Sundarbans are the sources of Suspended Particulate Matter (SPM), Oxides of Sulphur (SOx), Oxides of Nitrogen (NOx) 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	Condensate Fractionating Plant	LPG Bottling Plant	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	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓

		Cement Industry	Condensate Fractionating Plant	LPG Bottling Plant	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
	GHGs	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓
Pankhali, Dacope	PM	✓	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓
	SOx	✗	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓
	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	✗	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

		Cement Industry	Condensate Fractionating Plant	LPG Bottling Plant	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
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

29. Ambient noise levels were monitored as quarterly at nine locations during this session. Monitoring activities were carried out in March-14, July-14, October-14, January-15, April-15 and July/August-15. The detail of the monitoring plan is described in Table 4.1.

30. In this **2nd Quarter** monitoring of the **2nd year**, the noise level was recorded little lower than usual. The ambient noise is probably suppressed during this period of time due to the depression prevailing over the entire area resulting extreme rainfall, exacerbated by Tropical Cyclone "Komen" (The heavy rain developed as a slow-moving monsoon depression formed over Bangladesh during the last week of July and eventually organized itself into a tropical cyclone over the northern Bay of Bengal). Very few barges, trawlers and ships have been seen plying over the waterway at this time.

31. It has been found that the Noise is generated from the commonly known sources like the rural vehicles (human howler/ Nosimon, auto-rickshaw) while working beside the roads; whereas in case of the monitoring spot in or around the waterways, the sources are trawler, ship, sometimes waves breaking against the shore, etc.

4.1 Methodology

32. Noise levels were measured thrice in a day (morning, afternoon and evening) in each of the 9 (nine) 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

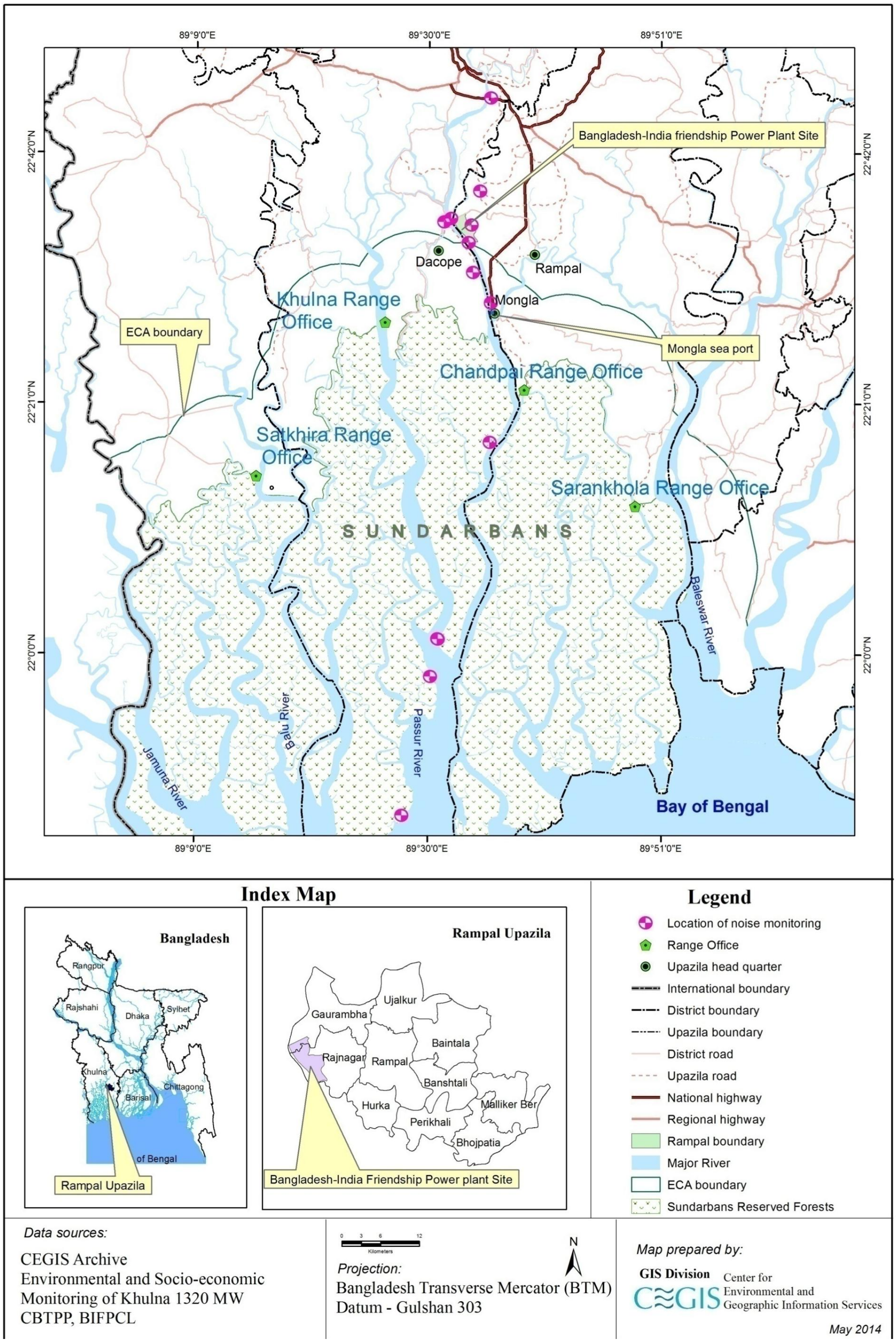
Photo 4.2: Professional conducting an ambient noise acquisition survey

4.2 Locations of Noise Monitoring

33. 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). Due to stormy situation and probability of surges, farthest two locations inside the Sundarbans (near the open sea) had been discarded from the itinerary of the trip to avoid any life risk.

Table 4.1: Noise Monitoirng Plan

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



Map 4.1: Noise Moniotring Locations

4.3 Results of Noise Monitoring

4.3.1 Noise at Dacope Upazila Parishad

34. The monitoring location was at Chalna Bazar 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 second quarter monitoring of the 2nd year has been recorded as the lowest (Table 4.2b).

35. There, the significant noise sources were road traffic and people's crowd. The road traffics were mostly from locally made engine van (locally called Nosimon), motor bike, easy bike (battery operated tri-cycle), etc. Traffic load was comparatively much lower than any time of previous monitoring that eventually resulted in less noise.

4.3.2 Noise at North West Corner of the Project Area

36. 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

37. This area is classified as residential where the standard maximum ambient noise level is 50dB (A) at day time (ECR, 1997). Noise levels during the first, second and third quarter monitoring of 1st year were found exceeding the standard limit (Table 4.2b) but similar to last quarter monitoring of 1st year and first quarter monitoring of the 2nd year, at this time of monitoring (2nd quarter of 2nd year), it was found well below the standard. The significant noise sources are rural 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

38. The South West corner of the Project area falls in Sapmari, Katakhali mouza of Rajnagar union. The area also falls under residential class. ECR, 1997, which 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 4.2b).

4.3.5 Noise at proposed township area of the Project

39. 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 previous quarterly monitoring(s), noise levels were within standard limit in this quarter monitoring too (Table 4.2b).

4.3.6 Noise at Barni, Gaurambha

40. 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 lower than the last quarterly monitoring which is within the acceptable standard limit. It's noteworthy that though this area

falls under rural classification, the commercial activities like bazaar, local traffic, crowd etc. are increasing day by day, thus the ambience is getting noisier.

4.3.7 Noise at Khan Jahan Ali Bridge, Khulna

41. The monitoring location is beside 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 this quarterly monitoring, noise levels were found slightly below than the usual (what was encountered in the previous visits) but those were well within the standard limit. Here the highway traffic is the main source of noise. In the day of monitoring, Noise level was recorded the highest during evening when traffic load was also higher. It is expected that this road will be busier in coming days due to the increased port activities.

4.3.8 Noise at Mongla Port area

42. 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 2nd quarter monitoring of the 2nd year, noise levels were found much lower than the standard.

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

4.3.9 Noise at Harbaria, Sundarbans

44. 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 against the shore.

45. Ships movement, engines of anchored ships, wind, birds, wave and wind action on tree leaves were the main sources of noise in this location.

Table 4.2a: Summary of the ambient noise monitoring in First Year

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)	A.noon (13:00)	Evening (18:00)	Day time AVG	Morning (9:00)	A.noon (13:00)	Evening (18:00)	Day time AVG	Morning (9:00)	A.noon (13:00)	Evening (18:00)	Day time AVG	Morning (9:00)	A.noon (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	54.63	51.92	53.7	54.21	53.28	70
2	NW Corner of the Project area	55.23	53	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
3	Chunkuri-2, Bajua	62.69	57.19	53.39	57.76	54.61	51.14	51.9	52.55	52.26	51.14	50.76	51.39	55.08	46.29	46.49	49.29	50
4	SW corner of the project area	49.2	NM	NM	49.2	44.55	48.94	49.33	47.6	45.56	45.1	47.18	45.95	36.57	34.24	37.27	36.03	50
5	Proposed Township area, project site	47.8	49.7	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
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	43.6	50
7	Khan Jahan Ali Bridge, Khulna	76.12	66.72	72.25	71.7	55.97	64.68	61.75	60.8	72.24	58.3	68.3	66.28	61.34	63.4	60.41	61.72	70
8	Mongla Port area	69.38	54.55	59.79	61.24	54.75	54.2	52.58	53.84	66.8	55.2	59.5	60.5	40.26	35.04	40.76	38.69	75
9	Harbaria, Sundarbans	39.24	NM	42.51	40.88	59.25	60.52	48.62	56.13	54.08	56.51	NM	55.3	36.36	32.4	NM	34.38	45
10	Akram Point, Sundarbans	40.95	41.98	39.9	40.94	48.95	46.86	NM	47.9	45.27	42.69	NM	43.98	37.9	30.75	NM	34.32	45
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	NM	37.37	45

Table 4.2b: Summary of the ambient noise monitoring in Second Year

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)	A.noon (13:00)	Evening (18:00)	Day time AVG	Morning (9:00)	A.noon (13:00)	Evening (18:00)	Day time AVG	Morning (9:00)	A.noon (13:00)	Evening (18:00)	Day time AVG	Morning (9:00)	A.noon (13:00)	Evening (18:00)	Day time AVG	Day time AVG
1	Chalna, Dacope	57.27	54.31	59.65	57.08	43.52	54.23	51.56	49.77									70
2	NW Corner of the Project area	45.05	42.15	46.8	44.67	37.58	40.91	46.18	41.56									50
3	Chunkuri-2, Bajua	45.9	48.19	NM	47.05	40.57	42.23	39.17	40.66									50
4	SW corner of the project area	40.6	43.25	46.89	43.58	44.57	44.30	42.36	43.75									50
5	Proposed Township area, project site	41.49	39.55	43.37	41.47	43.41	50.86	45.99	46.75									50
6	Barni, Gaurambha	58.23	50.11	NM	54.17	46.76	44.83	46.95	46.18									50
7	Khan Jahan Ali Bridge, Khulna	75.2	72.75	72.42	73.45	52.95	52.18	53.34	52.82									70
8	Mongla Port area	46.02	49.29	49.15	48.15	36.72	38.56	43.54	39.61									75
9	Harbaria, Sundarbans	67.06	64.05	64.99	65.37	39.33	30.74	NM	35.03									45
10	Akram Point, Sundarbans	53.35	56.37	NM	54.86	NM	NM	NM	-									45
11	Hiron Point, Sundarbans	47.48	48.2	NM	47.84	NM	NM	NM	-									45

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

5 Water Quality Monitoring

46. As per the Environmental Monitoring Plan the water quality monitoring has been carrying out quarterly at 15 locations in Passur River and Maidara River, and three locations of ground water. Since April 2014, water quality has been monitored for six (6) times. The monitoring covers 17 parameters and extra nine (10) parameters only at project site. Among these parameters, five parameters (pH, temperature, salinity, DO and BOD) are tested at site using portable instruments, 20 parameters are tested in DPHE and one parameter (oil and grease) is tested in BCSIR laboratory. The details of the monitoring plan are shown in **Table 5.1**.

47. This report includes laboratory analysis reports of water samples collected upto April, 2015 (first quarter of second year) and in-situ results of water quality monitoring up to July 2015 (second quarter of second year). The Laboratory results of water samples collected in July 2015 will be presented in the next report of quarterly monitoring.

48. During this second quarter of second year monitoring, it was not possible to monitor water quality in Akram point and Hiron point of Sundarbans due to prevailing rough river condition (stormy wind, high river current and heavy wave) that restricted the accessibility to that region. Generally, in this season pollution loads are insignificant so missing data in only two points will not be very critical issue. However, we still have measured data in upstream of Akram point and Hiron Point region which will give a general idea about the environmental quality of the Sundarbans region.

5.1 Methodology

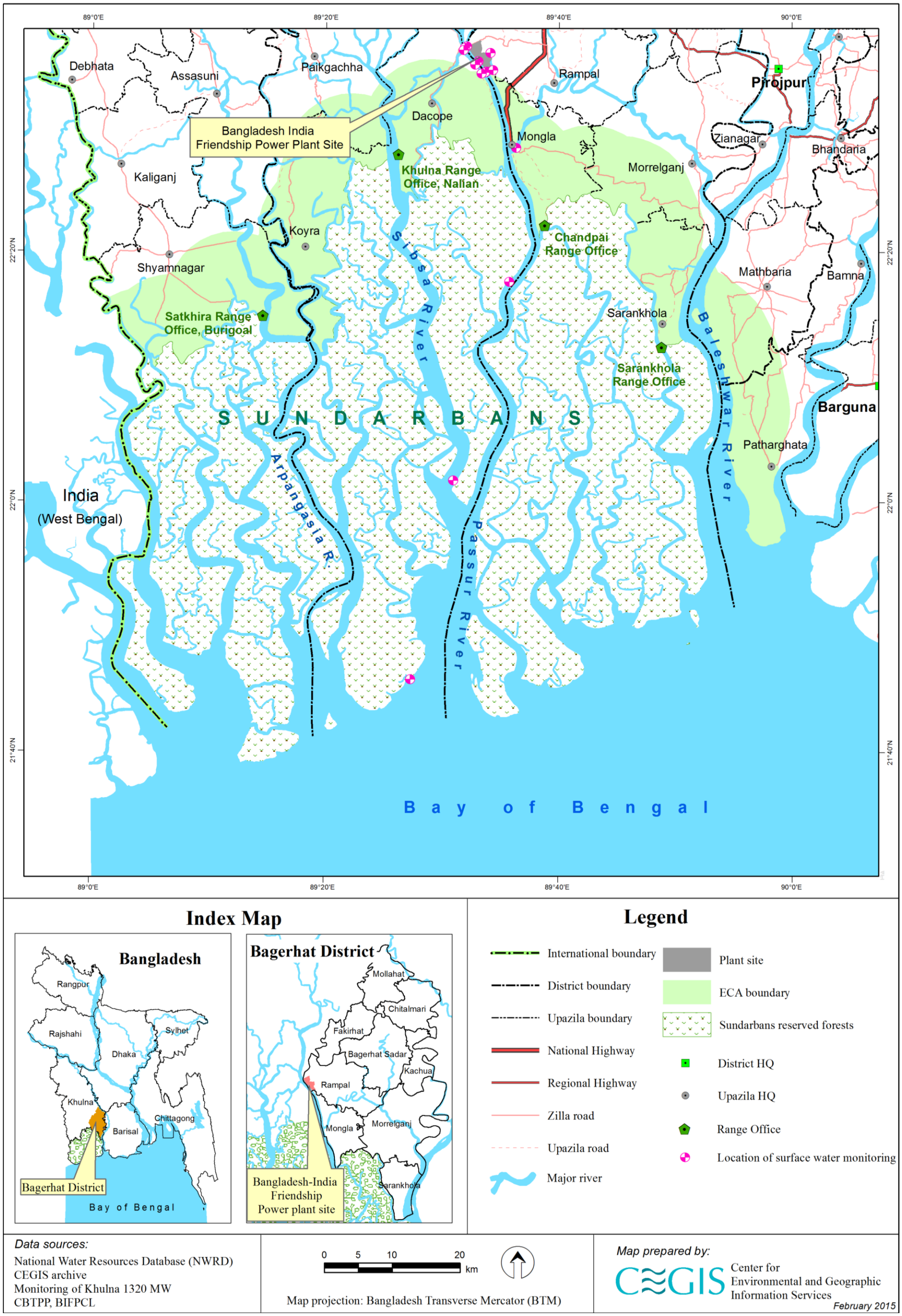
49. Monitoring of water quality directly depends on selection of water quality parameters, sampling points, sampling frequency, evaluation criteria etc. Standard practices have been followed for monitoring of water quality). This study is intended for calculating both surface and ground water quality parameters to reveal the present water quality status in the surroundings of Rampal Power Plant and the Sundarbans. As a part of entire monitoring activities, sample collection for 2nd quarterly monitoring of second year was scheduled from 28th to 6th August this year. In order to establish a strong baseline, monitoring results have not only been presented but also been compared with the national and international standards.

5.2 Sampling Location

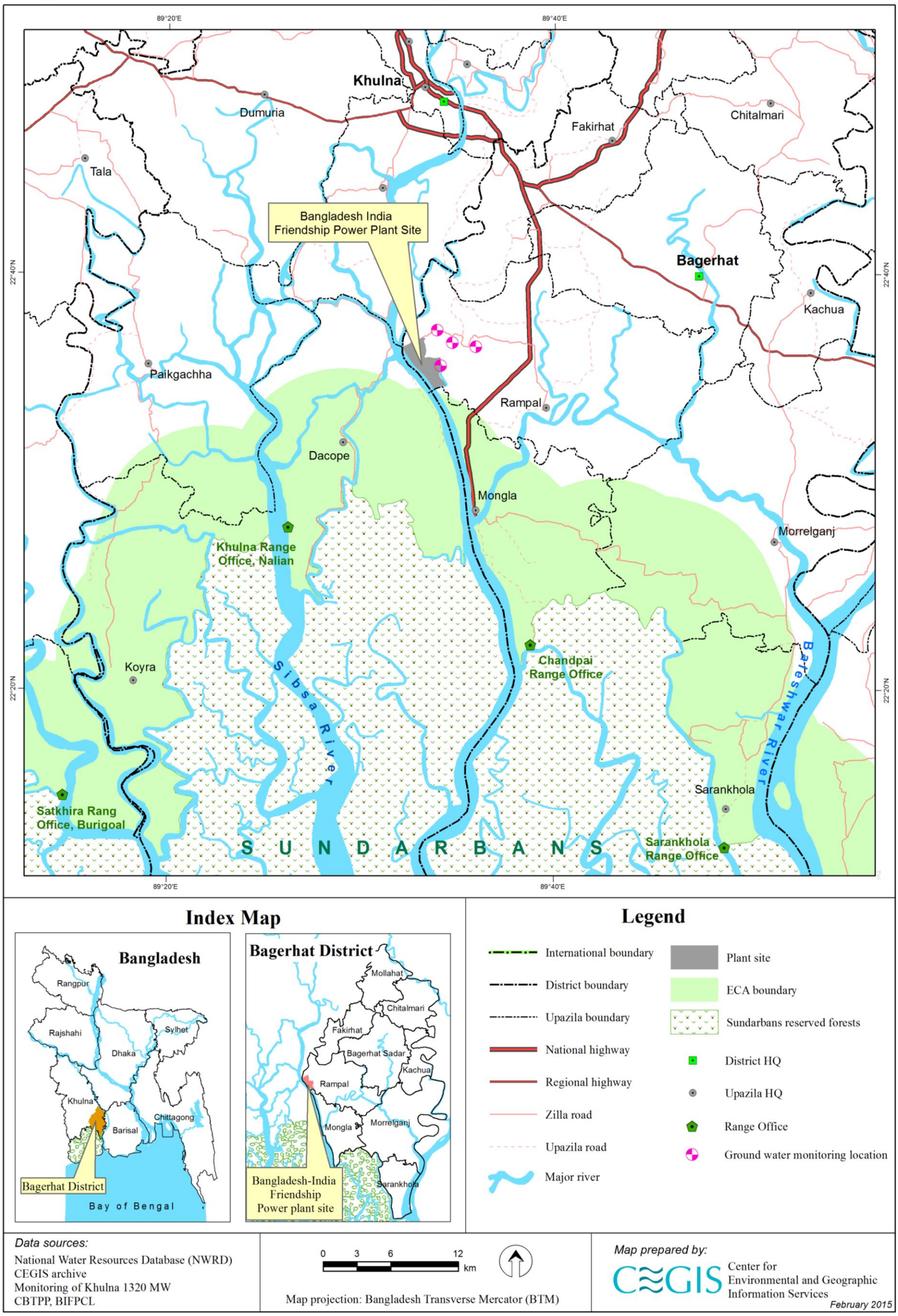
50. Similar to previous completed quarterly monitoring, water samples were collected from pre-selected 15 points for surface water and 4 points for groundwater (**Map 5.1 and 5.2**). These sampling points were preliminary selected at inception stage and finalized during first quarter monitoring of this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

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

Sl no	Monitoring Indicators	Locations	GPS Points (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, and January)	In-situ 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 of 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		
14		Passur river at Akram ponit of Sundarbans	23.00653	89.515028		
15		Passur river at Hiron point of Sundarbans	22.29531	89.592833		



Map 5.1: Surfacewater Quality Monitoring Locations



Map 5.2: Groundwater Quality Monitoring Locations

5.3 Sampling Procedure

51. 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 would in turn reduce the probability of error as well as increase the level of confidence of the study.

52. 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.

53. 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.

54. 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

55. 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 (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

56. Four points have been selected for monitoring the ground water quality of the study area. Among them, one well is located 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 hand pump tube wells. 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 Points (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)	In-situ measurement and Laboratory analysis
2		Rajnagar	22.612528	89.576056		
3		Kalekerber	22.609306	89.596278		
4		Kapasdanga	22.622528	89.563000		

5.3.3 Water quality analysis procedure

57. 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	^{0}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^{0}C
COD	ppm	Closed Reflux Method
Total Hardness	ppm	Titrimetric
Ortho-Phosphate (PO_4^{3-})	ppm	UV-VIS Spectrophotometers
Nitrate (NO_3^-)	ppm	UV-VIS Spectrophotometers
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

58. 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, NO_3^-, PO_4^{3-} and 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

59. In this monsoon season of second year monitoring study, pH values in the Passur River System (RS) remained almost alike comparing with the first year monitoring study of

the said season. In this monitoring, pH values ranged in between 6.9 - 8.1 that are within the standard limit (6.5 – 8.5) of ECR'97 for inland surface waters. Highest (8.1) pH value was found at Left Bank of Passur River at South West corner from the Project boundary , at Right Bank of Passur River at South West corner from the Project boundary and Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence. During first year of monitoring, pH value was found to be within 6.8- 7.1 at the same season.

60. The monitoring results showed a seasonal variation in pH of the Passur-Shibsha RS. According to the five consecutive quarterly monitoring results, the values of pH of pre-monsoon and monsoon seasons were found to be comparatively lower than post-monsoon and winter seasons which were conducted in 2014. The pH values were found to be ranged between 7.0 - 8.2 and 7.3 - 8.2 in post-monsoon and monsoon seasons respectively. 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 (Rahman et al., 2013) In contrary, comparatively lower pH values in post monsoon and monsoon periods mainly for the high upstream flow and rain fall runoff.

61. The pH value found in pre-monsoon of second year is almost same in nature found in past monitoring. No significant seasonal pH differences were observed except spatial variation in the river water. The measured pH values of selected monitoring locations during first and second year quarterly monitoring of Passur-Sibsha RS are presented in **Table 5.4**.

Table 5.4: pH Values of Passur River Water

Sl	Sampling Locations	pH Values						
		1st year				2nd Year		BD Standard
		April	July	Oct.	Jan.	April	July	
		1QM	2QM	3QM	4QM	1QM	2QM	
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	7.6	7.8	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	7.7	7.9	
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	7.8	7.8	
4	Left Bank of Passur River at Project site-Jetty	7.9	7.1	8.1	7.9	7.5	7.9	
5	Middle Passur River at Project site-Jetty	7.1	6.9	8.1	7.9	7.6	8	
6	Right Bank of Passur River at Project site-Jetty	7.1	6.9	8.2	7.9	7.7	8	
7	Left Bank of Passur River at South West corner from the Project boundary	7.4	7.0	8.1	7.6	7.5	8.1	
8	Middle of Passur River at	7.4	6.9	8.0	7.5	7.2	8	

Sl	Sampling Locations	pH Values						
		1st year				2nd Year		BD Standard
		April	July	Oct.	Jan.	April	July	
		1QM	2QM	3QM	4QM	1QM	2QM	
	South West corner from the Project boundary							
9	Right Bank of Passur River at South West corner from the Project boundary	7.3	6.8	8.0	7.8	7.3	8.1	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	7.4	6.9	8.1	7.7	7.5	8.1	
11	Maidara river near proposed township area	7.4	6.8	8.1	7.3	7.6	6.9	
12	Passur river at Passur-Mongla confluence	7.3	6.8	7.4	8.2	7.5	7.9	
13	Passur river at Harbaria of Sundarbans	7.9	6.9	8.0	8.1	7.7	7.9	
14	Passur river at Akram point of Sundarbans	7.2	6.9	7.9	8.1	7.7	NS	
15	Passur river at Hiron po.000int of Sundarbans	7.2	7.0	7.0	8.1	7.7	NS	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring , NS – Not Surveyed

(b) Temperature

62. During second year 2nd quarterly monitoring the surface water temperature varied from 29°C – 31.8°C, which is very common in this season. The temperature range was found relatively lower than the results obtained in first year 2nd monitoring study. Again, the obtained results showed a moderate conformity with the last monitoring results. Therefore, no temperature variations ultimately found in these two consecutive monitoring studies.

63. 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 (Bartram J et al., 1996). The normal river temperatures were measured during all the completed monitoring studies. Of them, winter was the cooler season than the pre-monsoon, monsoon and post-monsoon seasons 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 and second year quarterly monitoring of Passur-Sibsha RS are presented in **Table 5.5.**

Table 5.5: Surface Water Temperature in Passur River

Sl	Sampling Locations	Temperature (^oC)						
		1st Year				2nd Year		BD Standard
		Apr	Jul	Oct	Jan	Apr	Jul	
		1QM	2QM	3QM	4QM	1QM	2QM	
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	31	33	31	19	30	31.8	20 – 30 ^oC
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	31	33	31	20	30	30.5	
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	31	33	30	20	30	30.5	
4	Left Bank of Passur River at Project site-Jetty	31	33	31	19	31	30.8	
5	Middle Passur River at Project site-Jetty	30	32	31	19	30	30.6	
6	Right Left Bank of Passur River at Project site-Jetty	30	32	31	19	30	30.4	
7	Left Bank of Passur River at South West corner from the Project boundary	31	32	30	20	31	30.5	
8	Middle of Passur River at South West corner from the Project boundary	31	31	29	19	30	30.8	
9	Right Bank of Passur River at South West corner from the Project boundary	31	31	29	19	31	30.6	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	30	31	28	19	30	30.8	
11	Maidara river near proposed township area	30	32	27	20	30	31.6	
12	Passur river at Passur-Mongla confluence	29	30	32	19	30	29.8	
13	Passur river at Harbaria of Sundarbans	30	30	27	22	30	**29.0**	
14	Passur river at Akram point of Sundarbans	29	29	30	21	30	**NS**	
15	Passur river at Hiron point of Sundarbans	29	30	29	21	30	**NS**	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring , NS – Not Surveyed

(c) Salinity

64. Water salinity at the selected sampling stations of Passur-Sibsha RS of six consecutive periods is presented in **Table 5.6**. No salinity was found in the Passur river upto Harbaria in this monitoring period (July – August) while in July 2014 salinity was varying zero (near project site) to 19 ppt (near Hiron Point). The prevailing heavy rainfall (for more than a month) and fresh water flow from upstream suppress the salinity to zero level.

Table 5.6: Salinity (ppt) in Passur River

Sl	Sampling Locations	Salinity (ppt)					
		1st Year				2nd Year	
		Apr	Jul	Oct	Jan	Apr	Jul
		1st QM	2nd QM	3rd QM	4th QM	1st QM	2nd QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	11.5	2.5	0.0	4.5	13	0
2	Middle of Passur River at 100m u/s of North West corner from the Project boundary	11.5	0.3	0.0	4.1	15	0
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	11.5	0.2	0.0	4.5	16	0
4	Left Bank of Passur River at Project site-Jetty	12.0	2.2	0.0	4.7	9	0
5	Middle of Passur River at Project site-Jetty	12.0	0.3	0.0	5.1	13	0
6	Right Bank of Passur River at Project site-Jetty	12.0	0.5	0.0	5.0	14	0
7	Left Bank of Passur River at South West corner from the Project boundary	9.5	4.0	0.0	5.2	14	0
8	Middle of Passur River at South West corner from the Project boundary	9.0	0.0	0.0	5.2	13	0
9	Right Bank of Passur River at South West corner from the Project boundary	10.0	2.5	0.0	5.1	12	0
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	10.0	0.5	0.0	5.2	10	0
11	Maidara river near proposed township area	9.0	4.5	0.0	4.5	9	0
12	Passur river at Passur-Mongla confluence	10.0	9.5	0.0	5.0	14	0
13	Passur river at Harbaria of Sundarbans	12.0	10.0	0.0	6.0	15	0
14	Passur river at Akram point of Sundarbans	19.0	15.0	1.0	16.0	20	NS
15	Passur river at Hiron point of Sundarbans	23.0	19.5	2.0	23.0	25	NS

Source: CEGIS Field Survey- April, July, October 2014; January and April 20150

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring , NS – Not Surveyed

(d) Dissolved Oxygen

65. During all the monitoring seasons, dissolved oxygen was found sufficient for sustaining the aquatic fisheries except one point (4.9 mg/L) of middle of Passur river at 100 m upstream of North West corner from the project boundary in pre-monsoon of first year monitoring study. On the contrary, in second year, it was found above the standard limit of Bangladesh for sustaining the aquatic fisheries. In addition, in this monsoon, the DO level fluctuated from 5 to 7.5 mg/L. It has also been obtained that the results were relatively same with the results of the monsoon period of 2014.

