- Boiler fuel;
- Pilot fuel of flare stacks; and
- Gas engine generator.

375. **Chemicals:** Caustic Soda (NaOH) and Sulphuric Acid (H_2SO_4) would be supplied to the plant by tank lorry or other measures.

376. **Noise Limits:** Design guide and noise limits of different machineries are as follows:

- Design guide**:**For each rotating equipment (used for normal operation)

Facilities and Zones	Limit Level, dB(A)
For Process Compressor/ Turbine/Steam Turbine Generator	95 at one (1) m from source
For rotating machines other than Process Compressor, Turbine, and Steam Turbine Generator	90 at one (1) m from source

For reformer (used for normal operation)

Facilities	Limit Level, dB(A)
For Reformer	85 at one (1) m from source

For Plant Area (used for normal operation)

Facilities	Limit Level, dB(A)
At plant boundary	75 at day time 70 at night time

5.6.4 Atmospheric Emissions

377. Air effluent emission control in principle shall be in accordance with, International Finance Corporation (IFC), EHS Guidelines and The Environment Conservation Rules, 1997. Substances in gaseous emission are listed below in Table 5.7:

Table 5.7: Comparison of Project air emissions with standards

Parameter	Unit	Emission Source	Effluent Limitation as Design Basis[5]	Bangladesh Regulation[6]	EHS Guidelines, IFC 2007[7]
Ammonia[8]	mg/Nm^3	Granulation process unit Vent Stack (Dry basis)	150	-	50

[5]*Notes: At normal operation excluding ab-normal operating condition such as start-up, Shut down or low load operation.*

[6]*As per "The Environment Conservation Rules, 1997, Schedule-12, (E) Boiler of Industrial Unit"*
As per The Environment Conservation Rules, 1997, Schedule-12, (A) Fertilizer Plant"

[7]*As per 'IFC EHS Guidelines, Air Emission Levels for Nitrogenous Fertilizers Manufacturing Plants"*

8 Regarding ammonia emission from the Granulation stack, MHI has completed same size of urea fertilizer plant in recent years as the following figures: (a) In Oman: 160mg/Nm^3; (b) In Tatarstan: 160mg/Nm^3; and In Turkmenistan: 160mg/Nm^3. In case that 50mg/Nm3 which is IFC standard is applied, an additional acid scrubbing facility needs to be installed. An additional sulfuric acid line with its storage tank also needs to be installed and supplied to acid scrubber. About 10-40% ammonium sulphate solution will be produced in the process as by-product. Since ammonium sulphate solution cannot be treated in waste water treatment system, it shall be asked 3rd party company for treatment who can treat ammonium sulphate solution with the proper way such as incinerator. In addition, high corrosion issues for equipment, piping and instruments should be occurred in case of leakage troubles of ammonium sulphate solution. So, this acid scrubbing facility is not common facility in the world at this moment. Please also note that IFC standard is not mandatory figure but desirable target. The recent fertilizer

NO_2	mg/Nm[3]	Primary Reformer Furnace (Dry basis)	300 (3 vol % 02)	-	300
		Auxiliary Boiler (Dry basis)	150 (3 vol % 02)	150	300
Particulate Substance	mg/Nm[3]	Auxiliary Boiler (Dry basis)	100	100	50
Particulate Substance (Urea Dust)	mg/Nm[3] (Wet basis)	Granulator Vent Stack	50	150	50

Source: MHI (EPC Contractor)

5.7 Construction

378. Site Preparation: The major site preparation works are: (i) Filling of the existing lagoon and the pond either by dredged earth from the Shitalakhya River or by carried earth from other area;(ii) Removing and dumping of debris that will be generated due to dismantling of the existing structures in proper place; and(iii) Piling of the area where required. In addition to these, site preparation will also include a proper planning of drainage system to avoid any kind of water logging.

5.7.1 Construction Labor Camp

379. Ghorasal is an industrial area located in Ghorasal Municipality. Many workers, skilled or unskilled, from different parts of Bangladesh come to Ghorasal for work. They live in rented houses on monthly basis locally available and work in the industries. Because of this, renting out houses/rooms has become a lucrative additional source of monthly income of the local people. During site visit and discussion with the local BCIC authority, it is learnt that the EPC contractor will arrange accommodation facilities for about one-third of all workers (native and expatriate) numbering about 1,700 with utility services (e.g. water, electricity and sanitation facilities) inside the project boundary. In case of emergency, EPC Contractor can rent houses around the project site.

5.8 Human Resources Required During Construction and Operation

380. The estimated number of workers required during (i) Demolition; (ii) Site Preparation; (iii) Construction and (iv) Commissioning phases are as follows:

- Demolition Phase: During demolition phase, EPC contractor is expected to have manpower of around 400 at peak time, including unskilled, skilled, supervisors, engineers, management staffs, etc. Among the manpower, expatriate employees will be around 60.
- Site Preparation Phase: During site preparation, EPC contractor is expected to have manpower of around 600 at peak, including unskilled, skilled, supervisors, engineers, management staffs, etc. Among the manpower, expatriate employees will be around 100.
- Construction Phase: During construction, EPC contractor is expected to have manpower of around 4,000 at peak, including unskilled, skilled, supervisors,

plants which MHI has completed in Turkmenistan, Tatarstan, Oman, Malaysia and Algeria do not have this acid scrubbing facility due to above reason. And Turkmenistan and Tatarstan projects were financed by JBIC/NEXI same as well this GPUFP project.

designers, engineers, management staffs, etc. Among the manpower, expatriate employees will be around 1,500 and MHI employees will be around 30.

- Commissioning Phase: During commissioning, EPC Contractor will employ 2,700 persons as expected peak number. Among the manpower, expatriate employees will be around 600, MHI employees will be around 100 and the rest will be local.

5.9 Emission Monitoring System

381. The flue gas emission will be collected at different points (e.g., stack) in every hour by maintaining standard sampling procedure. The collected sample will be analysed in the chemical analytical laboratory for knowing the emission status of NOx, PM10 and NH3 in particular and compare with the Bangladesh Standard as well as the IFC Standard. Analyzed result will be distributed to all of the plant managers for taking necessary action if exceedance is found.

5.10 Environmental Quality Monitoring System

382. The Proponent is suggested to install two temporary portable ambient air quality monitoring stations (to monitor NOx, PM_{10} and NH_3) are recommended in the Project impact area. The locations of the stations will be based on the dispersion modeling output of maximum ground level concentrations in downwind directions. Noise level will be monitored at the sensitive locations in order to comply with the ECR Compliance Standard. Continuous Monitoring System for water quality monitoring should be installed at the discharge point of WWTS/ETP. The monitoring parameters would be as per Schedule 12 of ECR, 1997 and applicable IFC, 2007 Guidelines for the fertilizer factories.

6. Description of Baseline Environment

6.1 Introduction

383. The baseline condition has been defined considering the environmental perspective where the environmental sector has been differentiated into three types and these are: Physical Environment, Biological Environment and Social Environment. The Physical environment consists with meteorological, hydrological, topological, geological components and processes, hazards, land use and land cover pattern, water resources and land resources. The Biological environment includes agricultural resources, livestock resources, fisheries resources and ecosystems with aquatic and terrestrial flora and fauna. The social environment includes gender, cultural activities, economic status, livelihoodsetc. of the people residing in the study area. The study area has been delineated as 10 km radius area from the center of the proposed Project site. Both primary and secondary data were used to delineate the baseline condition.

6.2 Physical Environment

6.2.1 Land Resources

Agro-ecological Zones (AEZs)

384. The study area has fallen into two agro-ecological zones (AEZs), namely: i) Old Brahmaputra Floodplain (AEZ-9) and Madhupur Tract (AEZ-28) (FAO/UNDP 1988 and BARC; 2012). The study area belongs to 61% Old Brahmaputra Floodplain (AEZ-9) and 39% Madhupur Tract (AEZ-28). The distribution of AEZs in the study area is shown in Figure 6.1.

Land Use and Land Cover

385. Thestudy area of the proposed Project is considered 10 km radius from the project site. The project area is about 45 hectare (ha) having old buildings and a large open space with vegetation cover ranges from herbs to big trees. Possession of such vegetation leading the Project site as ecologically dominant area. The land use of the total study area is 31,457 ha of which agriculture land is14,134 ha. The remaining areas are covered by Rural settlements including homestead, Water bodies including Rivers, Khals, Beels, Ponds, Fresh Water Aquaculture; Orchards and forest and Others (Brickfield, Dump sites/Extraction sites, Built-up-Non-Linear). Detailed land use of the study area is presented in Figure 6.2and land cover areas of such land uses are presented inclusters in Table 6.1.

Table 6.1: Present land cover areas of the study area by land use cluster

Land Use Cluster	Land Cover Area (ha)	Percent (%) of Gross Area
Agriculture Land	14,134	45
Rural Settlements	12,958	41
Water Bodies (Rivers, Khals, Beels/Haors, Ponds, Fresh Water Aquaculture)	2,257	7
Orchards and Forest	276	1
Others (Brickfield, Dump sites/ Extraction sites, Build-Up-Non-Linear)	1,545	5
Road	286	1
Total/Gross	**31,457**	**100**

Source: Image analysis done by CEGIS, 2018

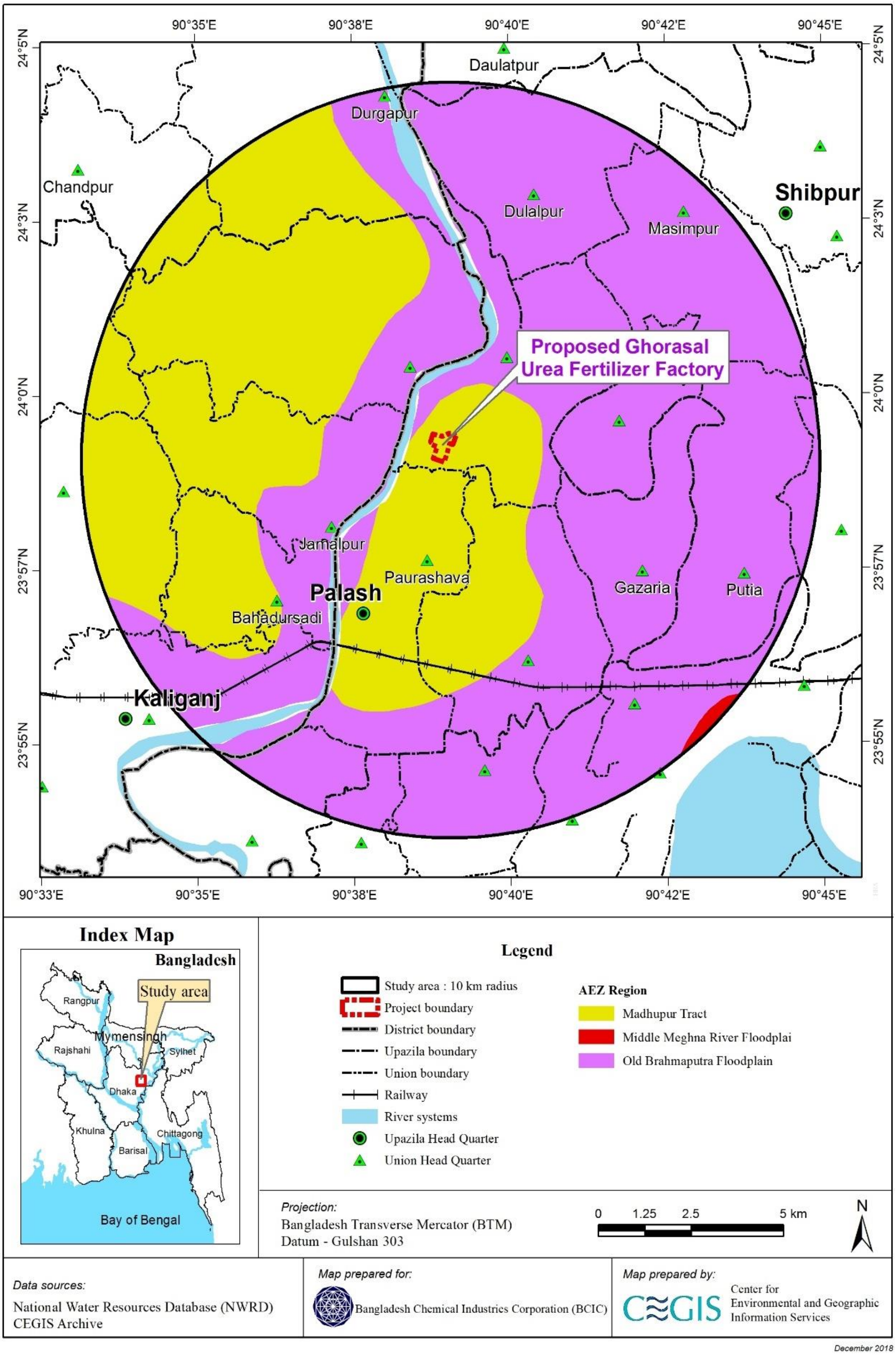


Figure 6.1: AEZ of the study area

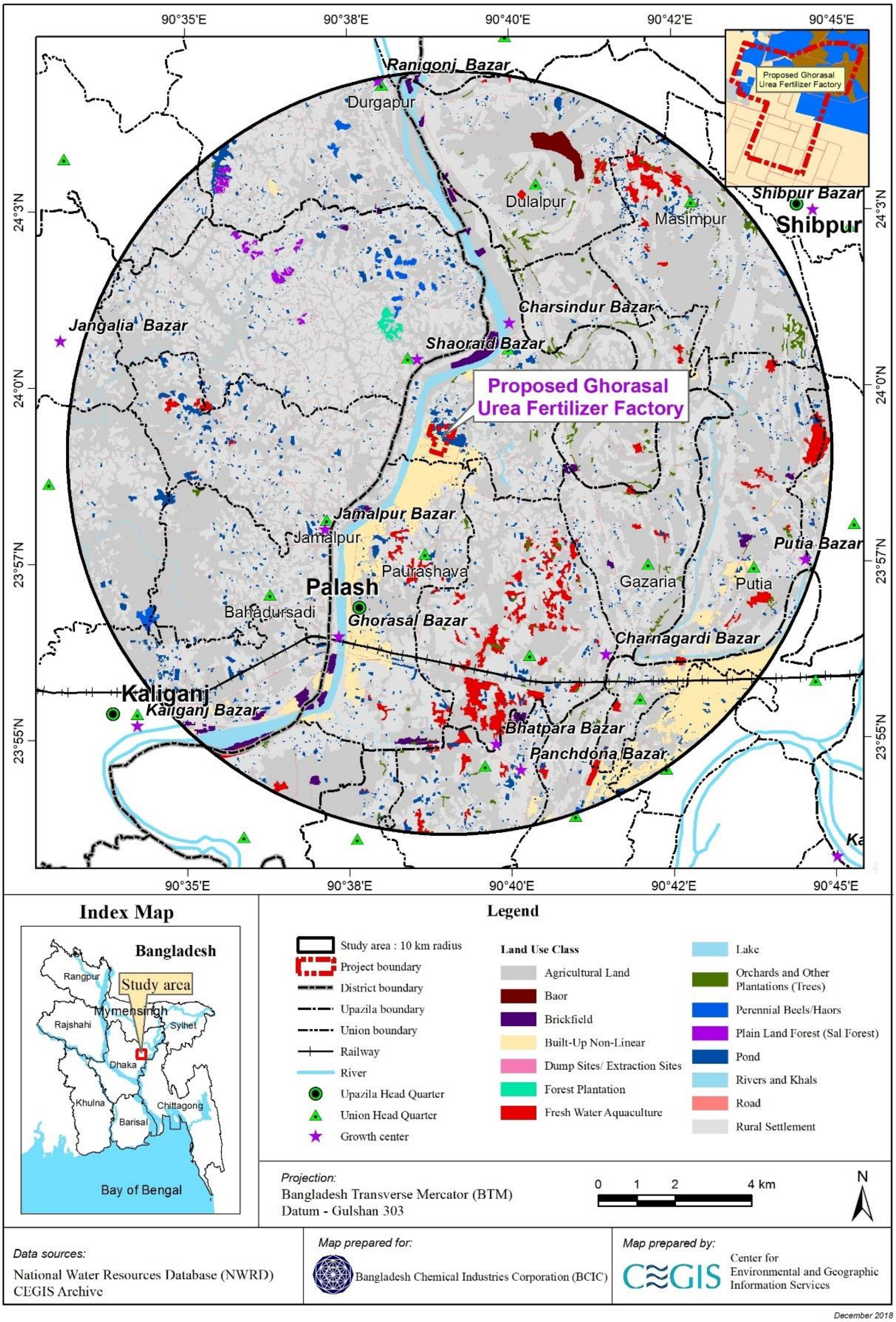


Figure 6.2: Land use mapof the study area

Soil Texture

386. Soiltexture is the relative proportions of sand, silt and clay. The dominant soil texture of the study area is loam (45%) followed by clay and clay loam (28%) and (26%) respectively.The detailed top soil texture of the study area is presented inTable 6.2.

