Draft Initial Environmental Examination (Main Report – Part 2 of 4)

Project Number: 52362-001
April 2019

BAN: Spectra Solar Power Project

Prepared by ERM India Private Limited for Spectra Solar Park Limited and the Asian Development Bank.

5. ENVIRONMENTAL AND SOCIAL BASELINE CONDITIONS

5.1 Introduction

This section describes the existing environmental and social baseline of the study area, which include the proposed Project site, and in a 5 km radial area around the proposed project site. This includes relevant components of physical, biological and socio-economic environment.

The purposes of describing the environmental settings of the study area are:

- To understand the project needs and environmental characteristics of the area; and
- To assess the quality of the existing environment, as well as the environmental impacts of the future developments being studied.

5.1.1 Study area

The study area has been delineated on the basis of the Area of Influence (AOI). The AOI of the Project comprises of the Project Site and the surrounding area, where influence of the Project activities is anticipated. The areas likely to be affected by the Project and its associated activities may include:

- The project activities and facilities that are directly owned, operated or managed by the project proponent (including by contractors) and that are components of the project, such as the power plant and transmission line to the power grid sub-station;
- Impacts from unplanned but predictable developments caused by the project that may occur later or at a related location such as increase in traffic on the approach road;
- Impacts on biodiversity or on ecosystem services upon which affected communities' livelihoods are dependent.

Study area map is presented in **Figure 5.1**.

5.1.2 Area of influence

Further to this, the AOI with respect to the environmental and social resources was considered based on the following reach[1] of impacts:

Air quality

- Fugitive dust emission during construction activity and gaseous emission from diesel operated machineries and vehicles used for transport of construction materials and machineries.
- Dust fall –typically up to 200 m from construction activities.

Noise

- Noise impact area (defined as the area over which an increase in environmental noise levels due to the project can be detected) –typically 500 m from project site and 100 m from the access roads; and

Water

- Surface water bodies within 0.05 km of the project footprint
- Ground water in 1-2 km radius of project footprint.

Flora and fauna (terrestrial and aquatic)

- The direct footprint of the project comprising the project site.

[1] Distance based on ERM's experience with similar projects

- The areas immediately adjacent to the project footprint within which a zone of ecological disturbance is created through increased dust, human presence and project related activities. This kind of disturbance has been estimated to occur within the project footprint and surrounding areas of about 500 m to 1 km from the activity areas.

Based on the above the AOI for environmental studies is limited to 1 km from the Project site. However, as per DoE guidelines for the study area of 5 km has been considered in this study, with focus on immediate vicinity of the Project site.

5.1.3 Study period

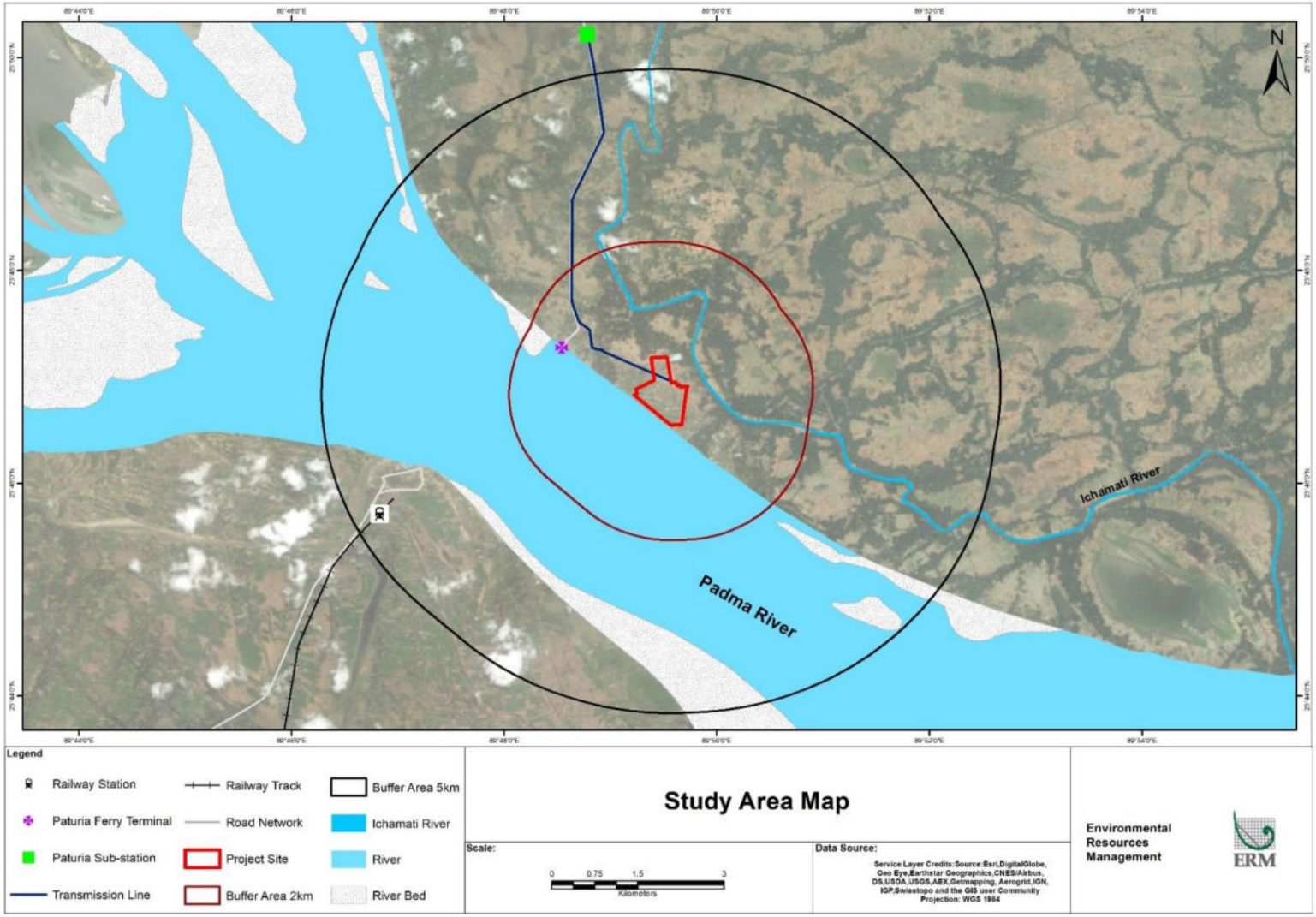
The baseline environment study was undertaken in February 2019.

5.1.4 Approach and methodology

The baseline data was collected through primary and secondary source of information with reference to the scope of work. This data is collected through a concerted effort of:

- Reconnaissance and field visits;
- Primary monitoring of key environmental parameters like air, noise, traffic soil, sediment, surface water, ground water. The primary monitoring was conducted by EQMS Consulting Limited, Bangladesh and Mitra S. K. Bangladesh.
- Information about geology, hydrology, prevailing natural hazards like floods, earthquakes etc. have been collected from literature reviews and authenticated information made available by government departments.
- Surveys were carried out to understand and record the biological environment prevailing in the area and the same was verified against published information and literature.
- The socioeconomic environment has been studied through social surveys, consultations with various stakeholders in the villages within the study area.
- Additionally, socioeconomic data have been obtained from the Census of Bangladesh reports.

Figure 5.1 Study Area Map



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5.2 Physical environment

5.2.1 Physiography

The project site and study area is situated on the lower region of the Ganges floodplain. This region includes the western part of the Ganges River Floodplain which is predominantly highland and medium highland. Most areas have a complex relief of broad and narrow ridges and inter-ridge depressions, separated by areas with smooth broad ridges and basins. The physiography map of the study area is presented in **Figure 5.2**.

5.2.2 Topography

The overall topography of the Manikganj district is medium terrain with undulations. The proposed project site is also medium to plain land with undulations. The general slope of the project site is towards east and south-east; i.e. towards Ichamati River. Most of the proposed project site located close to the Padma river side is high but the eastern sections are low.

A digital elevation model (DEM) or 3-D representation of the terrain surface of the study area is shown in **Figure 5.3**. All the relevant information are extracted from the Shuttle Rader Topography Mission (SRTM) DEM only. All the processing was done in the ARC GIS 10.4.1 software. DEM shows that the topography of the 5 km study area is predominantly a medium terrain with maximum elevation in the western part of the study area. The ground elevation was observed to vary from 12 – 16 m in isolated patches within the study area, followed by areas with elevation ranging between 08 – 12m and 4 – 8 m amsl. Continuous gradient was not observed in the study area. Most of the Site area falls in the 4 – 10 m amsl elevation. East-southeast portion of the Site being the lowest point varying between sub-zero – 4 m amsl.