66. 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. 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)					
		1st Year				2nd Year	BD Standard
		Apr	Jun	Oct	Jan	Apr	
		1QM	2QM	3QM	4QM	1QM	
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	6.2	5 or more (standard for sustaining fisheries)
2	Middle of Passur River at 100m u/s of North West corner from the Project boundary	4.9	6.8	7.7	6.6	6.4	
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	6.2	
4	Left Bank of Passur River at Project site-Jetty	5.7	6.8	7.6	5.8	6.2	
5	Middle of Passur River at Project site-Jetty	5.9	6.9	7.2	5.9	6.6	
6	Right Bank of Passur River at Project site-Jetty	5.8	6.6	8.0	6.8	6.4	
7	Left Bank of Passur River at South West corner from the Project boundary	6.6	7.3	5.6	6.1	6.3	
8	Middle of Passur River at South West corner from the Project boundary	6.5	7.1	5.6	6.9	6.5	
9	Right Bank of Passur River at South West corner from the Project boundary	6.5	7.2	5.8	6.6	6.4	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	6.0	6.5	8.0	6.0	6.2	
11	Maidara river near proposed township area	6.7	6.8	8.0	6.2	6.5	
12	Passur river at Passur-Mongla confluence	5.3	6.2	7.0	6.5	6.3	
13	Passur river at Harbaria of Sundarbans	5.4	5.9	7.0	6.6	5.8	
14	Passur river at Akram point of Sundarbans	7.9	6.4	7.7	6.7	6	
15	Passur river at Hiron point of Sundarbans	7.5	6.5	7.8	6.5	5.8	

Source: CEGIS Field Survey- April, July, October 2014; January and April 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 (BOD_5)

67. During this last monsoon monitoring, BOD_5 value varied from 2.4 mg/L - 5.3 mg/L. Highest value of BOD_5 was found at Left Bank of Passur River at South West corner from the Project boundary while the lowest was observed at Middle Passur River at 100m u/s of North West corner from the Project boundary. Including this last monitoring result, BOD_5 of previously monitored five seasons fully complied with the BD standard (6 or less for sustaining fisheries) except Right Bank of Passur River at South West corner from the Project boundary (6.5) which was observed in first year pre-monsoon season.

68. In general, among the six consecutive seasons, BOD_5 was found to be very low in winter season while comparatively high BOD_5 was observed in pre-monsoon and monsoon season of first and second year monitoring studies. The water temperature normally goes down 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_5. The measured BOD_5 values at different monitoring locations during first and second year monitoring of Passur-Shibsha RS are presented in **Table 5.8.**

Table 5.8: BOD_5 of Passur River Water

SL	Sampling Locations	Biochemical Oxygen Demand (mg/L)						
		1st Year				2nd Year		BD Standard
		Apr	Jul	Oct	Jan	Apr	July	
		1QM	2QM	3QM	4QM	1QM	1QM	
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	3.1	3	6 or less (for sustaining fisheries)
2	Middle of Passur River at 100m u/s of North West corner from the Project boundary	4.9	3.3	4.1	2.3	3.2	2.4	
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	3.1	2.9	
4	Left Bank of Passur River at Project site-Jetty	3.2	3.1	4.0	0.8	3	4.4	
5	Middle Passur River at Project site-Jetty	3.0	2.5	3.5	1.4	3.5	4.3	
6	Right Left Bank of Passur River at Project site-Jetty	5.8	3.5	3.6	2.0	3.4	3.7	
7	Left Bank of Passur River at South West corner from the Project boundary	3.9	2.8	2.6	1.0	3.1	5.3	
8	Middle of Passur River at South West corner from the Project boundary	3.8	3.3	2.8	2.6	3.2	5.2	
9	Right Bank of Passur River at South West corner from the Project boundary	6.5	3.8	2.9	2.1	3.4	5	
10	Maidara river of the South East corner of the Project at Ichamoti-Maidara confluence	3.2	3.3	5.5	1.5	3.2	3.9	
11	Maidara river near proposed township area	4.1	3.7	4.0	2.0	3.4	4.2	
12	Passur river at Passur-Mongla confluence	2.3	2.2	1.7	2.0	3.3	4.9	
13	Passur river at Harbaria of Sundarbans	2.2	2.5	2.6	1.9	2.4	3.9	
14	Passur river at Akram point of Sundarbans	5.0	2.9	3.7	2.2	3	NS	
15	Passur river at Hiron point of Sundarbans	4.3	2.7	3.9	2.3	2.7	NS	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring, NS – Not Surveyed

5.4.2 Laboratory tested parameters

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

69. Sediment load in Passur River is relatively high as it is located in the south western part of Bangladesh. Among the samples, the values of TDS varied from 13,600 mg/L to 25,300 mg/L. The observed results were quite similar to the previously monitored pre-monsoon results but showed significant difference than the results of those other two seasons. Before this monitoring period heavy rainfall was observed in Sundarbans. Moreover, in pre-monsoon and monsoon period the river receives huge amount of water from the upstream and from inland sources which intern increase the concentration of TDS.

70. The results confirmed a comparatively higher TDS concentration in the samples than the recommended level of Bangladesh and WHO (1000 mg/L) (WHO, 1993 & 2007) standards. In most of the observed locations, the TDS concentrations were seem to be lower in monsoon and post monsoon period and higher in pre-monsoon and winter season. The results also showed a similarity among the five consecutive seasons of monitoring. A Significant spatial variation was found and this may be because of the seawater and the erosion-accretion nature of the river.

71. The values of TH in the water samples were found to be ranged between 3000 mg/L to 3,670 mg/L, and found to be higher than those of other two seasons. The results showed a close similarity to that of 2014 pre monsoon period. It was also been observed that the values of TH in monsoon and post-monsoon were much lower than the other season. The concentration was also found to be higher (3640 mg/L) in downstream (Akram point and Hiron point) than the values found in upstream (3000 mg/L). However, availability of large volume of fresh water from upstream of the river mainly influenced to reduce the hardness of the water in monsoon and post-monsoon season. Similar to TDS, TH has the same increasing pattern of hardness from upstream to downstream in all the seasons of Passur-Shibsha RS.

72. Total Suspended Solid (TSS) includes solid materials of organic and inorganic in origins which are suspended in the water. In Passur and Shibsha Rivers system the suspended matters generally contain sand, clay, silt and loam. During The pre-monsoon period, the maximum TSS concentration (180 mg/L) was found in Hiron pont while the lowest amount was recorded as 147 mg/L and found at South West corner from the Project boundary. However, only in four spots TSS values were found to be within the standard (150 mg/L) suggested for Bangladesh (DOE, 1991) during pre-monsoon season. The values were relatively higher in winter seasson than in pre-monsoon period. During dry season (summer and winter season) the TSS value increases, probably due to less freshwater flow, urban runoff, industrial wastes, bank erosion, bottom feeders (such as carp), algae growth or wastewater discharges.

73. The results of the last monitoring period will be submitted in the next monitoring report. Because the data will be available after laboratory analysis.

74. The TDS, TH and TSS of pre-monsoon, monsoon, and post monsoon and winter 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)				
		1St Year				2nd year	1St Year				2nd year	1St Year				2nd year
		Apr	Jul	Oct	April	April	April	Jul	Oct	Jan	April	Apr	Jul	Oct	Jan	April
		1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	13060	251	176	4360	14400	2900	250	216	930	3000	59	126	234	180	160
2	Middle of Passur River at 100m u/s of North West corner from the Project boundary	12630	246	162	3950	14700	2500	180	218	870	3050	45	92	193	210	167
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	12900	383	153	4330	14900	2650	170	335	870	3250	53	112	174	230	170
4	Left Bank of Passur River at Project site-Jetty	13190	445	169	4750	14600	2550	175	390	940	3450	54	99	227	450	160
5	Middle Passur River at Project site-Jetty	13330	353	156	4920	14500	2600	275	340	990	3250	60	100	232	250	165
6	Right Bank of Passur River at Project site-Jetty	13380	402	152	4870	14200	2625	350	355	970	3200	55	105	186	200	155
7	Left Bank of Passur River at South West corner from the Project boundary	13180	655	162	5040	14500	2550	325	330	1045	3600	24	116	185	300	150
8	Middle of Passur River at South West corner from the Project boundary	13390	587	153	5050	14600	2800	350	345	1125	3670	27	112	536	530	147
9	Right Bank of Passur River at South West corner from the Project boundary	13240	916	154	5130	14250	2500	475	325	975	3540	67	37	459	450	155
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	12400	455	214	5050	14000	2500	450	350	980	3260	7	65	798	280	148
11	Maidara river near proposed township area	10970	2510	257	4390	13900	2400	725	330	970	3190	9	24	389	206	160
12	Passur river at Passur - Mongla confluence	12800	6410	209	5130	14050	3150	1400	377	1000	3210	50	310	203	280	165
13	Passur river at Harbaria of Sundarbans	12280	9360	285	4780	13900	2625	2150	345	970	3080	65	90	869	400	160
14	Passur river at Akram point of Sundarbans	21500	15960	3400	12350	13600	4500	3625	980	2380	3420	115	99	280	103	150
15	Passur river at Hiron point of Sundarbans	21500	14050	5720	17900	25300	4850	3050	1440	2690	3640	91	72	267	200	180

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

(b) Chemical Oxygen Demand

75. Generally, COD found to be higher in Passur-Shibsha RS as it contain high amount of organic content. The values of Chemical Oxygen Demand varied from 18 mg/L to 470 mg/L in this monitoring period. However, high values of COD indicate high levels of organic pollution in the river water (Sivasubramanium, 1999). 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 concentration of COD.

76. The results of the July monitoring period will be submitted with the next monitoring report. Because the data will be available after laboratory analysis.

77. The COD concentrations of pre-monsoon and winter seasons (dry) were found to be higher than monsoon and post-monsoon (rainy) seasons. In monsoon, higher discharge diluted the COD load in the river which also influenced to reduce COD concentration in post monsoon.

Table 5.10: COD of Passur River System

Sl	Sampling Locations	COD (mg/L)				
		1st Year				2nd year
		Apr	Jul	Oct	Jan	Apr
		1QM	2QM	3QM	4QM	1 QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	288	24	6	128	87
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	284	20	30	68	58
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	328	56	14	92	132
4	Left Bank of Passur River at Project site-Jetty	376	28	18	84	102
5	Middle Passur River at Project site-Jetty	400	60	14	116	110
6	Right Bank of Passur River at Project site-Jetty	364	496	18	108	88
7	Left Bank of Passur River at South West corner from the Project boundary	364	108	10	104	96
8	Middle of Passur River at South West corner from the Project boundary	400	40	22	16	18
9	Right Bank of Passur River at South West corner from the Project boundary	408	120	10	100	106
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	276	32	10	116	88
11	Maidara river near proposed township area	284	96	26	84	94
12	Passur river at Passur - Mongla confluence	408	172	14	96	92
13	Passur river at Harbaria of Sundarbans	372	216	14	96	102
14	Passur river at Akram point of Sundarbans	536	520	54	316	302
15	Passur river at Hiron point of Sundarbans	540	416	122	472	470

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

(c) Nitrate, Sulphate and Phosphate

78. The results of nitrate will be submitted in the next quarterly monitoring report as analysis procedures are in progress.

79. Naturally, SO_4^{2-} is higher in sea water as well as river in coastal region. From the observed dataset, it is seen that SO_4^{2-} is very high in pre-monsoon followed by the winter season and it ranged in between 820 mg/L to 1920 mg/L and 1040mg/L to 2600 mg/L in April, 2014 and April, 2015 respectively. It has also been observed that, SO_4^{2-} concentration were lower in monsoon (ranged 20-1,400 mg/L) and post monsoon (ranged 27-2,360 mg/L) except Akram and Hiron points of Sundarbans. Usually, SO_4^{2-} concentration of Passur-Shibsha RS increases in the direction of upstream to downstream. Comparatively lower SO_4^{2-} in monsoon and post monsoon seasons is indicating the dilution effect of upstream fresh water.

80. The values of PO_4^{2-} were found to be slightly higher in the 2014 pre-monsoon period (0.52-7.51 mg/L) than in the last pre-monsoon (0.47 mg/L to 0.86 mg/L). The results also indicated similarity with the post-monsoon period. However, the highest amount of phosphate was found in Left Bank of Passur River at of North West corner from the Project boundary while the lowest was recorded in Hiron point. In addition, significant variations were not found in all the observed locations.

81. The observed NO_3^{2-}, SO_4^{2-} and PO_4^{2-} concentrations at different monitoring locations of five consecutive monitoring periods are presented in **Table 5.11.**

Table 5.11: NO_3^{2-}, SO_4^{2-} and PO_4^{2-} concentration of Passur River System

Sl	Sampling Locations	NO_3^{2-} (mg/L)					SO_4^{2-} (mg/L)					PO_4^{2-} (mg/L)				
		1st Year				2nd year	1st Year				2nd year	1st Year				2nd year
		Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr
		1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	0.90	2.89	0.32	3	IL	1840	20	26	580	1360	0.52	2.23	0.67	0.32	0.86
2	Middle Passur River at 100m u/s of North West corner from the Project boundary	0.70	2.40	1.57	1.5	IL	1320	23	28	450	1260	0.50	1.99	1.12	0.61	0.53
3	Right Bank of Passur River at 100m u/s of North West corner from the Project boundary	0.10	3.20	1.84	4.3	IL	1280	36	34	480	1240	1.10	2.55	0.95	0.7	0.72
4	Left Bank of Passur River at Project site-Jetty	1.30	0.76	1.64	3.1	IL	1360	45	33	550	1240	2.10	0.45	0.92	0.43	0.49
5	Middle Passur River at Project site-Jetty	1.40	2.69	1.42	2.2	IL	1040	32	30	520	1120	2.20	2.13	1.11	0.41	0.68
6	Right Bank of Passur River at Project site-Jetty	1.10	2.98	1.33	8.5	IL	1320	20	27	540	820	2.00	2.42	0.99	0.55	0.61
7	Left Bank of Passur River at South West corner from the Project boundary	0.75	2.13	1.85	2.7	IL	1640	60	40	630	880	0.57	1.25	1.18	0.76	0.65
8	Middle of Passur River at South West corner from the Project boundary	1.10	2.43	2.09	1.8	IL	1520	40	35	560	1180	1.20	1.51	1.25	0.85	0.53
9	Right Bank of Passur River at South West corner from the Project boundary	1.20	2.05	2.21	1.9	IL	1280	80	64	620	900	1.50	1.10	1	0.53	0.6
10	Maidara river of the South East corner of the project at Ichamoti-Maidara confluence	0.3	2.18	2.26	6	IL	1120	20	63	570	1220	0.55	2.1	1.27	0.59	0.7
11	Maidara river near proposed township area	0.5	0.88	1.98	4	IL	1320	210	63	460	840	1.1	0.53	1.04	0.64	0.55
12	Passur river at Passur - Mongla confluence	0.6	1.52	1.64	4.5	IL	1360	620	44	630	980	1.3	0.35	0.86	0.42	0.71
13	Passur river at Harbaria of Sundarbans	1.4	1.75	1.67	2.7	IL	1560	860	69	590	900	1.1	0.56	1.22	0.61	0.59
14	Passur river at Akram point of Sundarbans	2.7	3.32	0.59	1.5	IL	2600	1400	1390	850	1540	1.3	0.29	0.8	0.42	0.61
15	Passur river at Hiron point of Sundarbans	0.8	2.84	0.4	2	IL	2080	1160	2360	1500	1920	7.51	0.29	1.09	0.44	0.47

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

IL= In laboratory

(d) Heavy Metals

82. The dataset of As concentrations demonstrated conformity among all the seasons. The values varied from 0.002 mg/L to 0.004 mg/L. On the other hand, the concentrations of Pb were found to be higher in January, 2014 and April 2015. Maximum values i.e. 0.297 mg/L and 0.309 mg/L were found in Akram point and Hiron point respectively in both the seasons. The values of Hg revealed a continuous contingency among all the spots in all the seasons. The values never exceeded more than 0.0020 mg/L.

83. As, BP and Hg concentrations were found to be very low in river water during all four seasons of pre-monsoon, monsoon, post monsoon and winter. As, Pb and Hg concentrations of four observed seasons are presented in **Table 5.12.**

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

Sl	Sampling Locations	As (mg/L)					Pb (mg/L)					Hg (mg/L)				
		1st Year				2nd year	1st Year				2nd year	1st Year				2nd year
		Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr
		1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM
1	Left Bank of Passur River at 100m u/s of North West corner from the Project boundary	0.002	0.003	0.004	0.003	0.002	0.053	0.004	0.002	0.104	0.098	<0.00015	<0.00015	<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	0.003	0.002	0.055	0.002	0.003	0.104	0.102	<0.00015	<0.00015	<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	0.003	0.003	0.055	0.005	0.002	0.111	0.138	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
4	Left Bank of Passur River at Project site-Jetty	0.002	0.004	0.004	0.004	0.002	0.057	0.002	0.003	0.154	0.142	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
5	Middle Passur River at Project site-Jetty	0.002	0.004	0.004	0.003	0.002	0.060	0.002	0.002	0.139	0.135	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
6	Right Bank of Passur River at Project site-Jetty	0.002	0.003	0.003	0.003	0.002	0.058	0.002	0.002	0.138	0.156	<0.00015	<0.00015	<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	0.003	0.002	0.053	0.002	0.003	0.16	0.142	<0.00015	<0.00015	<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	0.003	0.002	0.054	0.003	0.004	0.153	0.148	<0.00015	<0.00015	<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	0.003	0.002	0.056	0.005	0.004	0.139	0.163	<0.00015	<0.00015	<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	0.004	0.003	0.053	0.004	0.004	0.143	0.135	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
11	Maidara river near proposed township area	0.002	0.002	0.003	0.003	0.003	0.048	0.004	<0.002	0.133	0.14	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
12	Passur river at Passur - Mongla confluence	0.002	0.004	0.003	0.003	0.004	0.050	0.032	<0.002	0.141	0.14	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
13	Passur river at Harbaria of Sundarbans	0.004	0.003	0.004	0.004	0.004	0.043	0.044	0.004	0.137	0.13	<0.00015	<0.00015	<0.00015	<0.00015	<0.00015
14	Passur river at Akram point of Sundarbans	0.004	0.002	0.002	0.003	0.002	0.194	0.071	0.032	0.309	0.297	0.0020	<0.00015	<0.00015	<0.00015	<0.00015
15	Passur river at Hiron point of Sundarbans	0.003	0.002	0.003	0.002	0.002	0.224	0.050	0.07	0.309	0.291	0.0023	<0.00015	<0.00015	<0.00015	<0.00015

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

(e) Oil and Grease

84. In ordered to measure the concentration of oil and grease in Passur River, samples were taken in five locations during low tide from the 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.

85. During pre-monsoon, monsoon and post monsoon periods, the concentration of oil and grease was found negligible and all of the monitoring results fully meet the terms with the ECR' 1997 Standard. However, Passur and Shibsha rivers were containing high concentration of oil and grease in winter period. This high concentration may be the reason of 2014 Sundarbans oil spill occurred on December 9th. An amount of 350,000 litres (Philips, 2014) of furnace oil was sunk in the river which spread over a 350 km^2 area (Welle, 2014). However during the monitoring period the concentration of oil and grease exceeded the threshold limit in three specific sites. Among those sites the maximum values (39.1 mg/L) of oil and grease concentration was found in Harbaria. The residues of oil spill might not completely dissolved and due to this fact the values might be higher than the other sites. Some other facts might contribute to this higher amount of oil and grease e.g. discharge of oil and other organic residues from mother vessels, oil discharge from the fishing boats and other anthropogenic activities.

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)
		1st Year				2nd year		
		Apr	Jul	Oct	Jan	Apr		
		1QM	2QM	3QM	4QM	1QM		
1	Left Bank of Passur River at South West corner from the Project boundary	<5	<5	<5	>15	16.9	10	10
2	Mongla-Passur Confluence	<5	<5	<5	>15	13		
3	Passur river at Harbaria of Sundarbans	<5	6.3	<5	>20	39.1		
4	Passur river at Hiron point of Sundarbans	<5	<5	<5	>20	<5		
5	Akram Point of Sundarbans	<5	<5	<5	>20	<5		

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

*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

86. pH and temperature in observed locations fully complied with the drinking water quality standards set up by ECR, 1997 for the six seasons. The pH values of second year second quarter monitoring (July 2015) found to be varied from 8.1 to 8.3 while temperature was found to be in between 28^0C to 31^oC (Table 5.14). Both the results of pH and Temperature were found to be higher than the previously obtained dataset. It should be mentioned that ground water samples from Khalekharber was not collected because the tube well was completely damaged. The five consecutive monitoring results of pH and temperatures of selected locations are presented in **Table 5.14**.

Table 5.14: pH and Temperature of Ground Water

Sl	Locations	Tube Well Type	pH value							Temperature (^{o}C)						
			1st Year				2nd Year		BD Standard*	1st year				2nd Year		BD Standard*
			Apr	Jul	Oct	Jan	Apr	Jul		Apr	Jul	Oct	Jan	Apr	Jul	
			1st QM	2nd QM	3rd QM	4th QM	1st QM	2nd QM		1 QM	2 QM	3 QM	4 QM	1 QM	2nd QM	
1	Near Proposed Township	Deep (>600 ft)	7.6	7.7	7.9	8.0	TC	8.1	6.5 - 8.5	27.3	28.5	26	24.5	TC	**31**	20^0 – 30^0 C
2	Rajnagar	Deep (>600 ft)	7.6	7.8	8.0	8.2	7.8	8.3		29.6	29.9	28	22.5	28.6	**28**	
3	Kalekharber	Shallow (<250 ft)	6.3	6.5	NF	NF	NF	NF		27.5	28.7	NF	NF	NF	**NF**	
4	Kapasdanga	Deep (>600 ft)	7.6	7.7	8.0	8.1	7.9	8.3		29.2	28.9	28	25.1	28.8	**30**	

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

Note: 1QM= First Quarterly Monitoring 2QM = Second Quarterly, 3QM = Third Quarterly, 4QM = Fourth Quarterly Monitoring

NF=Non functional ,TC=temporarily closed, NF=Non functional Tube Well, D = Damaged Tube Well

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

(b) Salinity and Dissolved Oxygen

87. In all the observed locations, saline free groundwater was found during these six consecutive monitoring seasons. In case of dissolved oxygen, the values were found to be in between 5.9.0 – 6 mg/L. ECR 1997 defines DO standard as 6 mg/L but it is not clearly mentioned whether it is maximum or minimum concentration. In fact, World Health Organization (WHO) does not consider DO as a regulatory parameter for drinking water quality standard.

88. Sampling point of Kalekharber was found to be completely damaged. The six consecutive monitoring results of salinity and DO of selected locations are presented in **Table 5.15**.

Table 5.15: Salinity and DO in Groundwater

SI	Locations	Tube Well Type	Salinity (ppt)							DO (mg/L)						
			1st Year				2nd Year		BD Standard*	1st Year				2nd Year		BD Standard*
			Apr	Jul	Oct	Jan	Apr	Jul		Apr	Jul	Oct	Jan	Apr	Jul	
			1st QM	2nd QM	3rd QM	4th QM	1st	2nd		1st QM	2nd QM	3rd QM	4th QM	1st	2nd	
1	Near Proposed Township	Deep (>600 ft)	0	0	0	1	TC	0	N/A	4.4	5.2	6.5	6.7	TC	6	6 mg/L
2	Rajnagar	Deep (>600 ft)	0	0	0	0	0	0		6.0	6.2	7.7	6.3	6.0	5.9	
3	Kalekharber	Shallow (<250 ft)	0	0	NF	NF	NF	NF**		4.4	6.0	NF	NF	NF	NF**	
4	Kapasdanga	Deep (>600 ft)	0	0	0	0	0	0		6.4	6.5	6.1	6.5	6.6	6	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring
NF=Non functional; N/A=Not Available

TC=Temporarily closed, NF=Non functional Tube Well, D = Damaged Tube Well

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

5.5.2 Laboratory tested parameters

(a) TDS, TSS

89. In pre-monsoon of the first monitoring period, TDS was found to be very high in the observed sources but in the recent pre-monsoon period the results seemed to be within the standard limit. Though, in monsoon and winter, it was measured far below than the drinking water quality standard (1000 mg/L) except in township area.

90. TSS was measured in all the monitoring study except in first quarterly monitoring. The activities were not conducted in kalekharber and in Township area in 2015 pre monsoon period because one was found completely damaged and the other was temporarily unavailable. The values of TSS varied from 4 mg/L to 6 mg/L in the observed locations. However, the amount of TSS were found to be within the standard limit (10 mg/L).

91. Ground water TDS and TSS value of five consecutive monitoring periods have been presented in **Table 5.16**

Table 5.16: TDS and TSS concentrations in Groundwater

SI	Locations	Type of tube wells	TDS (mg/L)						TSS (mg/L)					
			1st Year				2nd year	BD Standard*	1st Year				2nd year	BD Standard*
			Apr	Jul	Oct	Jan	Apr		Apr	Jul	Oct	Jan	Apr	
			1 QM	2 QM	3 QM	4 QM	1 QM		1 QM	2 QM	3 QM	4 QM	1 QM	
1	Township near project site	Deep (>600 ft)	1113	999	-	1021	NF	1000 mg/L	-	6	19	40	NO	10 mg/L

2	Rajnagar	Deep (>600 ft)	4090	371	-	378	390		-	6	2	28	4	
3	Kalekharber	Shallow (<250 ft)	1055	970	-	NF	D		-	48	NF	NF	D	
4	Kapasdanga	Deep (>600 ft)	643	635	-	600	600		-	8	6	32	6	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

NF=Non functional Tube Well, D = Damaged Tube Well

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

(b) Total Hardness

92. Pre-monsoon to winter season, TH concentration was measured in two of the monitored locations and presented in **Table 5.17**

93. TH of Khalekharber has not been monitored since the third quarter monitoring due to physical damage of the hand pump. The monitored values were found to be far lower than the standard limit. However the concentrations varied from 138 mg/l to 216 mg/l. No incidents of weathering of Ca^{++} bearing minerals or excessive application of lime was not found during the monitoring period.

Table 5.17: TH concentrations in Groundwater

Sl No	Locations	Type of tube wells	TH (mg/L)					
			1st Year				2nd year	BD standard *
			Apr	Jul	Oct	Jan	Apr	
			1QM	2QM	3QM	4QM	1QM	
1	Township near project site	Deep (>600 ft)	425	250	300	235	NO	200-500 mg/L
2	Rajnagar	Deep (>600 ft)	220	175	180	110	138	
3	Kalekharber	Shallow (<250 ft)	780	450	NF	NF	D	
4	Kapasdanga	Deep (>600 ft)	190	140	180	125	216	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

NF=Non functional Tube Well, D = Damaged Tube Well

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

(c) Chemical Oxygen Demand

94. The Bangladesh standard for COD in drinking water is only 4.0 mg/L. However, all the monitoring tube wells showed higher concentration of COD than the limits imposed by ECR'97. COD concentrations found in between 14-18 mg/L. Low DO in ground water also cause high COD. The COD concentrations of all the monitoring locations are presented in **Table 5.18.**

Table 5.18: COD concentrations of monitored ground water locations

SI	Locations	Tube Well Type	COD (mg/L)					
			1st Year				2nd year	BD standard*
			Apr	Jul	Oct	Jan	Apr	
			1QM	2QM	3QM	4QM	1QM	
1	Township near project site	Deep (>600 ft)	32	32	34	20	NO	4
2	Rajnagar	Deep (>600 ft)	28	28	18	16	14	
3	Kalekharber	Shallow (<250 ft)	32	36	NF	NF	D	
4	Kapasdanga	Deep (>600 ft)	48	32	34	20	18	

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

NF=Non functional Tube Well, D = Damaged Tube Well

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

(d) Nitrate, Sulphate and Phosphate

The results of nitrate will be submitted in the next quarterly monitoring report as analysis procedures are in progress.

95. SO_4^{2-} and PO_4^{2-} concentrations monitoring of Passur-Shibsha RS have been appended in this study since second quarterly monitoring. Sulphate concentrations were found to be nil in all the point except in 2nd quarterly meeting. Though, a standard limit (400 mg/L for SO_4^{2-}**)** has been determined for safeguarding of health. On the contrary, the values of PO_4^{2-} were within the standard limit (6 mg/L). It has previously been told that due to some technical problem, the sampling activities were not carried out in Township area and Kalekharber. However, SO_4^{2-} and PO_4^{2-} concentrations were also found to be 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 all quarter monitoring study.

96. The observed ground water NO_3^{2-}, SO_4^{2-} and PO_4^{2-} concentrations are presented in **Table 5.19**.

Table 5.19: NO_3, SO_4 and PO_4 Concentrations in Ground Water

SI	Locations	Type of tube wells	NO_3^{2-} (mg/L) *BD Standard (10 mg/L)					SO_4^{2-} (mg/L) *BD Standard (400 mg/L)					PO_4^{2-} (mg/L) *BD Standard (6.0 mg/L)				
			1st Year				2nd year	1st Year				2nd year	1st Year				2nd year
			Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr
			1 QM	2 QM	3 QM	4 QM	1 QM	1 QM	2 QM	3 QM	4 QM	1 QM	1 QM	2 QM	3 QM	4 QM	1 QM
1	Township near project site	Deep (>600 ft)	0.20	0.48	<0.10	28	IL	-	3	-	-	-	-	2.2	-	0.74	NO

2	Rajnagar	Deep (>600 ft)	0.60	0.68	0.31	26	IL	-	2	-	-	-	-	2.5	-	0.44	1.98
3	Kalekharber	Shallow (<250 ft)	0.40	0.56	NF	NF	IL	-	3	NF	-	-	-	1.2	NF	NF	D
4	Kapasdanga	Deep (>600 ft)	0.80	0.40	0.80	13	IL	-	10	-	-	-	-	6.2	-	0.48	4.54

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

IL= In laboratory, NF=Non functional Tube Well, D = Damaged Tube Well

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

(e) Arsenic, Lead and Mercury

97. As per Bangladesh Standard, the maximum acceptable concentration of Arsenic in groundwater is 0.05 mg/L. Among all the the monitoring locations, the As concentration ranged in between 0.034 to 0.01 mg/L which is completely compatible with the BD standard. In case of Pb and Hg, very low concentrations were detected and remained much lower than the acceptable limit i.e. 0.05 mg/L and 0.001 mg/L respectively. (**Table 5.20**).