Table 6.2: Top soil texture of the study area

Soil texture	Area (ha)	% NCA
Clay	3,996	28
Clay Loam	3,725	26
Loam	6,413	45
Total	**14,134**	**100**

Source: Soil Resource Development Institute (SRDI), 1997

Soil Quality

387. The proposed Ghorasal-Polash Urea Fertilizer project area has fallen in Ghorasal Union under the Polash Upazila. There are five soil series in this area are: Tejgaon, Sayek, Payati, Kolma, and Khilga. Table 6.3shows that the soils of this area are low status of Organic Matter (OM). There are very high in Calcium (Ca), Phosphorus (P), Potassium (K), Iron (Fe) and Manganese (Mn); high in Sulphur (S) content; medium in Zinc (Zn) and Magnesium (Mg); Nitrogen (N) content in the soil is very low.

Table 6.3: Soil quality based on plant nutrient of the study area

Parameters	Unit	Max	Min	Average
pH	-	6.1	5.2	6
OM (Organic Matter)	(%)	0.9	0.1	1
Active acidity	Meq/100g	0.3	0.1	0
Ca (Calcium)	Meq/100g	9.8	2.9	6 **
Mg (Magnesium)	Meq/100g	3.54	0.85	2*
K (Potassium)	Meq/100g	1.2	0.38	1**
N (Nitrogen)	µg/g	42	27	35
P (Phosphorus)	µg/g	54	6	30 **
S (Sulphur)	µg/g	62	10	36
B (Boron)	µg/g	0.7	0.1	0
Fe (Iron)	µg/g	227	50	139 **
Mn (Manganese)	µg/g	49	8	29 **
Zn (Zinc)	µg/g	4	2	3*

Source: Soil Resource Development Institute (SRDI), 1997

388. Six (06) soil samples were collected from three locations,two layers for each location, of the study area during 19.12.2018 to 21.12.2018. These soil samples havebeen analyzed through the laboratory of Soil Resources Development Institute (SRDI), Dhaka for testing the Soil texture, Soil reaction (pH), Organic Matter (OM), Nitrogen (N), Phosphorus (P), Potassium (K), Sulphur (S), Chromium (Cr), Cadmium (Cd) and Lead (Pb). The result of soil analysis is given in Table 6.4.

Table 6.4: Analytical result of soil samples

Location	Sampling Layer	OM	pH	Total N (%)	P µg/g	K	S µg/g	Pb µg/g	Cd µg/g	Cr µg/g
Lagoon (Khanepur)	Upper Layer	0.76	4.0	0.04	1.89	0.09	87.09	22.5	0.00	29.25
	Lower Layer	0.84	4.3	0.04	1.09	0.09	261.5	15.51	0.01	40.00
Agriculture Field, Khanepur	Upper Layer	2.6	4.6	0.15	2.45	0.14	3.39	14.25	0.34	33.75
	Lower Layer	2.1	5.1	0.12	2.41	0.12	9.28	13.00	0.00	32.25
Agriculture Field, Nargana, Kaliganj	Upper Layer	2.44	5.1	0.14	1.23	0.13	17.07	12.25	0.10	41.50
	Lower Layer	1.77	5.6	0.10	1.54	0.12	21.39	12.00	0.00	44.50
Optimum level, SRDI, Bangladesh		-	-	0.27-0.36	15.8-21.0	0.27-0.36	22.5-30.0	-	-	-
Critical limit, SRDI, Bangladesh		-		0.12	7.00	0.12	10.00	-	-	-
DoE Standard Value (Bangladesh)		-	-	-	-	-	-	100	1.5	100

Source: Lab analysis done by SRDI for CEGIS, 2019

389. From the analyzed result, it has been observed that the texture of all soil sample is silt loam. In the lagoon area, Organic Matter contents (OM) are low. The pH levels were found which are very strongly acidic. On the other hand, Nitrogen (N), Phosphorous (P) and Potassium (K) level is very low but Sulphur (S) content is medium but Lagoon (Khanepur) Lower Layer is too high. All the parameters are within the optimum level, except the lower layer of Sulphur. It is also observed that, Lead (Pb), Cadmium (Cd) and Chromium (Cr) level are within the DoE standard.

390. In the agricultural land, Organic Matter contents (OM) are medium level and pH levels were found slightly acidic to strongly acidic in nature. On the other hand, Nitrogen (N), Phosphorous (P) and Potassium (K) level is very low to low but Sulphur (S) content is very low to medium level. All the parameters are within the optimum level. However, heavy metal concentrations of Chromium (Cr), Cadmium (Cd) and Lead (Pb) are within the DoE standard in agricultural land. Therefore, it is summarized that soil quality of the agriculture land is suitable for crop cultivation.

6.2.2 Topography

391. The study area mostly lies in a flat topography. Presently, the area is dominated by agricultural practices followed by settlements, industries, fishing during the wet season. The ground elevation gently lowers from East to West. The Project site is situated at the elevation ranges between 7-12 m PWD (Figure 6.3). The entire study area is vulnerable to occasional riverine flood. Information collected from the PUFFL authority, there was no record of flooding inundation after 1998 devastating flood. The topographic map envisages contour lines of the site. The project site has been developed, and it is a flat land with a large lagoon.

6.2.3 Geology

Physiography

392. Physiographically, the proposed Project site falls in the Madhupur tract and is surrounded by the Old Brahmaputra floodplain and the Young Brahmaputra and Jamuna

floodplain (Figure 6.4). The area is located in the central part of the Bengal basin– an extensive alluvial plain of the quaternary sediments laid down by the Ganges-Brahmaputra-Meghna river system.

393. The surface of the area is covered by paludal deposit. The thickness of this section ranges from seven (07) to nine (09) meters. It is composed of Holocene river alluvium, meander, inter-stream, swamp deposit, marsh clay and peat. Immediate below this section underlies 16,000 m thick sequence of quaternary sediments. Lithology shows that the area comprises of alternation of sand/silt and clay sequences.

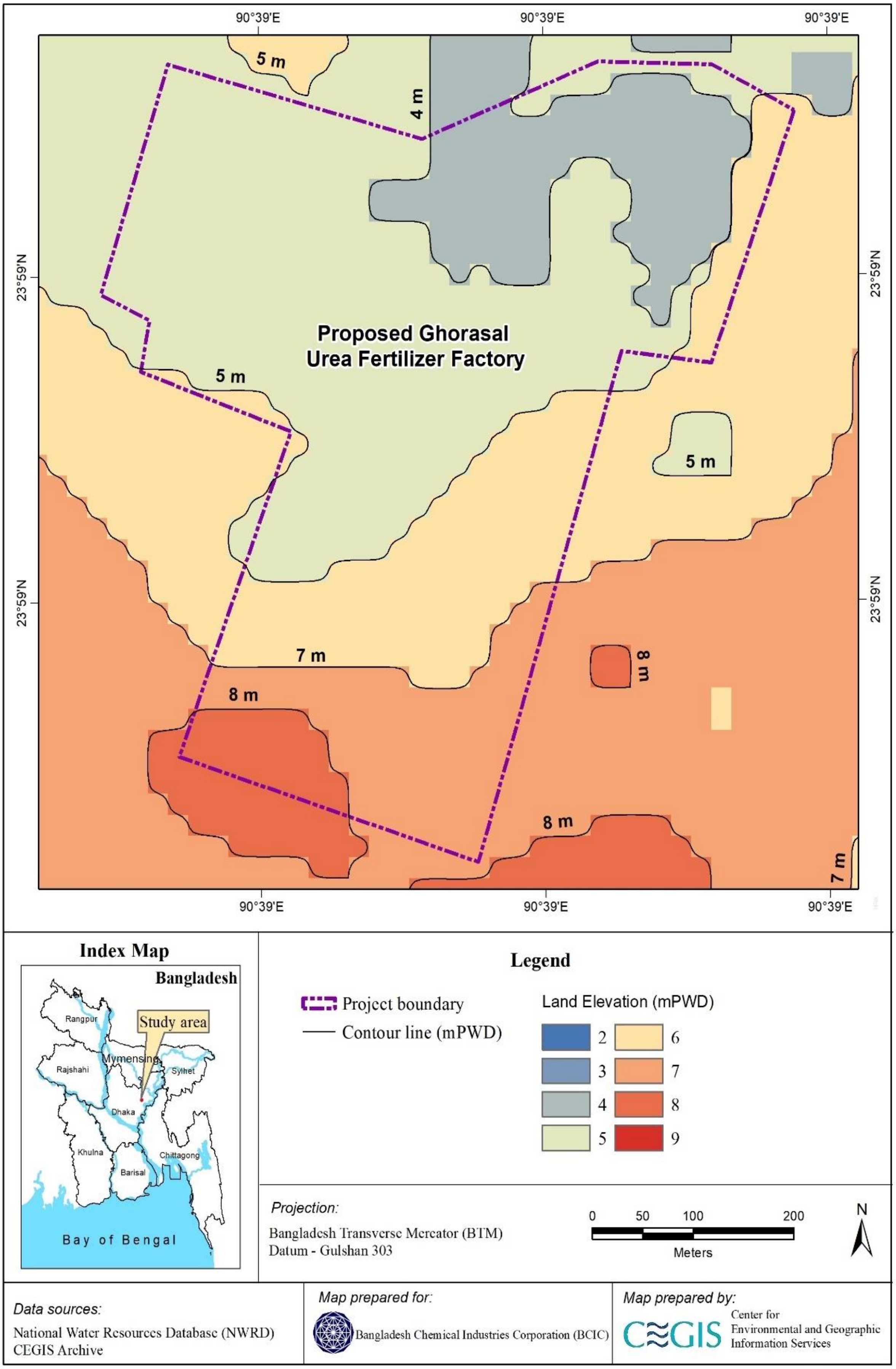


Figure 6.3: Topographic map of the proposed ProjectSite

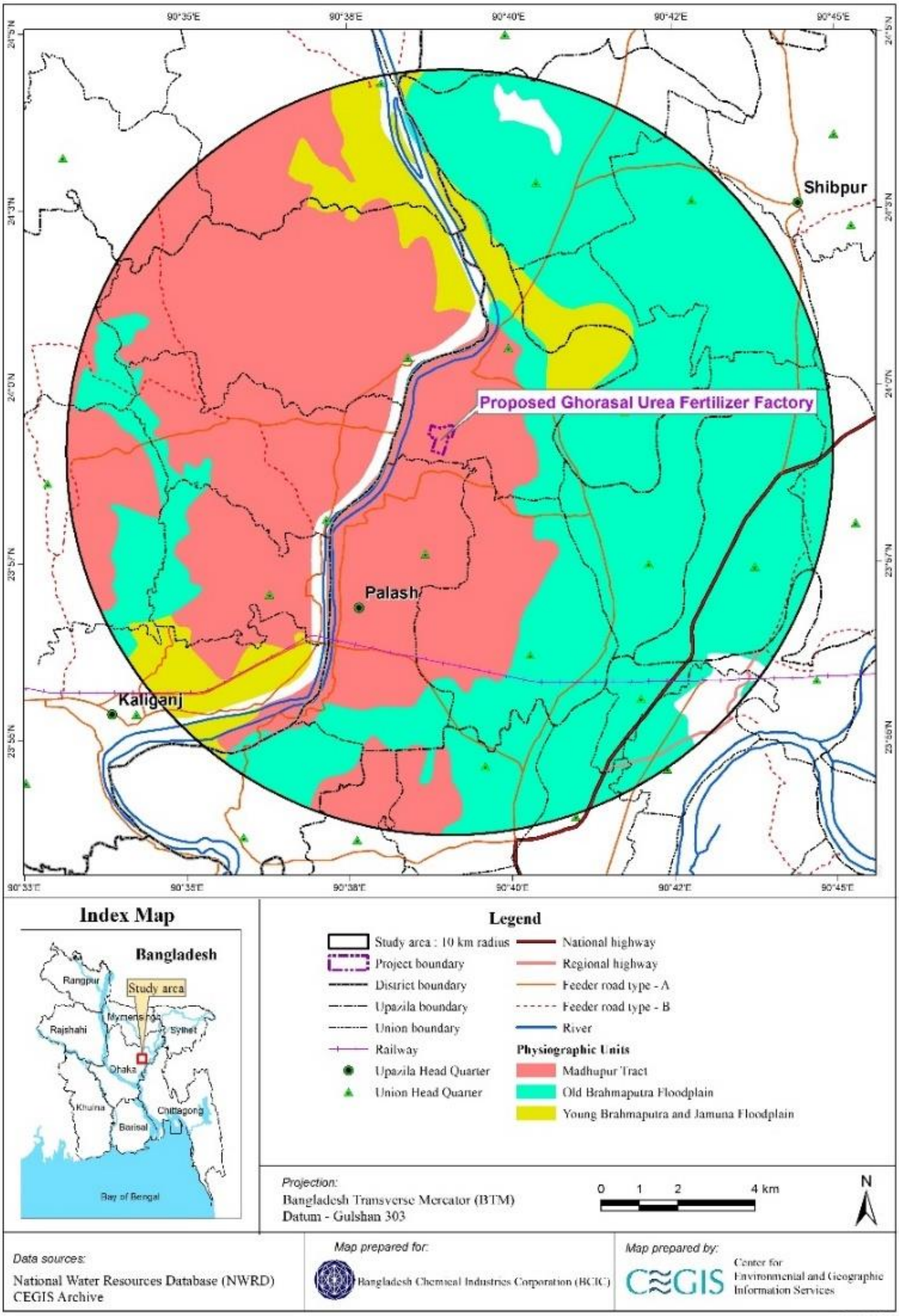


Figure 6.4: Physiographic map of the proposed Project Site

Surface Geology

394. The proposed Project site is situated on the Madhupur Tract (Figure 6.5). The surface is mostly covered with brown mottled clay,but sometimes covered with recent alluvium. The thickness of the Madhupur clay is seven to nine (07-09) meters thick. Below this layer, there is about 10,000 meters thick Tertiary sediment.

395. As per tectonic classification, the project area falls under Madhupur Tripura threshold of eastern platform flank of the Bengal basin. Tectonically this area is inactive and no apparent major structure like fault or fold exists in the region that might be geologically significant (Figure 6.6).