5.2.3 Geology

The geological evolution of Bangladesh is related to the uplift of the Himalayan mountains and outbuilding of deltaic landmass by major River systems having their origin in the uplifted Himalayas. This geology is mostly characterized by the rapid subsidence and filling of a basin in which a huge thickness of deltaic sediments were deposited as a mega delta built out and progressed towards the south. The floodplains of the Ganges (Padma), the Brahmaputra (Jamuna) and the Meghna Rivers (GBM Basin) cover approximately 40% of Bangladesh. The geology of Bangladesh can be divided into three distinct regions each having distinguishing characters of its own:

- **Stable Precambrian Platform in the North West-** characterized by limited to moderate thickness of sedimentary rocks above a Precambrian igneous and metamorphic basement.
- **Geo-Synclinal Basin in the southeast**- characterized by the huge thickness of clastic sedimentary rocks, mostly sandstone and shale of tertiary age. The basin is further subdivided into two parts, i.e. fold belt in east and a fore deep to the west. As the intensity of the folding decreases towards the west, the fold belts unit merges with the fore deep unit, which is characterized by only mild or no folding. So, the sedimentary layers are mostly horizontal to sub-horizontal and free from major tectonic deformation in the fore deep area covering the central part of the basin and this is expressed as River to delta plain topography of the land.
- **Hinge Zone-**is a 25 km wide northeast-southwest zone that separates the Precambrian platform in the northwest from the geosynclinals basin to the south east. It is also known as the Eocene hinge zone.

The study area was found to exhibit alluvial sand, alluvial silt and deltaic sand. Compact alluvial sand was found in the project site. Commonly, these silts are chiefly deposited in flood basins and are found mainly in the inter stream areas. These silts are commonly poorly stratified and have average grain size which decreases when moving away from main channels. The Geology of the study area is presented in **Figure 5.4**.