Table 5.20: As, Pb and Hg concentrations (mg/L) of monitored ground water locations

SI	Locations	As (mg/L) *BD Standard (0.05 mg/L)					Pb (mg/L) *BD Standard (0.05 mg/L)					Hg (mg/L) *BD Standard (0.001 mg/L)				
		1st Year				2nd year	1st Year				2nd year	1st Year				2nd year
		Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	Apr	Apr	Jul	Oct	Jan	APR
		1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM	1QM	2QM	3QM	4QM	1QM
1	Township near project site	0.013	0.020	0.012	0.014	NO	0.002	<0.002	0.004	0.023	NO	<0.0015	<0.0015	<0.005	<0.005	NO
2	Rajnagar	0.006	0.009	0.006	0.008	0.01	<0.002	<0.002	<0.002	0.016	0.013	<0.0015	<0.0015	<0.005	<0.005	<0.0015
3	Kalekharber	0.376	0.407	NF	NF	D	0.002	0.008	NF	NF	D	<0.0015	<0.0015	NF	NF	D
4	Kapasdanga	0.036	0.033	0.020	0.017	0.034	<0.002	0.004	<0.002	0.013	0.017	<0.0015	<0.0015	<0.005	<0.005	<0.0015

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

Note: 1QM= First Quarterly Monitoring, 2QM = Second Quarterly Monitoring, 3QM = Third Quarterly Monitoring, 4QM = Fourth Quarterly Monitoring

NF=Non functional Tube Well, D = Damaged Tube Well

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

6 Land Resources Monitoring

98. During the field visit on 3/4/15 to 6/4/15 soil samples were collected for dry season for the determination of pH, OM, EC, N, P, K, S, Ca, Mg, Na, Fe, Mn, Zn, B and heavy metal i.e Pb. in addition Cd has been analyzed and presented In this **2nd Quarter** Monitoring report of the **2nd year**.

6.1 Methodology

6.1.1 Monitoring Indicators

99. Land use, soil fertility/nutrient status, soil contamination with heavy metals and soil physical quality are 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 on the surrounding agriculture land. Therefore, monitoring of the selected indicators is very crucial for land resources monitoring in the study area.

6.1.2 Frequency

100. Soil samples for monitoring of soil fertility/nutrient status, soil contamination with heavy metals, samples of wet season were collected in the month of October, 2014 and results incorporated in the this (First quarter in second year) report. Dry season, soil samples were collected in April, 2015. In the next wet season soil samples will be collected in the month of October 2015.

6.1.3 Location

101. Five mouzas within the 10 Km radius of the power plant were selected for monitoring of land use, soil fertility/nutrient status, soil contamination with heavy metals. The selected mouzas are Baranpara, Chunkuri-2, Kapalirmet, Chalkghona and Basherhula. Locations of the soil samples collection is presented in the Map 6.1.

6.2 Process of soil samples collection

6.2.1 Land selection

102. Land was selected before 1st monitoring report through group discussion, especially with the land owners. Main emphasis was given to potential locations of dry/wet deposition of ash, SOx and NOx to be emitted from the Plant. All the selected areas were medium high (F1) land. The GPS readings were recorded on each location to facilitate the collection of soil samples from the exact locations in future. Details of the GPS information were presented in agriculture section.

Table 6.1: Land and Agricultural Resources 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	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		

6.2.2 Soil sample collection

103. Soil samples were collected from, five locations in three different depths (0-15 cm, 15-30 cm and 30-45 cm) in the monitoring area on April, 2015.

104. 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.

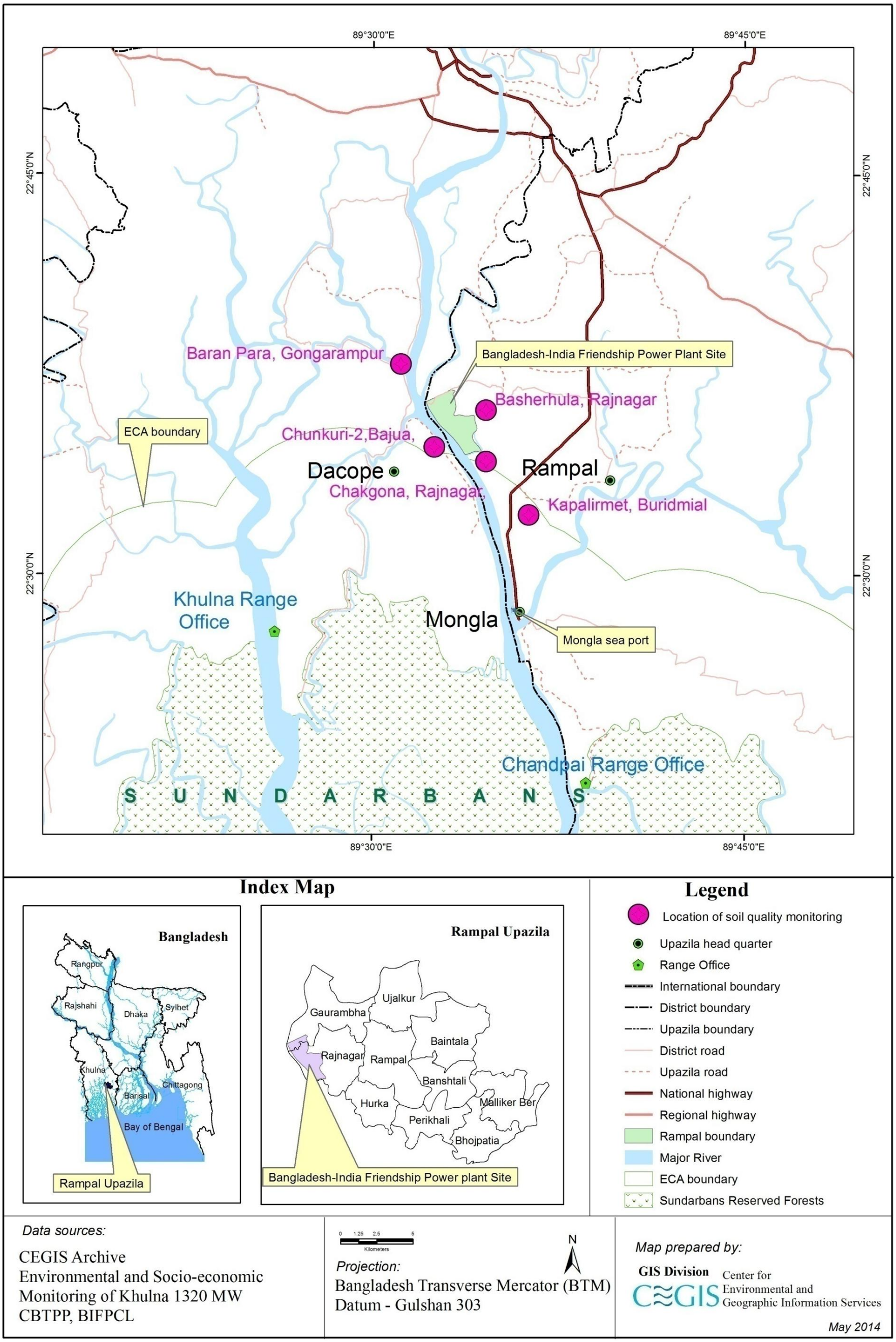
105. In the right hand picture at Kapalirmet, last year T.aman was cultivated. Farmers decided that this year he will go for shrimp or fish culture.

Photo 6.1: View of soil sample collection from monitoring land at Basherhula

Photo 6.2: View of soil sample collection from monitoring land at Kapalirmet

6.2.3 Laboratory analysis

106. 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 6.1: Soil Quality Monitoring Locations

6.3 Results of Monitoring

107. In general, organic matter content of the soil is low in the coastal regions of Bangladesh. Thus in addition to salinity, plant nutrients in soils affect plant growth.

108. In general monitoring study area comprises under the Agro-Ecological Zone-13 (Ganges Tidal Flood Plain) (BARC, 2012). So, the analysis report of soils of monitoring land was compared to the AEZ physico-chemical properties of soil to understand the variation of the soil fertility status.

109. The soil quality information on dry and wet season of 2013-14 as well as the dry season of 2014-15 is presented in the Table 6.2. We are comparing dry and wet season analysis results in the 2nd quarterly progress report of 2nd year.

110. We observed from the table that the dry season, soil salinity levels are 4.8-11.7 (ds/m) in the depth of 0-15 cm, 8.4-11.3 (ds/m) in 15-30cm and 9.6-10.9 (ds/m) in 30-45cm. It indicates that all locations suffer from slightly to moderately saline 2.0-12.0 (ds/m), which is a common scenario for the AEZ-13. The AEZ-13 area is suffers from slightly to highly saline 2.0->16.0 (ds/m), (SRDI, 2012). The wet season, soil salinity levels are 1.8- 8.5 (ds/m) in the depth of 0-15 cm, 2.0-7.0 (ds/m) in 15-30cm and 5.1-7.5 (ds/m) in 30-45cm. It was observed that salinity level decreased. It was also observed in wet season, the top and sub-surface soils of Baranpara, non saline with very slightly saline and rest are very slightly saline with some slightly saline. Rainfall effectively leached down the salts from the topsoil and subsoil to the substratum in all locations. The decrement of salinity might be due to dilution of salt as well as washout of soluble salts due to onset of monsoon rainfall in the concerned land. Soil salinity levels are 3.89-13.05 (ds/m) in the depth of 0-15 cm, 4.26-10.48 (ds/m) in 15-30cm and 3.99-10.0 (ds/m) in 30-45cm.Soil salinity level increases in top soil from the previous dry season and decreases in sub and sub stratum soil.

111. The dry season, pH levels are 4.2-7.7 in the depth of 0-15 cm, 4.3 -7.7 in 15 to 30cm, and 5.7-7.7 in 30-45cm. Generally, pH ranges 4.5-8.4 in AEZ 13 (BARC, 2012) because, soil is acid sulphate. It indicates that, pH level of all lands are very strongly acidic to slightly alkaline (4.2-7.7) in nature and show no appreciable trend down in the depths. The wet season, pH levels are 6.4-8.3 in the depth of 0-15 cm, 6.4-8.2 in 15-30cm and 6.2-8.2 in 30-45cm. It was observed that, pH level increased significantly over the dry season in all areas. It indicates that, pH ranges from neutral to moderately alkaline in nature. However, at the peak of rainfall of September soil pH tends to increase down the sampling depths due to vertical movement or translocation of dissolved cations, as a result, soil pH increased down the depth. The pH levels are 5.9-7.6 in the depth of 0-15 cm, 5.9 -7.8 in 15 to 30cm, and 6.0-7.8 in 30-45cm. It is revealed that, pH level increases in all depth from the dry season of 2013-14.

112. The dry season, Organic Matter (OM %) are 1.5- 3.1 in the depth of 0-15 cm, 1.7-8.2 in 15-30cm and 1.5-2.9 in 30-45cm. It indicates that, OM status is low to medium (1.0-3.4%) in all the monitoring land (BARC, 2012) which is also very common in the AEZ-13. The wet season, Organic Matter (OM %) are 1.2 – 2.5 in the depth of 0-15 cm, 0.91-2.2 in 15-30cm and 1.0-1.4 in 30-45cm. It has been found from the table, OM status decrease down noticeably in all depths. Organic Matter (OM %) are 0.93- 3.22 in the depth of 0-15 cm, 1.46-3.36 in 15-30cm and 1.62-4.03 in 30-45cm in dry season of 2014-15. It was observed that, OM status increases in all top soil over the previous dry season.

113. Concentration of Phosphorus (P) was found, 2.7-5.6(µg/g) in the depth of 0-15 cm, 2.7-13.6 (µg/g) in 15-30cm and 1.3-6.1(µg/g) in 30-45cm in dry season. Generally, P level is

very low to low ≤5.25-10.5 (µg/g) in this AEZ area. But, the concentration of P in wet season was found, 7.3 – 14.3(µg/g) in the depth of 0-15 cm, 5.3-22.8 (µg/g) in 15-30cm and 5.8-19.5(µg/g) in 30-45cm. P level was trend up from the dry season in all depths and above the critical value (7.00 µg/g). The concentration of P in dry season of 2014-15 was found, 4.11 – 8.19(µg/g) in the depth of 0-15 cm, 3.23-9.23 (µg/g) in 15-30cm and 5.67-9.24(µg/g) in 30-45cm. P level was trend up in the top and sub-stratum soil over the previous dry season and above the critical value.

114. In case of Nitrogen (N) level, it was found that 0.08-0.16% in the depth of 0-15 cm, 0.09-0.16% in 15-30cm and 0.8-0.15% in 30-45cm in all locations of the soil in dry season. This range is compatible to the general condition of this AEZ area where N level is low as 0.091-0.18(%). The wet season N levels are 0.06-0.12% in the depth of 0-15 cm, 0.05-0.12% in 15-30cm and 0.06-0.08% in 30-45cm. The N level showed decrease down over dry season and it was very low to low level. It was observed, low level from optimum level (0.271to 0.36%) in both season as well as equivalent to critical limit (0.12%) some cases. It was found that 0.05-0.18% in the depth of 0-15 cm, 0.08-0.19% in 15-30cm and 0.9-0.23% in 30-45cm in all locations of the soil in dry season of 2014-15. The N level showed increase over dry season of 2013-14 and it was very low to medium level.

115. Potassium (K) level was found, 1.0-1.6(meq/100g) in the depth of 0-15 cm, 1.0-1.5 (meq/100g) in 15-30cm and 1.0-1.5(meq/100g) in 30-45cm in dry season. The Potassium level was very high level in all locations in the dry season. But, generally the K level of this AEZ is medium to optimum 0.181-0.36 (meq/100gm). The wet season, 0.6–1.7(meq/100g) in the depth of 0-15 cm, 0.7-1.6 (meq/100g) in 15-30cm and 0.6-1.6(meq/100g) in 30-45cm, which was remarkably very high level in depths. The wet season, K level increase up in all locations from the dry season as well as higher than optimum level (0.271to 0.36 meq/100g) in both season. It was observed that, the K level of dry season in 2014-15, 1.32-2.97(meq/100g) in the depth of 0-15 cm, 1.13-2.68 (meq/100g) in 15-30cm and 1.16-2.60(meq/100g) in 30-45cm.The Potassium level tends to up in all locations in the dry season of 2013-14.

116. Calcium (Ca) level was found, 11.4–22.2(meq/100g) in the depth of 0-15 cm, 10.5-23.9 (meq/100g) in 15-30cm and 12.6-24.4 (meq/100g) in 30-45cm in dry season. The Ca level of dry season was higher than the general properties of soil in this AEZ. Generally, the Ca level of this AEZ-13 is optimum to high 4.51-7.5(meq/100g).The wet season, Ca levels are 12.9–31.4(meq/100g) in the depth of 0-15 cm, 14.3-32.6 (meq/100g) in 15-30cm and 14.4-34.4 (meq/100g) in 30-45cm which was higher than dry season as well as the general properties of soils in this AEZ. The Ca level was higher in both seasons from optimum level (4.51to 6.0 meq/100g). Calcium (Ca) level was found, 18.79–31.50(meq/100g) in the depth of 0-15 cm, 18.97-26.84 (meq/100g) in 15-30cm and 18.87-30.68(meq/100g) in 30-45 cm in dry season of 2014-15. It tends to higher than previous dry season.

117. The dry season, Magnesium (Mg) level was found, 9.8–11.9(meq/100g) in the depth of 0-15 cm, 7.1-16.3 (meq/100g) in 15-30cm and 10.4-15.9 (meq/100g) in 30-45cm. It was also observed that the dry season Mg levels varying from 7.1-16.3 (meq/100g) which was higher than the general properties of soil in this AEZ. Mg level of this AEZ-13 is medium to optimum 0.751-1.5(meq/100g) in nature. The wet season, Magnesium (Mg) level was found, 7.9–10.0(meq/100g) in the depth of 0-15 cm, 8.4-9.9 (meq/100g) in 15-30cm and 8.3-9.7 (meq/100g) in 30-45cm. The Mg level was decreased down the depths and lower than the dry season. Mg level was observed, higher in both seasons than the critical value (0.50meq/100g). Magnesium (Mg) level was found, 5.50–6.33(meq/100g) in the depth of 0-15 cm, 5.30-6.29 (meq/100g) in 15-30cm and 5.57-6.34 (meq/100g) in 30-45cm in the dry

season of 2014-15. The Mg level decrease over previous dry season of all depth of the monitoring land.

118. The dry season, Sodium (Na) level was found, 5.5–12.0(meq/100g) in the depth of 0-15 cm, 5.0-8.6 (meq/100g) in 15-30cm and 6.0-8.5 (meq/100g) in 30-45cm. On the other hand, the wet season Na status was 2.7–11.9(meq/100g) in the depth of 0-15 cm, 2.7-9.9 (meq/100g) in 15-30cm and 3.7-9.6 (meq/100g) in 30-45cm.The Na status showed significant difference among the sampling depths. The Na status was lower than dry season. The Na status was 5.22–12.51(meq/100g) in the depth of 0-15 cm, 5.45-10.61 (meq/100g) in 15-30cm and 5.76-10.92 (meq/100g) in 30-45cm. Na level was observed, higher than previous dry season.

119. In case of Sulphur (S) was found, 272.3 – 545.2(µg/g) in the depth of 0-15 cm, 280.5-513.7 (µg/g) in 15-30cm and 320.4-490.9(µg/g) in 30-45cm in dry season. The S level was much higher than the general soil properties of the AEZ13 in dry season. In AEZ 13, S level normally ranges from medium to optimum, 15.1-30.0 (µg/gm). The wet season S levels are 3.1– 41.4(µg/g) in the depth of 0-15 cm, 2.8-46.7 (µg/g) in 15-30cm and 5.6-32.8(µg/g) in 30-45cm. It is mentioned that, the wet season S level was very low to very high in nature and observed higher than optimum level (22.51-30.0 µg/gm) in both seasons. Sulfer (S) was found, 216.69 – 673.58(µg/g) in the depth of 0-15 cm, 236.58-307.65 (µg/g) in 15-30cm and 231.67-343.0(µg/g) in 30-45cm in dry season of 2014-15.It is revealed that, Sulphur level was higher in top soil compare than previous dry season.

120. The dry season Boron (B) levels are 0.5-1.2(µg/g) in the depth of 0-15 cm, 0.4-1.1 (µg/g) in 15-30cm and 0.7-1.4(µg/g) in 30-45cm and the B levels was medium to high as per SRDI, 2012. The B levels were little bit higher than the general properties of Soil of this AEZ. In the AEZ-13, B ranges from medium to optimum 0.31-0.6(µg/gm). The wet season Boron (B) levels are 0.6 – 1.3(µg/g) in the depth of 0-15 cm, 0.5-1.7 (µg/g) in 15-30cm and 0.7-1.5(µg/g) in 30-45cm.The wet season B level was optimum to high in nature. Boron (B) levels are 0.75-2.37(µg/g) in the depth of 0-15 cm, 0.21-1.86 (µg/g) in 15-30cm and 1.05-2.95 (µg/g) in 30-45cm in the dry season of 2014-15.The Boron level has been found higher over previous dry season.

121. The dry season, Iron (Fe) levels are 37.3 – 150.3(µg/g) in the depth of 0-15 cm, 39.1-124.1 (µg/g) in 15-30cm and 51.3-120.3 (µg/g) in 30-45cm. Iron (Fe) level was found very high as per the classification of SRDI in dry season. Besides this, the wet season, 189.0 – 258.7(µg/g) in the depth of 0-15 cm, 60.9-307.0 (µg/g) in 15-30cm and 113.9-247.9 (µg/g) in 30-45cm which showed very high from the dry season. The Iron (Fe) levels were found 34.56 – 53.37(µg/g) in the depth of 0-15 cm, 25.52-52.20 (µg/g) in 15-30cm and 29.70-177.70 (µg/g) in 30-45cm in the dry season of 2014-14.The Fe level found higher in the sub-stratum level over previous dry season.

122. The dry season, Zinc (Zn) levels are 0.8 – 1.9(µg/g) in the depth of 0-15 cm, 0.9-1.8 (µg/g) in 15-30cm and 0.9-2.1 (µg/g) in 30-45cm. The level of Zn in dry season was higher than the general level of Zn in this AEZ in the dry season in all locations. Generally, Zn varies from 0.451-1.35(µg/gm) in this AEZ. The Zn level of wet season are 1.0 – 4.9(µg/g) in the depth of 0-15 cm, 0.5-3.3 (µg/g) in 15-30cm and 0.4-2.9 (µg/g) in 30-45cm. The wet season Zn levels increased over the dry season. The Zinc (Zn) levels are 1.74-4.33(µg/g) in the depth of 0-15 cm, 1.04-2.0 (µg/g) in 15-30cm and 1.0-2.15 (µg/g) in 30-45cm in the present dry season. It was observed that, Zn level higher over previous dry season in all depth.

123. The dry season, manganese (Mn) levels are 3.4 – 7.3(µg/g) in the depth of 0-15 cm, 2.8-6.1 (µg/g) in 15-30cm and 2.7-3.9 (µg/g) in 30-45cm.The Mn levels was high but common in this AEZ 13. Generally, Mn level varies from 2.9 to 5.3(µg/gm) in this AEZ. The wet season, Mn concentration are 5.9 – 16.4(µg/g) in the depth of 0-15 cm, 5.9-13.8 (µg/g) in 15-30cm and 5.2-16.9(µg/g) in 30-45cm of the soils of monitoring locations. The Mn level was very high in all monitoring times over the dry season. The Zinc (Zn) levels are 1.74-4.33(µg/g) in the depth of 0-15 cm, 1.04-2.0 (µg/g) in 15-30cm and 1.0-2.15 (µg/g) in 30-45cm in the present dry season. It was observed that, Zn level higher over previous dry season in all depth.

124. In the dry season, Pb concentration observed in 12.5-31.8(µg/gm) in 0-15 cm depth, 6.3-31.8 (µg/gm) in 15-30 cm depth and 6.3-37.8(µg/gm) in 30-45 cm depth.In the wet season, Pb concentration observed in 25.1-33.7(µg/gm) in 0-15 cm depth, 28.4-37.7 (µg/gm) in 15-30 cm depth and 22.2-31.5(µg/gm) in 30-45 cm depth. Pb concentration observed in the dry season of 2014-15, 30.55-47.12 (µg/gm) in 0-15 cm depth, 30.81-33.66 (µg/gm) in 15-30 cm depth and 31.54-34.37(µg/gm) in 30-45 cm depth also observed higher than the previous dry season.

125. The Cadmium (Cd) was analyzed in this phase and will be continued. The concentration of Cadmium (Cd) observed 2.21-2.86(µg/gm) in 0-15 cm depth, 2.12-2.42 (µg/gm) in 15-30 cm depth and 2.11-2.55(µg/gm) in 30-45 cm depth.

126. The presence of Chloride (Cl-) is observed in all locations at all depths. During the monitoring, It was found to be varying from 398.4 to 3741.9 (µg/gm), except the sub-surface and substratum layer of Kapalirmet, top soil of Chokgona, top and sub-surface soil of Chunkuri-2 where Cl- levels were found as zero (0.0).

Table 6.2: Chemical Properties of Soil

Sl No	Location	Parameter	2013-2014				2014-2015				2015-2016			
			Dry season (April)	Remarks	Wet season (October)	Remarks	Dry season (April)	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	1.8	Non saline	10.01	Slightly saline						
		pH	4.2	Very strongly acidic	6.7	Neutral	7.6	Slightly alkaline						
		OM (%)	3.1	Medium	2.5	Medium	0.93	Very low						
		N (%)	0.16	Low	0.12	Low	0.05	Very low						
		K (meq/100g)	1.00	Very high	0.59	Very high	1.61	Very high						
		Ca (meq/100g)	11.3	Very high	14.3	Very high	31.50	Very high						
		Mg (meq/100g)	10.7	Very high	8.6	Very high	6.00	Very high						
		Na(meq/100g)	5.50	*	2.7	*	10.01	*						
		P(µg/gm)	2.7	Very low	14.3	Medium	8.19	Low						
		S(µg/gm)	523.2	Very high	41.4	Very high	354.40	Very high						
		B(µg/gm)	0.45	Medium	0.55	Very high	2.37	Very high						
		Fe(µg/gm)	150.3	Very high	258.6	Very high	49.72	Very high						
		Mn(µg/gm)	7.2	Very high	11.3	Very high	24.72	Very high						
		Zn(µg/gm)	1.4	Medium	1.2	Medium	1.88	High						
		Lead(Pb) (µg/gm)	31.8	*	33.7	*	32.21	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.39	*						
		Chloride (Cl^-) (µg/gm)	762.2	*	0	0	0	0						
		Subsurface soil(15-30cm)												
		EC(ds/m)	8.4	Moderately saline	2.0	Non saline	7.90	Very slightly saline						
		pH	4.3	Very strongly acidic	6.9	Neutral	7.8	Slightly alkaline						
		OM (%)	2.9	Medium	2.2	Medium	1.46	Low						
		N (%)	0.15	Low	0.2	Medium	0.08	Very low						
		K (meq/100g)	1.0	Very high	0.61	Very high	1.46	Very high						
		Ca(meq/100g)	10.48	Very high	14.3	Very high	26.84	Very high						
		Mg(meq/100g)	8.8	Very high	8.2	Very high	5.30	Very high						
		Na(meq/100g)	5.00	*	2.7	*	8.95	*						
		P(µg/gm)	2.9	Very low	22.8	High	9,23	Low						
		S(µg/gm)	513.7	Very high	31.4	High	307.65	Very high						
		B(µg/gm)	0.36	Medium	0.49	Optimum	1.86	Very high						
		Fe(µg/gm)	39.1	Very high	60.9	Very high	26.60	Very high						

		Mn(µg/gm)	3.3	High	10.9	Very high	41.87	Very high						
		Zn(µg/gm)	1.5	Optimum	0.87	Low	1.56	Optimum						
		Lead(Pb) (µg/gm)	31.8	*	32.1	*	31.54	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.42	*						
		Chloride (Cl^-)(µg/gm)	398.4	*	0	0	0	0						
		Substratum(30-45cm)												
		EC(ds/m)	9.6	Moderately saline	5.8	Very slightly saline	9.26	Slightly saline						
		pH	5.7	Slightly acidic	6.9	Neutral	7.7	Slightly alkaline						
		OM (%)	1.6	Low	1.1	Low	1.62	Low						
		N (%)	0.08	Very low	0.06	Very low	0.09	Very low						
		K (meq/100g)	1.0	Very high	0.6	Very high	2.00	Very high						
		Ca(meq/100g)	12.6	Very high	16.3	Very high	28.69	Very high						
		Mg(meq/100g)	15.9	Very high	8.8	Very high	5.57	Very high						
		Na(meq/100g)	6.00	*	3.7	*	9.91	*						
		P(µg/gm)	2.00	Very low	13.3	Medium	8.24	Low						
		S(µg/gm)	490.9	Very high	31.9	High	307.29	Very high						
		B(µg/gm)	0.73	High	0.77	Very high	1.67	Very high						
		Fe(µg/gm)	51.3	Very high	113.9	Very high	33.91	Very high						
		Mn(µg/gm)	3.9	Very high	5.2	Very high	88.75	Very high						
		Zn(µg/gm)	1.6	Optimum	0.49	Low	1.74							
		Lead(Pb) (µg/gm)	37.8	*	31.5	*	32.29	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.17	*						
		Chloride (Cl^-)(µg/gm)	692.9	*										
2.	Chunkuri-2	**Top soil (0-15cm)**												
		EC(ds/m)	11.2	Moderately saline	5.6	Very slightly saline	13.05	Strongly saline						
		pH	6.1	Slightly acidic	6.4	Slightly acidic	5.9	Optimum						
		OM (%)	2.1	Medium	1.2	Low	3.22	Medium						
		N (%)	0.11	Low	0.06	Very low	0.18	Low						
		K (meq/100g)	1.5	Very high	1.14	Very high	2.97	Very high						
		Ca(meq/100g)	12.3	Very high	12.9	Very high	27.15	Very high						
		Mg(meq/100g)	9.8	Very high	8.9	Very high	6.33	Very high						
		Na(meq/100g)	8.5	*	9.4	*	12.51	*						
		P(µg/gm)	2.7	Very low	12.8	Medium	8.34	Low						
		S(µg/gm)	401.9	Very high	16.9	Medium	673.58	Very high						
		B(µg/gm)	0.57	Optimum	0.74	High	0.75	High						
		Fe(µg/gm)	60.2	Very high	223.6	Very high	52.46	Very high						