Figure 6.5: General Geological map of Bangladesh showing study area

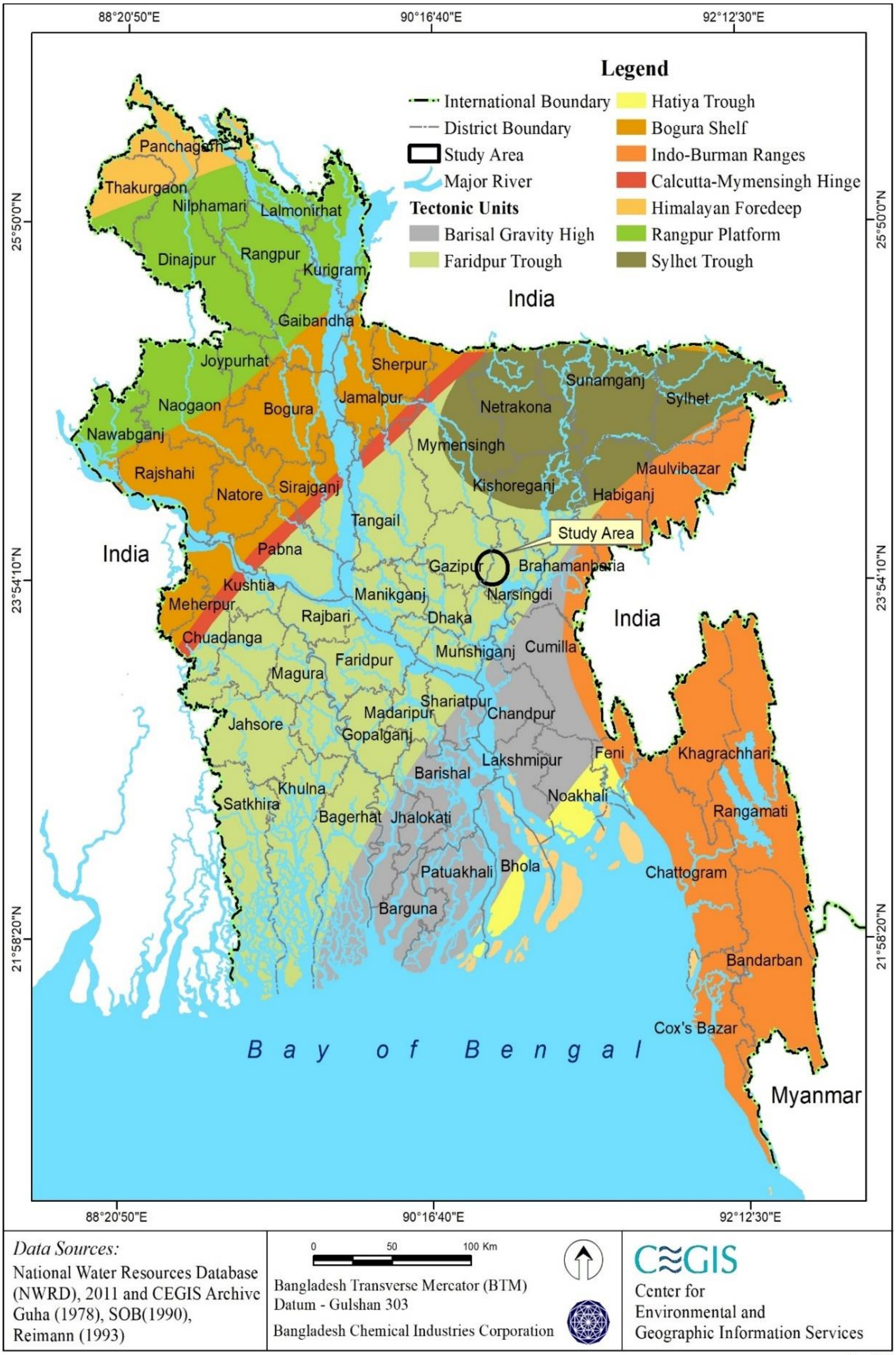


Figure 6.6: Generalized tectonic map of Bangladesh showing study area

6.2.4 Seismicity

396. Seismically Bangladesh is been divided into three zones. The country is divided into three seismic zones with zone coefficient Z equal to 0.075 (Zone 1), 0.15 (Zone 2), and 0.25 (Zone 3) g (acceleration due to gravity) (BNBC Map 1993).

397. The proposed GUFFP falls under zone-2 (Figure 6.7). This zone has the mediocre vulnerability for earthquake in Bangladesh with a risk of possible earthquake of magnitude 6 (on Richter scale).

Figure 6.7: Seismic zoning map for Bangladesh

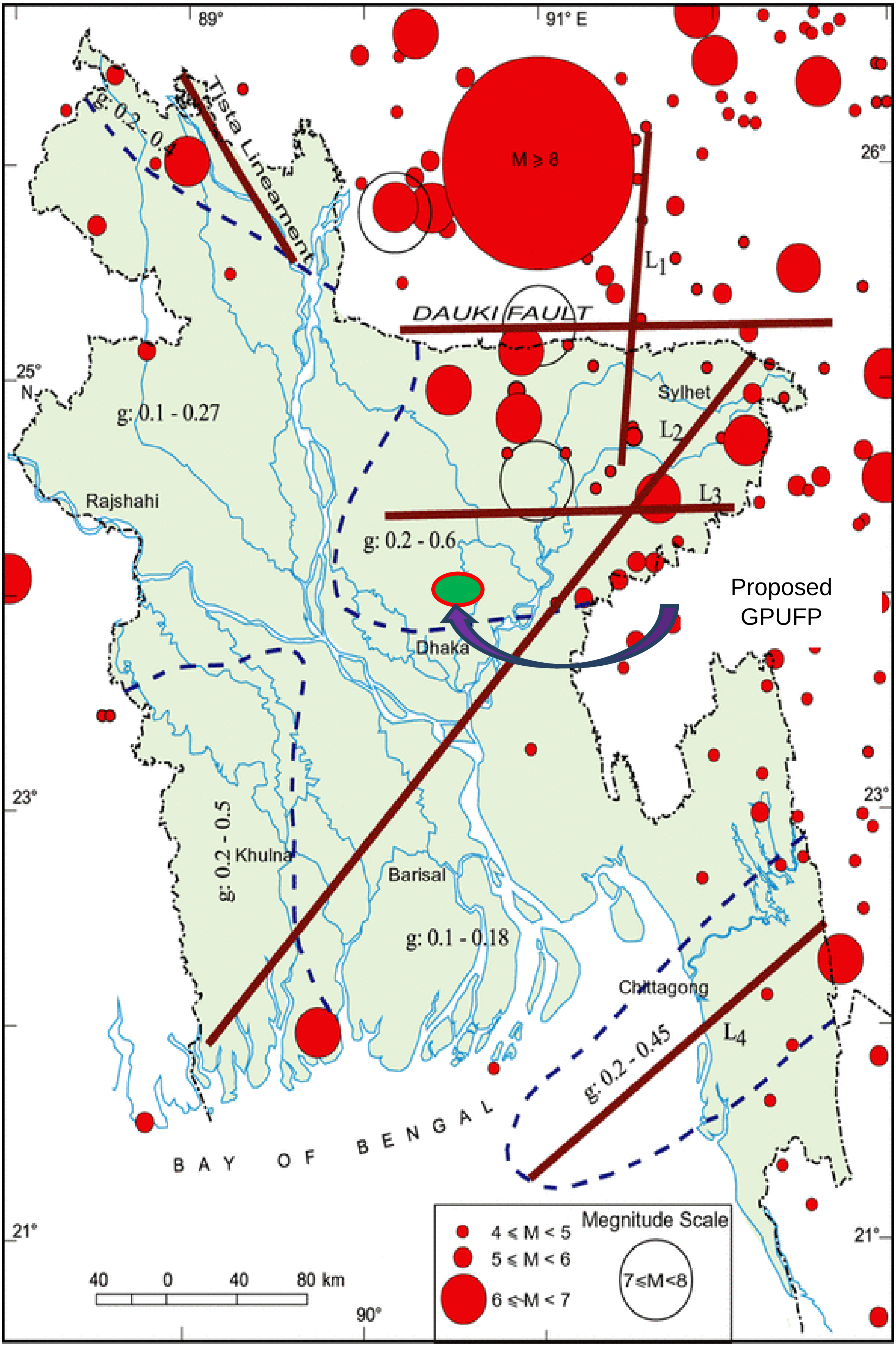


Figure 6.8: Seismic intensity map of Bangladesh showing project site

398. Details of seismic intensity and the historical records of earthquakes in and around Bangladesh are presented in Figure 6.8 and Table 6.5.

Table 6.5: List of major earthquakes in past 450 years

Sl. No.	Year	Source Area	Magnitude(Richter Scale)	Depth(km)
1	1548	Sylhet	-	-
2	1664	Shillong-Plateau	-	-
3	1762	Chittagong-Arakan	-	-
4	1858	Sandway, Myanmar	6.5	-
5	1869	Cachar, India	7.5	48
6	1885	Sirajganj, Bangladesh	7	72
7	1897	Assam, India	8.1	60
8	1906	Calcutta, India	5.5	-
9	1912	Mandalay, Myanmar	7.9	25
10	1918	Srimangal, Bangladesh	7.6	14
11	1930	Dhubri, India	7.1	60
12	1934	Bihar, India-Nepal	8.3	33
13	1938	Mawlaik, Myanmar	7.2	60
14	1950	Assam, Himalaya	8.6	25
15	1954	Manipur, India	7.4	180
16	1975	Assam, India	6.7	112
17	1984	Cachar, India	5.7	4
18	1988	Bihar, India-Nepal	6.6	65
19	1997	Sylhet, Bangladesh	5.6	35
20	1997	Bangladesh-Myanmar	5.3	56
21	1999	Maheskhali, Bangladesh	4.2	10
22	2003	Rangamati, Bangladesh	5.6	-
23	2011	Sikim, India	6.9	-
24	2015	Nepal	7.8	-
25	2015	Nepal	7.3	-

https://www.observerbd.com/2016/01/05/129456.php

399. Although several earthquakes of magnitudes 4 to 7 were reported in neighboring locations, no major earthquakes were reported in the proposed study area. However, the possible effects of a high magnitude earthquake in adjacent locations should not be overlooked and soil engineering properties at the project site needs to be examined in detail.

6.2.5 Water Resources and Hydrology

400. Polash area has become the potential industrial hub for its strong and favorable industrial infrastructure. About 28% of industrial product and its raw material of Bangladesh comes from Polash industrial zone. All the industries need water for their production purposes. The sources of water for the industries are mainly groundwater, surface water and rain water. The surface water sources includes river, khals and waterbodies (e.g. Baor, Lake, Perennial Beels etc.). However, the industries are using the surface water from the Shitalakha River.Total length of the Shitalakha River is about 110.9 km where in the study area it covers 22.6 km. There are other waterbodies like Baor, Lake, Perennial Beels, Rivers and Khals. The description of waterbodies under the study area is given in the Table 6.6 and methodology of data collection is given in Table 6.7. Further, the spatial distribution of water resources system has been presented in Figure 6.9.

Table 6.6: Breakdown of study area waterbodies

Water Bodies	Area (Ha)
Baor	68
Lake	12
Perennial Beels	69
Ponds	15
Rivers and Khals	653
Grand Total	**817**

Source: NWRD of WARPO archived in CEGIS

Table 6.7: Methodology to collect data on water resources

Parameter	DataSources	Methodology
SurfaceWaterhydrology		
Dryand wet seasonwaterlevel	BWDB	Mean monthlywaterleveldatahas beencollectedfromBWDBdatabase
Drainagesystem	CEGIS	Data has been gathered through image analysis and physical observation
Groundwaterhydrology		
Watertable	BMDand fieldinvestigation	Data has been collected from secondary sources and from different locations of the studyarea.

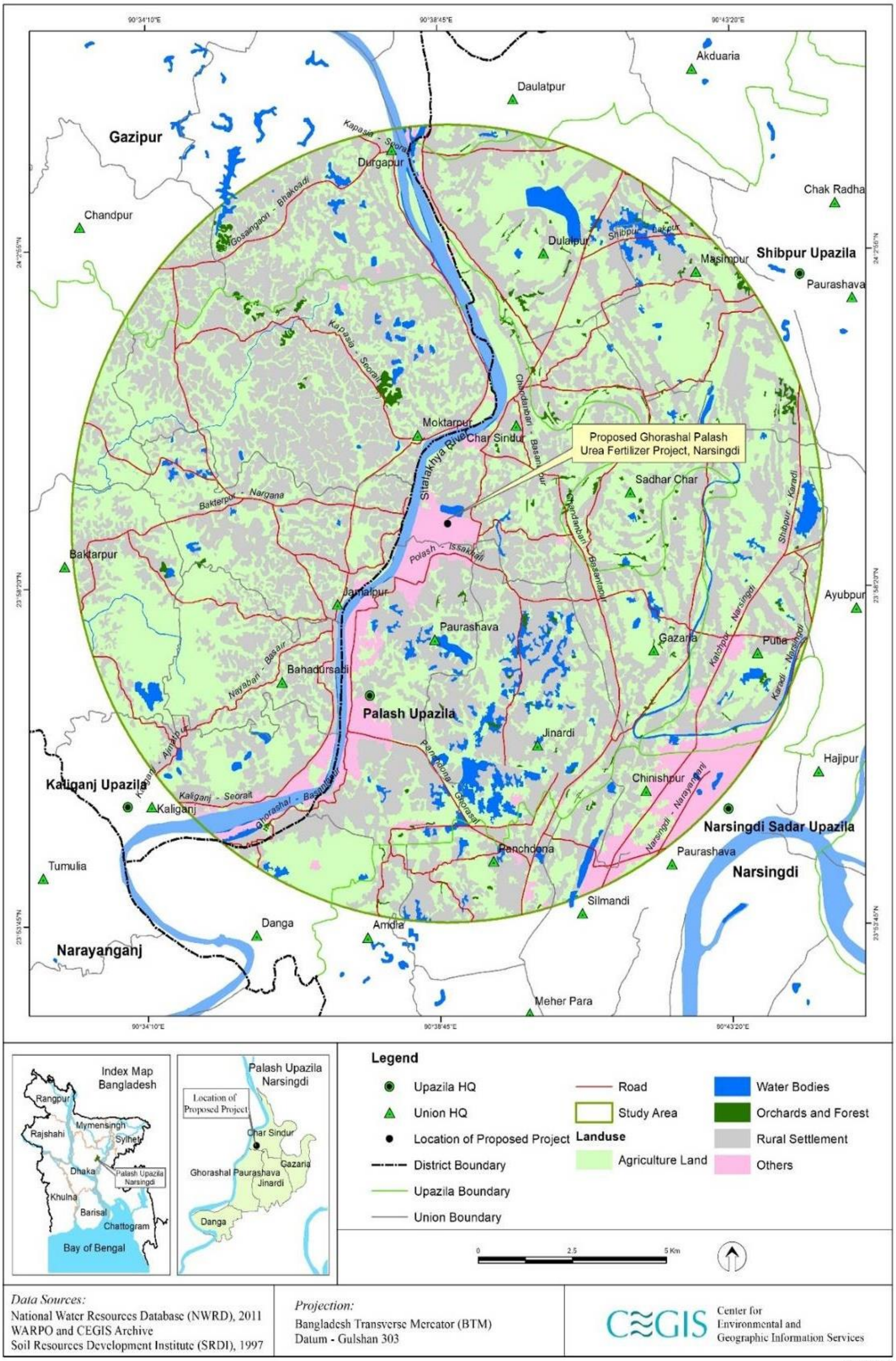
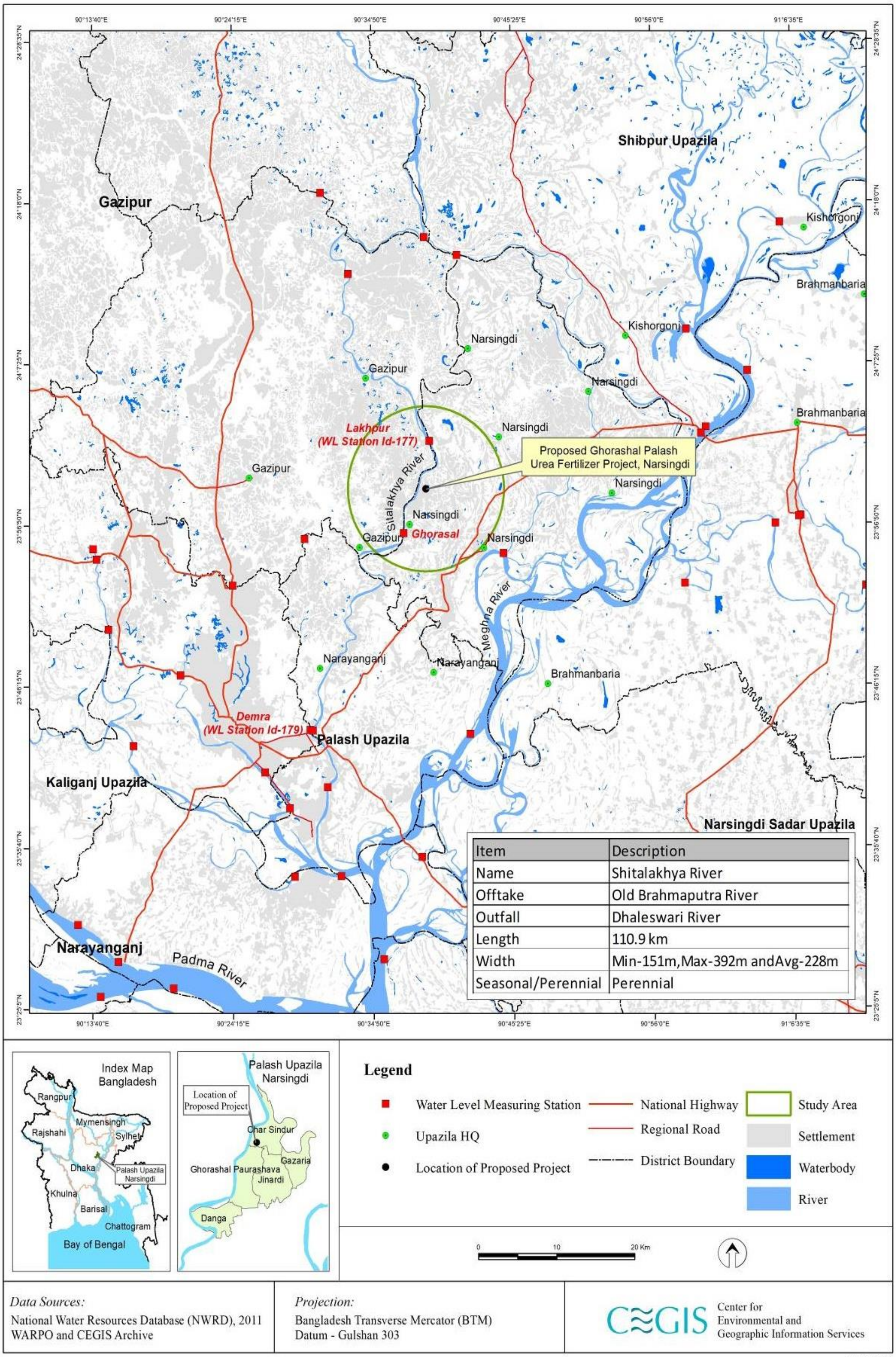