Figure 5.2 Physiography map of the Study Area

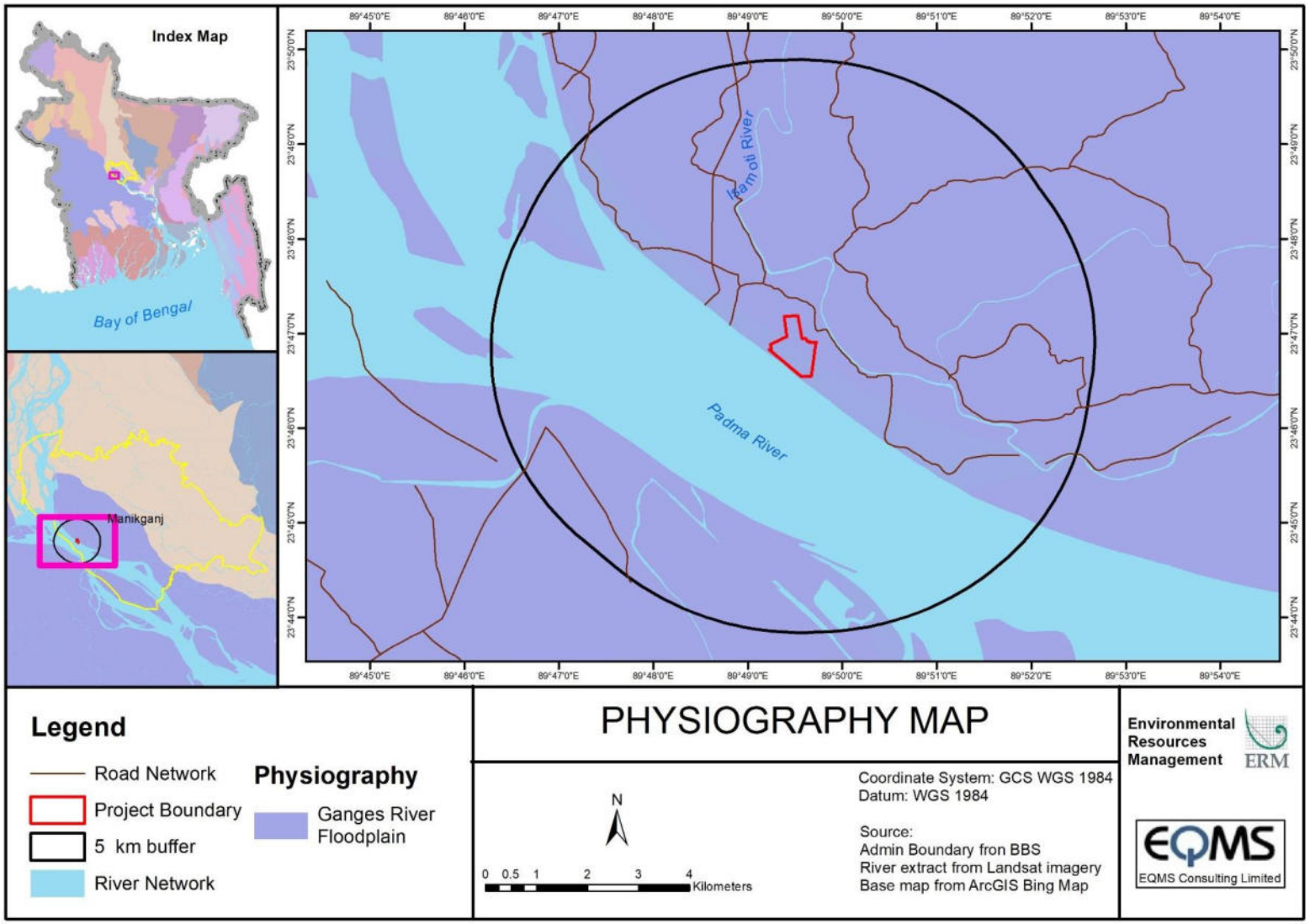


Figure 5.3 Digital Elevation Model of the Study Area

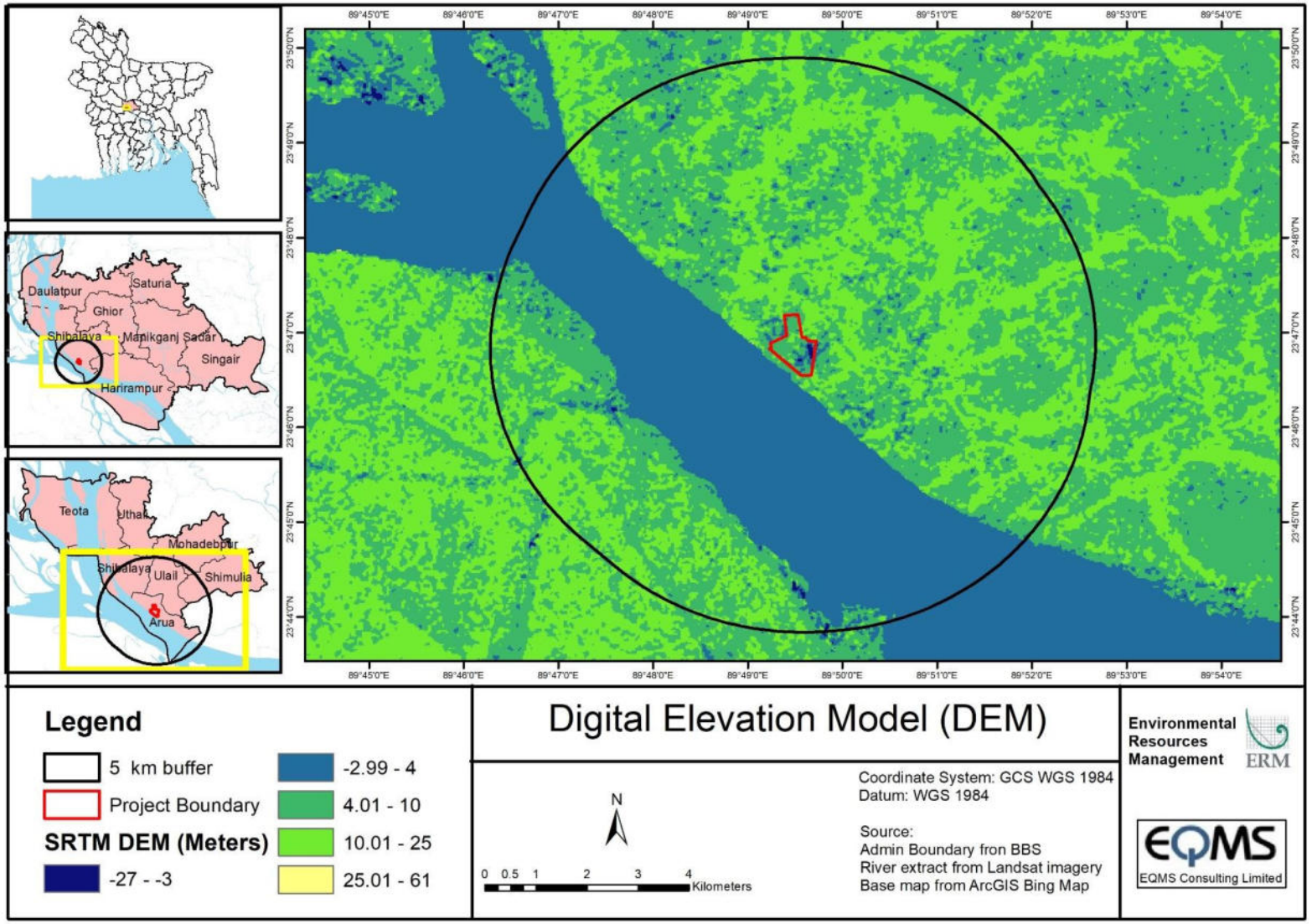
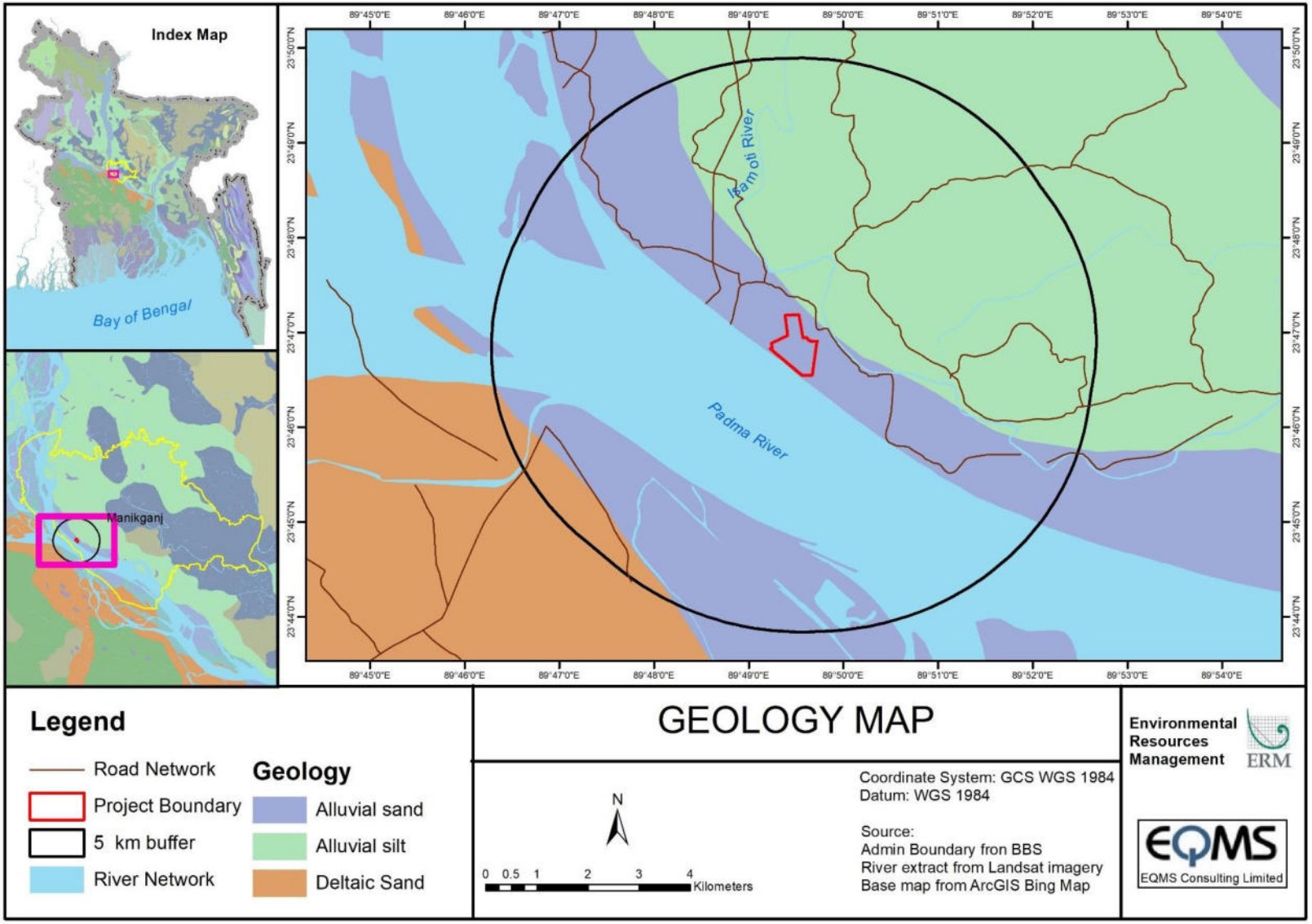


Figure 5.4 Geological Map of the Study Area



5.2.4 Land use

Land use/cover studies are an essential component in land resource evaluation and environmental studies. Land use study area has been conducted through analysis of satellite imagery.

5.2.4.1 Land Use of Study Area

The land use pattern shows that agricultural land (39.37%) occupies most of the area within the 5km buffer zone of the project site. The river occupies 34.47% of the land whereas settlement with homestead vegetation inhibits about 22.03%. Sand bar occupies 2.83% of the land while aquaculture, river bank, pond, beel (wetlands) and baor (stagnant wetlands) consist 1.3% of the lands within the 5km buffer zone of the project site. The land use of the study area presented in **Figure 5.5**.

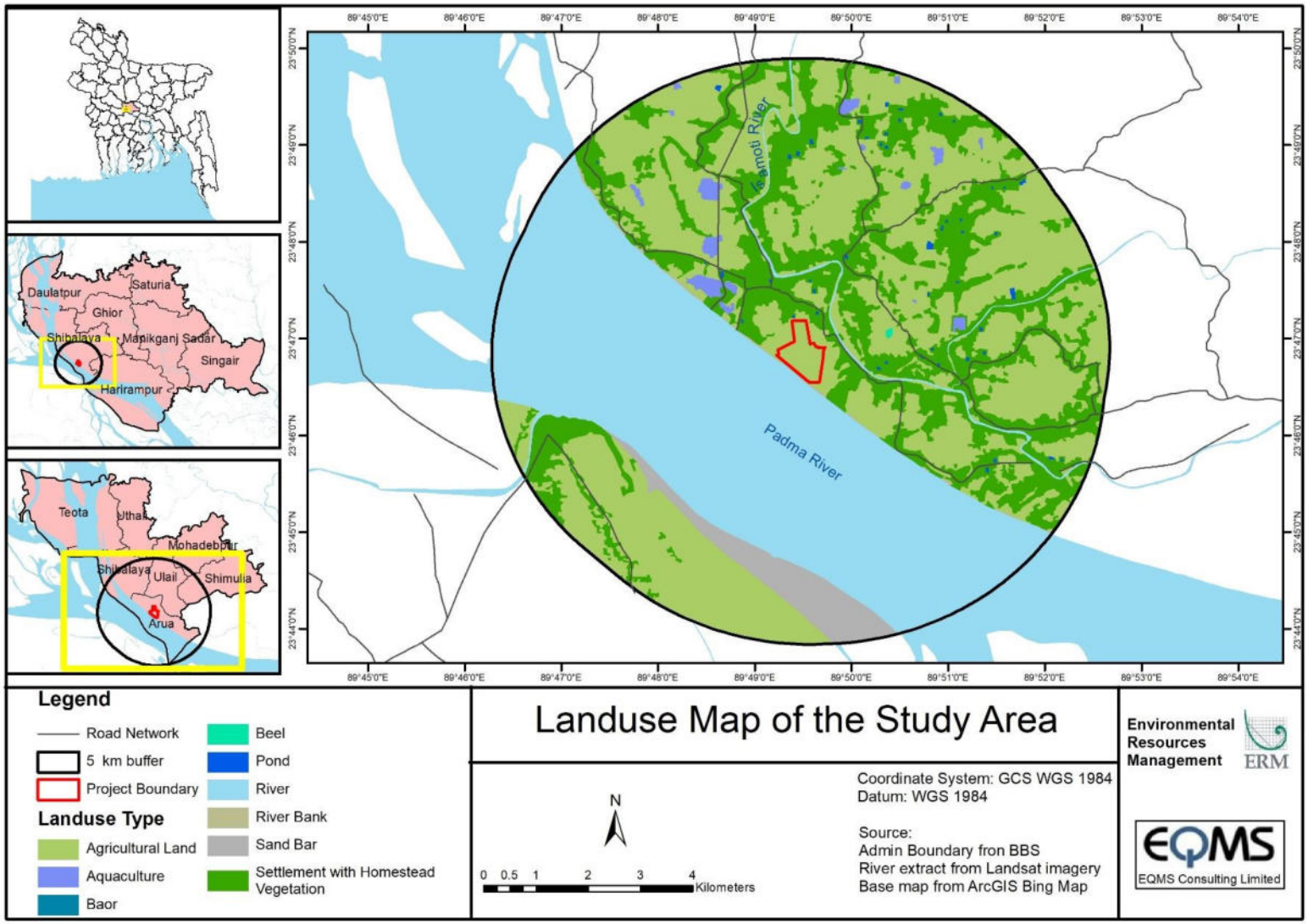
Table 5.1 Land Use/Land covers in the Study Area