		Mn(µg/gm)	5.3	Very high	12.8	Very high	74.59	Very high						
		Zn(µg/gm)	1.7	Medium	2.5	Very high	2.66	Very high						
		Lead(Pb) (µg/gm)	0.00	*	29.2	*	31.34	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.31	*						
		Chloride (Cl^-)(µg/gm)	1957.6	*										
		Subsurface soil(15-30cm)												
		EC(ds/m)	9.1	Moderately saline	5.6	Very slightly saline	10.48	Slightly saline						
		pH	6.7	Neutral	6.4	Slightly acidic	6.4	Optimum						
		OM (%)	1.8	Low	0.95	Very low	3.08	High						
		N (%)	0.09	Very low	0.06	Very low	0.17	Low						
		K (meq/100g)	1.6	Very high	1.1	Very high	2.68	Very high						
		Ca(meq/100g)	12.6	Very high	13.8	Very high	26.29	Very high						
		Mg(meq/100g)	9.5	Very high	8.9	Very high	6.29	Very high						
		Na(meq/100g)	8.5	*	9.9	Very high	10.61	*						
		P(µg/gm)	2.7	Very low	18.4	Optimum	7.32	Low						
		S(µg/gm)	280.5	Very high	23.8	Optimum	487.29	Very high						
		B(µg/gm)	1.1	Very high	1.7	Very high	0.92	Very high						
		Fe(µg/gm)	133.9	Very high	193.3	Very high	52.20	Very high						
		Mn(µg/gm)	2.8	Optimum	11.6	Very high	17.75	Very high						
		Zn(µg/gm)	0.99	Medium	1.4	Optimum	2.00	High						
		Lead(Pb) (µg/gm)	0.00	*	29.9	*	31.52	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.35	*						
		Chloride (Cl^-)(µg/gm)	1,472.5	*	0	0	0	0						
		Substratum(30-45cm)												
		EC(ds/m)	10.1	Moderately saline	5.3	Very slightly saline	10.00	Slightly saline						
		pH	6.6	Neutral	6.2	Slightly acidic	6.6	Neutral						
		OM (%)	1.9	Medium	1.4	Low	3.36	High						
		N (%)	0.09	Low	0.08	Low	0.19	Medium						
		K (meq/100g)	1.5	Very high	1.2	Very high	2.60	Very high						
		Ca(meq/100g)	13.7	Very high	34.4	Very high	18.87	Very high						
		Mg(meq/100g)	11.8	Very high	6.4	Very high	6.34	Very high						
		Na(meq/100g)	8.5	*	9.3	*	10.92	*						
		P(µg/gm)	1.3	Very low	19.5	Optimum	6.11	Low						
		S(µg/gm)	320.4	Very high	32.8	High	428.10	Very high						
		B(µg/gm)	1.14	Very high	1.5	Very high	1.12	Very high						
		Fe(µg/gm)	125.3	Very high	175.5	Very high	117.70	Very high						

		Mn(µg/gm)	2.7	Optimum	12.2	High	46.08	Very high						
		Zn(µg/gm)	1.8	Optimum	0.5	Low	2.15	High						
		Lead(Pb) (µg/gm)	31.3	*	29.7	*	32.46	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.12	*						
		Chloride (Cl^-)(µg/gm)	1715.0	*	0	0	0	0						
3.	Kapalirmet	**Top soil(0-15cm)**												
		EC(ds/m)	4.8	Slightly saline	8.5	Slightly saline	3.89	Non saline						
		pH	7.0	Neutral	7.6	Slightly alkaline	6.2	Optimum						
		OM (%)	3.0	Medium	1.5	Low	2.01	Medium						
		N (%)	0.2	Low	0.07	Very low	0.11	Low						
		K (meq/100g)	1.5	Very high	1.7	Very high	1.32	Very high						
		Ca(meq/100g)	18.2	Very high	19.9	Very high	27.04	Very high						
		Mg(meq/100g)	15.3	Very high	10.0	Very high	6.21	Very high						
		Na(meq/100g)	12.0	*	11.9	*	5.22	*						
		P(µg/gm)	3.2	Very low	7.3	Low	6.76	Very high						
		S(µg/gm)	545.2	Very high	20.8	Medium	216.69	Very high						
		B(µg/gm)	1.2	Very high	1.3	Very high	0.95	Very high						
		Fe(µg/gm)	37.3	Very high	230.2	Very high	34.56	Very high						
		Mn(µg/gm)	3.8	Very high	6.6	Very high	10.26	Very high						
		Zn(µg/gm)	2.0	High	1.0	Low	1.64	Optimum						
		Lead(Pb) (µg/gm)	12.5	*	28.9	*	47.12	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.86	*						
		Chloride (Cl^-)(µg/gm)	3741.9	*	0	0	0	0						
		Subsurface soil(15-30cm)												
		EC(ds/m)	11.1	Moderately saline	6.3	Very slightly saline	4.26	Very slightly saline						
		pH	7.2	Neutral	7.9	Moderately alkaline	6.3	Optimum						
		OM (%)	2.6	Medium	1.3	Low	3.36	High						
		N (%)	0.2	Low	0.06	Very low	0.19	Medium						
		K (meq/100g)	1.5	Very high	1.6	Very high	1.13	Very high						
		Ca(meq/100g)	11.7	Very high	14.4	Very high	25.16	Very high						
		Mg(meq/100g)	7.1	Very high	9.9	Very high	6.22	Very high						
		Na(meq/100g)	8.5	*	9.8	*	5.45	*						
		P(µg/gm)	3.8	Very low	5.6	Low	5.29	Low						
		S(µg/gm)	341.4	Very high	52.1	Very high	236.58	Very high						
		B(µg/gm)	0.86	Very high	1.6	Very high	0.21	Low						

		Fe(µg/gm)	140.2	Very high	249.0	Very high	30.03	Very high						
		Mn(µg/gm)	3.7	High	5.9	Very high	11.23	Very high						
		Zn(µg/gm)	0.94	Medium	0.5	Low	1.04	Medium						
		Lead(Pb) (µg/gm)	0.00	*	29.3	*	33.66	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.18	*						
		Chloride (Cl^-) (µg/gm)	2217.4	*	0	0	0	0						
		Substratum(30-45cm)												
		EC(ds/m)	10.8	Moderately saline	7.5	Very slightly saline	3.99	Non saline						
		pH	7.3	Neutral	7.8	Slightly alkaline	6.3	Optimum						
		OM (%)	2.8	Medium	1.3	Low	4.03	High						
		N (%)	0.15	Low	0.06	Very low	0.23	Medium						
		K (meq/100g)	1.5	Very high	1.6	Very high	1.16	Very high						
		Ca(meq/100g)	12.9	Very high	15.4	Very high	27.13	Very high						
		Mg(meq/100g)	10.4	Very high	9.7	Very high	6.25	Very high						
		Na(meq/100g)	8.5	*	9.6	*	5.76	*						
		P(µg/gm)	3.4	Very low	5.8	Low	9.24	Optimum						
		S(µg/gm)	345.1	Very high	5.6	Very low	231.67	Very high						
		B(µg/gm)	1.4	Very high	1.1	Very high	1.55	Very high						
		Fe(µg/gm)	120.3	Very high	247.8	Very high	33.82	Very high						
		Mn(µg/gm)	2.9	Optimum	7.2	Very high	53.90	Very high						
		Zn(µg/gm)	0.88	Low	0.79	Low	1.00	Medium						
		Lead(Pb) (µg/gm)	0.00	*	27.6	*	34.37	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.20	*						
		Chloride (Cl^-) (µg/gm)	1801.6	*	0	0	0	0						
4	Chakgona	**Top soil(0-15cm)**												
		EC(ds/m)	11.5	Moderately saline	7.2	Very slightly saline	7.36	Very slightly saline						
		pH	7.7	Slightly alkaline	8.0	Moderately alkaline	5.7	Optimum						
		OM (%)	1.5	Low	1.5	Low	2.13	Medium						
		N (%)	0.08	Low	0.08	Low	0.12	Low						
		K (meq/100g)	1.5	Very high	1.4	Very high	1.72	Very high						
		Ca(meq/100g)	22.2	Very high	14.3	Very high	18.79	Very high						
		Mg(meq/100g)	11.7	Very high	9.4	Very high	6.29	Very high						
		Na(meq/100g)	8.5	*	8.4	*	9.81	*						
		P(µg/gm)	5.6	Very low	9.2	Low	4.11	Very low						
		S(µg/gm)	444.2	Very high	4.1	Very low	440.19	Very high						
		B(µg/gm)	0.98	Very high	1.2	Very high	0.85	Very high						

		Fe(µg/gm)	55.3	Very high	189.0	Very high	41.14	Very high						
		Mn(µg/gm)	4.3	High	16.4	Very high	32.04	Very high						
		Zn(µg/gm)	0.76	Low	4.8	Very high	4.33	Very high						
		Lead (Pb) (µg/gm)	0.00	*	27.2	*	30.99	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.38	*						
		Chloride (Cl^-)(µg/gm)	1576.4	*	0	0	0	0						
		Subsurface soil(15-30cm)												
		EC(ds/m)	11.3	Moderately saline	6.2	Very slightly sine	7.81	Very slightly saline						
		pH	7.7	Slightly alkaline	8.2	Moderately alkaline	5.9	Optimum						
		OM (%)	2.6	Medium	1.3	Low	1.88	Medium						
		N (%)	0.13	Low	0.07	Very low	0.10	Low						
		K (meq/100g)	1.5	Very high	1.1	Very high	1.54	Very high						
		Ca(meq/100g)	22.6	Very high	17.8	Very high	18.96	Very high						
		Mg(meq/100g)	16.3	Very high	8.3	Very high	6.30	Very high						
		Na(meq/100g)	8.5	*	8.6	*	9.23	*						
		P(µg/gm)	13.6	Medium	9.4	Low	3.23	Very low						
		S(µg/gm)	415.6	Very high	47.7	Very high	393.37	Very high						
		B(µg/gm)	0.66	High	0.97	Very high	0.79	Very high						
		Fe(µg/gm)	124.1	Very high	172.7	Very high	25.52	Very high						
		Mn(µg/gm)	6.1	Very high	13.8	Very high	26.59	Very high						
		Zn(µg/gm)	1.1	Medium	3.2	Very high	1.09	Medium						
		Lead(Pb(µg/gm)	6.3	*	28.4	*	30.81	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.35	*						
		Chloride (Cl^-)(µg/gm)	2113.5	*	0	0	0	0						
		Substratum(30-45cm)												
		EC(ds/m)	10.9	Moderately saline	5.1	Very slightly saline	7.14	Very slightly saline						
		pH	7.5	Slightly alkaline	8.2	Moderately alkaline	6.0	Optimum						
		OM (%)	1.7	Low	1.0	Very low	2.94	Medium						
		N (%)	0.09	Very low	0.06	Very low	0.17	Low						
		K (meq/100g)	1.5	Very high	0.95	Very high	1.57	Very high						
		Ca(meq/100g)	13.9	Very high	14.4	Very high	19.10	Very high						
		Mg(meq/100g)	11.1	Very high	7.2	Very high	6.26	Very high						
		Na(meq/100g)	8.5	*	6.7	*	9.33	*						
		P(µg/gm)	4.1	Very low	9.5	Low	5.67	Low						
		S(µg/gm)	334.6	Very high	8.3	Low	343.00	Very high						

		B(µg/gm)	0.67	High	0.63	High	1.05	Very high						
		Fe(µg/gm)	75.3	Very high	160.0	Very high	29.70	Very high						
		Mn(µg/gm)	3.6	Very high	14.1	Very high	25.22	Very high						
		Zn(µg/gm)	1.7	Optimum	2.9	Very high	1.78							
		Lead(Pb) (µg/gm)	6.3	*	26.5	*	32.23	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.55	*						
		Chloride (Cl^-)(µg/gm)	1715.0	*	0	0	0	0						
5.	Berhulasha	**Top soil(0-15cm)**												
		EC(ds/m)	11.7	Moderately saline	6.0	Very slightly saline	7.14	Very slightly saline						
		pH	7.7	Slightly alkaline	8.3	Moderately alkaline	7.3	Neutral						
		OM (%)	1.7	Low	1.2	Low	1.74	Low						
		N (%)	0.09	Low	0.06	Very low	0.10	Low						
		K (meq/100g)	1.5	Very high	1.2	Very high	1.67	Very high						
		Ca(meq/100g)	23.6	Very high	31.4	Very high	25.26	Very high						
		Mg(meq/100g)	11.9	Very high	7.9	Very high	5.50	Very high						
		Na(meq/100g)	8.5	*	8.1	*	7.06	*						
		P(µg/gm)	4.5	Very low	7.4	Low	7.12	Low						
		S(µg/gm)	272.3	Very high	21.8	Medium	454.19	Very high						
		B(µg/gm)	0.94	Very high	1.1	Very high	1.00	Very high						
		Fe(µg/gm)	50.3	Very high	205.6	Very high	53.37	Very high						
		Mn(µg/gm)	3.4	High	5.9	Very high	49.22	Very high						
		Zn(µg/gm)	1.4	Medium	1.1	Medium	2.27	Very high						
		Lead(Pb(µg/gm)	18.8	*	25.1	*	30.55	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.21	*						
		Chloride (Cl^-)(µg/gm)	2442.6	*	0	0	0	0						
		Subsurface soil(15-30cm)												
		EC(ds/m)	10.7	Moderately saline	7.0	Very slightly saline	7.44	Very slightly saline						
		pH	7.7	Slightly alkaline	8.2	Moderately alkaline	7.7	Slightly alkaline						
		OM (%)	1.5	Low	0.9	Low	2.01	Medium						
		N (%)	0.08	Very low	0.05	Very low	0.11	Low						
		K (meq/100g)	1.0	Very high	1.2	Very high	2.20	Very high						
		Ca(meq/100g)	24.0	Very high	32.6	Very high	33.28	Very high						
		Mg(meq/100g)	11.7	Very high	8.4	Very high	6.10	Very high						
		Na(meq/100g)	7.0	*	10.1	*	8.66	*						
		P(µg/gm)	3.9	Very low	5.3	Low	8.19	Low						

		S(µg/gm)	317.2	Very high	2.8	Very low	379.38	Very high						
		B(µg/gm)	0.71	High	1.0	Very high	1.38	Very high						
		Fe(µg/gm)	121.4	Very high	307.0	Very high	53.18	Very high						
		Mn(µg/gm)	3.9	Very high	15.5	Very high	45.34	Very high						
		Zn(µg/gm)	1.8	Optimum	0.8	Low	1.99	High						
		Lead(Pb) (µg/gm)	18.8	*	23.7	*	31.49	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.32	*						
		Chloride (Cl^-) (µg/gm)	1611.1	*	0	0	0	0						
		Substratum(30-45cm)												
		EC(ds/m)	10.9	Moderately saline	6.3	Very slightly saline	6.68	Very slightly saline						
		pH	7.7	Slightly alkaline	8.2	Moderately alkaline	7.8	Slightly alkaline						
		OM (%)	1.5	Low	1.0	Low	2.81	Medium						
		N (%)	0.08	Very low	0.06	Very low	0.16	Low						
		K (meq/100g)	1.5	Very high	1.2	Very high	2.20	Very high						
		Ca(meq/100g)	24.4	Very high	32.1	Very high	30.68	Very high						
		Mg(meq/100g)	12.9	Very high	8.3	Very high	6.11	Very high						
		Na(meq/100g)	7.5	*	9.8	*	8.76	*						
		P(µg/gm)	6.1	Low	5.9	Low	11.14	Medium						
		S(µg/gm)	321.1	Very high	3.1	Very low	305.69	Very high						
		B(µg/gm)	0.63	High	0.85	Very high	2.95	Very high						
		Fe(µg/gm)	77.3	Very high	162.4	Very high	42.36	Very high						
		Mn(µg/gm)	3.2	High	16.9	Very high	31.74	Very high						
		Zn(µg/gm)	2.1	High	2.7	Very high	1.62	Optimum						
		Lead(Pb) (µg/gm)	25.00	*	22.2	*	31.54	*						
		Cadmium (Cd)(µg/gm)	0	0	0	0	2.44	*						
		Chloride (Cl^-)(µg/gm)	1489.8	*	0	0	0	0						

7 Agriculture Resources Monitoring

127. Monitoring of Agriculture Resources has been scheduled twice a year as per the contract. In this 2nd quarter monitoring report of the 2nd year, Agricultural resources monitoring chapter hasn't been populated due to the reason that no data have been collected during this period. The next monitoring has been scheduled in the month of October, 2015.

8 Fisheries Resources Monitoring

128. Fisheries resources have been monitored quarterly in a year. After completion of four quarters of first year of 2014-2015, and the first quarter of second year of 2015-2016, second quarter of the second year monitoring, has been conducted during the period of 3 to 6 August, 2015. This chapter contains the outcome of this second quarter monitoring along with earlier three quarters.

8.1 Monitoring Location

129. The monitoring activities are being 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 8.1**. These sites were selected in inception stage and finalized during first quarter monitoring.

Table 8.1: The Sampling Locations for Fisheries Resources Monitoirng

Site	Habitat Location	North	East	Habitat (River /Khal)	Area (ha)
Capture Fish Habitat					
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	Maidara	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
				Sub-total =	**19**
Shrimp/Fish Farm					
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
				Sub-total =	**163.86**
				Grand-total =	**182.86**

8.2 Methods, Tools and Techniques of Monitoring

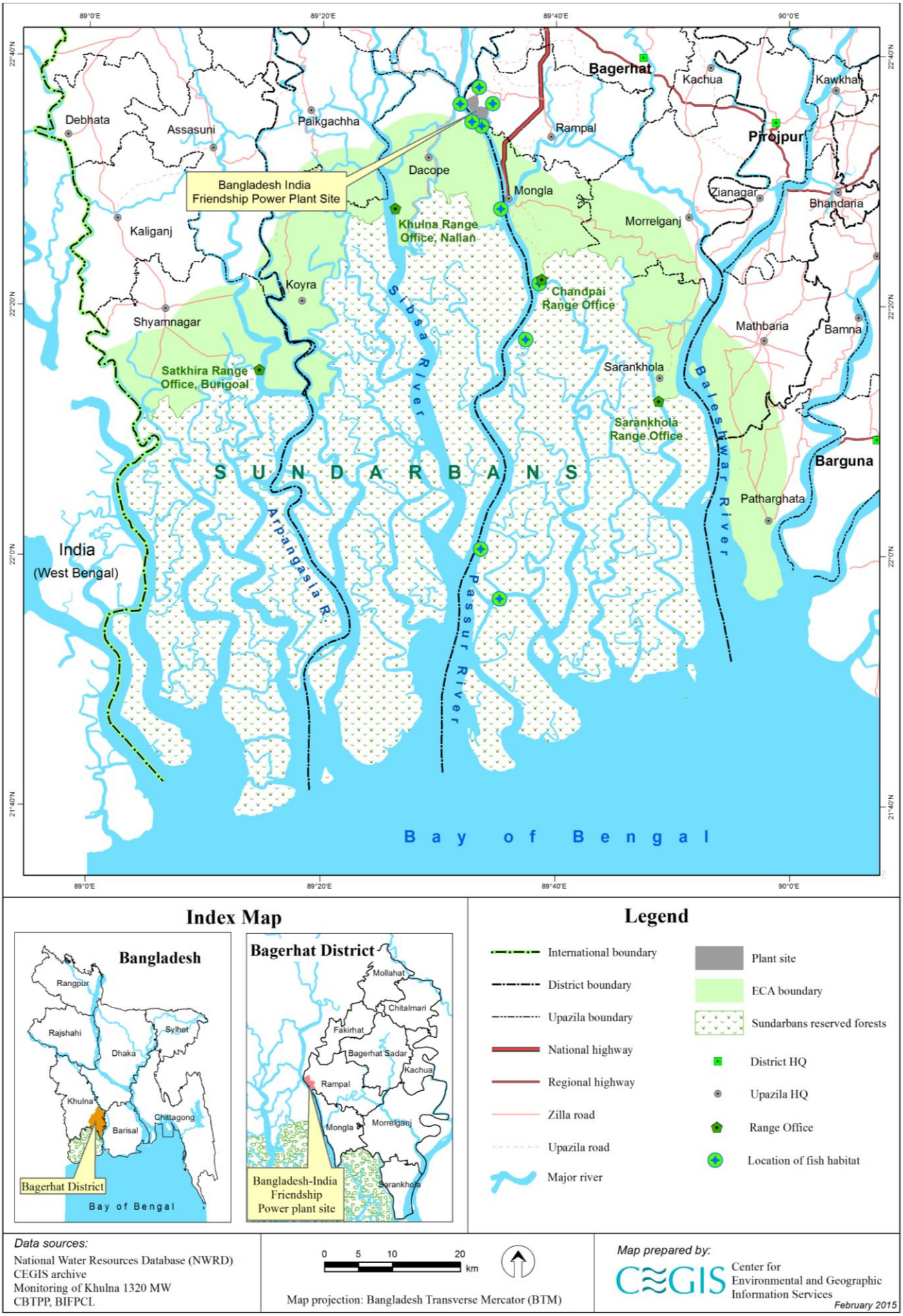
8.2.1 Fish Habitat Status Monitoring

130. 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)[1] for estimating the extent of similarity between pairs of data sets. The linkage distance was estimated with the similarity in species distribution.

131. 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 8.2** that will be estimated at the end of each monitoring year**.** The HIS 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 objective 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).

[1] 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 8.1: Fisheries Resources Monitoring Locaitons

Table 8.2: Data for Basic life Requirements for a Good Fish Community

Life Requirements	Variable Sl.	Habitat Variables	A	B	C	D	E	F	G
2014-2015									
Food (C_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							
2015-2016									
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 Sl.	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							

132. 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.

8.2.2 Fish Migration

133. Fish migration status has been observed at selected sites along the water ways used for carrying all sorts of cargo including 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.

8.2.3 Fish Biodiversity

134. 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 estimated by

analyzing Shannon-Weiner Index[2]. This index has produced values between 0 and 1. According to Shannon-Weiner Index classifies the diversity as –

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 Diverisity (VHD)

135. Fish species richness (FSR) has been analyzed using the Sympson's Index producing two types of values. The first one includes values between 0 (having only one species in the sample) and one (01) (having more than one species with same proportion) indicating general richness of the observed species distribution. The second one includes values that start from one (01) (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.

8.2.4 Fish-Shrimp Culture Practice

136. 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.

8.2.5 Fish Production

137. 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.

8.3 Outcome of 2nd Quarter Monitoring of the 2nd Year

138. Followed by the first quarter monitoring of the second year, second quarter monitoring has been conducted during the period of 3 to 7 August, 2015.

8.3.1 Fisheries Resources

139. 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 proposed Power Plant boundary. The farms were selected for monitoring on the basis of the probable dispersion of fly ash from the Plant in its operation

[2] 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 Diverisity (VHD).

stage. The culture fish habitat is about 164 ha in total. The fishing activities in the Passur River System (shown in **Photo 8.1**) 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.

140. 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.

8.3.2 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 and river flood
- A number of fish died because of indiscriminate activities (e.g. during catching of PL of tiger shrimp many other fries are also damaged)
- Fish diversity is highly dominated during lunar phase and tide condition.

8.3.3 Fish Habitat Status

(a) Habitat Classification

141. 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 8.1**) on the basis of abundance of different life stages of fish species in those habitats.

142. During 1st 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. In fourth monitoring phase in the month of January 2015 three habitats – i) Grazing ground, ii) Grazing and Breeding ground; and iii) Spawning, Nursery and Grazing ground have been identified. During the 1st quarter (April, 2015) of the second year three habitats – i) Grazing ground, ii) Nursery ground; and iii) Spawning and Nursery have been identified.

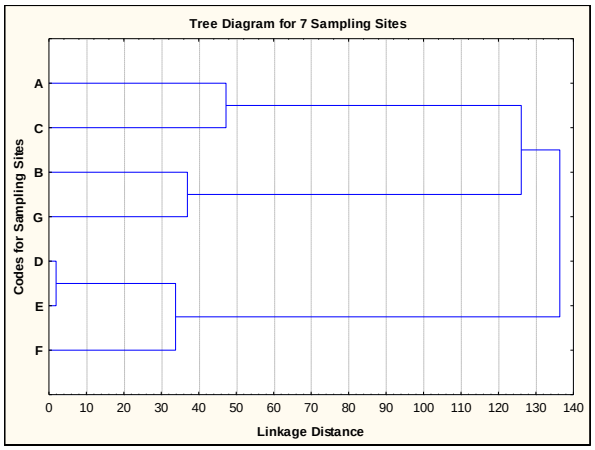
143. During the 2nd quarter monitoring of 2nd year (August, 2015) two habitats – i) Grazing and breeding ground and ii) Spawning and Nursery have been identified as shown in the **Figure-8.1**.

144. ***Spawning and Nursery Ground:*** The Harbaria Khal (C) and Mongla Point (E) respectively have been identified as the spawning and nursery ground in the Passur River System.

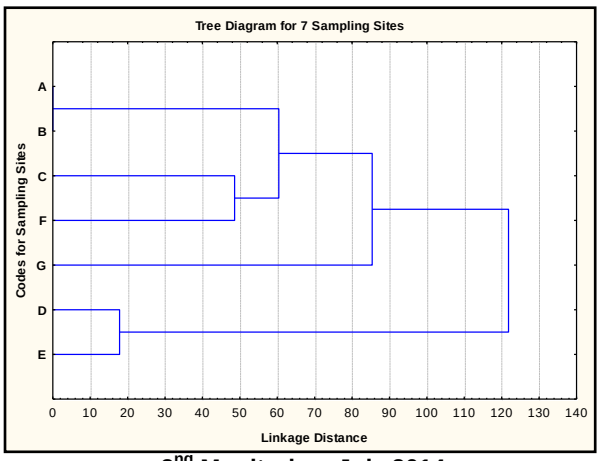
145. ***Breeding, Spawning and Grazing Ground:*** Among the sampling sites, the Sheola Khal at Chandpai (D), Chalna Point (G) and even Maidara-Passur confluence (F) are similar

in the distribution of life stages from Juveniles fish for maximum fish spcies. These habitats are classified as the breeding, spawning and grazing ground.

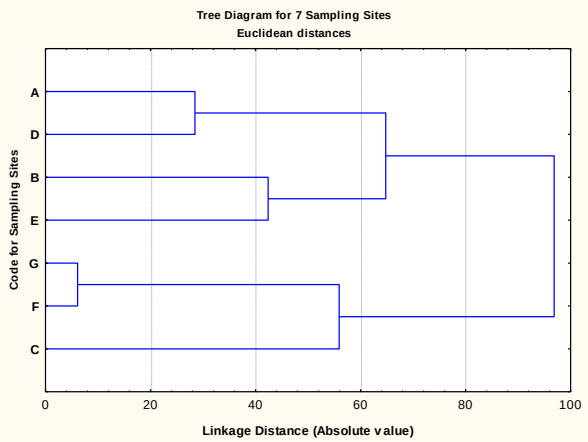
Photo 8.1: Fish habitat in the Passur River System



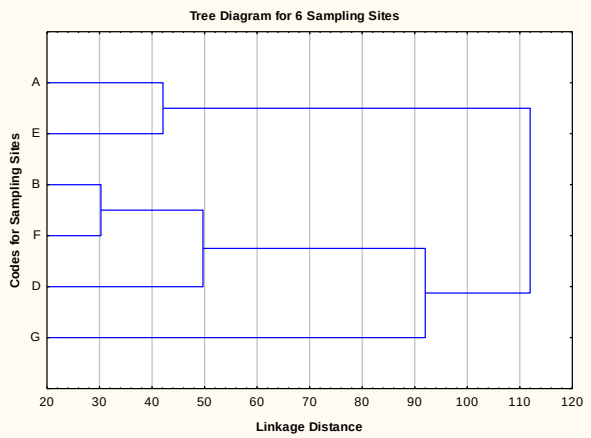
1st Monitoring, April, 2014



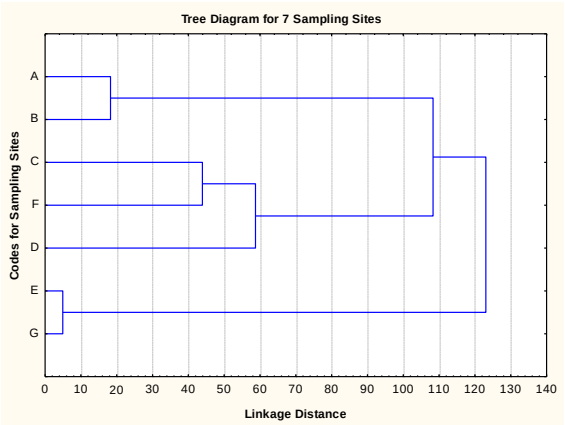
2nd Monitoring, July 2014



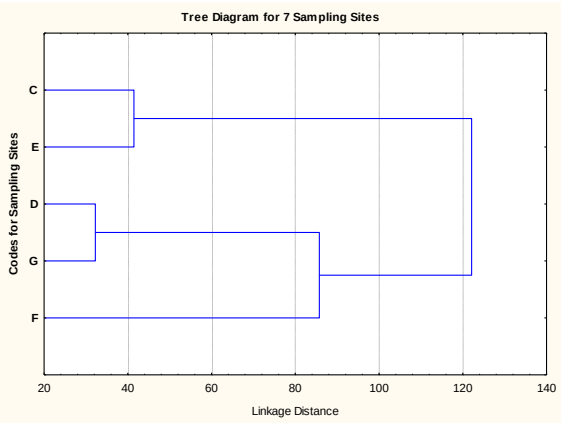
3rd Monitoring, October, 2014



4th Monitoring, January 2015



5th Monitoring, April, 2015

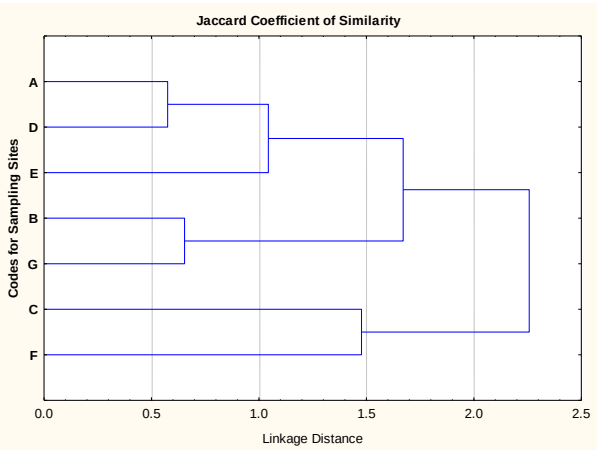


6th Monitoring, August, 2015

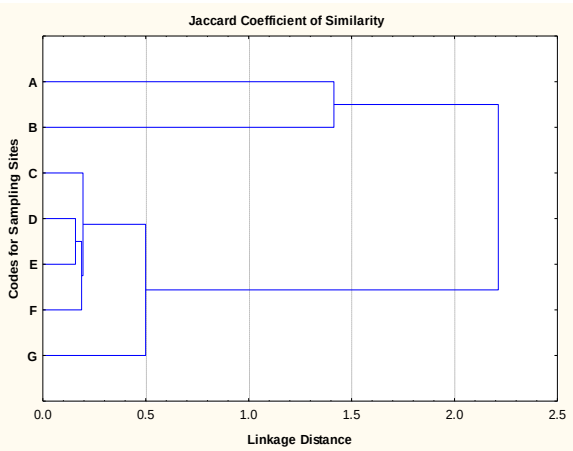
Figure 8.1: Habitat Classification on the basis of Different Life Stages of Fish Species

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

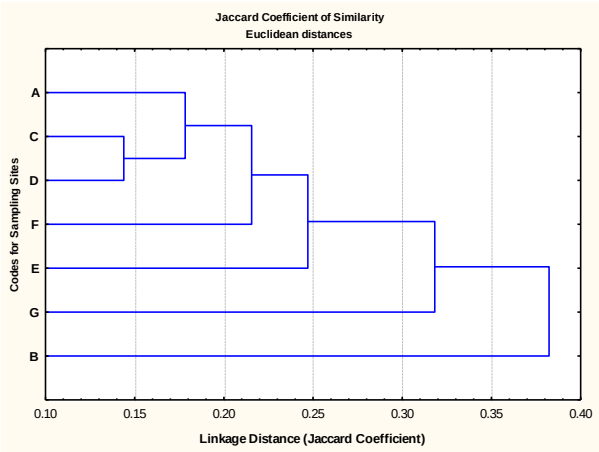
146. This figure analyses the distances among the JI (Jaccard Coefficient Index) indices which are opposite to the JI values. The length-wise distribution relationship among the sampling sites was also found different between first and second quarter of the second monitoring year (2015). In the second quarter of the year of 2015, the JI value between C and D sampling sites was the highest **(Figure 8.2)**.