Figure 6.9: Water resources system



Item	Description
Name	Shitalakhya River
Offtake	Old Brahmaputra River
Outfall	Dhaleswari River
Length	110.9 km
Width	Min-151m, Max-392m and Avg-228m
Seasonal/Perennial	Perennial

Figure 6.10: Water level measuring station of BWDB

Surface Water Resources

401. The Shitalakhya River flows in close proximity of the proposed site of the project, is a distributary of the Old Brahmaputra River (Figure 6.9). It receives fresh water flow from the Old Brahmaputra and the Lower Banar River. The off-take of the Shitalakhya River is Old Brahmaputra River at Monohordi Upazila under Narsingdi district and drains into the Dhaleswari River in Narayanganj district. Due to the desertion of the original link to the Old Brahmaputra River, the Shitalakhya River receives most of its freshwater flow presently through the Lower Banar River as shown in Figure 6.9. The relatively inert geo-morphological characteristics of the Shitalakhya River ensures fairly suitable water depths for navigation, throughout the year.

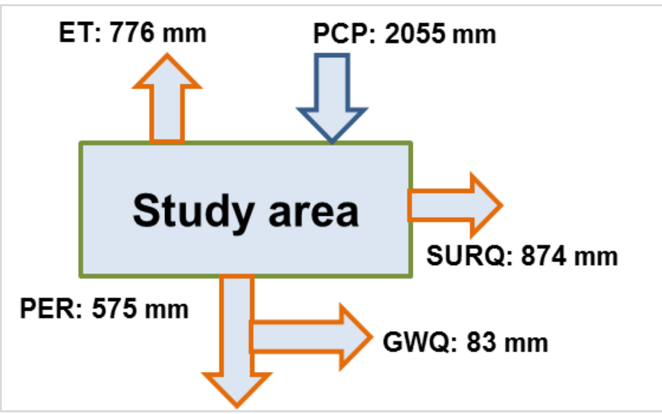
Surface Water System

402. The Shitalakhyais a tidal river and the maximum average variation of water level is 20 cm between high tide and low tide. The river is perennial in nature and BWDB data reveal that the average lowest discharge is during dry season (January) with a flow of 83 m^3/s and the average lowest water level during low tide is 0.94 mPWD close to the study area (Time series data analysis: 1981-2017). The average highest flow is observed during the rainy season (Jul- Sept) and varies from 1,181 m^3/s to 1,066 m^3/s and the average maximum water level during the high tide is 6.62 mPWD. There is no other significant surface water system found around the project area except the Shitalakhya River.

403. The river inundates nearby agricultural lands during monsoon and remains navigable round the year. The tendency of the river erosion is very low. Based on water availability and navigation facilities, a large number of industries were established along its banks both up and downstream. Bangladesh Inland Water Transport Authority (BIWTA) declared this river as a class III route of Bangladesh asthe relatively inert geo-morphological characteristics of the Shitalakhya River guarantee fairly suitable water depths for navigation, throughout the year.

Water Balance during Base Condition (1981-2017)

404. Water balance is the assessment of water resources and its use in the system. The main principle of water balance is that the difference between total incoming water and total losses should equal to the storage change in the system. The calibrated and validated model has been simulated for the period of 1981 to 2017 to estimate the availability of water for the study area. The simulation results of the annual and monthly water balance for the study area are shown in Figure 6.11.



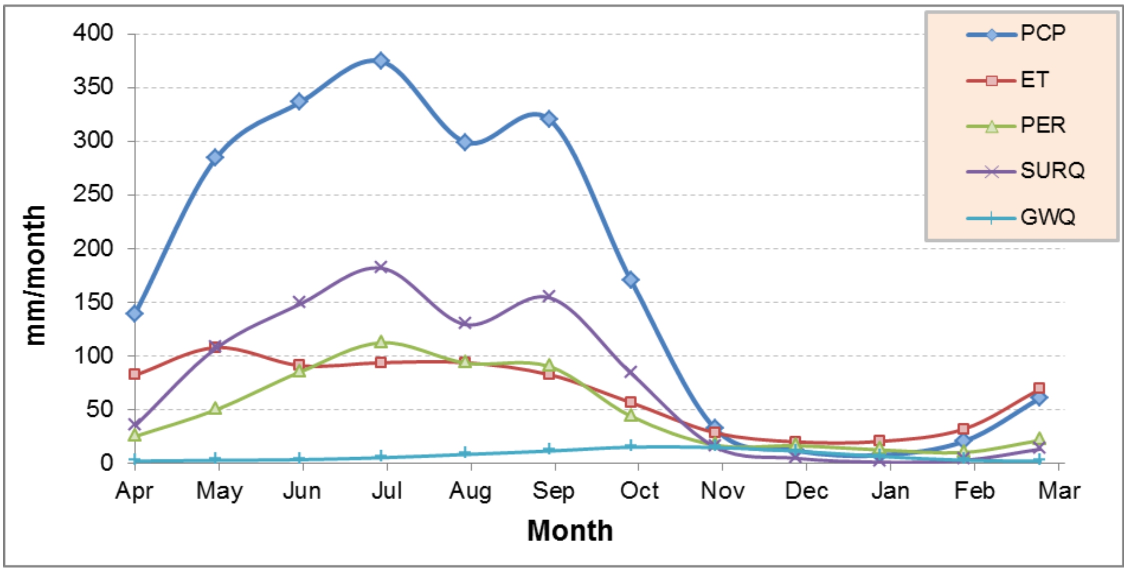


Figure 6.11: Water balance of the study area (a) annual and (b) monthly for the period 1981-2017

405. The average annual rainfall is 2,055 mm. The monsoon starts from April and reaches its peak in July. There is a decreasing trend of rainfall during the month of August, a slight increase in September and then rapidly decrease again. The maximum monthly precipitation is about 375 mm.

406. Rainfall in watersheds/catchments is the main inflow whereas the evapo-transpiration and percolation and other abstractions are losses. The balance contributed into the river as surface runoff and subsurface flow. The annual actual evapo-transpiration of the area is 776 mm which is 37% of the annual rainfall. The evapo-transpiration is maximum during April and May and which is about 107 mm per month. The evapo-transpiration rate is minimum during November to February. The percolation rate for the study area is 575 mm per year which is 28% of the annual rainfall. The percolation rate follows similar trend like rainfall and the maximum rate is 112 mm per month. After the losses of water through evapo-transpiration and percolation, the remaining water contributes to stream flow as overland flow and lateral (subsurface) flow. Around 43% (874 mm) of rainfall contributes to stream flow through surface runoff while the lateral flow is negligible only 83 mm.

Water Level Analysis

407. The Shitalakhyais a tidal river where the dry season tidal range is about 20 cm which reduces to a few centimeters during the monsoon. The average maximum and minimum water level varies seasonally from 5.42 m to 1.15 m in Dermra Station and 5.95m to 1.28 m in LakhpurStation of BWDB respectively at the project site during the base condition. Generally, the river reaches its highest water level in the months between July and September and the lowest in the months between January and March. The water level measuring stations of the study domain is given in Figure 6.10. Water level data of Demra and lakhpur stations are given below in Figure 6-12 and in Figure 6-13 respectively.

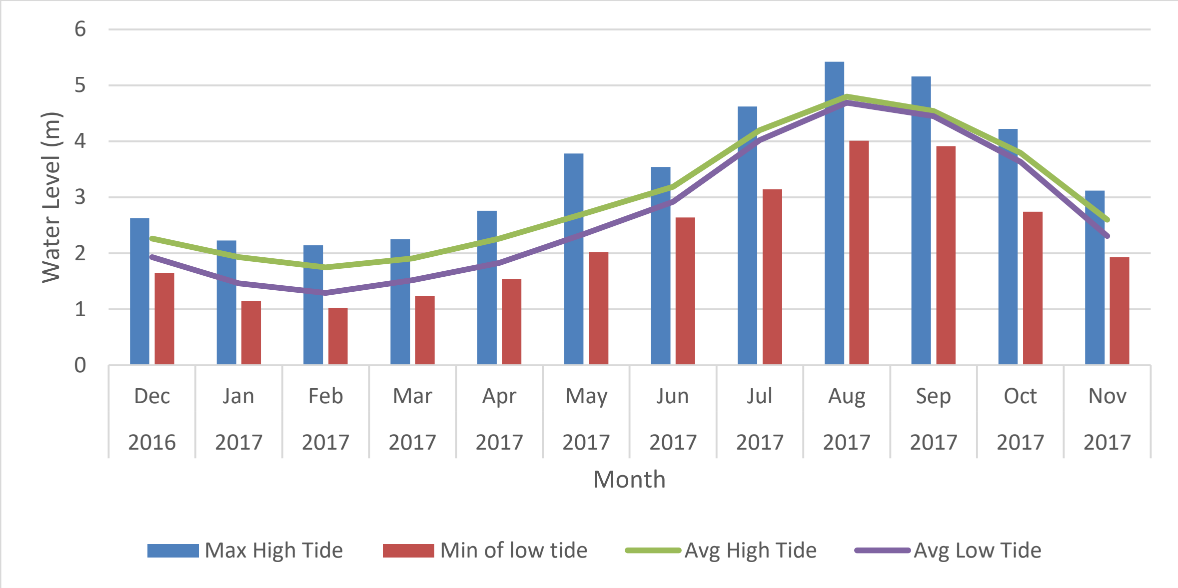


Figure 6.12: Water level at Demra station in 2017

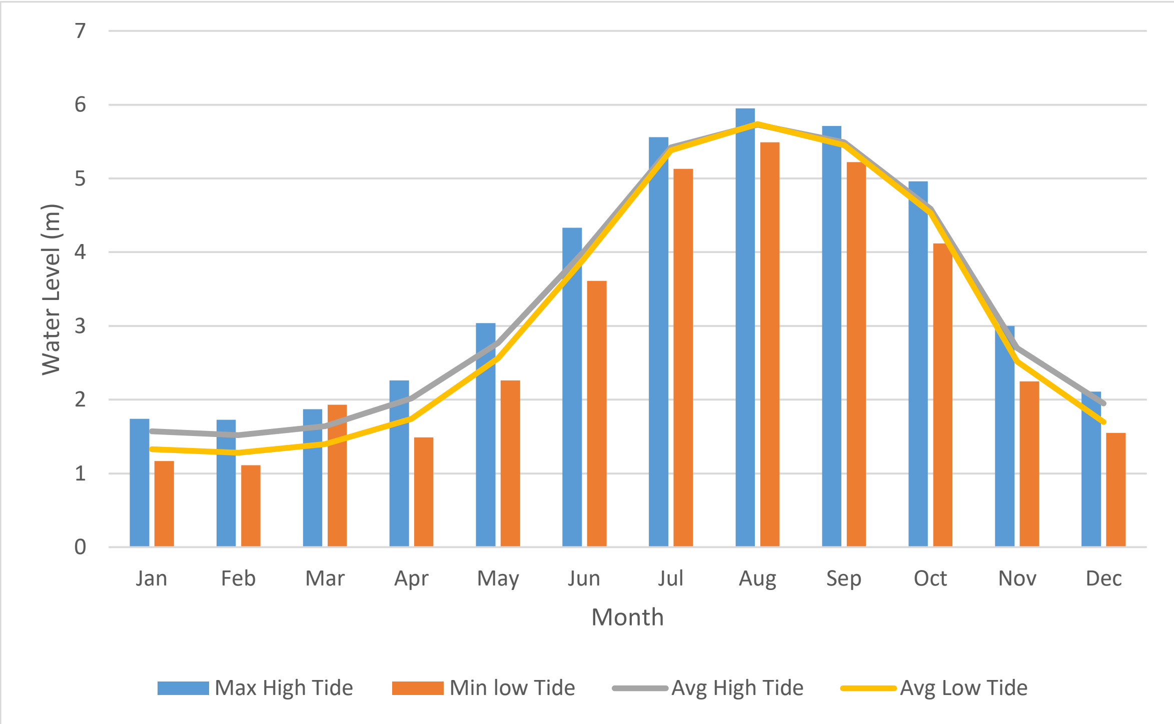


Figure 6.13: Water level at Lakhpur station in 2017

Discharge analysis

a) Average Seasonal Flow (1981-2017)

408. Theannual discharge distributed seasonally in Shitalakhya is about 7% (980 Mm^3) in dry (December-March), 6% (842 Mm^3) in pre monsoon (April-May), 72% (10,545 Mm^3) in monsoon (June-September), and 16% (2,300 Mm^3) in post-monsoon (October-November) seasons. The flows are mainly concentrated during the monsoon period (highest) and pre monsoon (lowest), as shown in Figure 6.14.