S. No.	Land use class	Area (Acre)	Percentage
1	Agricultural Land	9270.50	39.37
2	River	8117.87	34.47
3	Settlement with Homestead Vegetation	5188.36	22.03
4	Sand Bar	666.44	2.830
5	Aquaculture	194.38	0.825
6	River Bank	52.43	0.247
7	Pond	48.77	0.207
8	Beel (Wetlands)	4.46	0.019
9	Baor (Stagnant Wetlands)	0.60	0.002
	Total	**23543.83**	**100**

5.2.4.2 Land Use of Project Site

The proposed power plant will be constructed in the Arua Union under Shibalaya Upazilla in Manikganj District. SSPL has procured 138.78 acres land. As per revenue record, the major part of the project site was Nal (low laying agricultural land) around 95%. The land area of the project site remains inundated for almost six months every year The other land use details are Bari (homestead)- 3.80%, Bashjhar (bamboo thicket)- 0.07%, Bhiti (high land)- 0.21%, Matiyal (low non-agricultural land)- 0.32%, Palan (homestead garden area)- 0.10%, Bagan (orchard)- 0.22% and Doba (marshy land)- 0.06%.

Figure 5.5 Land Use Map of the Study Area



5.2.5 Soil Quality

5.2.5.1 Soil Type

The project site is covered by Calcareous dark grey floodplain soils and calcareous brown floodplain soils. Characteristics of the soil shows that this is mainly dark grey or brown clays with dark grey flood coatings, some calcareous throughout some with seasonally acid top soils and calcareous substratum within 4 feet. Brown calcareous loamy soils on highest ridges and near river-banks. The soil map of the study area is presented in **Figure 5.6**.

5.2.5.2 Primary Soil Monitoring

The project site was filled up with silver sand, which was sourced from the Padma/ Meghna River. Soil/ fill material sample (composite sample) was collected from the project site to understand the any contamination in the fill material. (Refer **Figure 5.24**)

Interpretation of soil monitoring results

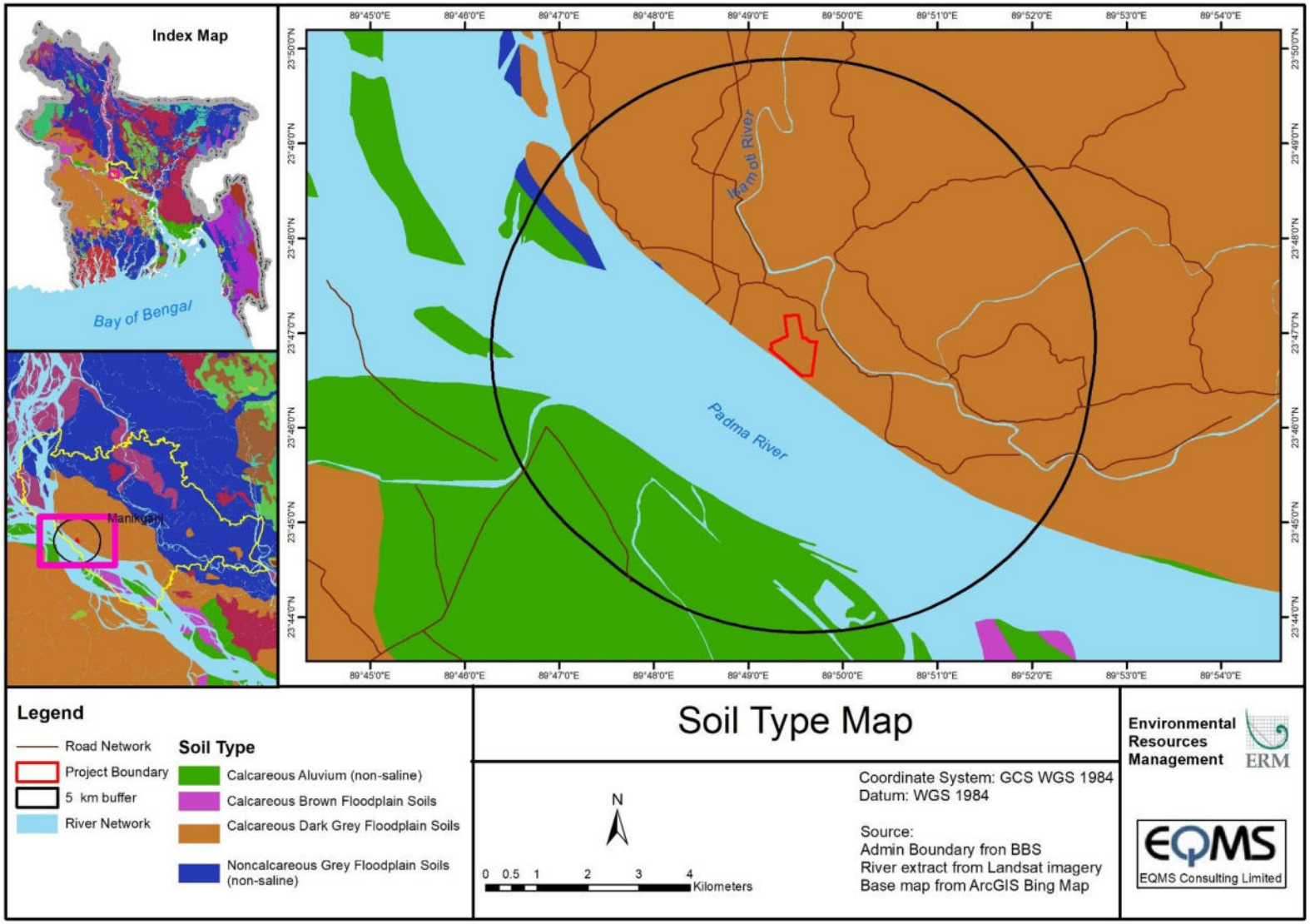
- pH: The pH level in soil sample was 8.17 indicating neutral.
- Texture: The texture of soil sample was found to be sandy in nature.
- EC: The EC was 36.6 micro Siemens/cm.
- Nitrogen content: The available nitrogen content was 22 mg/kg.
- Phosphorus content: The available phosphorus content was <3.0 mg/kg.
- Potassium content: The available potassium content was 29 mg/kg.
- Sodium Absorption Ratio (SAR): The SAR value in the soil was 0.01.
- Heavy Metals: The concentration of heavy metals in the soil was below detectable limit; like– Hg <0.1 mg/kg, Pb- <2.0 mg/kg, Cd <2.0 mg/kg, Co- <2.0 mg/kg, Cr+6- <2.0 mg/kg.
- Polynuclear Aromatic Hydrocarbons (as PAH): The concentration of PAH was <2.0 mg/kg.
- Total Petroleum Hydrocarbon (as TPH): The concentration of TPH was <10.0 mg/ kg.