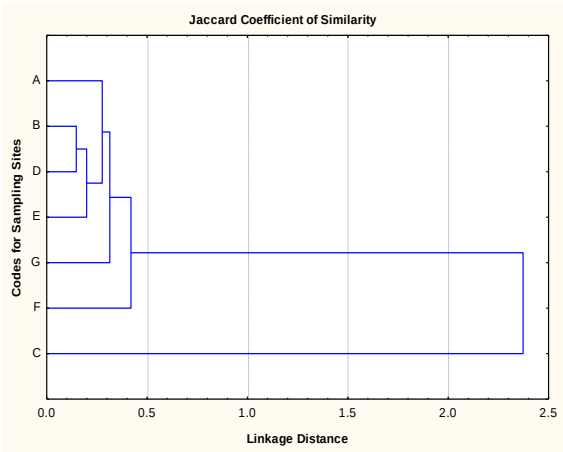
1st Monitoring, April, 2014



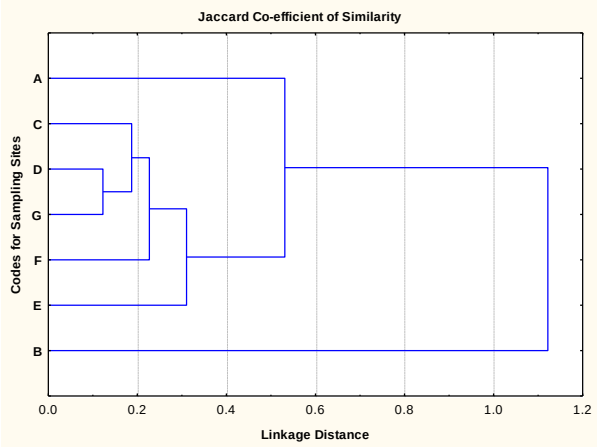
2nd Monitoring, July 2014



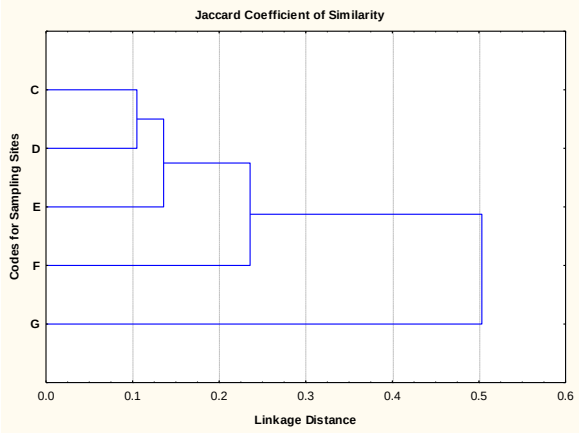
3rd Monitoring, October, 2014



4th Monitoring, January 2015



5th Monitoring, April, 2015



6th Monitoring, August, 2015

Figure 8.2: Dendogram Showing Similarity in Binary Species Composition in seven sampling **sites**

(b) Habitat Suitability Index (HSI)

147. Habitat Suitability Index (HSI) has been determined for the year of 2014 considering the exposure to water quality and the production performance of different fish species. Production performance has been measured through considering length-structured production assessment model (E. L. Cadima, 2003) Suitability analysis has been conducted by applying Iyengar and Sudarshan (1982) developed model. All considered data has been normalized through using UNDP developed normalization equation (UNDP, 2006).

148. Sheola khal at Chandpai has been found as the most suitable habitat for fish species among Passur River System which is followed by Haldikhali, Akram Point, Mongla Point, Harbaria, Maidara and Chalna Point (Table 8.3).

Table 8.3: Habitat Suitability Index (HSI) for selected spot in the study area

Sampling Sites	Location	HSI* (2014-2015)	HSI (2015-2016)	HSI (2016-2017)
A	Akram Point	0.334		
B	Haldikhali	0.408		
C	Harbaria	0.226		
D	Chandpai	0.520		

Sampling Sites	Location	HSI* (2014-2015)	HSI (2015-2016)	HSI (2016-2017)
E	Mongla Point	0.321		
F	Maidara	0.224		
G	Botiaghata, Chalna Point	0.218		

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

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

8.3.4 Fish Bio-diversity

149. 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 estimated by analyzing Shannon-Weiner Index.

a) Shannon-Weiner Index

150. In the second quarter monitoring of second year (2015), highest Shannon-Weiner index has been found at Chalna Point (0.95) indicating most evenly distributed fish species. On the contrary, lowest evenness has been found at Harbaria (shown in the **Table 8.4**).

Table 8.4: Site Wise Species Diversity using Shannon–Weiner Index

Site	Species No												Shannon-Weiner Index*											
	1st QM (April, 2014)	2nd QM (July, 2014)	3rd QM	4th QM	5th QM	6th QM	7th QM	8th QM	9th QM	10th QM	11th QM	12th QM	1st QM	2nd QM	3rd QM	4th QM	5th QM	6th QM	7th QM	8th QM	9th QM	10th QM	11th QM	12th QM
A	33	0	13	7	3	-							0.49	0	0.73	0.57	0.96	-						
B	12	0	24	14	0	-							0.85	0	0.57	0.39	0.00	-						
C	2	12	9	0	11	26							0.29	0.77	0.40	0.00	0.78	0.59						
D	12	22	15	26	27	24							0.31	0.78	0.73	0.51	0.65	0.72						
E	7	13	10	11	6	16							0.38	0.60	0.76	0.77	0.15	0.73						
F	3	13	6	4	10	8							0.82	0.77	0.54	0.60	0.67	0.39						
G	6	3	5	7	18	3							0.68	0.82	0.72	0.66	0.18	0.95						

*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)

151. Fish species richness has been identified through Simpson's Index[3]. Considerable difference was noticed in the fish species richness (FSR) in different habitat classes (**Table 8.5** and **Figure-8.3**).

152. In this monitoring phase, maximum FSR was obtained in Sheola khal at Chandpai (n=8), while very low FSR was recorded in Passur river at Maidara (n=2). Among habitats in upstream portions of the Passur river, Mongla Point was home to a rich assemblage of Tit

[3] 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.

Punti, Bagda, Golda, Bhangan, Khorsula and Tengra; Maidara River at Baro Durgapur of Horina Chingri and Chami Chingri and at Chalna Point of Hilsha, Paissa and Tapsi. Among habitats in lower stream portions, Chandpai was rich in Bagda, Bairagi, Chami Chingri, Goda Chingri, Horina Chingri, Katali Chingri, Motka Chingri and Nona Bele and at Harbaria in Chami Chingri, Chaka Chingri, Bagda and Horina Chingri.

Table 8.5: 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	3	-						
B	Haldikhali	7	0	4	2	0	-						
C	Harbaria	1	5	2	0	4	4						
D	Chandpai	2	2	5	4	5	8						
E	Mongla Point	1	10	4	5	3	6						
F	Maidara at Baro Durgapur	3	6	2	2	4	2						
G	Botiaghata, Chalna Point	3	3	2	3	1	3						

Rupchanda in 1st Quarter Monitoring

Chela in 2nd Quarter Monitoring

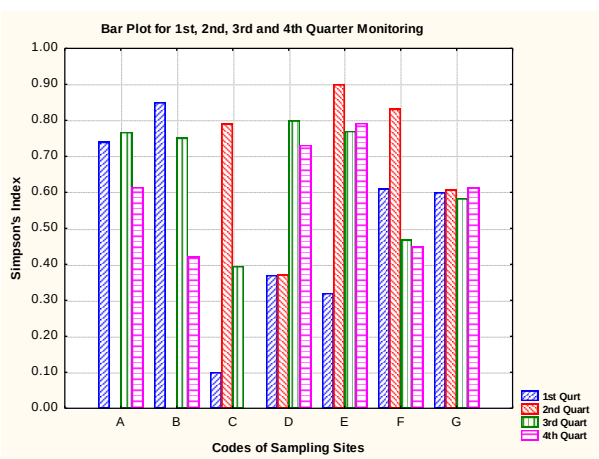
Phesa, Chela, Hilsa, Gagla Tengra

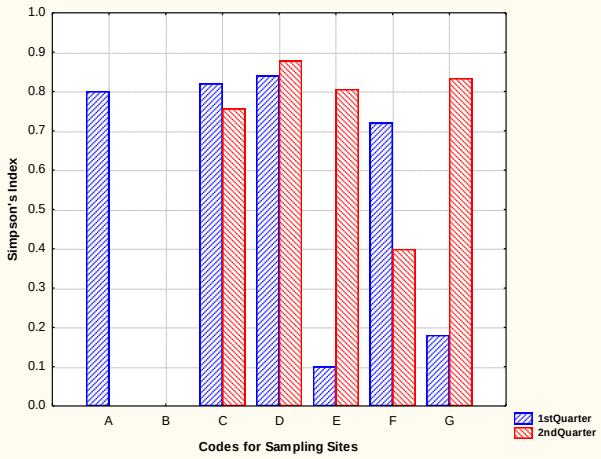
Harina Chingri

Fish Species at 3rd Quarter Monitoring

	
Amadi Chela	Banspata
Fish Species in Upstream of Passur River at 4th Quarter Monitoring	
	
Adult Poma in Chalna Point	Fry of Bagda at Chalna Point
	
Meth and Gagra Tengra	Gagra Tengra
Fish species found in 1st quarter of the second monitoring year (2015-16)	
	
Mutkure and Paissa	**Khorsula**

Menu	Vetki
Fish species found in 2nd quarter of the second monitoring year (2015-16)	
Photo 8.2: Length-wise distribution of fish species	





2014-2015	2015-2016

Figure 8.3: Site wise fish species richness (FSR) in the Passur River System. FSR is identified though Simpson's Index

c) Fish Community Structure

153. Fish community structure has been analyzed through counting the length-wise fish individuals (**Photo 8.2**). The following Table 8.6, 8.7 and Figure 8.4 for second quarter of second monitoring year shows that juveniles for fin fish were more widely distributed among the middle and lower stretches of the Passur River. Among these Bele, Bagda, Golda, Paissa, Poma, and Boiragi fish were widely distributed among the sampling sites. However, brood female of Nona Bele hae been observed in Sheola Khal at Chandpai, Banspata and Tapsi in Passur at Maidara and Hilsha at Chalna Point in second quarter monitoring of 2nd year (2015) in the month of August.

Table 8.6: Occurrence of Species

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

Tapse	*Polynemus paradiseus*	-	+	+	+	-	-	+						
Datina			-	-	-	+	-	-						
Jaba			-	-	-	+	-	-						
Shol	*Channa striatus*		-	-	-	+	-	-						
Magur	*Clarias batrachus*		-	-	-	+	-	-						
Koi	*Anabas testudineus*		-	-	-	+	-	-						
Vetki			-	-	-	+	+	+						
Gangania			-	-	-	+	+	-						

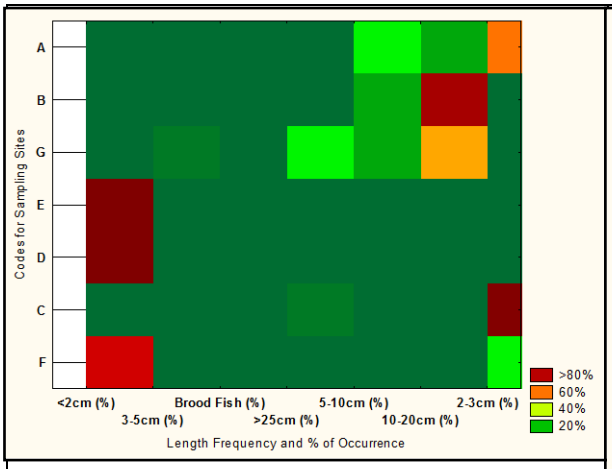
**Local Status Source: IUCN Red List*

Table 8.7: Length-wise species distribution in sampling sites

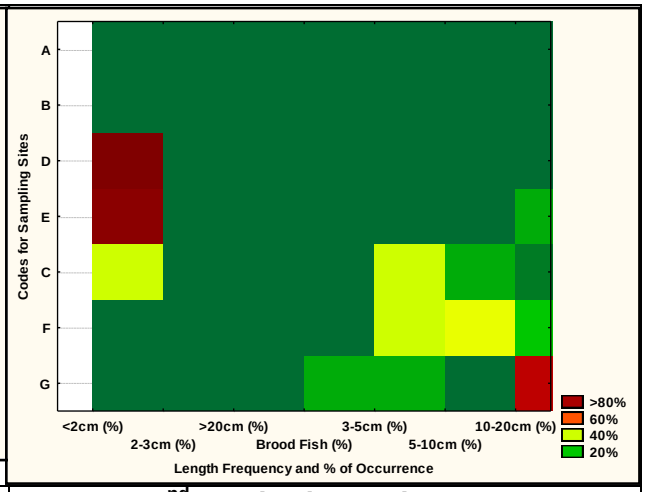
Fish Species	Site	L (< 2cm)	L (2 to 3cm)	L (3 to 5cm)	L (5 to 10cm)	L (10 to 20cm)	L (> 25cm)	Brood Fish
Tit Punti	Mongla Point	97	3	0	0	0	0	0
Bagda	Chandpai	0	0	0	0	100	0	0
	Harbaria	100	0	0	0	0	0	0
	Mongla Point	100	0	0	0	0	0	0
Baim	Harbaria	0	0	20	80	0	0	0
Bairagi	Chandpai	0	0	0	0	100	0	0
	Harbaria	0	100	0	0	0	0	0
Banspata	Chandpai	0	0	0	100	0	0	0
	Maidara	0	0	0	0	0	0	100
Bata	Harbaria	100	0	0	0	0	0	0
Bele	Chandpai	0	0	0	50	50	0	0
	Harbaria	100	0	0	0	0	0	0
	Mongla Point	44	22	0	33	0	0	0
Bhangan	Mongla Point	100	0	0	0	0	0	0
Birguna	Harbaria	100	0	0	0	0	0	0
Chaka Chingri	Harbaria	100	0	0	0	0	0	0
Chami Chingri	Chandpai	0	0	38	63	0	0	0
	Harbaria	0	100	0	0	0	0	0
	Maidara	0	0	100	0	0	0	0
Chata Bele	Harbaria	100	0	0	0	0	0	0
Chitra	Chandpai	0	100	0	0	0	0	0
Dogri	Harbaria	20	60	0	20	0	0	0
Goda Chingri	Chandpai	0	0	100	0	0	0	0
0	Harbaria	0	100	0	0	0	0	0
Golda	Chandpai	0	0	0	100	0	0	0
	Harbaria	100	0	0	0	0	0	0
	Mongla Point	100	0	0	0	0	0	0
Gulsha Tengra	Chandpai	0	0	0	59	41	0	0
	Mongla Point	0	0	0	100	0	0	0
Hilsha	Chalna Point	0	0	0	0	0	0	100
Horina Chingri	Chandpai	0	0	40	60	0	0	0
	Harbaria	16	84	0	0	0	0	0
	Maidara	0	0	100	0	0	0	0
	Mongla Point	0	0	100	0	0	0	0
Kain Magur	Chandpai	0	0	0	0	100	0	0
Kalti	Chandpai	0	0	100	0	0	0	0

Fish Species	Site	L (< 2cm)	L (2 to 3cm)	L (3 to 5cm)	L (5 to 10cm)	L (10 to 20cm)	L (> 25cm)	Brood Fish
	Harbaria	0	100	0	0	0	0	0
Katali Chingri	Chandpai	0	0	100	0	0	0	0
	Harbaria	0	100	0	0	0	0	0
Khorsula	Mongla Point	78	0	0	0	20	2	0
Kuchia	Chandpai	0	0	0	0	0	100	0
	Harbaria	0	0	0	0	0	100	0
Lal Chanda	Harbaria	100	0	0	0	0	0	0
Lal Chewa	Chandpai	0	0	0	75	25	0	0
	Harbaria	33	33	0	17	0	17	0
Motka Chingri	Chandpai	0	100	0	0	0	0	0
	Harbaria	81	19	0	0	0	0	0
	Mongla Point	0	100	0	0	0	0	0
Mutkura	Chandpai	0	100	0	0	0	0	0
Nona Bele	Chandpai	0	0	0	0	0	0	100
	Harbaria	0	100	0	0	0	0	0
Paissa	Chandpai	0	0	0	100	0	0	0
	Maidara	0	0	0	0	50	50	0
	Mongla Point	5	0	0	60	35	0	0
Phessa	Maidara	0	0	0	0	100	0	0
Poma	Chalna Point	0	0	25	50	25	0	0
	Chandpai	0	0	0	100	0	0	0
	Harbaria	100	0	0	0	0	0	0
	Maidara	0	0	0	0	97	3	0
Potka	Harbaria	100	0	0	0	0	0	0
Ram Chanda	Mongla Point	100	0	0	0	0	0	0
Rekha	Mongla Point	0	0	0	100	0	0	0
Sada Bele	Harbaria	100	0	0	0	0	0	0
Sada Chela	Chandpai	0	0	100	0	0	0	0
	Harbaria	20	80	0	0	0	0	0
Sada Chewa	Mongla Point	0	0	0	0	0	100	0
Tapsi	Chalna Point	0	0	0	100	0	0	0
	Maidara	0	0	0	0	75	0	25
Tel Gule	Chandpai	0	0	0	0	100	0	0
Tengra	Chandpai	0	0	100	0	0	0	0
	Harbaria	0	100	0	0	0	0	0
	Mongla Point	100	0	0	0	0	0	0
Tit Punti	Harbaria	50	50	0	0	0	0	0
Tular Dandi	Maidara	0	0	0	0	100	0	0
Vetki	Chandpai	0	0	0	0	100	0	0
	Mongla Point	33	0	0	0	0	67	0

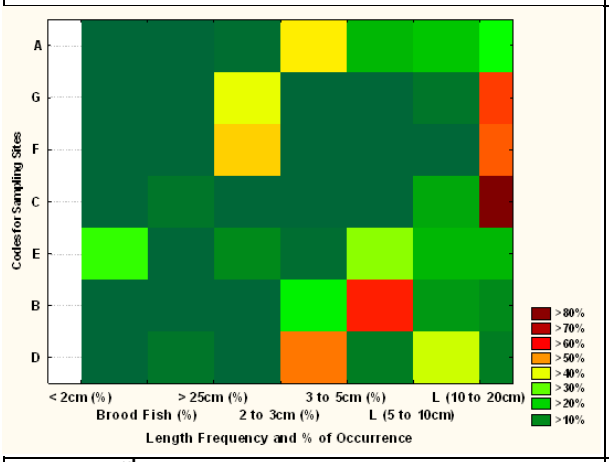
Source: CEGIS field survey, 2015



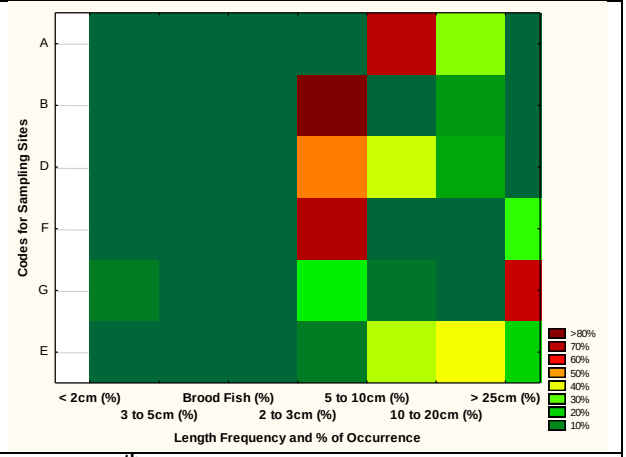
1st Monitoring, April, 2014



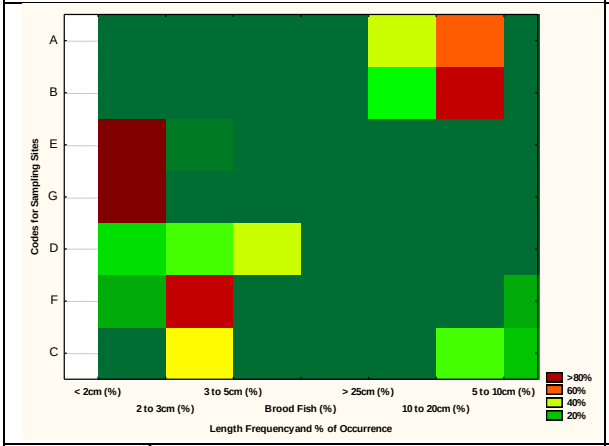
2nd Monitoring, July 2014



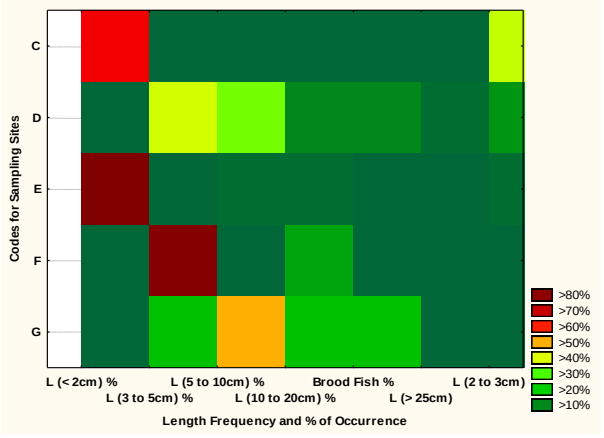
3rd Monitoring, October, 2014



4th Monitoring, January 2015



5th Monitoring, April, 2015



6th Monitoring, August, 2015

Figure 8.4: 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

8.3.5 Fish Migration

(a) Migratory Species Diversity

154. Migratory species have been identified by analyzing the common species available in the regular catch from the sampling sites. Fish species like Bagda attains the maximum abundance among the migratory fish species observed in second quarter of second monitoring year. The relative abundance of the migratory species is give below in the **Figure 8.5**.

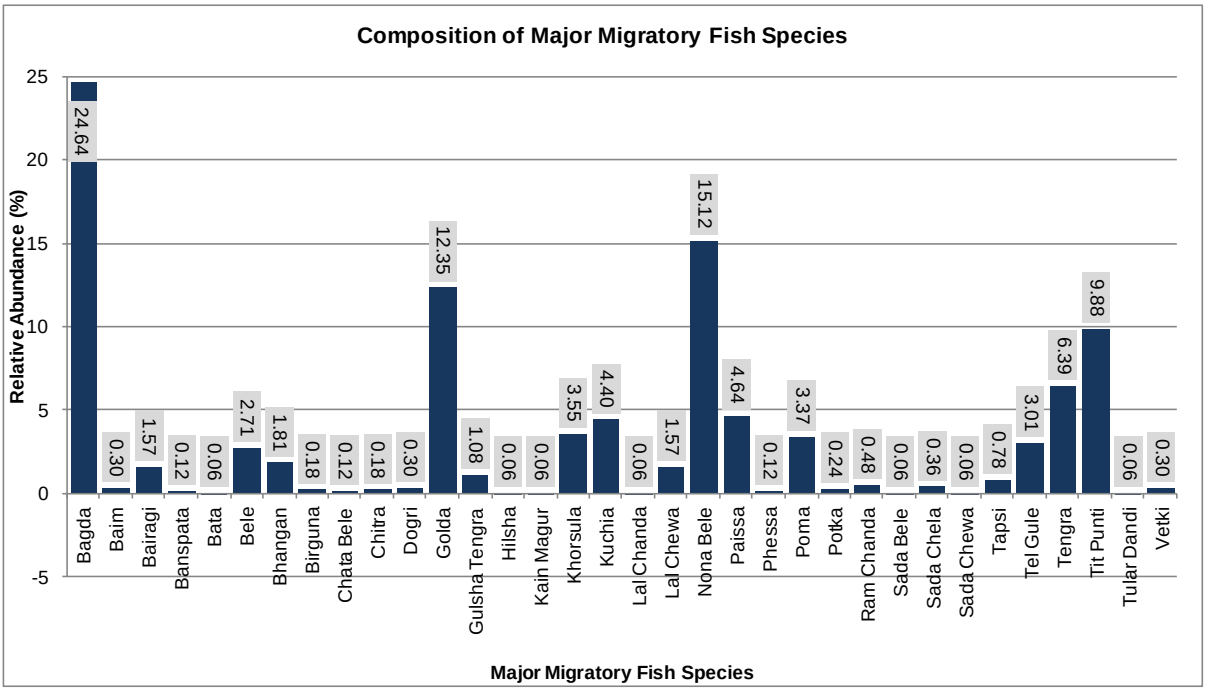


Figure 8.5: Relative abundance of major migratory fish species in sampling sites

(b) Migration Extent, Time and Purpose

155. 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 8.8).