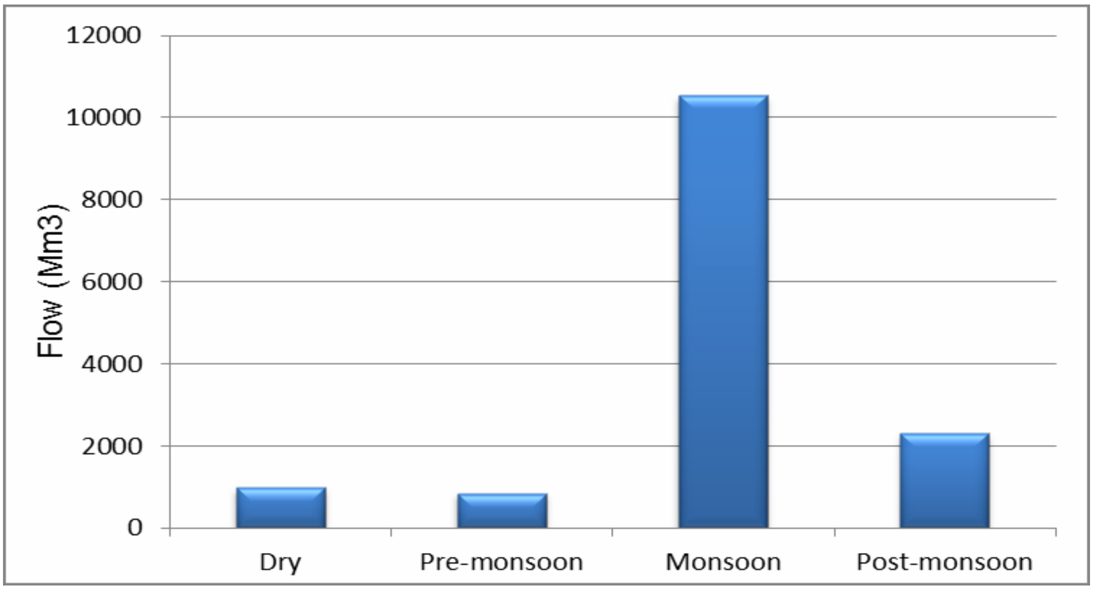


Figure 6.14: Average seasonal outflow from the basin during 1981-2017

b) Historical Annual Flow (1981-2017)

409. From thehistorical annual flow of the study area it is found that the outflow of the basin has been reduced gradually after 2000. Before 2000, the annual flow was 16,000 – 22,000 Mm^3 while it has been reduced to 9,000 – 14,000 Mm^3 in the recent years.

c) RiverWater Flow and UFFL and PUFFL

410. Itis estimated that the environmental flow of the Shitalakhya River is about 92.2 m^3/s and average dry season flow is about 83 m^3/s. The existing UFFL and PUFFL fertilizer factories of the Ghorasal have been withdrawing a total of about 0.5833 m^3/s (2,100 t/h; UFFL-1100 t/h and PUFFL-1000 t/h) from the Shitalakhya. The proposed GPUFP will require 0.5667 m^3/s (2,040 t/h, Gross intake), which is only 0.61% of the environmental flow and only 0.68% of the average dry season flow of the Shitalakhya River.

411. Waste water from the fertilizer factories are disposed to lagoons and it creates adverse effect on the components of the ambient environment. NH^3 mixed water injects into the lagoon and after dilution and settling down, this water discharges intothe Shitalkhya River without due treatment. So, this contaminated water also harms the aquatic fauna and degrading the naturality of the Shitalakhya River. Gradually, it hampers the Aquatic Ecosystem of the Shitalakhya River. It also causes a number of diseases (e.g., respiratory problem, vomiting, belly swollen, etc.) among the villagers who lives nearby the lagoon.

d) Navigability of the Project Site River Section

412. Afteranalyzing the average minimum water level of 1981-2017and longitudinal profile of the river, it is found that throughout the year the Shitalakhya maintains a minimum of more than 4 m depth in the whole reach of the river as shown in Figure 6.15. The relatively inert geo-morphological characteristics of the river made fairly suitable water depths for navigation. Moreover, due to its lesser fluvial activity, riverbank erosion is negligible and shifting of the thalweg or navigation channel from one bank to the other is not dynamic in nature. These characteristics of the river have facilitated the growth of industries, commercial centers, power plants and fertilizer factories on either side of its banks. The chainages

(Ch0.00kmatLakhpur;Ch8.40kmnearUFFLandCh47.65kmatDemra) are considered for analyzing long profile of the river section.

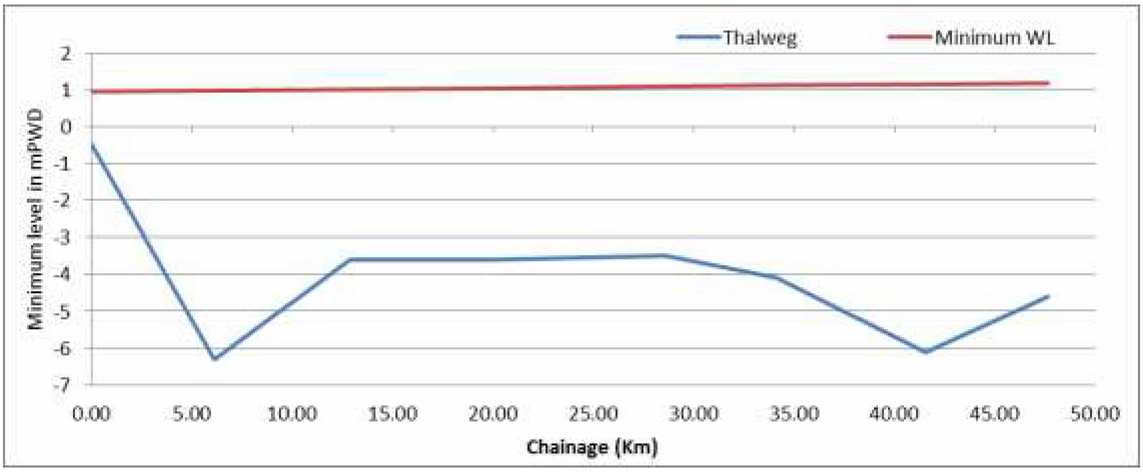


Figure 6.15: Long profile of the Shitalakhya River from Lakhpur to Demra

Groundwater Uses

413. InUFFL and PUFFL, Ground water abstracted by deep tubewell is usually used in the colonies as potable use while potable purpose in the Factory is met up by treated river water. Some treated river water is also used as potable water in the colonies. It is reported from the DPHE that the average depth of the shallow tube well in the project area is 61 m (200 ft). BWDB data reveals that groundwater level of Polash Upazila is about 6.5 m below the ground surface. Drawdown effect of groundwater is started at Ghorasal area due to extensive withdrawal by the industries and the local inhabitants. Now-a-day, people around the factory area are using not only hand pump but also using motor pump to extract Ground water below 50-60 m from the ground level.

6.2.6 Hazards

Natural Hazards

414. Bangladesh is a natural hazard prone country due to its geographical and deltaic location. In addition to that, the land characteristics of the country, its climatic condition and the impact of climate change make the country more vulnerable to natural hazards. The mostly occurred natural hazardsare: cyclone with storm surge, tornado, flood, coastal andriver bank erosion, landslides, water logging, drought and earthquake. However, the hazard profile is different for different parts of the country.

415. The location of the proposed Project site is situated in the central zone of the country. Analyzing the location, it is observed that the nearby Shitalakhya River is not very much sand braided river and the bank of this river is comparatively less erosion prone. Additionally, the topographyof the Project site indicates that it is not situated in the floodplain and therefore, the site is not very much prone to flood either. Landslides occurs only in the hilly areas of Bangladesh which is far away from the project site. On the other hand, the coastal region is mostly prone to cyclone and storm surges and coastal erosion. Moreover, the North-Western part of the country is prone to drought due to the scarcity of water. According to the seismic zone, the Project site falls under Zone-II which holds the middle class of risk with seismic

coefficient of 0.15 among the three zones. Although the Project site is at the middle class of risk zone, earthquake hazard is more of a regional concern than that of the local, as Bangladesh is surrounded by regions of high seismicity. It should be mentioned, that the tectonic activities of thesurrounding regionsbeyond the border are the main causes of frequent earthquake in Bangladesh.

Chemical Hazards (Health Concern)

416. There are two Urea fertilizer factories located in the Project Site. Hazardous situations can occur due to hoses coming loose or bursting when the chemicals/materials are being transferred from one tank to another. Personal exposures to ammonia and acute respiratory effects were reported in workers at the factory. Urea plant workers had higher mean exposure to ammonia and prevalence of acute respiratory symptoms than did workers in the ammonia plant. The symptoms with highest prevalence in the urea plant were chest tightness and cough. Forced vital capacity (FVC) and Forced Expiratory Volume (FEV1) decreased significantly across the work shift among urea plant workers. The higher level of exposure to ammonia in the urea plant was associated with an increased prevalence of respiratory symptoms and an acute decline in lung function.

417. On the other hand, there are two gas-based captive Power Plants (8 MW each) for the daily electricity use of the existing fertilizer factories. As the Power Plants are natural gas based, hence, formation of SO_2 is insignificant and pollution of air is negligible.

6.2.7 Climate and Meteorology

418. The project Site is located in Dhaka Division. According to Köppen Climate classification, it falls under ‘Aw’ category which is characterized by tropical wet and dry climate. Here, it experiences hot and humid summer and dry winter. According to climate characteristics, Bangladesh is divided into 7 different climate sub-regions. The study area of the project falls under “G”, which is the south-central climate zone of the country (Figure 6-16).

Figure 6.16: Climatic zone of the proposed Urea Factory

419. The summary of the analysis of the climatic and meteorological parameters are discussed in the following sections:

Temperature

420. Temperature data of Dhaka Station from Bangladesh Meteorological Department (BMD) for 34 years (from January 1987- December 2017) has been analyzed to see the monthly variation of the maximum temperature which is between 28.48^{0}C to 37.14^{0}C. The monthly variation of the minimum temperature is 9.5^{0}C to 24.9^{0}C. The maximum recorded temperature in Dhaka station was 39.6^{0}C, which occurred on March, 1999 and April, 2009. On January 1995, the minimum temperature was recorded as 6.5^{0}C in Dhaka. The warmest month of the year is April and the coldest month of the year is January. Figure 6.17 shows the maximum, minimum, average of maximum and average of minimum temperature of Dhaka station from 1987 to 2017(Source: BMD).

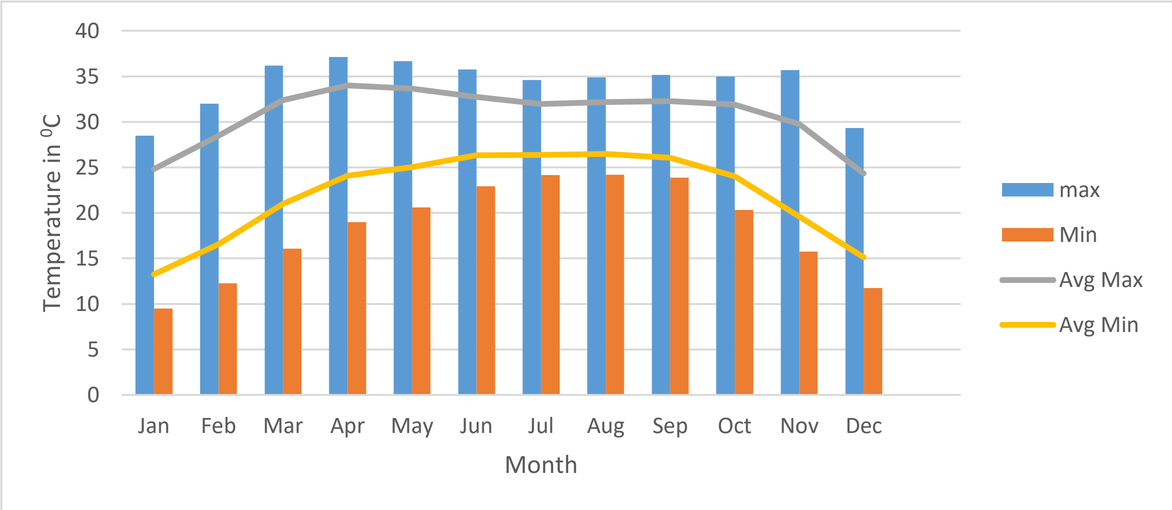


Figure 6.17: Monthly maximum, minimum and average temperature (1987-2017)

Rainfall

421. Monsoon is a prominent season in this area. The average monthly rainfall during monsoon (June-September) season from 1980-2017 is 332 mm/month. The variance in the maximum rainfall during monsoon season is 836 mm/month to 552 mm/month, whereas the variance in the minimum rainfall is 136 mm/month to 59 mm/month. The maximum 836 mm/month rainfall was recorded during September of the year 2004. Annual average rainfall is 2066 mm/year and the highest recorded yearly rainfall was 3028 mm in the year 1984. The driest period of the year is winter when the average monthly rainfall varies from 21 mm/month to 7.21 mm/month. Figure 6.18 shows the maximum, minimum and average rainfall from 1980-2017.

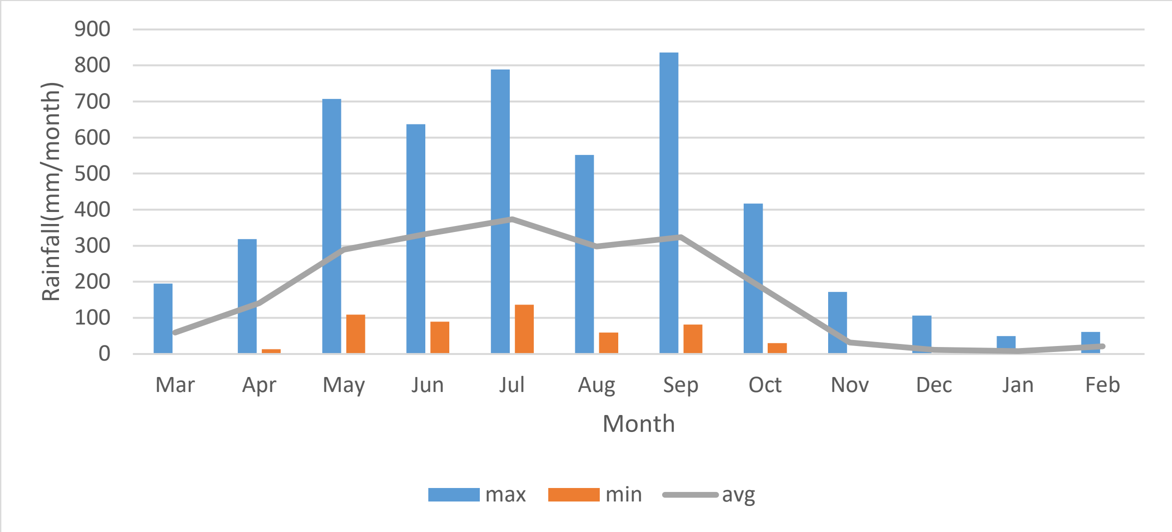


Figure 6.18: Monthly Maximum, Minimum and Average Rainfall

422. The drainage system of the area is based on the Shitalakhya River (Figure 6.19). There are many drainage canals in and around the Project site falls into the river carrying the rainfall runoff as storm water. During torrential rainfall, the drainage system of the UFFL and PUFFL sometimes fail to accommodate storm water draianing into the river. At that time, the factory premise as well as the emergency Urea stack (when fertilizer production is in peak level) on the road becomes flooded. As a result, much damage occurs to Urea pile and count substantial financial loss.