The soil quality results are provided in **Appendix D**.

Conclusion

The white river sand has been utilised as fill material. The analysis of fill material results reveals that that the material was not contaminated with heavy metals like Hg, Pb, Cd, Cr and Co. The concentration of PHA and TPH was below detection limit.

Figure 5.6 Soil Type Map of the Study Area



5.2.6 Natural Hazards

5.2.6.1 Earthquakes

As per the BNBC-1993, Seismic Zoning Map of Bangladesh, the country is divided into three seismic zones (**Figure 5.7**). The northern part of the country that includes the greater districts of Rangpur, Mymensingh, and Sylhet are in the Zone-3 where earthquake shock of maximum intensity of IX of the Modified Mercalli Scale is possible. The Zone-2 includes the greater districts of Dinajpur, Bogra, Dhaka and Chittagong and the shocks of intensity of VIII are possible. The southern part of the country, the least active region, where the maximum intensity is not likely to exceed VII, is in the Zone-1. The Project site falls within the Zone-II area which has a moderate seismic zone coefficient of 0.5g. Additionally, the area experiences a less possibility of occurrence of earthquakes.

Manikganj is moderately vulnerable to earthquake because of its close proximity to Madhupur Fault (75km far) and Dauki Fault. In the generalized tectonic areas of Bangladesh, Manikganj is also located in the medium risk zone.

Table 5.2 Earthquakes in the Manikganj area

S. No.	Year	Magnitude	Details
1.	1885	7.0	Known as the Bengal Earthquake. Occurred on 14 July with 7.0 magnitude and the epicentre was at Manikganj. This event was generally associated with the deep-seated Jamuna Fault.
2.	2008	3.8	Known as the Manikganj earthquake. A minor earthquake jolted Dhaka and surroundings on the evening of 20 March 2008 and created considerable panic among the city dwellers. The epicentre was situated in Manikganj 41 km west-northwest of DUEO. It was believed to be originated from the Madhupur fault.

5.2.6.2 Cyclone and Storm Surges:

Bangladesh, due to its unique geographic location, repeatedly becomes the landing ground of cyclones formed in the Bay of Bengal. These cyclones are devastating and cause extensive damage to life, property and livestock. The cyclones occur in two seasons, April-June and October-November – i.e. before and after the rainy season.

Cyclones in Bangladesh are presently classified according to their intensity and the following nomenclature is in use:

- Depression (winds up to 62 km/hr.);
- Cyclonic storm (winds from 63 to 87 km/hr.);
- Severe cyclonic storm (winds from 88 to 118 km/hr.); and
- Very severe cyclonic storm of hurricane intensity (winds above 118 km/hr.).

As shown in **Figure 5.8** the Project site does not fall under cyclone affected area.

5.2.6.3 Tornado:

The project site is vulnerable to tornado as the Manikganj District got hit by one of the deadliest tornado ever. The Daulatpur–Saturia, Bangladesh tornado occurred in the Manikganj District, Bangladesh on April 26, 1989. It was the costliest and deadliest tornado in Bangladesh's history. There is great uncertainty about the death toll, but estimates indicate that it was devastating and had the fatality around 1,300 people, which would make it the deadliest tornado in history. The tornado affected the cities of Daulatpur

and Saturia the most, moving east through Daulatpur and eventually northeast and into Saturia. Previously, the area that the tornado hit had been in a state of drought for six months, possibly generating tornadic conditions. On April 17, 1973, another tornado in the Manikganj region having the fatality around 681 people.[1]

Bangladesh is one of the countries with the highest frequency of tornadoes, behind the United States and Canada. Bangladesh has received other deadly tornadoes, but this particular storm of 1989 was the worst in the country's history.

SSPL needs to take proper preparedness and coping mechanism and come up with a management plan to deal with these sort of extreme events.

[1] http://article.sciencepublishinggroup.com/html/10.11648.j.ajep.20160504.11.html

Figure 5.7 Earthquake Zone Map of the Study Area

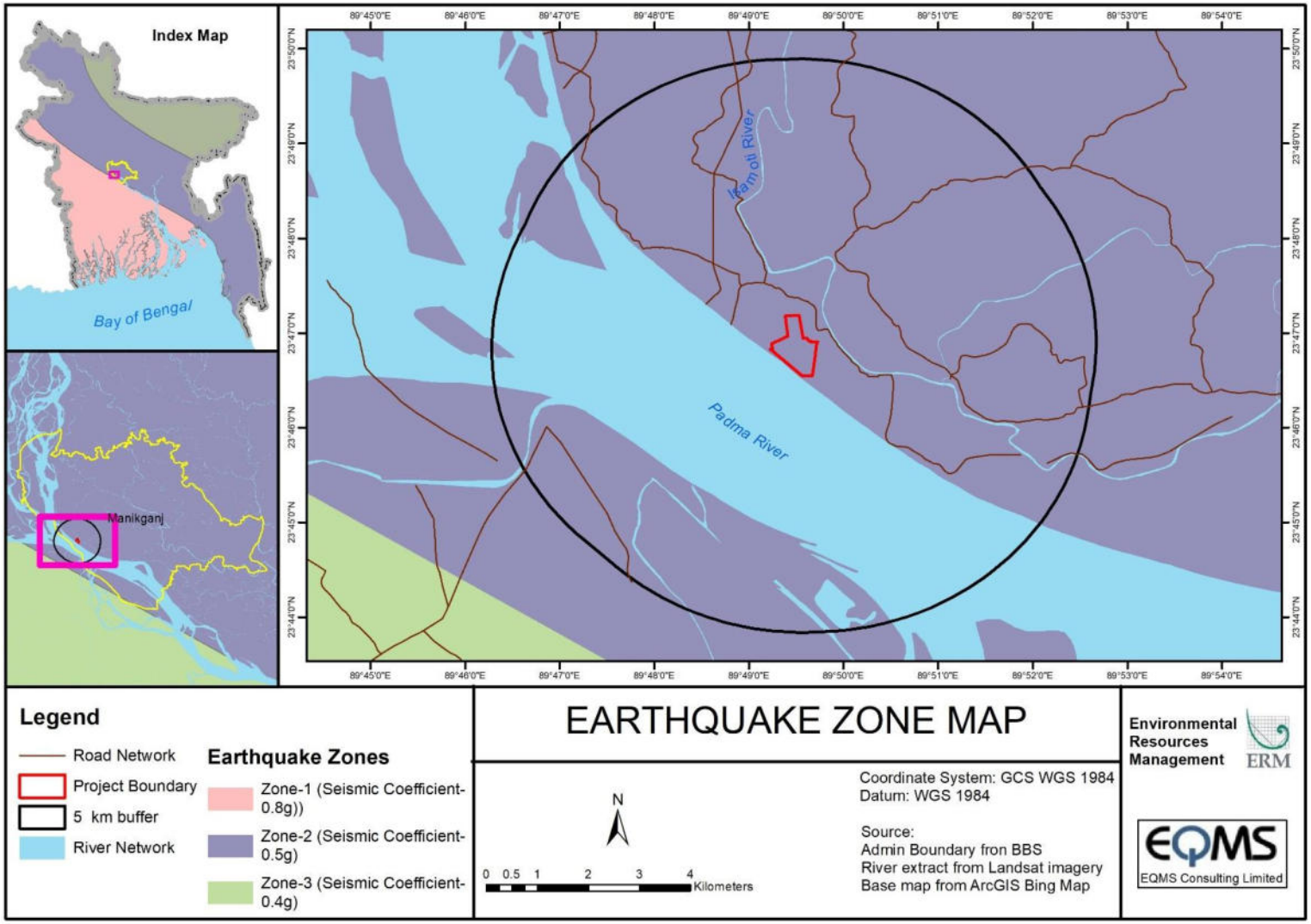
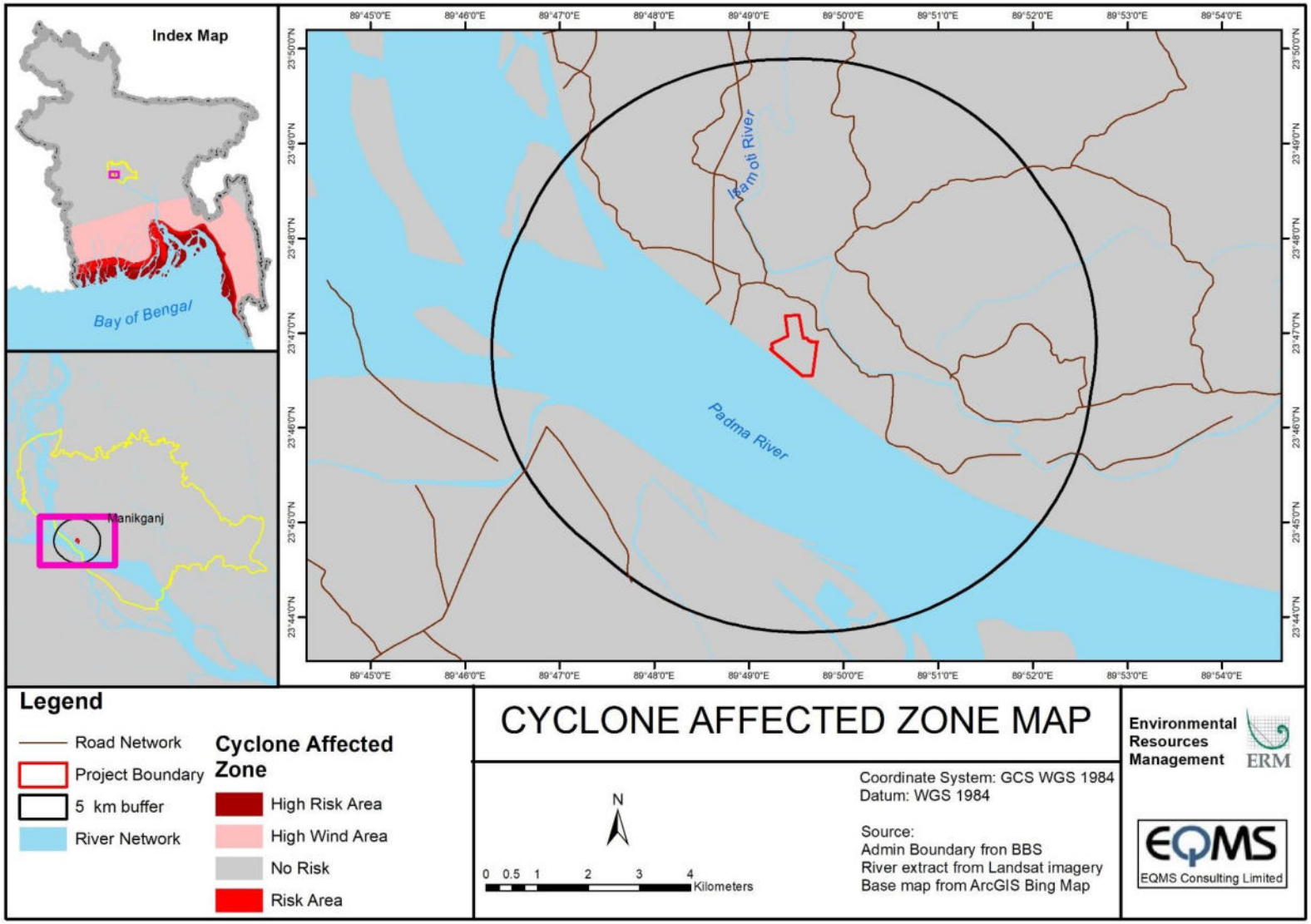