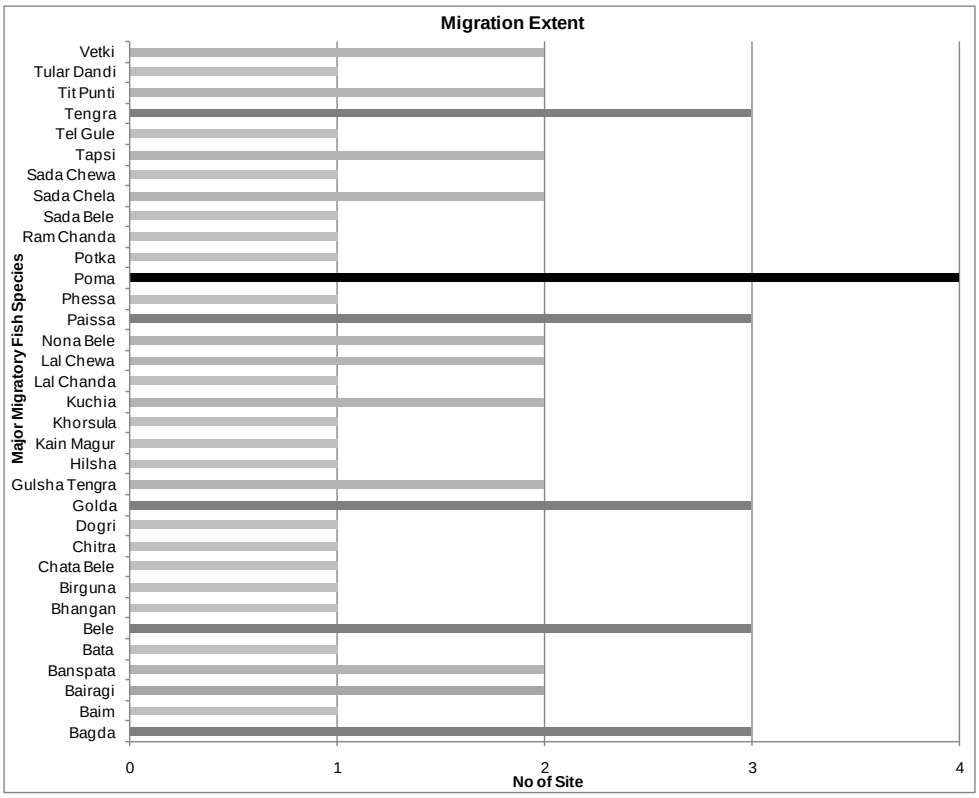


Figure 8.6: Migration extent of major migratory fish species in sampling sites

Table 8.8: 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	-	-	-	Feeding						
		Adult	-	-	Feeding and Growing	-	-	Feeding						
	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	-	-	Feeding						
		Brood Fish	-	-	-	-	-	Breeding and Spawning						
Boiragi	Haldikhali	Juvenile and Age-1 adult	Feeding and Growing	-	Feeding and Growing	-	-	-						
	Akram Point	Juvenile and Age-1 adult	Feeding and Growing	-	-	-	Feeding and Growing	-						
	Chandpai	Fry	Breeding and Spawning	Breeding and Spawning	Feeding and Growing	Feeding	-	Feeding						
	Chalna Point	Juvenile and Age-1 adult	Feeding and Growing	-	-	-	Feeding and Growing	-						
	Harbaria	Juvenile	Feeding and Growing	-	-	-	-	Feeding						
	Mongla Point	Fry	-	Nursing	-	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)
	South-west of the Project	Juvenile	-	Feeding and Growing	-	-	-	-						
Chapila	Haldikhali	Juvenile	Feeding and Growing	-	-	-	-	-						
	Akram Point	Juvenile	Feeding and Growing	-	-	-	-	-						
	Mongla Point	Fry	-	Nursing	-	-	-	-						
	South-west of the Project	Age-1 adult	-	Feeding and Growing	-	-	-	-						
Loitta	Haldikhali	Juvenile and Age-1 adult	Feeding and Growing	-	Feeding and Growing	-	-	-						
	Akram Point	Juvenile	Feeding and Growing	-	-	-	Feeding and Growing	-						
	Akram Point	Age-1 adult	-	-	Feeding and Growing	-	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	-	-	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	-	-	-	Feeding						
	Chandpai	Juvenile	-	-	Feeding and Growing	Feeding	Feeding and Growing	-						
	Haldikhali	Fry and Juvenile	-	-	Nursing	-	-	-						
	Harbaria	Adult and Brood Fish	-	-	Breeding and Spawning	-	-	-						
		Fry and Juvenile						Spawning and						

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)
								Nursery						
	Mongla Point	Fry, Juvenile and Age-1 adult	-	-	Spawning, Feeding and Growing	-	-	-						
	Mongla Point	Adult	-	-		Feeding	-	Feeding						
	South-west of the Project	Adult	-	-	Feeding	Feeding	-	Feeding						
	Chalna Point	Juvenile, Adult and Brood Fish	Breeding and Spawning	-	-	-	-	-						
	Chalna Point	Juvenile and Adult	-	-	Feeding and Growing	Feeding	Feeding and Growing	-						
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	-	-	-	Nursery						
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	-	-	Feeding and Growing	-						
	Chalna Point	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	-	Feeding and Growing	-						
Gulsha Tengra	Haldikhali	Adult	Feeding and Breeding	-	-	-	-	-						

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)
	Akram Point	Adult	Feeding and Breeding	-	-	-	-	-						
	Chandpai	Age-1 adult	-	-	-	Feeding	-	Feeding						
	Mongla Point	Age-1 adult	-	Feeding and Growing	-	Feeding	-	Feeding						
Potka	Haldikhali	Adult	Feeding and Breeding	-	-	-	-	-						
	Chandpai	Fry	Spawning	Spawning and Nursing	-	-	-	-						
	Chandpai	Adult	-	-	-	Feeding	-	-						
	Mongla Point	Fry	Spawning	-	-	-	-	-						
	Harbaria	Fry	-	-	-	-	-	Nursery						
Paira Chanda	Akram Point	Adult	Feeding	-	-	-	-	-						
	Chandpai	Fry	Breeding and Spawning	-	-	-	-	-						
Chewa	Akram Point	Juvenile and Adult	Feeding	-	Feeding and Growing	-	-	-						
	Chandpai	Fry and Juvenile	Spawning	-	Feeding and Growing	-	Nursing and Grazing	Nursery						
	Chandpai	Adult	-	-	-	Feeding	-	Feeding						
	Haldikhali	Juvenile and Adult	-	-	Feeding and Growing	-	-	-						
	Harbaria	Juvenile and Adult	-	-	Feeding and Growing	-	-	Feeding and Nursery						
	Mongla Point	Juvenile	-	Feeding and Growing	-	-	-	-						
	South-west of the Project	Juvenile	-	Feeding and Growing	-	-	-	-						
	Chalna Point	Adult	-	-	-	-	Feeding	-						
Bele	Akram Point	Adult	Feeding	-	Feeding	Feeding	-	-						
	Haldikhali	Juvenile-1, Juvenile and Adult	-	-	Nursing and Growing	Feeding	-	-						
	Harbaria	Juvenile and Adult	-	-	Feeding and Growing	-	Feeding and Growing	Nursery and Feediing						
	Chandpai	Fry	Breeding and Spawning	Nursing	-	-	Nursing	Nursery						

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)
	Chandpai	Juvenile and Adult	-	-	Feeding and Growing	Feeding	-	Feeding						
	Mongla Point	Fry	Breeding and Spawning	-	-	-	-	Nursery						
	Mongla Point	Fry, Juvenile-1 and Juvenile			Nursing and Growing	-	-	-						
	Mongla Point	Juvenile and Adult	-	-	-	Feeding	Feeding and Growing	Feeding						
	Chalna Point	Fry	Breeding and Spawning	Nursing	-	-	Nursing	-						
	Chalna Point	Adult	-	-	-	Feeding	-	-						
	South-west of the Project	Juvenile and Age-1 adult	-	Feeding and Growing	Feeding and Growing	Feeding	Feeding and Growing	-						
Tular Dandi (Nona bele)	Akram Point	Adult	Feeding	-	-	-	-	-						
	South-west of the Project	Adult	-	-	Feeding	-	-	-						
	Chalna Point	Adult	Feeding	-	Feeding	-	Feeding	-						
Tairel	Akram Point	Adult	Feeding	-	-	-	-	-						
	Mongla Point	Juvenile	Feeding	-	-	-	-	-						
Phessa	Akram Point	Adult	Feeding	-	-	-	-	-						
	Akram Point	Juvenile	-	-	Feeding and Growing	-	-	-						
	Haldikhali	Juvenile	-	-	Feeding and Growing	-	-	-						
	Haldikhali	Adult	-	-	-	Feeding	-	-						
	Chalna Point	Juvenile and Adult	Feeding	Feeding and Growing	-	-	-	-						
	Chalna Point	Adult	-	-	Feeding	Feeding	Feeding	-						
	Mongla Point	Adult	-	-	Feeding	Feeding	-	-						
	Chandpai	Juvenile and Adult	Feeding	Feeding and Growing	-	-	Feeding and Growing	-						
	South-west of the Project	Juvenile and Adult	Feeding	Feeding and Growing	-	-	-	-						
	South-west of the Project	Adult	-	-	Feeding	Feeding	-	Feeding						
Paissa	Akram Point	Juvenile and Adult	Feeding	-	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)
	Haldikhali	Juvenile and Adult	Feeding	-	Feeding and Growing	Feeding	-	-						
	Harbaria	Juvenile-1 and Juvenile	-	-	Feeding	-	Feeding and Growing	-						
	Chandpai	Fry	Breeding and Spawning	-	-	-	Nursing	-						
	Chandpai	Juvenile and Adult	-	-	Feeding and Growing	-	-	Nursery and Feeding						
	Mongla Point	Fry	Breeding and Spawning	-	-	-	-	Nursery						
		Age-1 Adult	-	-	-	-	Feeding and Growing	Feeding						
	South-west of the Project	Fry, Juvenile and Age-1 adult	Breeding and Spawning	Feeding and Growing	-	-	Feeding and Growing	-						
		Adult	-	-	-	-	-	Feeding						
Banshpata	Chandpai	Juvenile	Feeding	-	-	-	-	-						
	Chandpai	Adult	-	-	-	Feeding	-	Feeding						
	Haldikhali	Juvnile and adult	-	-	Feeding and Growing	Feeding	-	-						
	Mongla Point	Fry and Adult	Feeding	Nursing	-	-	-	-						
	Mongla Point	Adult	-	-	-	Feeding	-	-						
	South-west of the Project	Adult	-	-	Feeding	Feeding	-	Breeding and Spawning						
	Chalna Point	Adult	-	-	Feeding	Feeding	-	-						
Hilsa	Haldikhali	Juvenile	-	-	Feeding and Growing	-	-	-						
	Mongla Point	Adult	-	-	Feeding	-	-	-						
	Chalna Point	Brood fish	-	-	-	-	-	Breeding and Spawning						
Pangas	Haldikhali	Juvenile	-	-	Feeding and Growing	-	-	-						
	Mongla Point	Juvenile and Adult	-	-	Feeding	-	-	-						

Source: Field findings at different times

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

156. It is interpreted from the findings that in the month of August fish species migrate to the upper reaches of the Passur River for feeding purpose.

8.3.6 Shrimp/Fish Farm

157. 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

158. 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 previous monitoring phase, most of the stocks are still collected from wild source of the Passur River in the present monitoring phase too.

159. In this monitoring year, the majority of seeds for Bagda stock of the entire selected shrimp/fish farm are collected from the wild sources and very few are collected from hatchery (Masum Hatchery). The stocking density varies with the size of the ghers, socio-economic status of the gher owners and seed availability. The highest stocking rate has been observed in case of gher in Bhekatkhali Khal, Rajnagar (**Table 8.9**).

Table 8.9: Stocking Pattern of Fish/Shrimp farm

Location	Fish Species	Stocking Density (No/ha)	Stocking Date	Mortality Rate (%)	Food Item	Total Production (ton)
Bhekatkhali Khal, Rajnagar	Bagda	8,316	First Week, Jan-July	25	Natural	1.6
	Horina Chingri	Natural Stocking				1
	Chali Chingri					0.5
	Paissa					0.25
	Bele			-		0.25
Kapashdanga-Muralia	Bagda	1,556	15, Jan-15, June	20		1.67
	Chali Chingri	Natural Stocking				0.30
	Horina Chingri					0.50
	Bele					0.30
	Paissa					0.25
Chunkuri-2	Bagda	1,200	First-Jan	50		3.5

Source: CEGIS Field Survey, 2014 & 2015

(b) Shrimp/Fish Growth Rate and Mortality

160. During the second quarter of second monitoring year, the highest growth rate has been observed in the case of Chhoto Charer Gher at Rajnagar and lowest at Gher of Kapasdanga. The highest mortality has been reported in case of gher in Chunkuri-2 due to river flood and viral infection in the month of August (**Table 8.10**).

Table 8.10: Growth Rate and Mortality of Fish/Shrimp

Gher No.	1st QM (April, 2014)		2nd QM (July, 2014)		3rd QM (Oct, 2014)		4th QM		5th QM		6th QM		7th QM		8th QM		9th QM		10th QM		11th QM		12th QM	
	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)	Growth Rate (cm/day)	Mortality (%)
1	0.3	15-20	0.2	40	0.25	50	-	-	-	30	0.18	25												
2	0.3	30-35	0.3	94	0.25	10	-	-	-	-	0.14	20												
3	0.2	25-30	0.2	25	0.20	65	-	-	-	10	0.15	50												

Source: CEGIS Field Survey, 2014 & 2015

8.3.7 Fish Production

(a) Capture Fish Production

161. In second quarter monitoring of the second year, the highest productivity has been found in Sheola Khal at Chandpai **(Table 8.11**). The lowest in the Harbaria, because most of the fishes have been found in the age of fry which are not considered productive yet.

162. The present study observed that Bahundi, Charpata, Net, Ber (Ilish and Vola Jal), Jhaki Jal and Khepla Jal are frequently used to catch fish. The highest catch susceptibility has been found in the case of Charpata Jal (8.75 kg/haul) (**Table 8.11**). The following table also expresses that Ber Jal and Jhaki Jal are very commonly used in upper reach and Bahundi Jal in lower reach of the Passur River. Moreover, the highest catch is observed in Sheola Khal at Chandpai and lowest in the Harbaria in this monitoring phase (**Table-8.12**).

Table 8.11: Total Catch in Different Gears in the Sampling Sites

Site. No	Site	Habitat	Gear Name/Type	Haul Duration (hr)	No of Haul	Total Catch (kg)	kg/haul
C	Harbaria	Harbaria Khal	Bahundi Jal	1.75	2.00	0.33	0.00
D	Chandpai	Sheola Khal	Bahundi Jal	3.65	1.00	3.25	3.25
			Charpata Jal	6.00	1.00	8.75	8.75
E	Mongla Point	Passur River	Jhaki Jal	2.56	120.00	1.20	0.01
			Net Jal	4.15	7.00	0.00	0.00
F	Maidara	Passur River	Net Jal	3.15	1.00	0.50	0.50
			Vola Jal	6.20	6.00	0.80	0.13
G	Chalna Point	Passur River	Ilish Jal	1.00	1.00	1.60	1.60

Source: Catch assessment survey, CEGIS (2015)

Table 8.12: Total Catch in the Sampling Sites

Sampling Site	Total Catch (kg)											
	1st QM (April, 2014)	2nd QM (July, 2014)	3rd QM	4th QM	5th QM	6th QM	7th QM	8th QM	9th QM	10th QM	11th QM	12th QM
A	28*	0	3	28.7	6	-						
B	65	0	1	3.3	0	-						
C	1,559	0.5	8	8.7	1.05	0.33						
D	**	12	3	30.0	10.5	5.08						
E	**	0.6	5	0	0.5	0.40						
F	**	1.2	13	3.7	1.5	0.70						
G	**	1.6	4	0.7	2.9	0.83						

*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

163. The present study on shrimp/fish farm in the second quarter monitoring of 2nd year phase showed that the highest production was in the Gher of Rajnagar and lowest in Gher of Kapasdanga **(Table 8.13)**.

Table 8.13: The Present Catch in Three Sampling Ghers

Sampling Site	Total Catch (kg)																							
	1st QM (April, 2014)		2nd QM (July, 2014)		3rd QM		4th QM		5th QM		6th QM		7th QM		8th QM		9th QM		10th QM		11th QM		12th 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	-	-	Bagda	-	Bagda	1.6												
	Vetki	1.57	Bele	0	Gusha Chingri	-	-	-	Horina Chingri	1	Horina Chingri	1												
	Bele	0.98	Cheng	0	Harina Chingri	-	-	-	Tengra	-	Chali Chingri	0.5												
	Harina Chingri	0.78	Bhangan	0	Rui (kg)	-	-	-	Paissa	-	Paissa	0.25												
	Chali Chingri	0.11	Chali Chingri	0	Catla (kg)	-	-	-	Chela	-	Bele	0.25												
	Chaka Chingri	0.08			-	-	-	-	Vetki	-	-	-												
Sub-total =		**8.52**		**6.42**		**4.8**	**-**	-		**1**		**3.06**												
2	Bagda	4	Bagda	1	Bagda	7	-	-	Bagda	-	Bagda	1.67												
	Harina Chingri	2	HarinaHarina Chingri	0.33	Vetki	1	-	-	-	-	Chali Chingri	0.30												
	Chali Chingri	0.18	Chali Chingri	0.08	Paissa	10	-	-	-	-	Horina Chingri	0.50												
	-	-	Golda Chingri	0.01	Phessa	2.4	-	-	-	-	Bele	0.30												
	-	-	Bele	0.08	Bhangan	1.7	-	-	-	-	Paissa	0.25												
	-	-	Tengra&Paissa	0.04	Golda Chingri	0.9	-	-	-	-	-	-												
	-	-	-		Gulsha Tengra	0.2	-	-	-	-	-	-												

Sampling Site	Total Catch (kg)																							
	1st QM (April, 2014)		2nd QM (July, 2014)		3rd QM		4th QM		5th QM		6th QM		7th QM		8th QM		9th QM		10th QM		11th QM		12th QM	
Sub-total =		**6.00**		**2.00**		**23**		-	-	**-**		**3.02**												
3	Bagda	1.38	Bagda	2.4	Bagda	1.5	-	-	Bagda	-	Bagda	3.5												
	Harina Chingri	0.34	Harina Chingri	0.34	Paissa	10	-	-	-	-	-	-												
	Chali Chingri	0.17	Chali Chingri	0.17	Tengra	10	-	-	-	-	-	-												
	-	-	-	-	Bele	20	-	-	-	-	-	-												
	-	-	-	-	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**	-	-		**1**		**3.5**												

Source: CEGIS Field Survey, 2014 & 2015

9 Ecosystem and Biodiversity Monitoring

9.1 Terrestrial Ecosystem

164. 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.

9.1.1 Description of the selected sites

165. 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 it's 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 damaged by past Cyclone Aila.

9.1.2 Species Composition of selected homestead vegetation

Homestead at Rajnagar

166. Among the trees, Gewa *(Excoecaria agallocha)* is dominating among all trees. Moist and saline soil favors luxurious succession of this mangrove plant in homestead vegetation. Beside this, Safeda *(Manilkara zapota)* and Boroi *(Zizyphus sp)* are the two species of fruit yielding trees. Monocots including Narikel *(Cocos nucifera)* and Khejur *(Phoenix sylvestris)* occupied the top canopy of the vegetation. 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

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

Homestead at Chalkghona

168. 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 (Excoecaria 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 9.1.

Photo 9.1: A part of homestead vegetation at Rajnagar Village

Homestead at Barni

169. The homestead at Barni 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 9.1.

Table 9.1: Species Composition of studied homestead vegetation

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

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

Source: CEGIS Field Monitoring, April 2014 and June 2014

9.1.3 Species Diversity of homestead vegetation

170. 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 9.2.

Table 9.2: 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	*Cocos nucifera*	Narikel	Palmae	39	7.8	975
	2	*Excoecaria agallocha*	Gewa	Euphorbiaceae	36	7.2	720
	3	*Phoenix sylvestris*	Khejur	Palmae	24	4.8	600
	4	*Psidium guajava*	Peyara	Myrtaceae	17	3.4	567
	5	*Carica papaya*	Pepey	Caricaceae	5	1.0	500
Borni	1	*Swietenia mehagoni*	Mehogani	Meliaceae	11	2.2	550
	2	*Excoecaria agallocha*	Gewa	Euphorbiaceae	8	1.6	400
	3	*Areca catechu*	Supari	Palmae	10	2	333
	4	*Musa sp*	Kola	Musaceae	6	1.2	300

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

Source: CEGIS Field Monitoring, April 2014 and June 2014

9.1.4 Diversity Index of Sampling homesteads vegetation

171. 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 9.3: 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: CEGIS Vegetation Survey, April 2014 and June 2014

9.1.5 Plant health

172. Plant health of this area is not satisfactory. Vegetation structure of this area is tree dominant. Random saline water shrimp farming is a big threat to plant health of this area. Expansion of shrimp farming in this area triggered increase of soil salinity. For this reason, plant succession, growth and productivity have fallen down.

Plant Diseases and symptoms in homestead vegetation

173. 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 this regards, a number of common tree species have been observed in each homesteads.

174. Leaf spot, leaf blast, nut fall, Mite damage on nut fruit 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 at a same time of the year, but it was tried to observe the existing disease symptoms. Leaf spot and mite damage on fruits is the common symptoms of *Cocos nucifera.* In addition, bud/trunk rot, lethal yellowing and diameter loss at top portion of this monocot is also common symptom of this plant in all location. Fungal/ bacterial infection is not remarkable in the homesteads. But Leaf Anthracnose on *Mangifera indica* and Bacteriosis on *Psidium guajava* is commonly found most of the trees. *Phoenix sylvestris* also found unhealthy due to leaf yellowing from manganese deficiency.

Photo 9.2 : Unhealthy coconut and date palm plant at studied homesteads in Rajnagar and Borni

Number of disease affected trees

175. Trees look livelier in all the monitoring locations than previous season. Coconut (*Cocos nucifera)* and Date Palm (*Phoenix sylvestris)* showed remarkable change in health improvement at all the studied homesteads. Homestead vegetation in Rajnagar showed remarkable change in the number of healthy plants. Except for the Coconut and date palm, health situation of other plants are about unchanged.

176. Following table represent the proportion of healthy and unhealthy plants in studied homesteads.

Table 9.4: 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)	4th QM (Jan 2015)	5th QM (Apr 2015)	6th QM (Aug 2015)	1st QM (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4th QM (Jan 2015)	5th QM (Apr 2015)	6th QM (Aug 2015)
Rajnagar	*Cocos nucifera*	17	NS	7	11*	11	2	13	NS	10	5	5	15	4
	Phoenix sylvestris	25	NS	10	21	21	3	16	NS	15	4	4	22	9
	Manilkara zapota	1	NS	1	1	1	1	1	NS	0	0	0	0	0
	Albizia saman	2	NS	2	2	2	2	2	NS	0	0	0	0	0
	Excoecaria agallocha	100	NS	100	98*	98	100	100	NS	0	1	1	0	0
	Mangifera indica	3	NS	2	3	3	1	3	NS	1	0	0	2	0
	Psidium guajava	2	NS	0	2	2	0	2	NS	2	0	0	2	0
Borni	*Cocos nucifera*	10	3	7	10	10	7	9	7	3	0	0	3	1
	Phoenix sylvestris	12	12	7	8	8	9	11	0	5	4	4	3	1
	Borassus flabellifer	6	3	5	6	6	6	6	3	1	0	0	0	0
	Mangifera indica	6	3	3	5	5	2	6	3	3	1	1	4	0
	Excoecaria agallocha	18	18	18	18	18	18	18	0	0	0	0	0	0
	Swietenia mehogani	11	11	11	11	11	10	11	0	0	0	0	1	0
	Areca catechu	10	10	4	8	8	2	8	0	6	2	2	8	2
	Manilkara zapota	1	1	1	1	1	1	1	0	0	0	0	0	0
	Psidium guajava	2	0	1	2	2	3	2	2	1	0	0	-1	0
Kalekarber Dighi	*Cocos nucifera*	56	21	50	55	55	54	54	35	5	1	1	2	2
	Phoenix sylvestris	10	10	7	10	10	9	10	0	3	0	0	1	0
	Mangifera indica	5	3	5	5	5	5	5	1	1	0	0	0	0
	Manilkara zapota	2	1	1	1	1	2	1	0	0	0	0	-1	0
	Borassus flabellifer	8	8	8	8	8	8	8	0	0	0	0	0	0
	Zizyphus sp	1	1	1	1	1	1	1	0	0	0	0	0	0
	Psidium guajava	8	7	8	8	8	8	8	0	0	0	0	0	0
	Tamarindus indica	2	2	2	2	2	1	2	0	0	0	0	1	0
Chalkghona	*Cocos nucifera*	39	35	20	34	34	5	19	25	19	5	5	34	20
	Phoenix sylvestris	24	24	14	23	23	18	19	0	10	1	1	6	5
	Albizia saman	3	1	3	3	3	2	3	0	0	0	0	1	0
	Excoecaria agallocha	36	36	36	35	35	36	36	0	0	1	1	0	0
	Manilkara zapota	1	1	1	1	1	1	1	0	0	0	0	0	0
	Psidium guajava	17	16	10	17	17	17	17	1	7	0	0	0	0
	Mangifera indica	7	5	6	7	7	7	7	2	1	0	0	0	0
	Borassus flabellifer	2	2	2	2	2	2	2	0	0	0	0	0	0

Note: NS = Not Surveyed

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

9.1.6 Vegetation canopy status

177. 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 monitored in different time intervals.

Species representation in different canopy layers of homestead vegetation

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

Estimated Canopy cover in homestead vegetation of sampling sites

179. Minor change of canopy status of all the studied homestead vegetation was observed in this monitoring period. Canopy coverage at studied homestead vegetation in Chalkghona Village showed improvement than previous monitoring status. This sample homestead contains some new planted saplings whose canopy have increased due to vegetative growth in this rainy season. Except this, canopy status of the other sample homesteads did not change significantly.

180. Canopy coverage of the studied homesteads is presented in following table:

Table 9.5: Vegetation Canopy Cover in different studied homesteads

Location	% of canopy Coverage					
	1st QM (Apr 2014)	2nd QM (Jun 2014)	3rd QM (Oct 2014)	4th QM (Jan 2015)	5th QM (Apr 2015)	6th QM (Aug 2015)
Rajnagar	NS	19	19	17	20	20
Borni	NS	26	18	18	12	14
Kalekarber	NS	20	24	25	23	24
Chalkghona	NS	13	24	22	17	21

Note: NS = Not Surveyed

9.1.7 Bird Habitat

Local birds and their nesting behavior

181. 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 favor good number of water dependent bird species in this area. Most of the birds are nesting on tall trees of homesteads. Coconut and Gewa are considered as 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 9.6.

Table 9.6: Local Bird Species of the study area

Scientific Name	Common Name	Local Name
Accipiter badius	Shikra	Shikra
Acridotheres fuscus	Jungle Myna	Jhuti Shalik
Acridotheres tristis	Common Myna	Bhat Shalik
Actitis hvpoleucos	Common Sandpiper	Chah Pakhi
Aegithina tiphia	Common Iora	Pati Fatikjal
Alcedo atthis	Common Kingfisher	Pati Machranga
Amaurornis phoenicurus	White-breasted Waterhen	Dholabook Dahuk

Scientific Name	Common Name	Local Name
Ardeola grayii	Indian Pond Heron	Deshi Kanibok
Athene brama	Spotted Owlet	Khuruley Pencha
Bubulcus ibis	Cattle Egret	Go Boga
Butorides striatus	Little Heron	Choto Bok
Casmerodius albus	Great Egret	Jattha Bok
Centropus bengalensis	Lesser Coucal	Kana Kukka
Copsychus saularis	Oriental Magpie-Robin	Udoi Doel
Cypsiurus balasiensis	Asian Palm Swift	Ashio Talbatashi
Dendrocygna bicolor	Fulvous Whistling-Duck	Boro Sarali
Dendrocitta vagabunda	Rufous Treepie	Khoira Harichacha
Dendrocygna javanica	Lesser Whistling Duck	Choto Sarali
Dendrocopos macei	Fulvos breasted woodpecker	Kathkurali
Dicrurus macrocercus	Black Drongo	Kala Fingey
Dinopium benghalense	Black ramped Frameback	-
Egretta garzetta	Little Egret	Choto Boga
Eudynamys scolopacea	Asian Koel	Kokil
Gallinula chloropus	Common Moorhen	Jolmurgi
Halcyon smyrnensis	White-throated Kingfisher	Dholagola Machranga
Haliastur indus	Brahminy Kite	Shonkho Chil
Ixobrychus cinnamomeus	Cinnamon Bittern	Nolkhoka
Ixobrychus sinensis	Yellow Bittern	-
Ketupa zeylonensis	Brown fish owl	Bhutum pecha
Lanus schach	Long-tailed Shrike	Lenja Latora
Macronous gularis	Striped Tit Babbler	-
Megalaima haemacephala	Coppersmith Barbet	Choto Boshonto Bauri
Merops orientalis	Green Bee Eater	Suichora
Motacilla maderaspatensis	White-browed Wagtail	-
Nectarinia asiatica	Purple Sunbird	Durgo Tuntuni
Netapus coromandelianus	Cotton pygmy goose	Bali Hansh
Oriolus xanthornus	Black-hooded Oriole	Kalamatha Benebou
Orthotomus sutorius	Common Tailorbird	Pati Tuntuni
Passer domesticus	House Sparrow	Charui
Phalacrocorax niger	Little Cormorant	Choto Pankouri
Porzana fusca	Ruddy-breasted Crake	Ranga Ulti
Porphyrio porphyrio	Purple Swamphen	Kalim
Pycnonotus cafer	Red Vented Bulbul	Bulbuli
Rhipidura albicollis	White-throated Fantail	Dholagola Chatighurani
Sterna albifrons	Little tern	Choto Gangchil
Streptopelia chinensis	Spotted Dove	Tila Ghughu
Streptopelia tranquebarica	Red Collared Dove	Penchi Ghughu

Scientific Name	Common Name	Local Name
Sturnus contra	Asian pied starling	Go Shalik
Tachybaptus ruficollis	Little Grebe	Choto Duburi
Todiramphus chloris	Collared Kingfisher	Dholaghar Machranga
Treron bicincta	Orange-breasted Green Pigeon	-
Tyto abba	Barn owl	Laksmi pecha
Upupa epops	Hoopoe	Hudhud
Vanells indicus	Red-wattled Lapwing	Lal Hotiti

Source: CEGIS Field Monitoring, April 2014

Migratory birds and their habitats

182. In this monitoring season, no migratory bird was observed. Hence, migratory birds and their habitats have not been described.

Bird species and number of Bird nests in sampling sites

183. A total of 6 bird nests were observed at studied homestead vegetation in Rajnagar village. Little Egret and Little Cormorant are the dweller avifaunal species those nested on Gewa *(Excoecaria agallocha)* trees. No bird nest was sighted at other three studied homestead vegetation.

Table 9.7: 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)				5th QM (Apr 2015)				6th QM (Aug 2015)			
	R	B	K	C	R	B	K	C	R	B	K	C	R	B	K	C	R	B	K	C				
Little Cormorant	NS	-	NS	-	12	-	-		-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Little Egret	NS	-	NS	1	4	-	-		-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-
Asian Pied Starling	NS	1	NS	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tailor Bird	NS	-	NS	1		-	-		-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Spotted Dove	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-

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

9.1.8 Butterfly occurrence

184. Population of butterflies was observed to be lower than previous monitoring season. 4 species of butterflies have been recorded from different monitoring locations of the study area. Of which, Small Grass Yellow are commonly found at Rajnagar, Kalekarber and Chalkghona villages. Among other species, Grey Pansy, Dainty Grass Blue and Common Rose have also been found.

Recorded butterfly species and their occurrences are listed in Table 9.8 below:

Table 9.8: 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)				4th QM (Jan 2015)				5th QM (Apr 2015)				6th QM (Aug 2015)			
		R	B	K	C	R	B	K	C	R	B	K	C	R	B	K	C	R	B	K	C	R	B	K	C
Blue Tiger	*Tirumala hamata*										**	*													
Lime Butterfly	*Papilio demoleus*								*				*		*		*								
Chocolate Argus	*Junonia hedonia*					*		*						*											
Common albatross	*Appias albina*																			*					
Common Cerulean	*Jamides celeno*											*													
Common Crow	*Euploea core*					*		*	*	*	*		*				*		*						
Common Emigrant	*Catopsilia pomona*									*	*	**	*		*	*									
Common Gull	*Cepora nerissa*										*														
Common Leopard	*Papilo phalantha*										*	*													
Common palmfly	*Elymnias hypermnestra*										*	*			*		*		*						
Common Pierrot	*Castalius rosimon*										*		*			*									
Common Rose	*Pachliopta aristolochiae*												*					*				*			
Common Sailor	*Neptis hylas*																	*							
Dainty Grass-blue	*Zizula hylax*										*	*												*	*
Danaid Eggfly	*Hypolimnas misippus*															*									
Evening Brown	*Melanitis leda*	NS	NS	NS	NS				*						*		*			***					
Foscus Swallowtail	*Papilio fuscus*																								
Grey Pansy	*Junonia atlites*										*											*			
Indian sunbeam	*Curetis thetis*												*						*						
Lemon Pansy	*Junonia lemonius*										*					*									
Mangrove Jewel	*Hypochrysops epicurus*						*		**																
Stripped Tiger	*Danaus genutia*									*		*													
Orchard Swallowtail	*Papilio aegeus*					*	**													*					
Pale Grass Blue	*Pseudozizeria maha*																		**	**					
Three spot Grass Yellow	*Eurema blanda*									*	**		*												
Peacock pansy	*Junonia almana*										**								*						
Rice Swift	*Borbo cinnara*										**	*	**				*								
Small Grass-yellow	*Eurema smilax*						**									*			*	**		**		**	*
Spotted Pea-blue	*Euchrysops cnejus*																								
Swamp Tiger	*Danaus affinis*																*			*					

Note: Occurrence Status; ''= Occasional, '**' = Common, '-'=Not Found*
'R'=Rajnagar, 'B'=Borni, 'K'=Kalekarber, 'C'=Chalkghona

9.2 Aquatic Ecosystem Monitoring

185. Rivers, canals, ponds and saline water shrimp farms are the main wetlands 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 intervened by human. Therefore, canals are not actual flowing or stagnant water system.