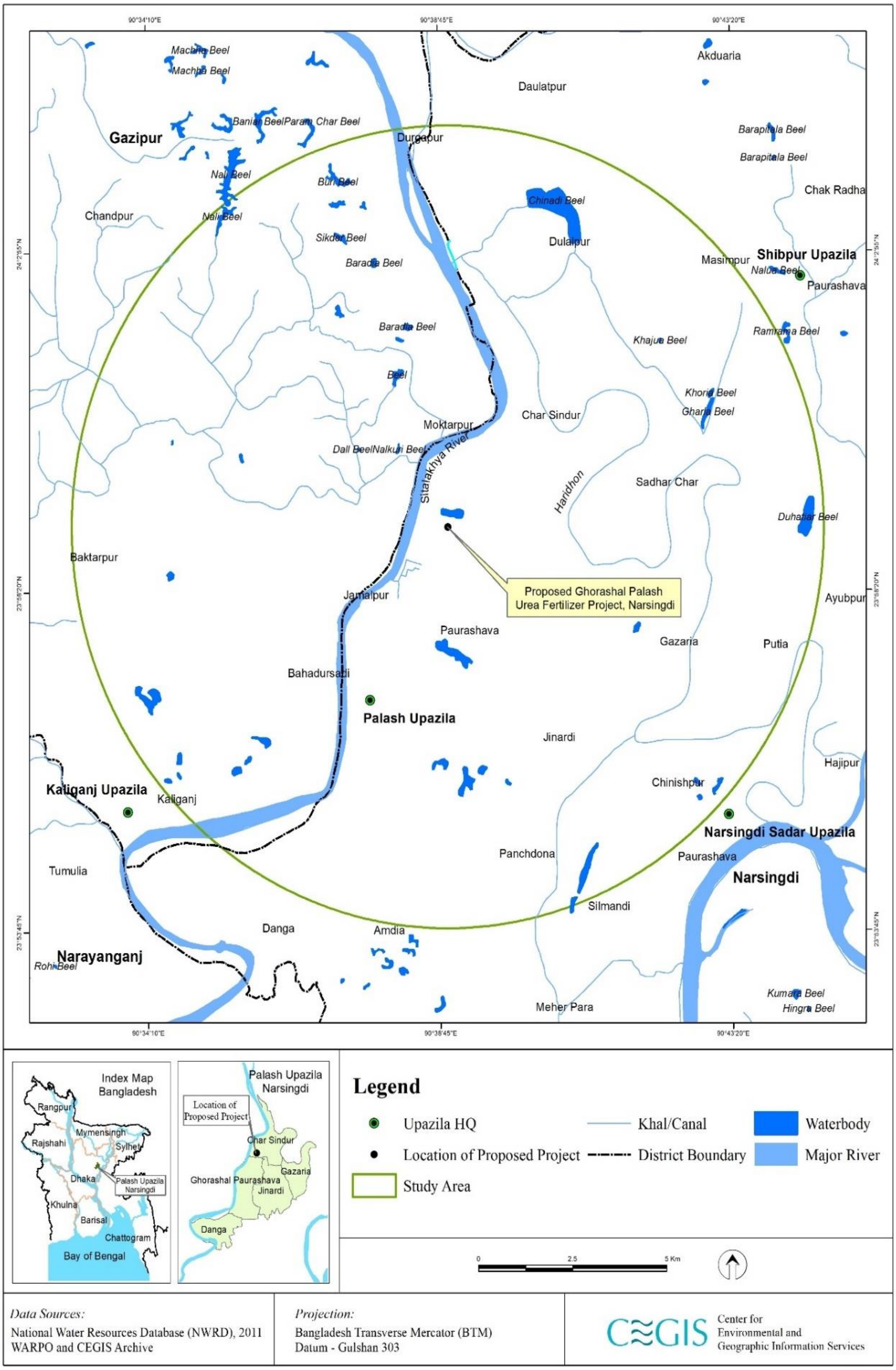


Figure 6.19: Drainage system network of the study area

Humidity

423. The average relative humidity remains higher during the monsoon season. The variance in the average relative humidity throughout the year is 82.61% to 61.29%, whereas during monsoon the variance is 83.77% to 82.40%. Figure 6.20 shows the maximum, minimum and average relative humidity of Dhaka station from January 1988 to January 2018.

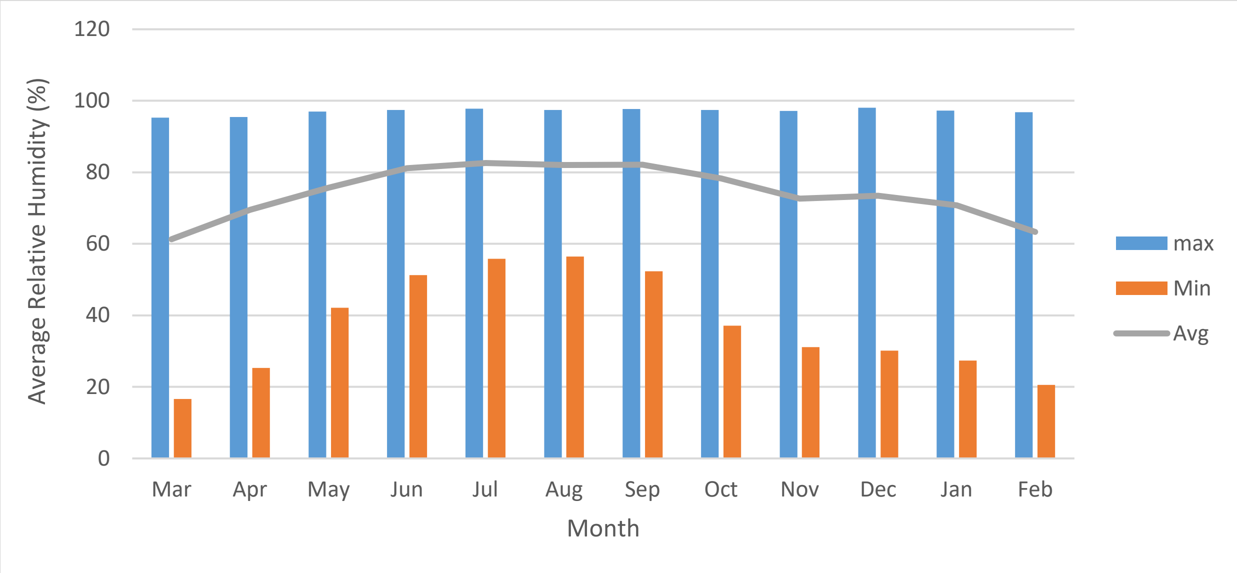


Figure 6.20: Maximum, MinimumandAverageRelativeHumidity (1988-2018)

Wind Speed and Direction

424. The direction of wind varies depending on the seasons. Therefore, whole year has been categorized into four clusters of months and these are: Cluster-1 which is called winter: December-February, Cluster- 2 which is called Pre-Monsoon: March to May, Cluster- 3 which is called Monsoon: June to September, and Cluster- 4 which is called Post Monsoon: October to November. Wind speed data and direction have been collected from the Dhaka BMD station at a height of 10 m from the ground level. During the months of clusters 1 and 4 wind direction is predominantly from northwest to southeast direction, inclined towards East and for clusters 2 and 3 it is predominantly from Suth and southeast to North and northwest. In cluster 1 calm wind prevails for 34.66% of total period, similarly it is 10.0% for cluster 2, 11.42% for cluster 3, and 53.56% for cluster 4, respectively. Figure 6.21 (a, b, c and d) presents the wind speed and direction graphically round the year.

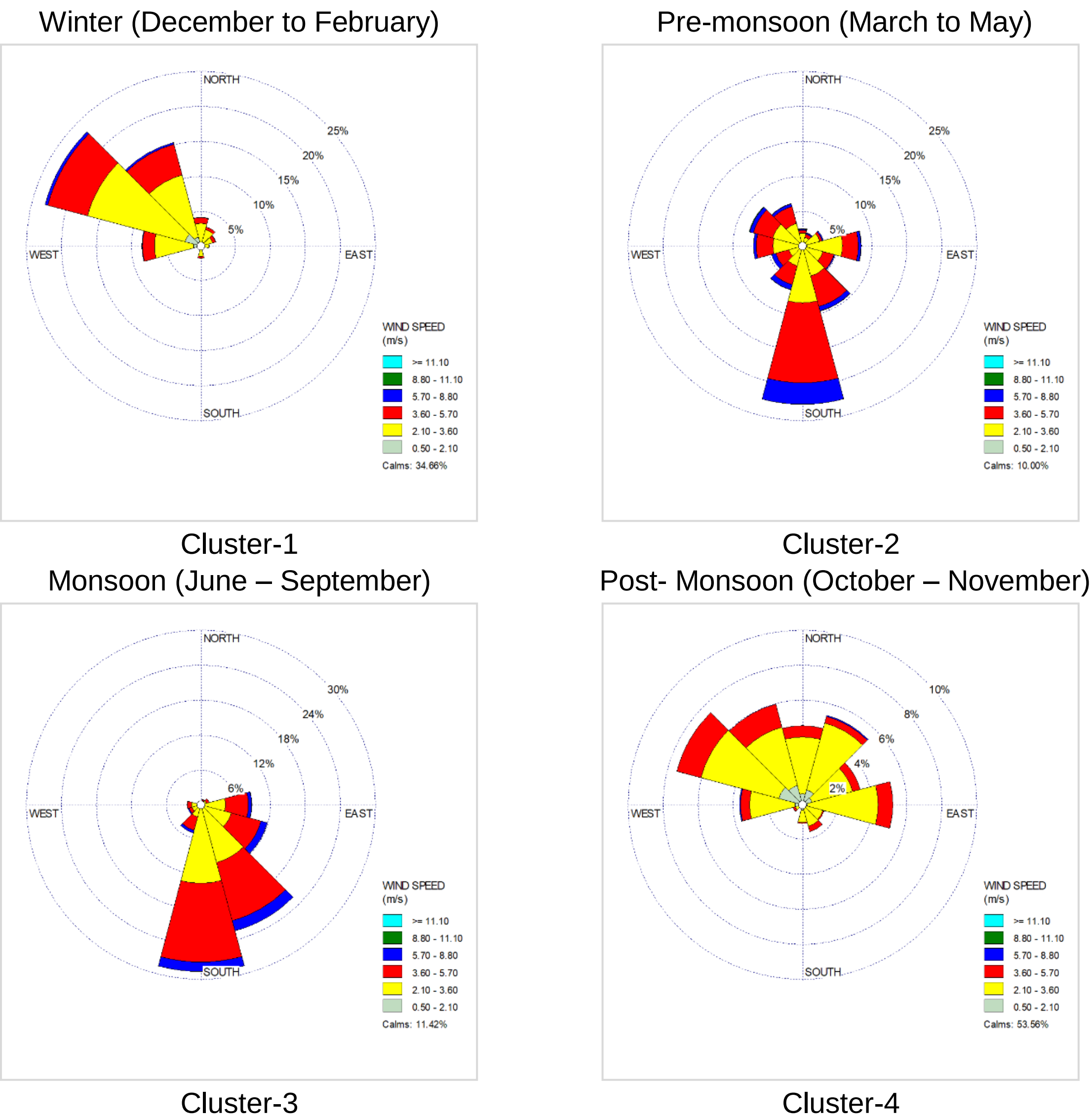


Figure 6.21: Wind rose at Dhaka station

425. The Figure 6.22 shows wind speed and direction round the year for 2018 based on data collected at Dhaka Station and calm wind prevails for 24.8 % time of the year.

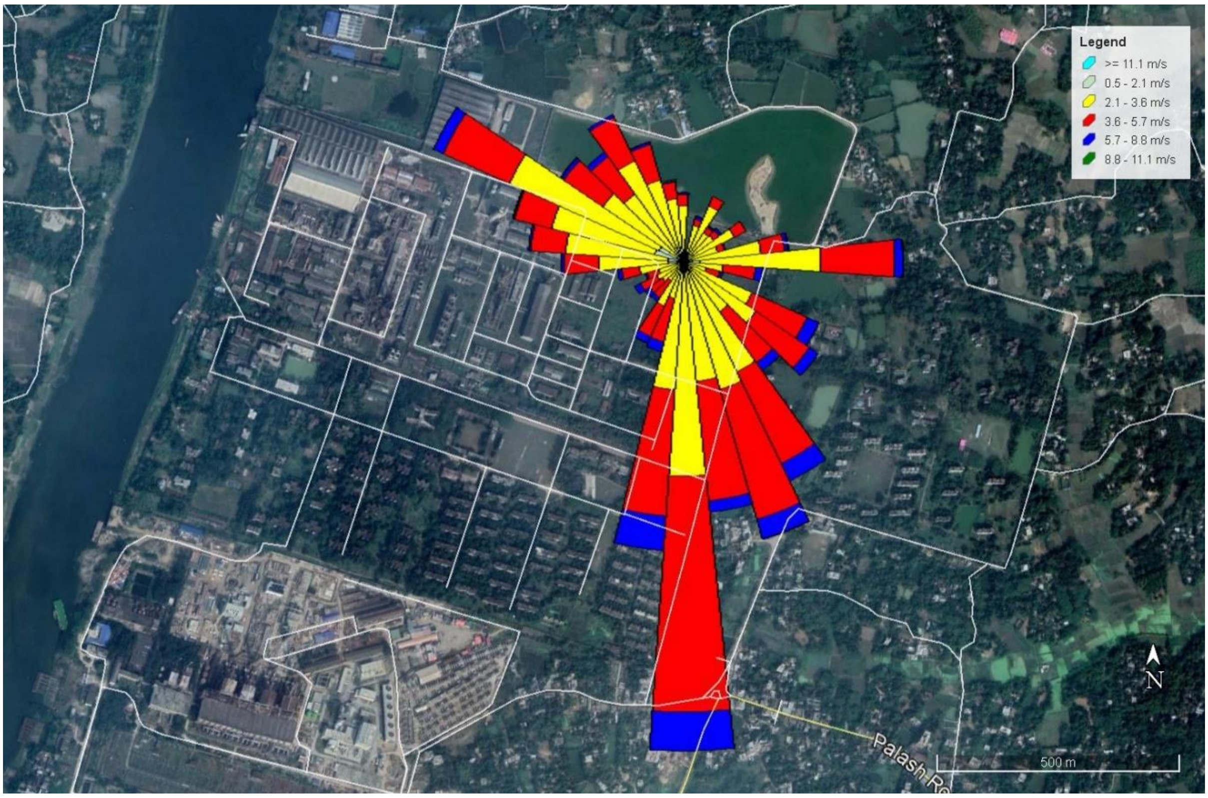


Figure 6.22: Annual wind rose for 2018

6.2.8 Ambient Air Quality

426. The ambient air quality of the airshed of the proposed Project area has been monitored primarily. A systematically designed air quality surveillance monitoring program was formed on account of impact assessment on air environment due to proposed project activities. The basic consideration for designing the air quality sampling locations were representativeness of the airshed, sensitivity of the locations, duration of monitoring and monitoring of all relevant and important pollution parameters (ECR 1997 and subsequent amendments).

427. The parameters selected for presenting the ambient air quality are Suspended Particulate Matter (SPM), Particulate Matter (PM_{10} & $PM_{2.5}$), Sulphur Dioxide (SO_2), Oxides of Nitrogen (NO_x), Carbon Monoxide (CO), Ozone (O_3), Ammonia (NH_3), Hydrogen Sulphide (H_2S) and Volatile Organic Carbon (VOC). The design of the network of ambient air quality monitoring stations in the study area was done based on the following criteria:

- Meteorological conditions basically the wind direction
- Topography on the study area
- Representation of the regional background levels
- Sensitivity of the areas
- Influence of the existing sources
- Major human settlements in the study area

428. The surrounding area of the proposed Project site is semi-urban in nature and consists of major industrial set up along with existing power plants. Considering all these factors, the existing and potential future emission sources of air quality of the project site

airshed monitoring is immensely necessary. Due to the unavailability of monitoring station at nearby the proposed Project Site, the closest CAMS No. 4 (Gazipur Station) of DoE recorded data were studied to get a general overview about the air quality in the proposed project airshed. The measured station data along with the national standards for the major air quality parameters are given in Table 6.8 below. Data results indicate that concentration of NO_2 (ppb), $PM_{2.5}$ (in µg/m^3) and PM_{10} (in µg/m^3) significantly exceeded the National Ambient Air Quality Standard during the winter months. However, the concentration of air particulate matters remain below the maximum allowable limit in the rainy season because of the flushing with rain water. It should be noted that the average rainfall during the monsoon varies between 129 mm and 388mm. The rest of the parameters were found within the permissible limit, and less likely to pose any significant health hazard to the local residents.