Figure 5.8 Cyclone Affected Area Map



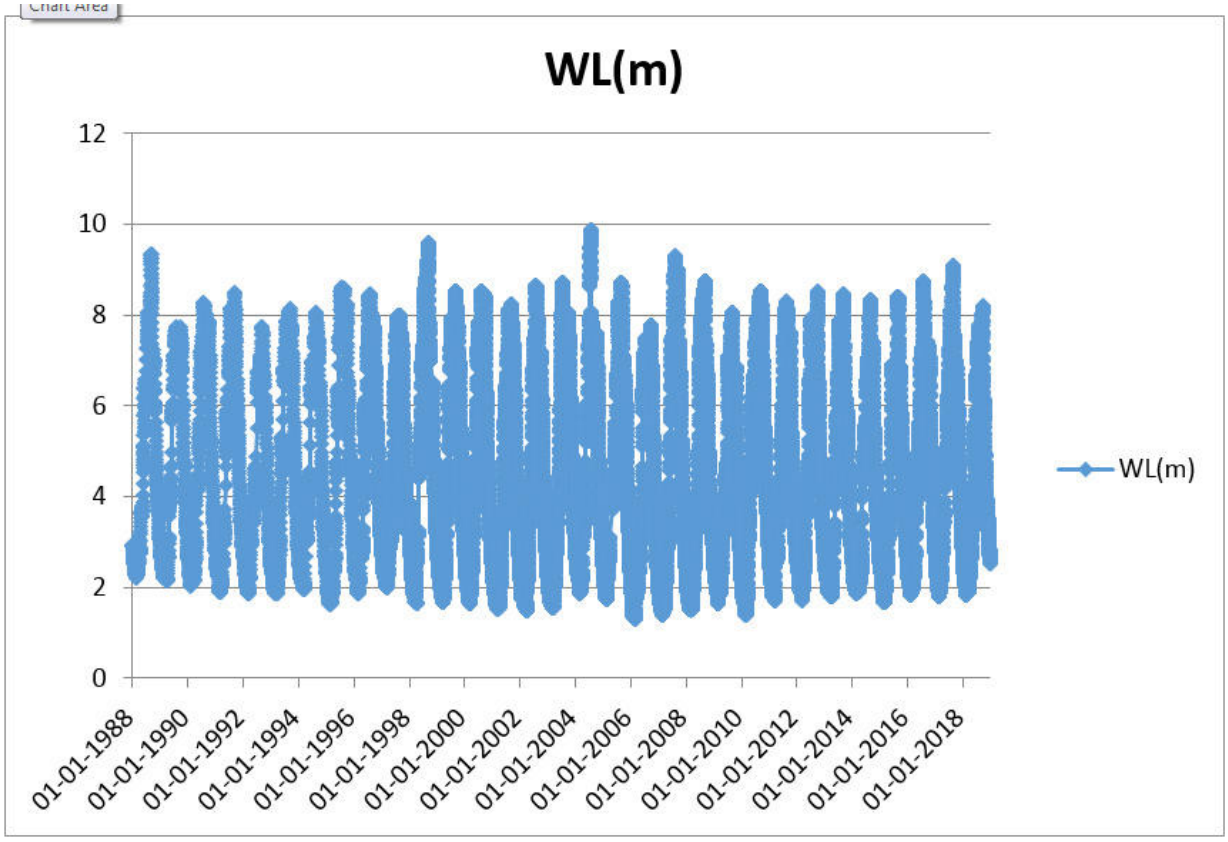
5.2.6.4 Floods

Every year near about one-fifth of Bangladesh undergoes flood during the monsoon season. Flood season in Bangladesh starts as early as June and can continue until November. The maximum recorded historical high water level has been measured at Baruria Transit; 9.89 meters during the flood of 2004. Floods in Bangladesh can be divided into three categories:

- Monsoon flood - seasonal, increases slowly and decreases slowly, inundate vast areas and causes huge loss to the life and property;
- Flash flood-from sudden torrential flows, following a brief intense rainstorm or the bursting of a natural or manmade dam or levee; and
- Tidal flood - short duration, height is generally 3-6m, prevents inland flood drainage.

Figure 5.9 shows the 30 years water level data of Baruria Transit (Padma River and Ichamoti River).