9.2.1 Monitoring Locations

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

9.2.2 Dolphin Occurrence

Dolphin migration route in study area

187. Two dolphin species (Ganges River Dolphin and Irrawaddi Dolphin) travel throughout the Passur river for whole of the year. The Ganges river dolphin *(Platanista gangetica)* migrates from estuary regions to upstream connected rivers like Rupsha and Madhumoti. Though Irrawardi Dolphin *(Orcaella brevirostris)* 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.

Dolphin occurrence in Passur River

188. Occurrence of dolphin have been monitored by boat transect along about 20 km length of Passur River and 5 km of Maidara River surrounding the project area. The transect was started from Mongla Forest Ghat in last ebb tide of the river. At first quarter of the transect survey, spring tide started. The transect ended at mouth of Chunkuri river near Chalna Bazar. A total of 6 Ganges River dolphins have been sighted in Passur River and most of them occurred near the confluence point of Passur and Mungla River.

189. Map 9.1 shows the transect route and occurrence of dolphins at surrounding rivers of the plant site.

190. At the river confluence in front of Dhangmari Forest Station near Koromjal also, two dolphin folks containing 5-7 dolphins was observed during neap tide. The survey result is presented in Table: 9.9.

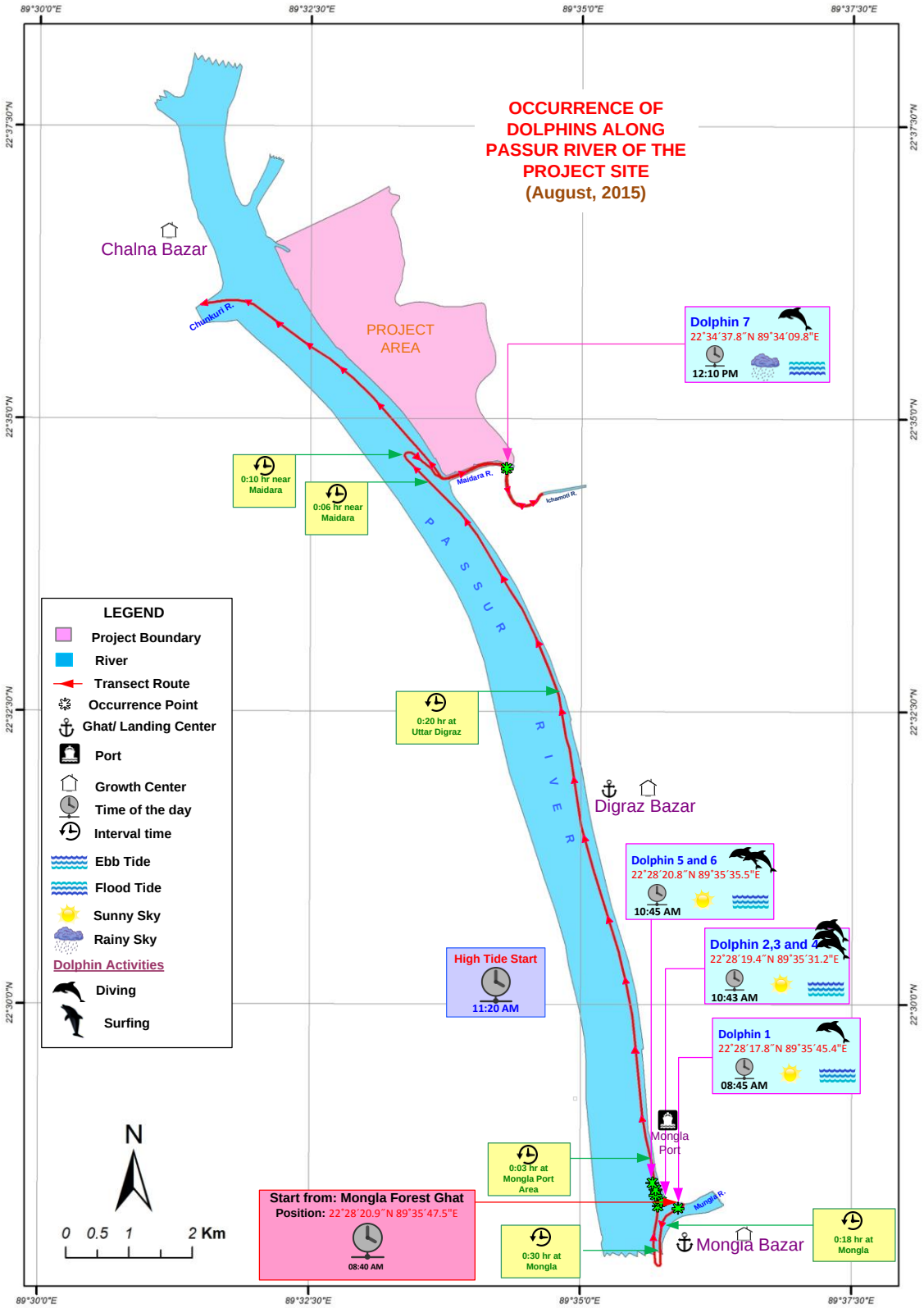
Dolphin occurrence in Maidara River

191. At the Maidara-Ichamoti confluence, one individual dolphin was recorded during high tide.

Table 9.9: Dolphin observation Datasheet

Location of River systems	Occurrence Status											
	1st QM (Apr 2014)		2nd QM (Jun 2014)		3rd QM (Oct 2014)		4th QM (Jan 2015)		5th QM (Apr 2015)		6th QM (Aug 2015)	
	F T	N T	F T	N T	F T	N T	F T	N T	F T	N T	F T	N T
Passur River Near Project Site	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Karamjal	NS	NS	NS	N	NS	Y	Y	Y	N	N	NS	Y
Harbaria	NS	NS	NS	N	NS	Y	Y	N	N	N	N	N
Akram Point	NS	NS	NS	N	NS	N	NS	Y	Y	Y	NS	NS
Sarankhola	NS	NS	NS	N	NS	NS	N	N	N	N	NS	NS
Moidara River	Y	N	N	N	Y	Y	Y	N	Y	N	Y	N

Note: FT=Flood Tide, NT=Neap Tide, NS=Not Surveyed,
Occurrence Status: Y = Occurred, N = Not occurred



Map 9.1: Occurrence of Dolphin at Passur and Maidara River along the project site (August 2015)

10 Sundarbans Forest Health Monitoring

10.1 Monitoring Indicator

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

i. Species richness, diversity, evenness, dominancy (yearly)
ii. Regeneration, recruitment, seedling survival (Quarterly)
iii. Canopy cover, pneumatophores , Crab hole density, light intensity (Leaf area index and net canopy photosynthesis (Quarterly)
iv. tree height, diameter, and biomass (Yearly)
v. Disease and damage (Timber, branch, leaves, Quarterly)
vi. Soil nutrient and quality (Yearly):
    - Soil nutrients- N,P,
    - Bulk density, organic carbon
    - Soil pH, salinity

193. Monitoring frequency for different indicators is different. In this quarter, the following indicators were observed

- Regeneration and survival percentage
- Canopy cover, pneumatophores
- Crab hole density
- lichen presence

194. This report also covers the 1st year 4th quarter monitoring's soil parameters as below:

- Ecosystem carbon stocks
- Bulk density, organic carbon
- Soil pH, salinity
- N and P

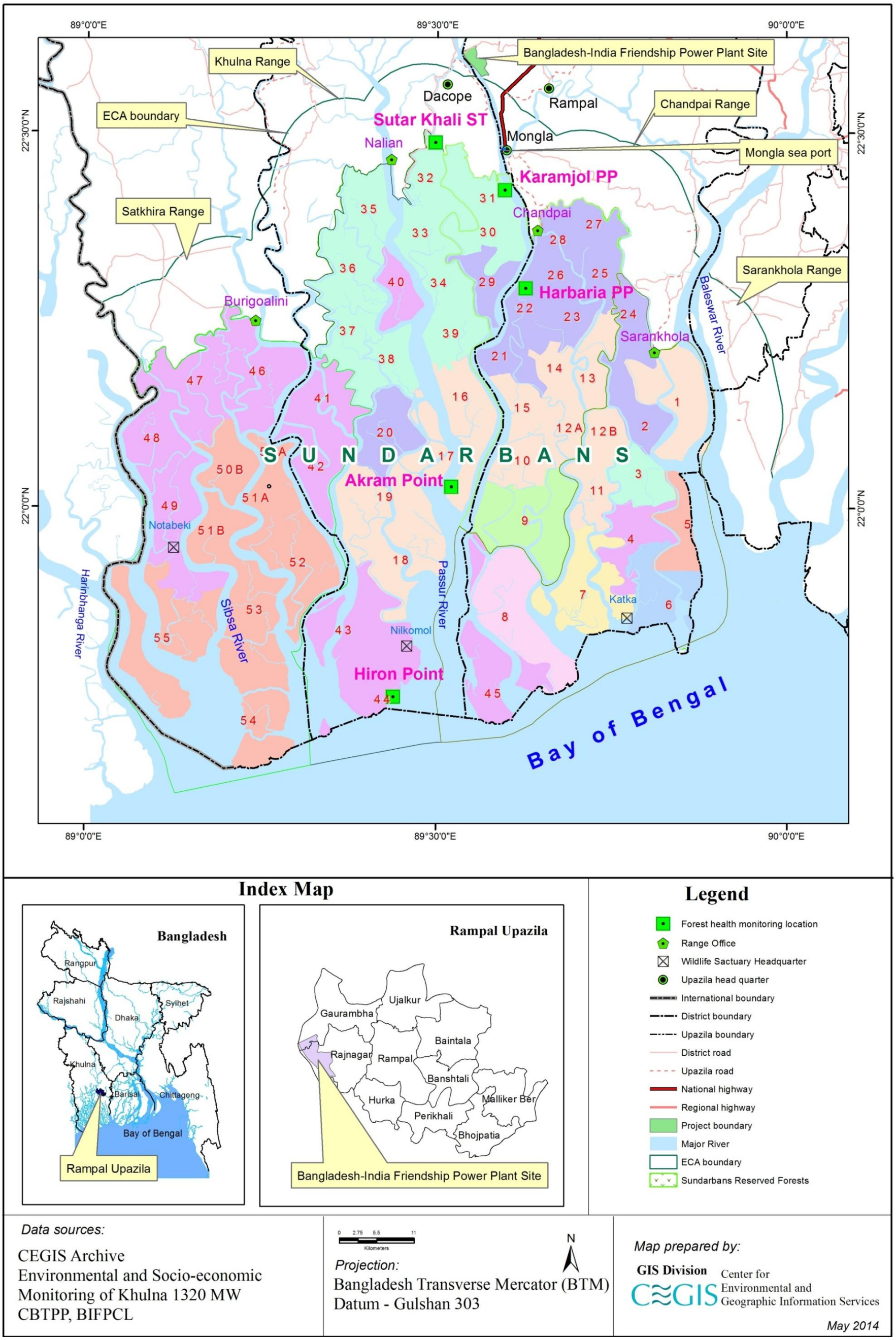
10.2 Monitoring location

195. Five sites were selected on the basis of the survey conducted from April 3 to 6, 2014 (Map 10.1). Among them, four sites along the Passur River at Karamjal, 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. However, in the current monitoring, the two sites (Akram Point and Hiron Point) were not visited due to adverse weather condition.

10.3 Method

10.3.1 Sampling design

196. 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 10.2). 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 10.1: Location Map of Sundarbans Forest health Monitoring Plots

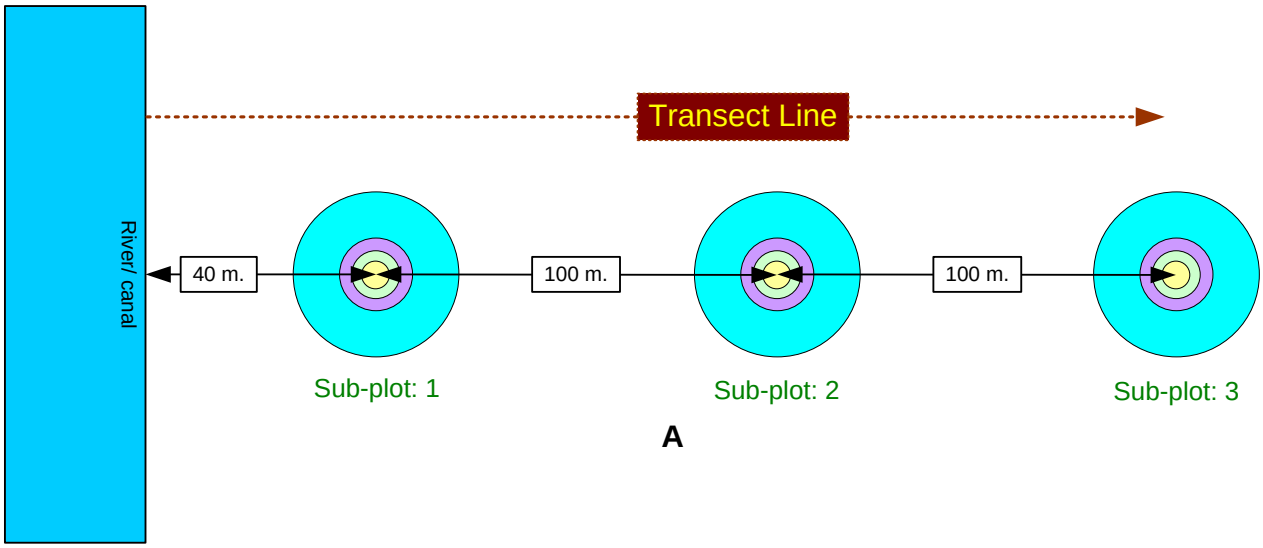


Figure 10.1: Layout of the subplots and transect line perpendicular from ecotone (river or canal bank)

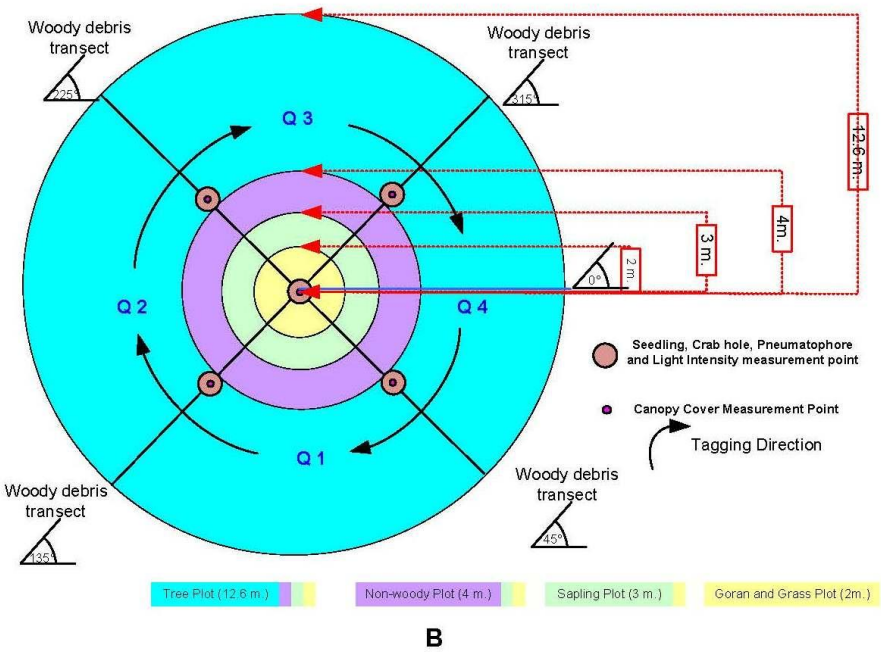


Figure 10.2: Layout of the survey activities in each subplot

10.3.2 Forest Health Survey

(a) Trees

197. The tag number of trees (DBH ≥ 5cm and lean angle greater than 450) was monitored and rewritten if any shade was found within 12.62 m radius circle.

Photo 10.1: CEGIS Professionals checking tree tag number and recording lichen cover

Pneumatophore

198. 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; the total number of pneumatophores was recorded with its living status whether live or dead within a circular area of one meter radius at five points of each subplot. The first one was laid out in the centre of each subplot and other four were in the midpoint of the four woody debris transects that were facing at 45°, 135°, 225° and 315°. Then subplot Pneumatophores density was estimated by averaging the points values. First the total

Photo 10.3: CEGIS Surveyor counting Pneumatophore and seedling at Harbaria

Crab hole

199. 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 1 m radius circle in each subplot centre and in the midpoint of four woody debries transects (Figure: 10.2).

Photo 10.4: CEGIS Surveyor counting crab hole at Harbaria monitoring site in SRF

Canopy cover

200. Canopy cover (%) was estimated by a spherical densiometer which is a gridded convex mirror that provides a simple and inexpensive approach of measuring canopy cover. The densiometer was held at a distance of 30–40 cm in front of the body and at an elbow height, so that head is not visible in the mirror. After leveling the instrument using the level bubble, the dots not occupied by canopy 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 (Figure:10.2). 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 averaging of these five readings.

Photo 10.5: CEGIS Crew member taking canopy cover % at August 2015 Monitoring

(b) Woody debris

201. Woody debris is defined as any dead woody materials (twigs, branches or stems of trees or shrubs) that have fallen and lies up to a height of 2 meters above the forest floor. Dead trees that lean at an angle > 45° from true vertical were also counted (Donato, et al., 2009).

202. The planar intersect technique involves counting intersections of woody pieces with a vertical sampling plane (transect) (Harmon et al., 1996) was followed (Donato, et al., 2009). A survey tape was stretched from the subplot centre for 10 meters in each of the 4 cardinal directions, oriented at 45° angles from the main transect line. A compass was used to run the transect tape on a straight line. Woody debris intersecting the transected plane was recorded, up to a height of 2 meters above the forest floor.

Photo 10.6: Surveyor laying out transect for wood debris survey using compass

Photo 10.7: Woody debris transects at 45°, 135°, 225° and 315° direction from subplot center

203. Woody debris was categorized into 4 size classes (Table 10.1): Small, Medium, Large, and Extra-Large. An aluminum down-wood gauge (Fuel Gauge) was used to determine the size class of each piece encountered.

Table 10.1: Classification of Wooden Debris

Sl No	Classes	Size (in cm)
1	Small	0.0 - 0.6
2	Medium	0.6 – 2.5
3	Large	2.5 – 7.6
4	Extra-large	≥ 7.6

204. Small, medium, and large pieces were tallied as the number of pieces that crossed the transect tape. For Extra-large pieces, the actual diameter over which the transect line was crossed, was measured and the decay status also recorded as sound (machete bounces off or only sinks slightly when struck) or rotten (machete sinks deeply and wood is crumbly with significant loss).

205. Each of the transect line was made sub-sections and these sub-sections start from the distal end of transect (meter 12.62). Small pieces were only tallied for 2 meters of transect (from meter 12.62 to meter 10.62). Medium pieces were only tallied for 5 meters of transect (from meter 12.62 to meter 7.62) and the large and extra-large pieces were measured along the 12.62 meter transect.

Lichen

206. The presence and absence of live 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 10.8: Lichen (white circle) on *Kakra (Bruguiera sexangula* tree at Karamjol monitoring site

(c) Net Photosynthesis

207. Light absorption by the forest canopy can be used to estimate leaf area index. By using this leaf area index, the net photosynthesis can be measured. Leaf area index and net canopy photosynthesis are calculated as follows:

- Leaf area index = loge (I/Io) / -k m_2 leaf area /m_2 area of ground (where k value is 0.5)
- Leaf area index correction = Leaf area index x Cos (O x 3.141593/180)

  (where 0 is zenith Angle of the sun for a given latitude, longitude, date and time of day from internet).
- Net canopy photosynthesis = Leaf area x rate of photosynthesis (0. g C /m_2) x day length

(d) Soil sampling

208. An open face split auger (1m long) will be used to pull out one meter long soil core (Kuaffman, and Donato, 2012). Soil core will be taken around the centre of the each plot. From the 100 cm soil core, a 5 cm long subsample will be 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 (Kuaffman, and Donato, 2012).

Photo 10.9: CEGIS Professionals scaling out the soil sample on Sundri tree at Hiron point

209. ***Bulk Density:*** Bulk density was measured according to Maynard and Curran, 2007. Collected samples were oven-dried at 105°C until constant weight by using an air flow oven (Wisd, WOF-W305, Korea). The oven-dried samples were weighted and the corresponding volume of core was measured and bulk density (BD) of the soil sample was calculated with the following equation:

Bulk Density (BD) = Wt105°C/Vcore

Vcore = πDcore2Lcore/4

Where, Wt105°C is the weight of oven dried soil, Vcore is the volume of the core, Dcore is the inner diameter of the core and Lcore is the length of the core.

210. ***Soil Salinity (EC):*** Soil Salinity (EC) was measured according to Mostara and Roy, 2008. 1:2 ratio of soil and water (w/v) extraction was followed to determine soil EC. 10 g of soil was added with 20 ml of distilled water in a 250 ml Erlenmeyer flask. This mixture was shaken on a reciprocating shaker for 1 hour and was filtered through Whatman No-1 filter paper. EC of the filtrated extraction was measured by using an EC meter (Neomet EC-470L, istek Inc, Korea)

211. ***Soil pH:*** Soil pH was measured according to Miller and Kissel, 2010. 1:2 ratio of soil and water (w/v) extraction was followed to determine soil pH. 10 g of soil was added with 20 ml of distilled water in a 250 ml Erlenmeyer flask. The mixture was shaken on a reciprocating shaker for 30 min and allowed the slurry to settle for 30 min. pH of the slurry was measured by a pH meter (Hach, sension3, USA).

212. ***Total Organic Carbon:*** Loss of ignition (LOI) method was followed to measure organic carbon in soil sample (Allen et al., 1974). One gram of soil was taken in a pre-

weighted porcelain cup and oven-dried at 105 °C for 24 hours. The oven-dried sample was then placed in digital Muffle furnace (WiseTherm F, Wisd, Korea) at 450 °C for four hours. After ignition the sample was then placed in desiccators to allow it to room temperature and weight it again to calculate the loss of ignition (LOI%) using the following formula

$$LOI\% = (Wt105\ °C - Wt450\ °C)/Wt105\ °C$$

Where, Wt105 °C is the weight of soil at 105 °C and Wt450 °C is the weight of soil at 450 °C.

213. The LOI% is usually accounted as organic matter percentage. A total of 50% of LOI% or ash free mass was considered as the C content in the sample (Allen, 1989). However, the LOI or organic matter can be converted to organic carbon according to Nelson and Sommers, 1996 by using a universal conversion factor 1.724 (Van Bemmelen factor) based on the assumption that organic matter contains 58% organic C (i.e., Organic C% = Organic matter (%)/l.724)

214. ***Soil Total Kjeldahl Nitrogen:*** Soil Total Kjeldahl Nitrogen was measured according to Baethgen and Alley (1989). The digestion of soil sample was carried out with concentrated H2SO4 catalyst mixture (100:10:1 of K2SO4:CuSO4:Se) (Bremner and Mulvaney, 1982) in a block digester (VELP DK-6, VELP Scientifica) and diluted the digest with distilled water to a final volume of 100 ml. The Nitrogen concentration of the digest was then analyzed colorimetrically using UV-VIS Spectrophotometer (Hitachi U-2910, Japan). 5.5 ml working buffer solution (0.1M Na2HPO4, 5% Na-K tartrate, 5.4% NaOH), 4 ml Na Salicylate-Na nitroprusside solution (15% - 0.03%), 2 ml Na hypochlorite solution were added to 1 ml of aliquots. Absorbance of the sample was then measured at 650 nm wavelength after 45 minutes.

215. ***Soil Total Phosphorus:*** Total Phosphorus in soil was measured according to Olsen and Sommers (1982). The digestion of soil sample was carried out with concentrated HNO3 and 60% Perchloric acid (HClO4). The digest was then diluted to a final volume of 100 ml with distilled water. 10 ml of Ammonium Paramolybdate-Vanadate reagent was added in 2 ml of sample aliquots and diluted the solution to 25 ml with distilled water. The Phosphorus concentration was then analyzed colorimetrically with UV-VIS Spectrophotometer (Hitachi U-2910, Japan) at 470 nm wavelength after 20 minutes of sample preparation.

10.3.3 Biomass computation

(a) Tree and Saplings

216. Aboveground biomass of tree and sapling of all tree species were (except Gewa) estimated by using Chave, et al., (2005) allomatric equation as yet site and species specific allomatric model is not available. Komiyama et al., (2008) equation was used to estimate below ground biomass if species specific biomass equations are unavailable.

- $AGB\ (kg) = \rho \times \exp(-1.349 + 1.980 \ln(dbh) + 0.207 \times (\ln(dbh))^2 - 0.0281(\ln(dbh))^3$
- $BGB\ (kg) = 0.199 \times (\rho)^{0.899} \times (dbh)^{2.22}$

  Where, ABG = above ground biomass; BGD = belowground biomass; DBH = diameter at breast height

(b) Gewa: The biomass of Gewa was estimated using a site specific allometric equation developed by Mahmood et al. (2015).

$$\text{Biomass} = 10^{(1.0996*LOG((dbh)^2)-0.8572)}$$

(c) Palm

217. In case of palm, like Hental (*Phoenix paludosa*), the Peterson et al., (2005) allometric equation for palm was used.

$$\text{Biomass (kg)} = 6.666+12.826 \times (ht)^{0.5} \times \ln (ht)$$

Where, ht = height

(d) Lianas

218. Lianas biomass was estimated by the following allometric equation:

$$\text{Lianas (kg)} = dbh^{2.657} \times e^{-0.968}$$ (Schnitzer *et al.,* 2005).

219. Some non-tree vegetation biomass was calculated using average biomass (Table. 11.2) develop by one time destructive harvest during SRF carbon Inventory 2009-10 (Rahman, 2015)

Table 11.2: Average Biomass of Species Developed by Destructive Process

Species name	Average biomass (kg)
Golpatta (per frond)	2
Tiger fern (Per clump)	0.3
Hargoza (Per stem)	0.05
Pandanus	0.29
Goran (Small)	0.0048
Goran (Medium)	0.37
Goran (Large)	3.64
Goran (Extra large)	10.55

(e) Woody debris

Small, medium and large

220. These data were collected as counts only. The quadratic mean diameter for each class was used in the following planar intercepts volume equation and it were 0.45 cm, 1.20 cm and 3.17 cm for small , medium and large, respectively. Then the woody debris volume was multiplied by using class-specific wood densities developed by destructive harvest and it were 0.59 kg/m^{-3} 0.54 kg/m^{-3} 0.48 kg/m^{-3} for small, medium and large, respectively.

- Small, medium and large
  - Volume (m^3ha^{-1}) = $\frac{N_i \times QMD_i^2}{8 \times L}$ (QMD=Quadratic mean diameter) (Van Wagner (1968) and Brown (1971))

Extra large

221. The diameter of each type was measured. The volume per hectare of extra-large woody debris classes were calculated by the following formula. Then it was multiplied by the densities derived from destructive for the each category (0.39 kg/ m^{-3} for sound and 0.24 kg/m^{-3} for rotten) in order to get biomass.

  - Volume (m^3ha^{-1}) = $\frac{d_1^2 + d_2^2 + d_3^2 + \cdots d_n^2}{8 \times L}$

(Van Wagner (1968) and Brown (1971))

Woody Debris Biomass (Mg ha^{-1}) = Volume (m^3 ha^{-1}) × Wood density (g cm^{-3})

Soil C;

Soil C (Mg C /ha) = Depth interval * Bulk Density* OC %* 0.01 (Rahman et al., 2015)

10.3.4 Total biomass density and total carbon density

222. Total biomass density (Mg/ ha) = (Tree (ABG + BGB) + Saplings/seedling (ABG + BGB) + Non Tree Vegetation biomass

10.3.5 Total carbon density (Mg/ha) = Total biomass density X 0.5 + Soil C

10.4 Statistical analysis

223. 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. Tukey HSD multiple comparison test were performed whenever any significant change was marked in ANOVA.

10.5 Monitoring Result and discussion of SRF Health

10.5.1 Canopy

224. The canopy cover percentage in Sutar Khali monitoring site was varied significantly among the five subsequent monitoring ($P<0.05$). From the Tukey HSD test (a multiple comparison test) it was found that the 2nd year 1st mentioning's canopy cover % was significant lower than other four quarters monitoring ($P<0.05$). However, the cover percentage was found similar in other three sites among the four monitoring period ($P> 0.05$; Figure 10.3). In Karamjol and Harbaria monitoring sites, there were no significant difference

exist among the five monitoring period. In all the three sites were greater than 60% which is treated as healthy foliage condition.