Table 6.8: Ambient air quality in January and July, 2018 at CAMS-4

Parameter	Unit	NAAQS	Summary	CAMS-4 (Gazipur) Lat.: 23.99N, Long.: 90.42E	
				January 2018	July 2018
SO_2- 24 hr	ppb	140	Average	1.42	15.9
			Max	4.80	35.7
			Min	0.26	3.87
NO_2- 24 hr	ppb	53	Average	45.1	1.65
			Max	76.6	3.89
			Min	16.8	0.66
CO- 1 hr	ppm	35	Average	DNA	DNA
			Max	DNA	DNA
			Min	DNA	DNA
CO- 8 hr	ppm	9	Average	DNA	1.41
			Max	DNA	2.69
			Min	DNA	0.38
O_3- 1 hr	ppb	120	Average	DNA	3.50
			Max	DNA	8.81
			Min	DNA	1.14
O_3- 8 hr	ppb	80	Average	DNA	DNA
			Max	DNA	DNA
			Min	DNA	DNA
$PM_{2.5}$- 24hr	µg/m^3	65	Average	208	28
			Max	271	74.5
			Min	123	7.76
PM_{10}- 24hr	µg/m^3	150	Average	300	52.8
			Max	423	117
			Min	203	21

Source:*DoE, 2018;* ***Note:*** *CAMS- Continuous Air Monitoring Station; NAAQS- National Ambient Air Quality Standard; ppb- Parts per Billion; ppm- Parts per Million; DNA*- Data Not Available due to malfunction of the analyzer/sensor (Source: CASE project-Monthly Air Quality Monitoring Report, January and July 2018.*

429. In addition to this air quality has been monitored in the Project site. After reconnaissance of the area and observing the topographical features and review of the available meteorological data and local conditions, the sampling sites were chosen which will be the representative of the project area airshed. A network of five ambient air-sampling locations has been selected for assessment of the existing status of air environment within the study zone (Figure 6.23).

Figure 6.23: Ambient air sampling locations

430. Monitoring stations were installed at least 15 m distance from local sources. The height of sampling points was kept between 4-6 m (free from obstructions). Ambient air quality was monitored inside the Project site for continuous 24 hours for each of the location. During sampling period, the weather was sunny and the wind direction was from North-West to South-East. Table 6.9 shows the monitoring result of the ambient air quality at the sampling locations. Maximum ambient air quality monitoring results were found within the standard limit of ECR, 1997 as well as of IFC, 2007 standard except SPM and $PM_{2.5}$. Exceedances of SPM were observed in four locations out of five locations and $PM_{2.5}$ were observed in two locations situated peripherally. In case of NOx, the IFC standard stands for annual and 1-hr where the monitoring data recorded for 24hrs. However, the ambient NOx data will be within the standard limit of IFC annual standard.

Table 6.9: Ambient air quality in the project airshed

Sampling Point	Concentration of Different Parameters in Ambient Air (µg/m^3)									
	SPM	SO_2	NO_x	CO	O_3	NH_3*	H_2S*	PM_{10}	$PM_{2.5}$	T VOC
AQ-1	257	7.4	35.2	0.38	24.6	34.8	<10	126.4	58.2	41.46
AQ-2	245.2	8.5	42.4	0.87	38.7	108.2	<10	119.4	53.5	<4.2
AQ-3	189.2	7	38.7	0.75	26.8	36.5	<10	96.7	48.6	157.1
AQ-4	293.4	9.2	48.6	0.98	37.7	733	<10	140.8	76.7	227.92
AQ-5	293.8	8.3	40.3	1.15	30.5	173.5	<10	145.2	74.8	59.37
ECR, 2005	200	365	100	10000	157	3480	280	150	65	-
	8-Hr	24-Hr	Annual	8-Hr	8-Hr	Max	Max	24 Hr	24 Hr	-
IFC, 2007	-	20	40	-	100	-	-	150 (IT-1)	75 (IT-1)	
		24 Hr	Annual		8-Hr	-	-	24-Hr		

Source: *Field measurement done by CEGIS, 2019;* ***Notes:*** **Schedule – 8(Standards for Odor) of ECR 1997 has been used; This monitoring was conducted by - Respirable Dust Sampler (Model-Envirotech India APM-460BL) and Fine Particulate Sampler (Model-Envirotech APM-550).*

431. The monitoring results are a good representative of the status of the proposed Project airshed. Presently, the area is semi-urban in nature and consists of major industrial set up along with existing UFFL and PUFFL, Power Plants and brick kilns etc. Existing road dust from the paved and unpaved road, vehicular movement, emission from the fertilizer and power plant industries, pollen, emission from the lagoons and windblown dust from agricultural lands and exposed earth, domestic cooking are the potential sources of air pollution at present.

6.2.9 Odor

432. Odor can be defined as the “perception of smell” or in scientific terms as “a sensation resulting from the reception of stimulus by the olfactory sensory system” (CPCB 2008). Whether pleasant or unpleasant, Odor is induced by inhaling air-borne volatile organics or inorganic component. Odor emission often consists of a complex mixture of many odorous compounds but for fertilizer factories ammonia (NH_3) is the main chemical components that produce strong pungent smell for the human.

433. In ECR 1997, the major chemical constituent of odor are identified and fixed their limit at Schedule-8 which has been shown in Table 6.10 especially for NH_3.

Table 6.10: Standard for Odor of ECR, 1997: SCHEDULE- 8

Parameter	Chemical Formula	Standard Limit (in ppm)
Ammonia	NH_3	1 – 5

434. Odor is one of the major environmental and social problem encountered by the local inhabitants living adjacent to the existing Fertilizer Factories. Particularly, those communities who live around the Lagoon are experiencing serious nuisance by the odor of NH_3.

435. Because of the significant environmental hazards of NH_3, National Pollutant Inventory, (DEH, 2004) and AP-42 (USEPA, 1998) has estimated typical release of NH_3 into the water from Urea Manufacturing process. Around 0.0199 kg/hr/source of NH_3 release from fugitive sources from a Urea Fertilizer factory (NPI, 2004: Table-9). It is mixed with the water and release to the lagoon. Volatile gas NH_3 is lighter than air and tends to rise, because of this fact it generally does not settle in low-lying areas. According to Aneja. V.P. et.al. in 2001, average emission flux of NH_3 from a lagoon is 40.7-120.3 µg/m_2-min of fertilizer factories. During the field measurement the quantity of NH_3 and H_2S and Total VOC has been presented in Table 6.11.

Table 6.11: Quantity of odors component at different sampling locations

Sampling Point	NH_3 (µg/m^3)	H_2S^*(µg/m^3)	Total VOC(µg/m^3)
AQ-1	34.8	<10	41.46
AQ-2	108.2	<10	<4.2
AQ-3	36.5	<10	157.1
AQ-4	733	<10	227.92
AQ-5	173.5	<10	59.37
ECR, 1997 (Schedule -8, Rule-12)	3480	280	-
	Max	Max	-

Source: Field measurement done by CEGIS, 2019

436. The people who lives near the lagoon suffer a lot due to unpleasant odor which generates from contaminated water and ammonia gas. Ammonia is a colourless and highly irritating gas with a sharp suffocating odor. It dissolves easily in water to form ammonium hydroxide solution which can cause irritation and burns. Gradually, it hampers the entire Aquatic Ecosystem of the Shitalakhya River. It also causes a lot of diseases among the villagers who live nearby the lagoon. The diseases are bronchitis, allergy, eye irritation, skin diseases, belly swollen, even lung cancer, etc.

6.2.10 Acoustic Environment

437. Excessive noise generation from industrial activities, vehicle movements, chattering, chirping of birds etc., might have noticeable negative impacts on surrounding environment. Continuous high noise or impulse noise may cause health hazards to both the people living in the area and the workers.

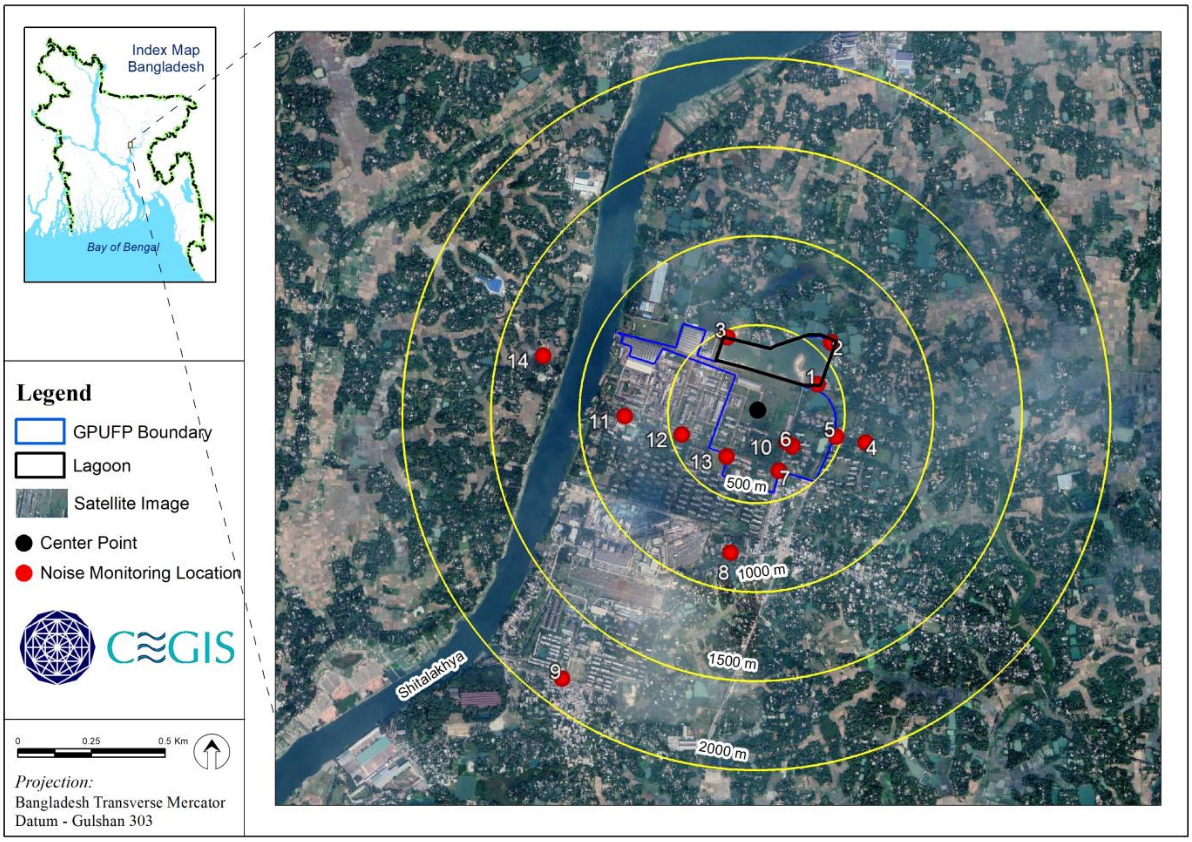


Figure 6.24: Sampling points of noise levels around the project site

438. Among the fourteen samples collected, thirteen of those were recorded within one kmradius around the proposed project area (Figure6.24). Only one sampling point was located at 1.75km distance from the center of the proposed GUFF. Noise levels varied between 48.1 dBA to 78.1 dBA during the day time and 42.7 dBA to 65.7 dBA during night time. The noise levels at all of the sample locations showed a comparatively higher variability in daytime (std dev. 8.31) compared to night time (std dev. 6.66), which is usual considering the higher variations of daytime activities at different noise generation sources.

439. As per the ECR, 2006 and IFC 2007, the permissible level of noise were exceeded in several receptors point where the noise level were recorded. Characteristics of the receptors

or the place sensitivity, source type and distance from the sources are the key for recorded noise level in the study area. The major sources of noise are plant operation, winds and chirping of birds, vehicle movement, whistles/horns of buses and trucks, gas transmission, industrial activities, public gathering etc. Table 6.12 shows the noise level in different places during day and night period and its compliance status with respect to ECR, 2006 and IFC, 2007. Noise levels at the UFFL and PUFFL colonies and in front of the TGTDCL's mosque are found exceeded the standards.

Table 6.12: Measured day and night time noise levels in and around the project site

Sl. No.	Name of the Location	Location Types	Measured Noise		ECR, 2006	IFC, 2007	Compliance Status
			Noise Level [dB(A)]				
1	SEcorner of the Lagoon	Commercial	Day	62.4	70	70	Yes
			Night	56.8	60	70	Yes
2	NE corner of the Lagoon	Commercial	Day	62.0	70	70	Yes
			Night	54.9	60	70	Yes
3	NW corner of the Lagoon	Commercial	Day	63.4	70	70	Yes
			Night	58.7	60	70	Yes
4	PUFFL colony school	Silent	Day	48.1	50	55	Yes
			Night	42.7	40	45	No
5	PUFFL colony mosque	Silent	Day	60.2	50	55	No
			Night	43.1	40	45	No
6	PUFFL colony main gate	Residential	Day	55.0	55	55	Yes
			Night	46.8	45	45	No
7	UFFL main gate	Industrial	Day	75.6	75	70	No
			Night	54.7	70	70	Yes
8	TGTDCL mosque	Commercial	Day	78.1	70	70	No
			Night	65.7	60	70	No
9	GPSmain gate	Commercial	Day	68.4	70	70	Yes
			Night	56.8	60	70	Yes
10	PUFFL main gate	Industrial	Day	56.9	75	70	Yes
			Night	46.7	70	70	Yes
11	UFFL Training Institute	Industrial	Day	61.5	75	70	Yes
			Night	54.4	70	70	Yes
12	Officer's Club	Industrial	Day	60.8	75	70	Yes
			Night	52.7	70	70	Yes
13	Road side corner of UFFL school field	Industrial	Day	55.3	75	70	No
			Night	51.6	70	70	No
14	Nargana Purbo Para School	Silent	Day	56.3	50	55	No
			Night	46.2	40	45	No

Source: Field measurement done by CEGIS, 2019; Note: SE- Southeast, NE- Northeast and NW- Northwest

6.2.11 Water Quality

Methods

440. Major surface water body comprises with Shitalakhya River, Lagoon and Ponds adjacent to the Fertilizer factory. On the other hand, groundwater comprises with shallow and deep tube-well situated at the north side of the fertilizer plant (north side of the lagoon) inside the community. To get the water quality picture extensively, last two consecutive years were

observed following dry and wet season of the resources. In addition, discharged effluent quality were also observed here.

441. To cover a wide range of parameters both In-situ and Ex-situ techniques were followed. Parameters of pH, Temperature, Dissolved Oxygen (DO), Total Suspended Solids (TDS) and Hardness were examined In-situ while Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonium ion (NH_4^+) Sulphate (SO_4^{2-}), Chloride (Cl^-), Silica (SiO_2) and Total Iron (Fe) were for Ex-situ test.

Historic Pollution Records of the Shitalakhya River

442. Around 15 years back, pH values were within the range in the Shitalakhya River, which World Health Organization (WHO) has recommended for drinking water that is, 6.5 to 8.5. In 2001, 2002 and 2003 water pH was respectively average 7.2, 6.6 and 7.0 ppm. In 2015, it has been reduced to 5.6 in pre-monsoon and 6.6 in post monsoon season in an average. Slight acidic in nature due to the discharge of chemicals and other municipal and domestic wastes along with pesticides from agricultural fields.