Figure 5.9 30 years water level data of Baruria Transit

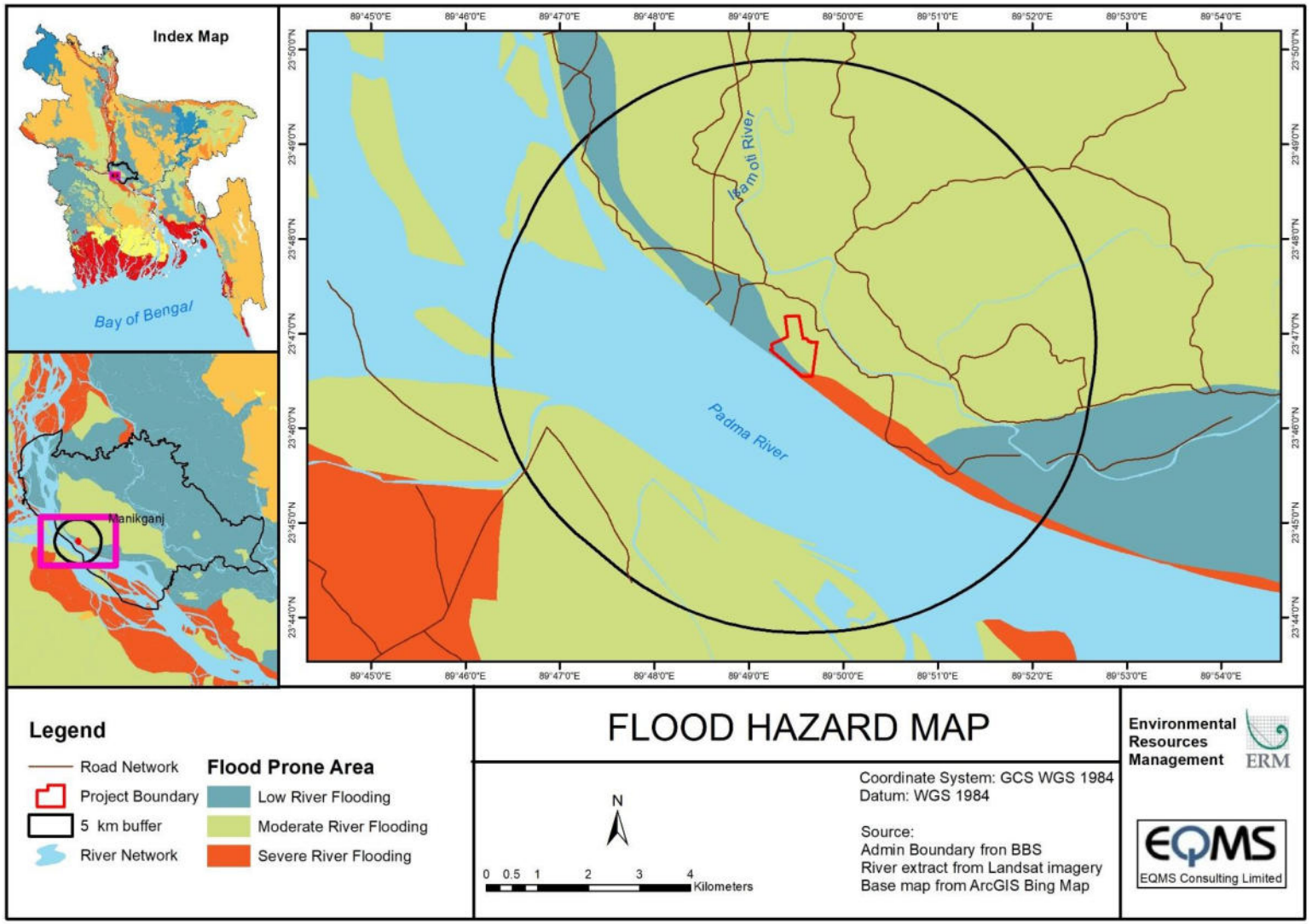


Source: Bangladesh Water Development Board (BWDB), February 2019

Figure 5.10 shows the flood affected areas of Bangladesh and the project site. As can be seen, the projects site lies at the low river flooding to moderate River flooding zone.

As per the consultation during baseline survey, the proposed project site was submerged during the floods that occurred in 1988, 1998 and 2004. Flooding in the area mainly arises due to bank spillage from the Padma River as well as intense rainfall during the monsoon seasons.

Figure 5.10 Flood Hazard Map of the Study Area

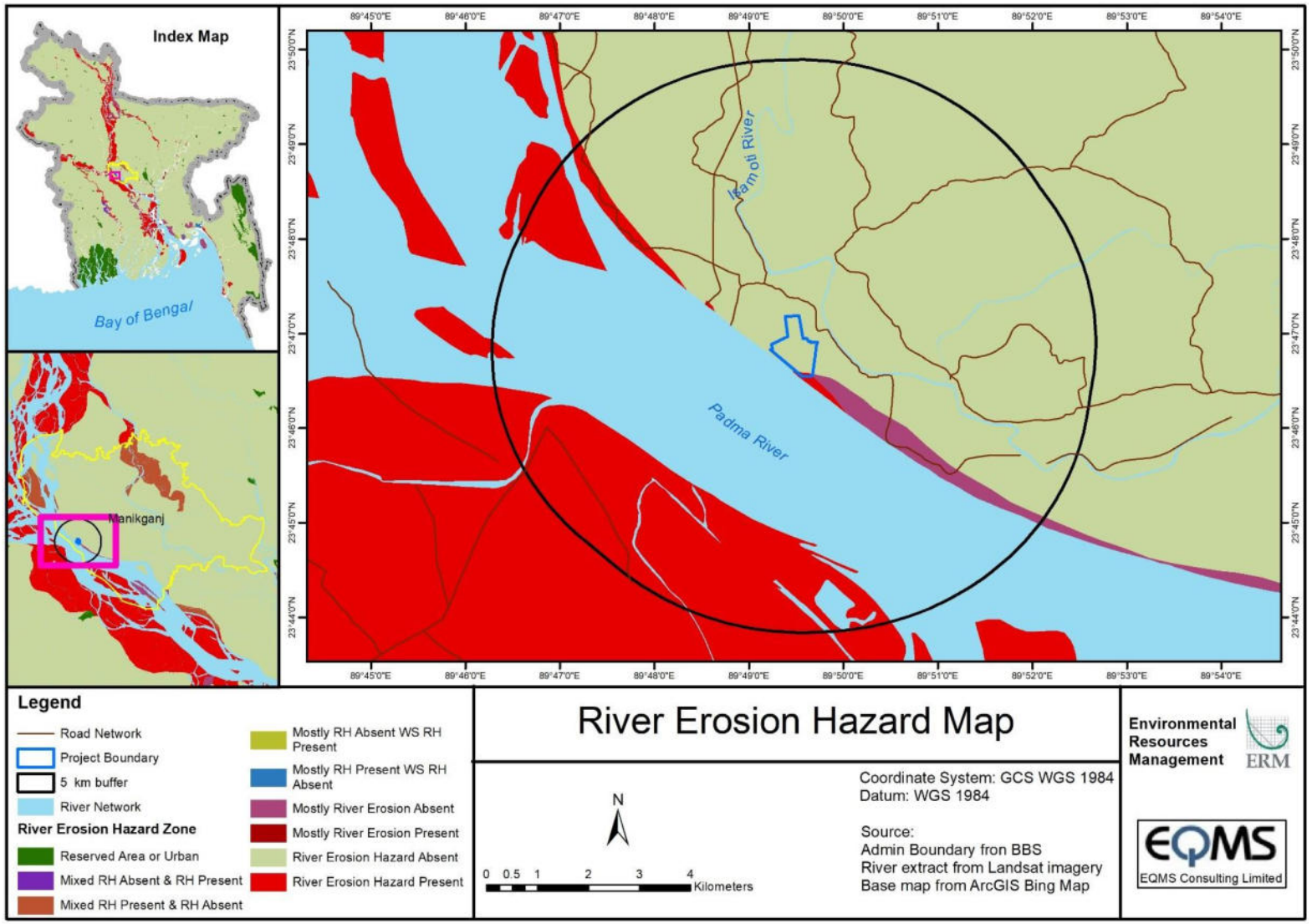


5.2.6.5 Riverbank Erosion:

Riverbank erosion is one of the most unpredictable, critical and complex type of disaster, that takes tolls less in lives but more in livelihood as agricultural land and homesteads along with other livelihood options that are evacuated. The project site lies on the confluence point of the mighty Rivers the Padma (Ganges) and the Jamuna (the Brahmaputra) which makes it vulnerable to riverbank erosion. From January 2007 to January 2013 average rate of erosion in Shibalaya Upazilla was more than three percent per year. Drastic rate of erosion occurred from January 2013 to July 2017 when average rate of erosion was about 9% per year. **Figure 5.11** shows that the project site is moderately prone to riverbank erosion.

During the baseline survey it was noted that the project site is already been elevated about 2-2.5m which would make it less vulnerable to flood hazard. The proponent has started constructing an erosion protection retention wall. However a flood impact assessment may ensure the relevant impact situation and adequacy of flood protection measures.