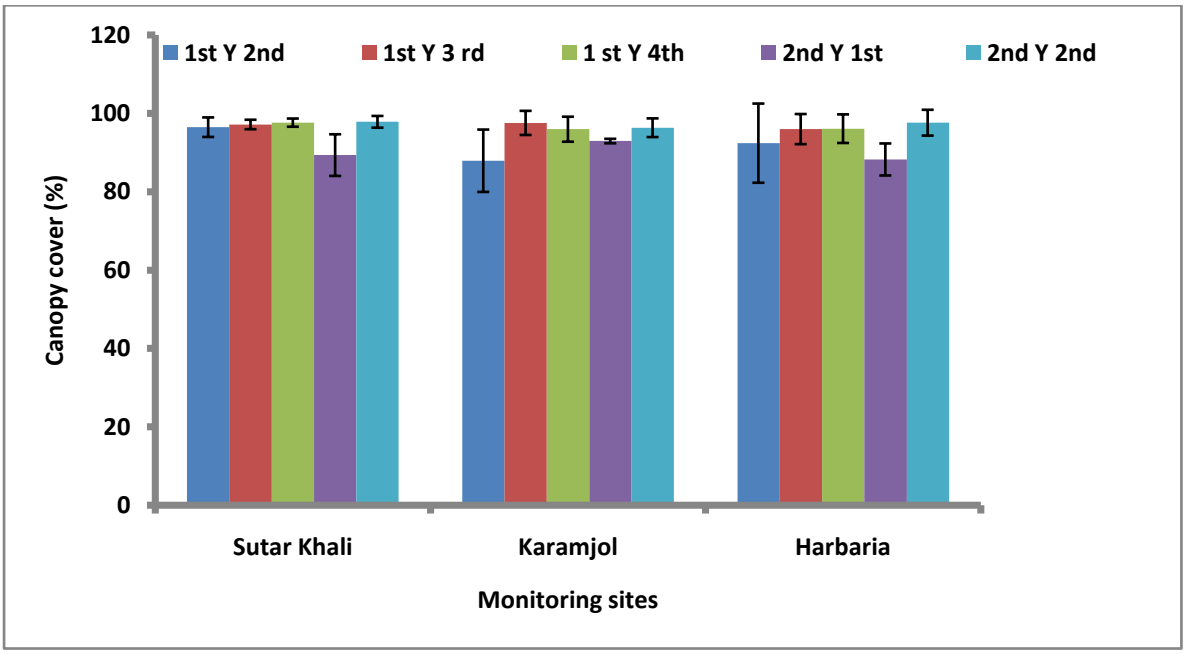


Figure 10.3: Comparision of mean (± 95% CI) canopy cover (%) among the five monitoring period in the three sites.

10.5.2 Pneumatophore

225. The mean density of pneumatophores was not significantly varied during the four monitoring periods in all of the study sites (P > 0.05; Figure. 10.4). 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.

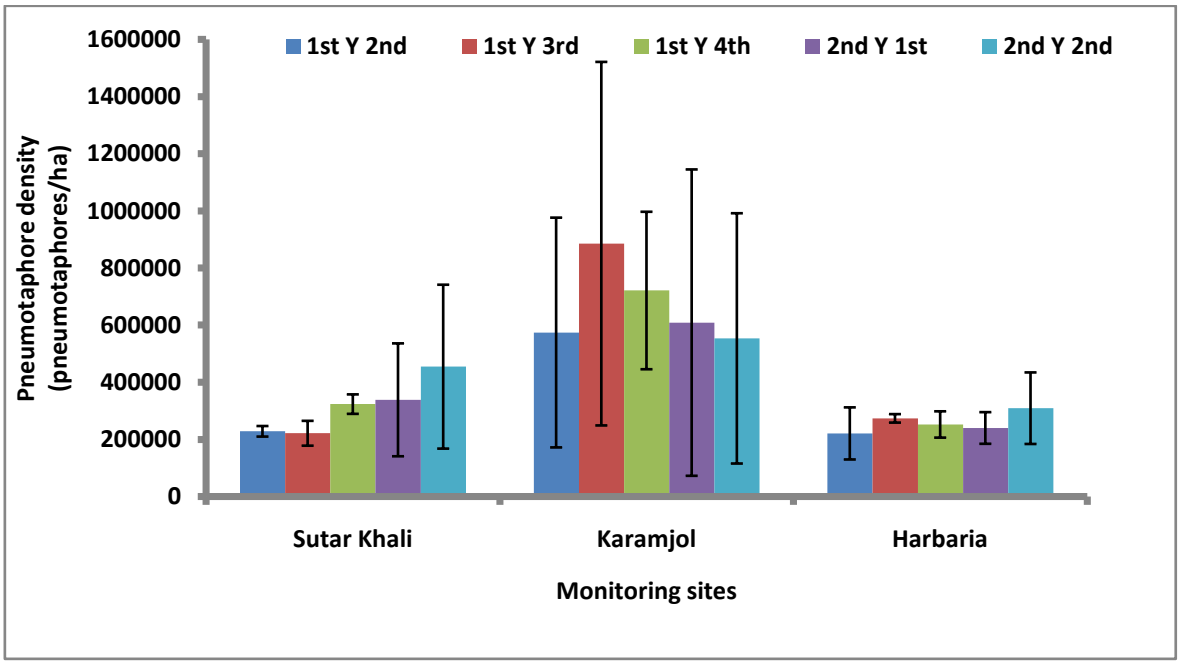


Figure 10.4: Average (± 95% CI) number of pneumatophores density among the five quarters in the three monitoring sites of the SRF

10.5.3 Crab hole

226. The density of crab hole at the three monitoring sites was not significantly varied among the four monitoring periods (P<0.05; figure 10.5).However, it found lower in the current monitoring (figure10.5). It may be due to the revised of sampling design in the current monitoring. In the previous montoring(s), crab hole density was measured only one point at plot centre but in this monitoring we measured it at five point (Figure 10.2).

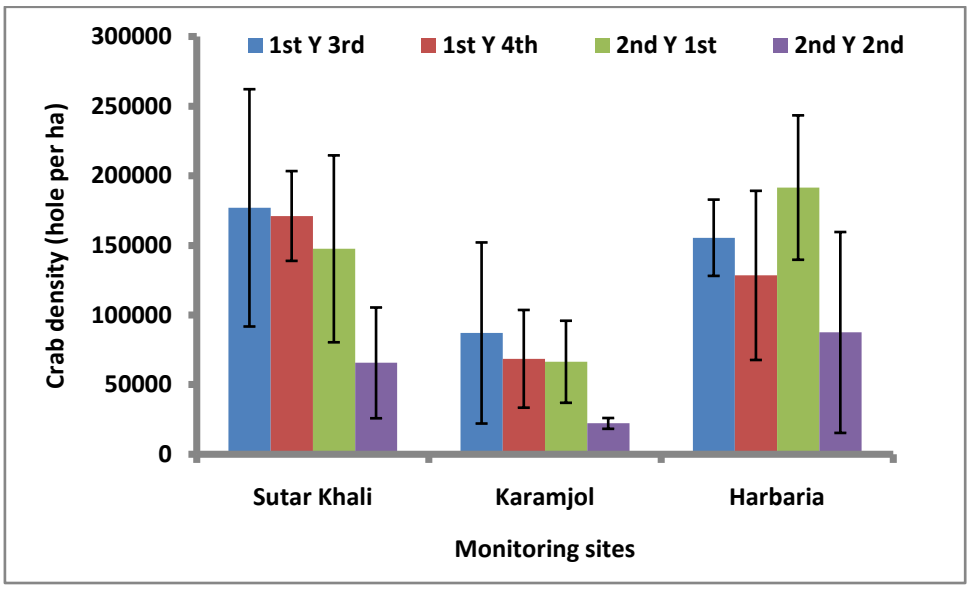


Figure 10.5: Comparision of mean (± 95% CI) crab hole density among the four quarters in the three monitoring sites of the SRF.

10.5.4 Seedling regeneration

227. According to ANOVA analysis, the seedlings density among the five monitoring periods was not significantly varied across the three monitoring sites (P>0.05; Figure. 10.6). However, an increasing trend of seedling survival was found in all sites. This may be because of the time of seed germination and seedlings grow up in SRF.

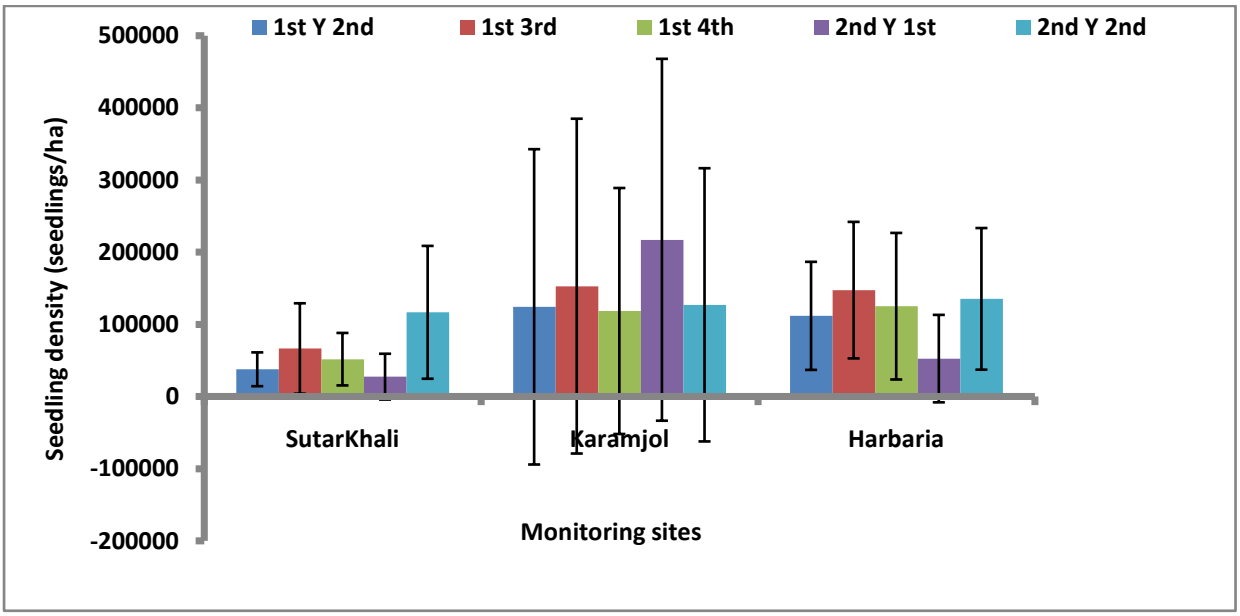


Figure 10.6: Comparision of mean (± 95% CI) seedlings density among five subsequent monitorings in the three sites of the SRF

10.5.5 Pest and insect

Lichen

228. In the three monitoring sites, the lichen coverage (percentage at DBH) on tree was gradually reduced among the four subsequent quarters (P<0.05; Table 11.1). In this monitoring, though the lichen coverage was reduced compared to previous monitoring at the three sites, the Sutarkhali and Karamjal sites were exhibited as good condition(Pathfinder Science 2006; standard ;community with 5 % is assumed that the ecosystem has abundant lichen).. However, this figure was extremely lower in Harbaria site. Several factors may be responsible for this condition such as temperature and air pollutants etc as in this site larger ships unload their goods to lighter ships.

Table 10.1: Comparison of mean (± 95 % CI) percentage of lichen and their changes among the five quarters in the three monitoring sites of the SRF

Monitoring Sites	Monitoring quarter				Change in Lichen %			
	2nd Y 2nd	2nd Y 1st	1st Y 4th	1st Y 2nd	2nd Y 2nd -2nd Y 1st	2nd Y 1st - 1st Y 4th	2nd Y 1st -1st Y 2nd	1st Y 4th -1st Y 2nd
Sutar Khali	5.79 ±1.23	13.74 ±2.21	27.06 ±5.41	20.26 ±2.64	-7.95 ±3.36	-13.33 ±3.91	-6.52 ±2.23	6.81 ±6.09
Karamjol	5.63 ±3.59	8.12 ±4.22	11.19 ±4.34	24.45 ±0.14	-2.49 ±5.70	-3.07 ±1.02	-16.33 ±4.10	-13.26 ±4.21
Harbaria	1.82 ±1.70	2.34 ±2.06	9.79 ±5.15	22.91 ±3.15	-0.52 ±1.12	-7.45 ±3.73	-20.57 ±3.40	-13.12 ±3.45

10.5.6 Ecosystem carbon stocks

229. During the fourth quarter monitoring on January 2015 total ecosystem carbon stocks (ESC) data were collected but laboratory analysis it was not included in that monitoring report. The ESC was almost double across the five monitoring sites from the reported carbon stocks of SRF (255 Mg C ha^{-1}; FD, 2010; Table 10.2). This difference could be due to the methodology for soil carbon assessment and use of site specific allomeric equation for *Excoecaria agallocha*. In SRF carbon inventory 2010, only two soil samples were collected (0-30 cm and 30-100 cm depth intervals), while in this monitoring soil samples were collected 4 depth intervals (Table 10.2). The highest ESC was found in Akram Point followed by Karamjol, Harbaria, Sutar Khali, and Hiron Point (Table 10.2), where the ESC differed depending on species and tree size.

Table 10.2: Comparison of mean (± 95 % CI) Carbon stocks among the five monitoring sites in SRF

Carbon pools	Monitoring sites				
	Sutar Khali	Karamjol	Harbaria	Akram Point	Hiron Point
AGB					
Tree	69.42±26.05	72.40±26.12	79.98±37.02	156.14±118.4	86.54±26.03

				8	
Saplings	8.45±4.04	1.46±1.85	12.21±6.62	0.14±0.16	1.67±1.68
seedlings	0.65±0.42	1.44±2.08	1.53±1.24	0.07±0.07	0.89±0.74
NTV	0.12±0.11	0.28±0.57	0.93±1.85	0.00±0.00	0.30±0.59
Goran	1.84±3.28	0.00±0.00	0.59±0.59	3.84±3.50	23.85±5.38
Down wood	1.09±0.43	1.53±0.68	1.17±0.25	1.83±0.62	1.31±0.12
Total AGB	81.57±28.18	77.11±21.45	96.40±29.98	162.02±114.55	114.56±21.70
BGB					
Tree	41.65±15.63	43.44±15.67	47.99±22.21	93.69±71.09	51.92±15.62
SBG	6.65±3.14	1.14±1.47	9.95±5.56	0.12±0.14	1.46±1.46
Total BGB	48.30±14.60	44.58±14.47	57.94±17.04	93.81±71.14	53.38±14.24
Soil					
0-15	41.81±7.46	60.38±6.90	77.97±34.82	62.47±8.08	36.96±25.66
15-30	62.91±21.45	63.36±14.88	51.47±15.12	63.99±26.52	44.69±15.90
30-50	90.50±37.19	96.88±29.25	71.58±20.49	81.90±41.92	68.56±17.38
50-100	185.17±35.27	301.51±37.01	233.29±30.34	203.31±97.01	163.91±30.10
Total Soil	380.38±86.03	522.13±79.89	434.30±92.29	411.67±114.71	314.11±68.24
Total BG	428.68±91.27	566.71±93.06	492.24±79.17	505.48±146.61	367.50±79.83
ECS	**510.25 ±107.12**	**643.82 ±112.93**	**588.63 ±58.32**	**667.50 ±237.62**	**482.06 ±96.43**

Note: ABG-Aboveground Biomass, BGB-Belowground biomass, BG-Belowground, ECS-Ecosystem Carbon Stocks

10.5.7 Soil properties

230. The mean bulk density, Soil pH, soil salinity, OC%, N and P contain across the five monitoring sites were given in table 10.3. The bulk density pH and P contain of soil across the depth intervals in the five monitoring showed a similar figure. The mean bulk density of the monitoring sites was slightly higher than that of the rage of bulk density of SRF (1.18-1.27 g cm-3). Lower bulk density indicates that the site have more organic matter. According to this fact the Harbaria site's soil contained more organic matter, less compact, and more porous. Soil salinity was found highest in Akram Point (4.98±0.50 ms cm-1), while this figure was lowest in Sutar Khali (3.07±0.66 ms cm^{-1}, Table 10.3). According to soil salinity based classification of SRF the study sites were fall in Miohaline (low salinity) zone (Karim, 1988). The N concentration was found similar in Karamjol, Harbaria and Akram Point (Table 10.3). Lowest N concentration was found at Hiron Point, the most seaward site while moderate N concentration was observed at Sutar Khali site (Table 10.3).

Table 10.3: Comparison of mean (± 95 % CI) soil properties among the five monitoring sites in SRF

Soil depth (cm)	Soil parameters					
	Bulk density (g cm^{-3})	Soil pH	Soil Salinity ms cm^{-1}	OC %	N (mg g^{-1})	P (mg g^{-1})
Sutar Khali						
0-15	1.50±0.08	7.60±0.17	2.64±0.33	1.85±0.33	0.43±0.11	0.53±0.04
15-30	1.56±0.10	7.59±0.33	2.49±0.29	2.70±0.88	0.45±0.20	0.43±0.18
30-50	1.46±0.09	7.83±0.07	3.19±0.84	3.15±1.48	0.51±0.15	0.51±0.03
50-100	1.39±0.21	7.78±0.25	3.94±0.91	2.72±0.90	0.56±0.47	0.51±0.09
0-100	1.48±0.07	7.70±0.13	3.07±0.66	2.60±0.54	0.49±0.06	0.50±0.04
Karamjol						
0-15	1.58±0.17	7.07±0.08	3.29±1.18	2.55±0.02	0.53±0.13	0.53±0.06
15-30	1.60±0.03	7.01±0.19	3.53±0.92	2.65±0.62	0.53±0.08	0.53±0.02
30-50	1.67±0.09	7.16±0.34	4.15±0.43	2.89±0.85	0.59±0.27	0.52±0.02
50-100	1.78±0.35	7.38±0.33	4.56±1.53	3.50±1.07	0.68±0.53	0.51±0.07
0-100	1.66±0.09	7.16±0.16	3.88±0.58	2.90±0.43	0.58±0.07	0.52±0.01
Harbaria						
0-15	1.49±0.13	7.23±0.46	3.04±0.22	3.56±1.78	0.60±0.25	0.51±0.03
15-30	1.45±0.13	7.45±0.45	3.21±1.05	2.40±0.87	0.61±0.59	0.51±0.01
30-50	1.40±0.30	7.02±1.00	3.00±0.80	2.69±1.18	0.73±0.29	0.52±0.04
50-100	1.40±0.23	7.20±0.62	3.19±1.95	3.41±0.88	0.47±0.26	0.51±0.01
0-100	1.43±0.04	7.23±0.18	3.11±0.11	3.01±0.56	0.60±0.11	0.51±0.00
Akram Point						
0-15	1.45±0.08	7.52±0.23	5.42±1.93	2.88±0.35	0.52±0.47	0.49±0.03
15-30	1.76±0.20	7.53±0.18	4.34±1.55	2.41±0.91	0.59±0.24	0.50±0.04
30-50	1.36±0.21	7.47±0.33	5.33±1.92	3.01±1.54	0.68±0.42	0.46±0.15
50-100	1.61±0.14	7.49±0.32	4.81±1.31	2.48±1.02	0.59±0.31	0.51±0.05
0-100	1.55±0.18	7.50±0.03	4.98±0.50	2.69±0.30	0.59±0.06	0.49±0.02
Hiron Point						
0-15	1.72±0.23	7.49±0.32	2.98±2.42	1.51±1.17	0.39±0.55	0.83±0.42
15-30	1.59±0.32	7.11±0.30	3.61±0.68	1.84±0.33	0.26±0.17	0.63±0.12
30-50	1.70±0.06	7.33±0.37	4.40±0.63	2.03±0.58	0.43±0.12	0.53±0.04

50-100	1.75±0.05	7.48±0.35	3.40±1.18	1.88±0.35	0.42±0.20	0.51±0.07
0-100	1.69±0.07	7.36±0.18	3.60±0.60	1.82±0.22	0.37±0.08	0.63±0.15

10.6 Net photosynthesis

231. Net photosynthesis of the three monitoring site are given in the table 10.4. Sutar Khali and Karamjol similar net canopy photosynthesis, while this figure was found lower in Harbaria Site. This is because it has lower leaf area index (Table 10.4).

Monitoring Sites	Leaf area index	Net canopy Photosynthesis (g C $m^{-2}s^{-1}$)
Sutar Khali	3.82	2.48
Karamjol	3.89	2.52
Harbaria	2.08	1.35

10.7 Conclusion

232. This was the 6th monitoring of the forest health of SRF. In this monitoring we investigated canopy cover, pneumatophore, crab hole density, seedling density, net canopy photosynthesis rate and tree tag numbers. In the three monitoring sites, all the forest health parameters were sound except lichen coverage. Lichen coverage was reduced first to fifth monitoring in the three monitoring sites. However, in Sutar Khali and Karamjol this parameter was good but in Harbaria site this figure is extremely lower than that of level of good condition. Several factors may be responsible for this condition such as temperature and air pollutants etc. as in this site larger ships unload their goods to lighter ships. The carbon stocks and soil properties that were measured during January 2015, also included in this report. The highest ESC was found in Akram Point followed by Karamjol, Harbaria, Sutar Khali, and Hiron Point, where the ESC varied depending on species and tree size. Soil salinity was found highest in Akram Point, while this figure was lowest in Sutar Khali. The soil pH, P and bulk density almost similar in the five monitoring sites.

11 Socio-economic Condition and Socio Safeguard Monitoring

233. Socio-economic Monitoring has been scheduled twice a year as per the contract. In this 2nd quarter monitoring report of the 2nd year, Socio-economic Condition and Socio Safeguard monitoring chapter hasn't been populated due to the reason that no data have been collected during this period. The next monitoring has been scheduled in the month of October, 2015.

References

"Assessing the oil spill's impact on Bangladesh's Sundarbans forest". Deutsche Welle. December 17, 2014.

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.

Bartram J and Balance R (1996), Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, UNEP/WHO, Chapter 2.

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, Poungparn 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?

Phillips, Tom (13 December 2014). "Fears for rare wildlife as oil 'catastrophe' strikes Bangladesh". The Daily Telegraph. Retrieved 15 December 2014.

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.

Raman S M B, Sarder L, Rahaman M S, Ghosh A K, Biswas S K, Siraj S S, Huq K A, Hasanuzzaman A F M and Islam S S (2013), Nutrient dynamics in the Sundarbans mangrove estuarine system of Bangladesh under different weather and tidal cycle, Ecological process, springer, page 5.

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. 4th Edn. S. Chandel and Co. Ramnagar, New Delhi –110055. 197

Sivasubramanium R (1999). Water quality of river Periyar (River Suruliyar) in Tamil Nadu. In: Mishra SR (Ed.). Limnological Research in India. Daya publishing house, Delhi

Skilleter, 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

Table A: Checklist of Monitoring for ESMP Implementation (During Pre-Construction and Land Development)

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
1	Generation of Noise within the BIFPCL's Plant Premise	• Conduct noise survey around and inside the site boundary • Reducing Noise and Vibrations to country's ambient standards, and occupational health and safety standards • Introducing vehicle speed limit and speed limit monitoring system • Green Plantation around the project boundary • Switching off/throttled downing of machines/equipments/generators which are not in use			
2	Dust Generation from Land development activities and other construction works	• Conducting dust monitoring and visual inspection around the site boundary • 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 • If yes, do they monitor vehicle speed regularly?			
3	Water Quality	• 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			

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
		protected from wind and rain action • No storing of backfilling materials/spoil stored on river bank/slope • No disposal of waste and waste water to river or canal.			
4	Waste Management System	• Provision of onsite waste management system			
5	Compensation and Resettlement	• Prepare Proper resettlement action plant 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 • Has a resettlement plan been developed which includes compensation, restoration, livelihood, living standards etc. based on proper socio economic studies? • Provide/take extra care/caution for the disadvantaged/vulnerable group/s (i.e. women,			

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
		children, ethnic minorities, indigenous people etc.) • Provision of monitoring the compensation and resettlement process			
6	Livelihood and living	• Does the project pose any threat to the livelihood/living standards of the local people? • If yes, are adequate steps taken to reduce the impacts • Has the company developed any policy which prioritizes the local laborers in employment opportunities? • Is there any possibility that large vehicle related to the project will cause traffic induced disturbance/s to the local dwellers? • If yes, are there any mitigative steps taken to decrease the disturbance/s? • Has the road network been developed after the project was proposed and during the construction phase? • Are there separate water and sanitation facilities for the construction workers in the project area?			
	Green House Gas Controlling Measures	• Use of efficient generator 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			

Table B: Checklist of Monitoring ESMP Implementation (During Pre-Construction and Land Development)

(Labor and Working Condition)

Basic Data

Sl No	Description	Values
1	Direct Workers	
2	Contracted Workers	
3	Supply Chain Workers	
	Child labor	
	0 - 12	
	13 - 14	
	14 - 18	

Checklist for Labor and Working Condition

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
1	Working Conditions and Management of Worker Relationship	• Preparation of Human Resources Policies and Procedures for Direct workers • Defined Working condition and Terms of Employment for direct worker • Sustainably equivalent terms and condition for migrant workers • Compliance to national law of forming worker organization • No discrimination and equal opportunity for all • Measures for protecting past discrimination • Grievance Mechanism			
	Protecting Workforce	• The client will not employ children in any manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to			

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
		the child's health or physical, mental, spiritual, moral, or social development. • No Force Labor			
	Safety at site	• 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.) • 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 • Availability of First Aid at work place • Preparation and Follow of Emergency Response Plan • adequate fire precautions in place (for example, fire • 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			

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
	Occupational Health and Safety Procedure	• Provision of complete EHS division in the Human Resources Planning/Organogram • Preparation of Safety Policy to be adopted during plant operation			
	Workers Well Being	• Establishment Grievance Mechanisms • 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			

Table C: Checklist of Monitoring ESMP Implementation (During Pre-Construction and Land Development)

(Community Health, Safety and Security)

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
1	Disturbance to nearby community due to Dust from newly developed land and Noise from construction activities	• Construction of boundary wall around the project are • Installation of water spraying system to control dusts • Conducting dust monitoring and visual inspection around the site boundary • Adoption of Noise management plan			
2	Grievance of local people	• Availability and operation of Grievance Redress Mechanism • Maintaining open communication channel with the local community			
3	Risk of breaching Community Safety	• Construction of boundary wall/safety fence around the project area • Practicing Risk Assessment and Evaluation Process • Practicing safe management for hazardous materials which may pose threat to the community • Availability and operation of Emergency Response Plan • Maintaining open communication channel with the local community • Training and instruction to the security personnel about their behaviour and			

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
		communication with the local people • Aware the security personnel about the right of the community people			
	Community Health Risk	• Provision of providing health service facilities to community if the project posses any health risk like sexually transmitted disease, communicable disease, vector-related Implement all pollution mitigation measures to ensure safeguarding to community			
	Youth Employment	• Providing training/awareness program for the local youth to let them aware about the required qualification to get involved in the project related activities			
	Public Communication, Consultation and Awareness	• Arranging public communication/consultation meeting • Sharing of project information with local people • Organizing environmental and social awareness programs/meetings			

Table D: Checklist of Monitoring ESMP Implementation (During Pre-Construction and Land Development)

(Biodiversity and Sustainable Management of Living Natural Resources)

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
1	Runoff (contain mostly sediment load) from newly developed land falls into nearby river and channel.	• Installation of proper run on/runoff drains • Use of sediment fences, traps and basins for trapping the sediment, if required			
2	Disturbance to nearby ecosystem due to different construction activities	• No cutting/ felling of trees existing along the river bed • Implementation of on-site waste and air quality management plan • Limiting soil extraction activities limited within the defined area • Limiting the vegetation clearance and base stripping process within the project boundary • Safety fence around the construction site • 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 • Initiate Green plantation • No plantation of non-native species • Retaining top soil for future habitat restoration • No degradation of critical habitat?			
3	Occupation of river, inter-tidal areas and wetlands	• No encroachment of inter-tidal flood plain area			Complied

Sl no	Potential Impacts	Proposed EMP	Actual Implementation	Recommended Action	Compliance Status
		• No disturbance to Dolphin community • Monitoring of Ecosystem Health and Monitoring of Sundarbans Forest Health • If required, embankment should be constructed considering a set back distance from river/canal bank • Slope protection work along the Maidara River should be completed on an urgent basis before rainy season come and • BIFPCL may take initiatives of excavating of silted reach of Maidara river near proposed township area to facilitate proper functioning of River for maintaining tidal dynamics			

Annex II: Photo Album

Environmental Monitoring of Rampal PP (July/August 2015)

Team Composition

Estimating Canopy density by Densiometer at Koromjal

Record forest land condition at Koromjal site

Lay outing of sampling sites at Harbaria

Fish catch assessment at Harbaria

Measuring DBH of tree and record keeping at harbaria sites

Plot Lay outing at Harbaria site

Counting seedlings and crab holes at Harbaria

Plot Lay outing at Sutarkhali site

Measuring light intensity under forest canopy at Sutarkhali site

Fish Catch Assessment at Passur River near Mongla Port

Fish Catch Assessment at Passur River along the project sites

Annex III: 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, NO_3 and PO_4
	River Morphology,
	Tidal inundation
	Drainage Network
	Erosion and Accretion
	Ground water quality
Air quality	SOx

Monitoring Parameter	Indicators
	NOx
	SPM (PM_{10} and $PM_{2.5}$)
	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 1st quarterly monitoring report at the end of three (3) months from the date of signing contract;
- Submission of 2nd quarterly monitoring report at the end of six (6) months from the date of signing contract;
- Submission of 3rd quarterly monitoring report at the end of nine (9) months from the date of signing contract;
- Submission of Annual (1st) monitoring report at the end of one (1) year from the date of signing contract;
- Submission of 5th quarterly monitoring report at the end of fifteen (15) months from the date of signing contract;
- Submission of 6th quarterly monitoring report at the end of eighteen (18) months from the date of signing contract;
- Submission of 7th quarterly monitoring report at the end of twenty one (21) months from the date of signing contract;
- Submission of Annual (2nd) monitoring report at the end of twenty four (24) months from the date of signing contract;
- Submission of 9th quarterly monitoring report at the end of twenty seven (27) months from the date of signing contract;
- Submission of 10th quarterly monitoring report at the end of thirty (30) months from the date of signing contract;
- Submission of 11th quarterly monitoring report at the end of thirty three (33) months from the date of signing contract;
- Submission of Annual (3rd) 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.