443. WHO suggest that 4-5 ppm of DO is the minimum amount that will support a large, diverse fish population. The DO level in good fishing waters generally averages about 9.0 ppm. In the Shitalakhya River DO was on an average 6.28 ppm in 2001. Moreover, average 7.0 ppm and 6.3 ppm was in correspondently 2002 and 2003 (Islam, M. J., 2008). DO is changes in the river. This DO reduced to 1.2 ppm in pre-monsoon and 1.6 ppm in post-monsoon season in 2015, which indicated high organic pollution of the river. However, in 2015 and 2016, DO was found around 3.5-4.2 ppm considering both dry and wet seasons (DoE, 2016). This extreme low DO might be due to the variation of seasons and sampling sites. In the pre-monsoon, BOD was less than 4.0 ppm in 2003, which was increased to more than 4.5 ppm in 2015. COD was around 8.8 ppm in pre-monsoon while it reduced a bit (6.5 ppm) in post-monsoon season. TDS was found 112 ppm in pre-monsoon, which was a bit less in post-monsoon season in 2015.

444. Phosphorous is a vital element for all the living beings, especially for plant life. However, if the quantity of phosphorous gets much higher in the water body it speeds up eutrophication of that river and lake. The standard limit of phosphorous for drinking water quality is 4-20 ppm (WHO, 1998 and 2008). In the pre-monsoon season, the range of phosphorous is 392-401 ppm and in post monsoon, it is 39-38 ppm in the Shitalakhya River which is very high than the standard limit.

445. In case of metal pollution, in pre-monsoon season of the year 2008, arsenic (observed 0.002ppm; standard 0.05ppm), lead (observed 0.001ppm; standard 0.05ppm), manganese (observed 0.05ppm; standard 0.ppm), copper (observed 0.0025ppm; standard 1.0ppm) and zinc (observed 0.02ppm; standard 5.0ppm) were found within the acceptable limit of the standards for drinking water of Bangladesh (ECR’1997). Only, cadmium was showed high concentration (0.01ppm) than the same standard 0.005 ppm. In terms of metal pollution, the entire river reach was not bad at all (Mokadddes et al., 2013).

Surface Water Quality

446. Physical parameters such as Temperature, pH, DO, TDS, Total Hardness and Total Alkalinity were analyzed as a part of evaluating the water quality of the river passes beside the Project site along the stretch of the UFFL and PUFFL. Physical quality of the Shitalakhya is presented in Table 6.13**.**

Table 6.13: Physical quality of the Shitalakhya River

Sl. No.	Parameters	Dry Season (February)		Wet Season (July)		Standard Value	Reference
		2017	2018	2017	2018		
1	Temperature (°C)	24.2	23.0	29.8	29.7	30.0	2
2	pH	7.4	8.1	7.2	7.0	6.5-8.5	1
3	Dissolve Oxygen (mg/l)	6.1	6.2	5.3	3.8	≥5	1
4	Total Dissolved Solids (mg/l)	288	264	290	274	1000	1
5	Total Hardness as $CaCO_3$ (mg/l)	175	192	44	71	200-500	1
6	Total Alkalinity as $CaCO_3$ (mg/l)	201	202	54	60	-	

Source: BCIC, 2018

447. Physical characteristics of the Shitalakhya River water is quite good except for DO. According to the Table 6.13**,** it was found that water temperature varied 23-24°C in dry period, which increased a bit in the wet season. These changes are usual and all comply with the DoE standards (30 °C). The pH value also meets the standards as it ranges in between 7.0-8.1 (pH standard: 6.5-8.5).

448. DO is the amount of oxygen dissolved in a waterbody such as river, lake or stream. It is vital for underwater life as aquatic creatures need to breathe. From the Table 6.13 analyzed on the physical parameters of the Shitalakhya River, it is known that the value of Dissolved Oxygen was observed to be lower in the Wet Season than in the Dry Season. In 2018, the values were 6.2 and 3.8 in Dry and Wet season respectively. In 2017, the values were 6.1 and 5.3 in Dry and Wet season respectively. In 2018, the value of DO went below the standards (5 mg/L). Several reasons might have contributed to the reduction of DO level. One of the main reasons may be releasing of NH_3 mixed water into the river from the lagoon of existing urea fertilizer factories along with other NH_3 industries located nearby.

449. There is no mention of the standard value for Total Alkalinity in the ECR, 1997. But, various sources state that Total Alkalinity as $CaCO_3$ should be within 20-200 (mg/L) to maintain the buffer state. The stabilized pH level also indicates that the buffer state is maintained in the Shitalakhya River. Based on the result, it was found that, total alkalinity in all the observed seasons complied with the range of 20-200 mg/L.

450. Biochemical Oxygen Demand (BOD) is the measure of the quantity of oxygen used by the microorganisms during the oxidation of organic matter in that sample. Aerobic biological organisms break down the organic material present in a waterbody at a certain temperature. In the Shitalakhya River, the BOD range is 3.2-3.8 mg/L in the dry season of 2017 and 2018 respectively and 3.2-8.0 mg/L in the wet seasons of the respective years. For inland surface water quality, the acceptable limit considered by DoE is 10.0 mg/L for BOD (ECR' 2017 Draft Version), Table 6.14.

451. Chemical Oxygen Demand (COD) is an indicative measure of the quantity of oxygen, which can be consumed by reactions of oxidizing soluble and particulate organic matter in water. Similar to BOD, it provides an indication to the assessment of discharging wastewater will have on the surrounding environment. In the dry season, the COD range is 5.6-8.0 mg/L and in the wet season, it is 5.7-9.2 mg/L in the Shitalakhya River. The permissible limit of COD for inland surface water is 25 mg/L (ECR' 2017 Draft Version). The Shitalakhya River showed good quality of water in terms of its oxygen demand for decomposing inorganic nutrients available in the waterbody.

Table 6.14: Organic Pollution status of the Shitalakhya River

Sl. No.	Parameters	Dry Season (February)		Wet Season (July)		Standard Value	Reference
		2017	2018	2017	2018		
1	BOD (mg/l)	3.2	3.8	8.0	3.2	≤10	1
2	COD (mg/l)	5.6	8.0	9.2	5.7	25	1

Source: BCIC, 2018

452. Among the chemical parameters, Ammonium (NH_4^+), Chloride (Cl^-), Sulfate (SO_4^{2-}), Silica (as SiO_2), Total Iron was determined using methods of volumetric analysis. Data is presented in the Table 6.15.

Table 6.15: Chemical quality of the Shitalakhya River

SL	Parameters	Dry Season (February)		Wet Season (July)		Standards as per ECR, 1997	Reference
		2017	2018	2017	2018		
1	Ammonium NH_4^+ (mg/l)	10	0.3	0.35	0.09	1.5	1
2	Chloride (mg/l)	22	8	4.8	8.2	150-600	2
3	Sulfate (mg/l)	1	4	10.5	4.2	400	2
4	Silica (mg/l)	25.2	24	6	5.7	-	-
5	Total Iron (mg/l)	0.01	0.05	0.5	0.09	2	2

Source: BCIC, 2018

453. Values for Chloride, Sulfate and Total Iron are well within the standards appraised by DoE (ECR, 2017 Draft Version). Sulfates are discharged into water from mines and smelters and from Kraft pulp and paper mills, textile mills and tanneries. The low concentration of Sulfates indicates the water quality (in the vicinity of the project area) is not polluted by chemical wastes of these types of industries. Values for Chloride, Sulfate and Total Iron are well within the standards in this area.

454. Only in the dry season of 2017, the value of NH4+ (10) was beyond the limit. The levels of NH4+, was well above the limits starting from January 2017 to April 2017. In fact, the recorded levels of NH4+ from January to April were 5.0 mg/L, 10.0 mg/L, 5.0 mg/L and 3.8 mg/L. All of these values are well above the standards mentioned in the ECR, 1997. Therefore, in the dry period, Shitalakhya River has an issue of high ammonia. This was happened probably because of releasing of ammonia mixed water from the lagoon into the river water in 2017.

455. There is no standard value for Silica in water. But there is a significant drop of value of Silicabetween the dry and wet season. In March, April, May and June, the recorded amount of Silica was 26.7 mg/L, 21.0 mg/L, 16.0 mg/L and 5.2 mg/L respectively. This indicates that in the dry season there were more Silica in the River of Shitalakhya than in the wet season. High upstream water might dilute Silica concentration vastly.

Ground Water Quality

456. Water quality was checked for ground water at several locations around the Project site especially at the north side of the lagoon where communities reside the most. Water samples were collected from various depths below the ground level. Here, depths of less than 40m have been termed as 'Shallow' and depths of more than 40m have been termed as 'Deep' tube wells.

457. As far as fertilizer factory is concerned, the values of pH, NH_4^+ and NO_3^- were analyzed to determine the chemical characteristics of ground water available in the region of the proposed Project Site. The detail field observation is presented in Table 6.16.

458. The values of pH, NH_4^+ and NO_3^- at all the observed locations are within the standard limits. This indicates that the ground water available in that area is suitable for drinking water considering fertilizer factory after disinfection only.

Table 6.16: Water quality of the observed tube-wells around the project site

No.	Location	Category	Depth (m)	Dry season pH		Wet season pH		Dry season NH_4^+		Wet season NH_4^+		Dry season NO_3^-		Wet season NO_3^-	
				--				mg/l				mg/l			
Standards				*6.5-8.5*				*1.5*				*10*			
Observation Year				*2017*	*2018*	*2017*	*2018*	*2017*	*2018*	*2017*	*2018*	*2017*	*2018*	*2017*	*2018*
1	North of Lagoon	Deep	75	6.4	7.3	6.4	7.3	0.2	0.1	0.1	0.1	1.4	0.4	0.4	0.4
2	Fouzi Jute Mill	Deep	63	6.9	7.2	6.9	7.2	0.4	0.1	0.1	0.1	2.8	0.4	0.4	0.5
3	Deep Tube well no. 6	Deep	150	6.1	6.7	6.1	6.7	1.2	0.2	0.1	0.2	1.6	0.8	1.3	0.8
4	North of Lagoon	Shallow	15	6.7	7.1	6.7	7.1	1.3	0.1	0.1	0.2	1.4	0.4	0.6	0.6
5	North of Lagoon	Shallow	21	7.0	7.2	7.0	7.2	0.4	0.9	0.1	0.1	1.1	0.5	0.5	0.4

Source: BCIC, 2018

6.2.12 Effluent Analysis Report

459. The physical parameters of Temperature, Color, pH, DO, Total Dissolved Solids (TDS), and Total Suspended Solids (TSS) were analyzed as a part of evaluating the quality of the effluent discharged into the Shitalakhya River/lagoon around the Project site. Data of Physical parameters are presented in the Table 6.17.

Table 6.17: Physical quality of the effluents of Ghorasal Fertilizer Factory Ltd.

Sl. No.	Parameters	Dry Season (February)		Wet Season (July)		Standard Value	Ref.
		2017	2018	2017	2018		
1	Temperature (°C)	25.3	22.0	29.5	30.2	40-45	4
2	pH	7.7	7.9	7.3	7.0	6.0-9.0	1
3	DO(mg/l)	6.7	6.4	5.6	6.9	4.5-8	4
4	Total Dissolved Solids (mg/l)	390	300	284	330	2100	4
5	Suspended Solids (mg/l)	18	10	10	62	100	1
6	Color (Hazen Unit)	Not Objectionable	Not Objectionable	Not Objectionable	Not Objectionable	-	-

Source: BCIC, 2018

460. All the physical parameters were found to comply with the DoE standards. It is stated in Draft ECR 2017, Schedule 8 that the temperature of the effluent to be discharged into the river must not be greater than by 3°C than the temperature of the river water. Temperature of river water in Shitalakhya varies from 22°C to 30°C (Mottalib et al., 2016). So, the temperature of the effluent must be within 25-30°C. The recorded temperature of the effluent complies with this standard as well. The rest of the parameters such as pH, DO, TDS and Suspended solids were also complied with the ECR Standard (Table 6.18) (Water Quality Standard for Fertilizer Factory). The color of the effluent was unobjectionable in every aspects.

461. Analysis of organic pollution was also performed to check the condition of effluent quality. The values and analysis are presented in Table 6.18. Values of BOD are within the standard values mentioned in the ECR. The values in dry period are less than the values in wet period in 2017. The BOD values were 7.4 mg/L and 6.9 mg/L respectively in the dry and wet season in 2017. In 2018, there was not much difference from the valuesthat were recorded in 2017.

462. A similar trend was observed in case of COD values. The values exhibit a decline in 2017 from the dry period to wet period. COD values went down from 12.3 mg/L in dry period to 9.7 mg/L in wet period. However, in 2018, the values are stabilized and are 7.8 mg/L & 7.2 mg/L in dry & wet period respectively.

463. After doing a trend line analysis, it was observed that both BOD and COD values increase rapidly in dry season, but stay relatively constant over the wet period.

Table 6.18: Organic pollutants in the effluent quality, Urea Fertilizer Factory Ltd, Ghorasal, Narsingdi

Sl.No.	Parameters	Dry Season (February)		Wet Season (July)		Standard Value	Ref.
		2017	2018	2017	2018		
1	BOD (mg/l)	7.4	7.0	9.0	6.9	30	1
2	COD (mg/l)	12.3	7.8	9.7	7.2	200	1

Source: BCIC, 2018

464. Methods of volumetric and gravimetric analysis were performed to determine the amount of the following chemical pollutants present in the effluent- Ammoniacal Nitrogen (NH_3-N), Chloride as NaCl, Sulphate, Phosphate, and Iron. The observed data analysis is presented in Table 6.19.

Table 6.19: Chemical quality of the effluents of Ghorasal Fertilizer Factory Ltd.

Sl. No.	Parameters	Dry Season (February)		Wet Season (July)		Standard Value	Ref.
		2017	2018	2017	2018		
1	NH_3-N (mg/l)	22.4	7.0	4.8	0.75	40	1
2	Chloride as NaCl (mg/l)	88.7	15.4	16.4	23.0	600	1
3	Sulphate (SO_4^{2-}) (mg/l)	3.4	3.3	8.9	3.5	400	3
4	Phosphate (PO_4^{3-}) (mg/l)	1.2	0.5	1.2	0.8	2	3
5	Iron (mg/l)	0.03	0.18	0.35	0.07	2	4

Source: BCIC, 2018

465. It is observed from the data presented in Table 6.18that chemical parameters of effluent water are well within the ECR standards. The amount of NH_3-N shows a rapid declination between the dry period and wet period. In 2017 February, the amount was 22.4 mg/l and in July, the value went down to 4.8 mg/l. The same trend can be observed in 2018. The value in the dry period was 7.0 mg/l and the value in wet period went down to 0.75 mg/l.

466. Values of Phosphate also exhibits a similar trend. In both 2017 & 2018, the amount of PO_4present in the sample was 1.52 mg/l. In the wet period, the values were 0.54 mg/l and 0.62 mg/l respectively.

467. Amount of Chloride exhibited maximum values in the dry period of 2017. It was well within the limits of ECR values.

Loading of Pollutants into the Shitalakhya River

468. Loadings of pollutants from the existing UFFL and PUFFL and proposed factory (GPUFP) is estimated here. The constituent load at any given time can be determined if the constituent concentration and the discharge at the time of sampling is known. The load is computed as follows:

$$L = \frac{C * Q}{(1000 * 907.18)} ton/day$$

469. Where, L is the constituent load, in short tons per day; C is the constituent concentration, in milligrams per liter; Q is discharge at time of sampling, in cubic feet per/day; and the result is divided by 1000 for the conversion of mg into Kg and then by 907.18 for the conversion of Kg into short ton (US ton). In calculating loadings, concentrations of pollutants