Figure 5.11 Riverbank Erosion Map of the Study Area



5.2.7 Climate and meteorology

5.2.7.1 Climate

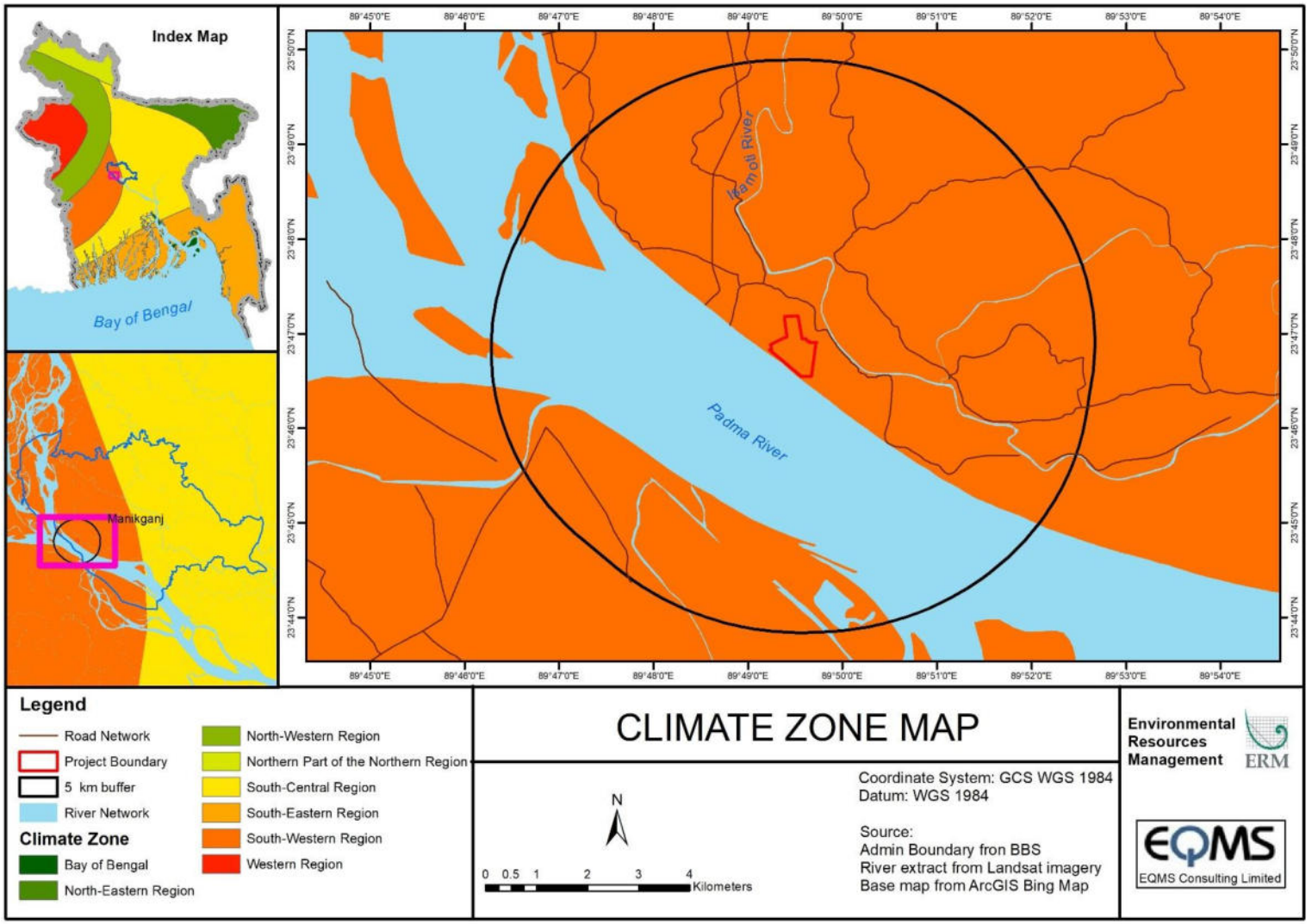
Bangladesh is located in the tropical monsoon region and its climate is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. From the climatic point of view, three distinct seasons can be recognized in Bangladesh - the cool dry season from November through February, the pre-monsoon hot season from March through June, and the rainy monsoon season which lasts from June through September. January is the coolest month with temperatures averaging near 26℃ and April the warmest with temperatures from 33℃ to 36℃. Most places receive more than 1,525 mm of rain a year, and areas near the hills receive 5,080 mm. Most rains occur during the monsoon (June-September) and little in winter (November-February). Moderate rains are also reported in the months of March, April and October.

Climatic Zones of Bangladesh are presented in **Figure 5.12** and as per that, the Manikganj District falls in South-Western Region. In this zone rainfall is abundant, averaging 2,376 mm (93.5 in) per year. The range of temperature is, as can be expected, much less than to the west, but somewhat more than in South-eastern zone. This is a transitory zone between the South-eastern, North-western and most of the severe hail storms, nor'wester and tornadoes are recorded in this area.

To assess the climatic conditions of the project area, climatology data has been obtained from Bangladesh Meteorological Department (BMD). Long-term average climatic data collected from the nearest meteorological station at Tangail District. Tangail weather station is 50km far from the project site (1987 to 2018) reflects the monsoonal effects on climate in this region:

- Annual maximum temperature 39.4ºC;
- Annual minimum temperature 6.1ºC;
- Mean annual relative humidity 80.6%;
- Total maximum annual rainfall 2,376 mm (93.5 in).

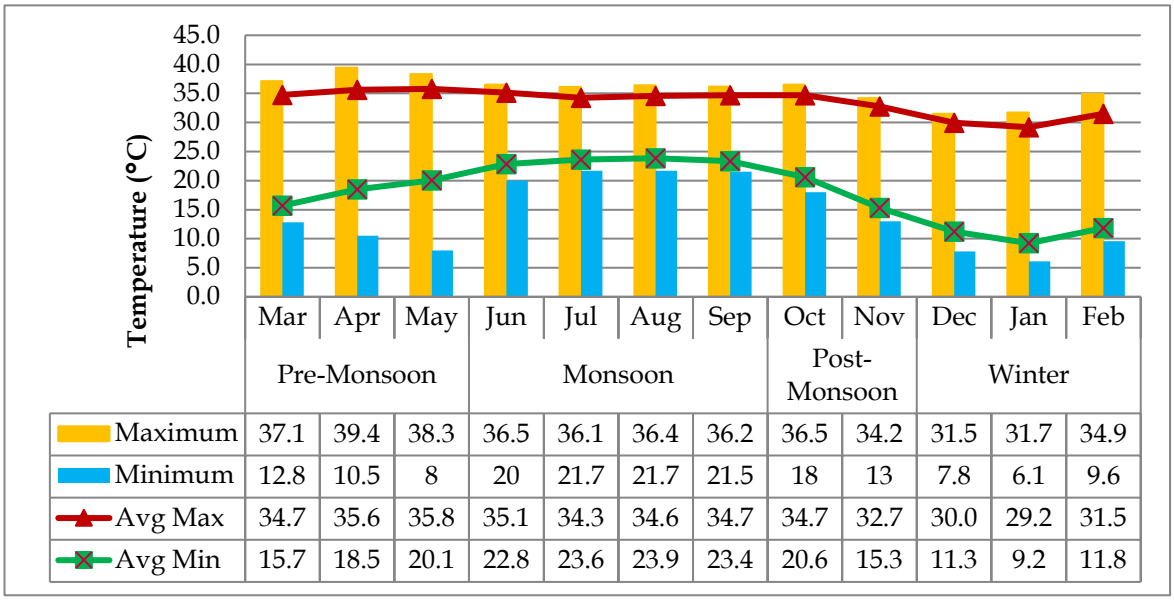
Figure 5.12 Climatic Zones of Bangladesh and Study Area



5.2.7.2 Temperature

The maximum, minimum and average temperatures recorded at the Tangail weather station which is 50km far from the project site are presented below in **Figure 5.13**. The data analysis of 30 years (1987-2018) shows that monthly maximum temperature varies from 33.0℃ to 39.0℃ whereas monthly minimum temperature varies from 6.1℃ to 21.7℃.

Figure 5.13 Monthly Maximum, Minimum and Average Temperatures (1987-2018)



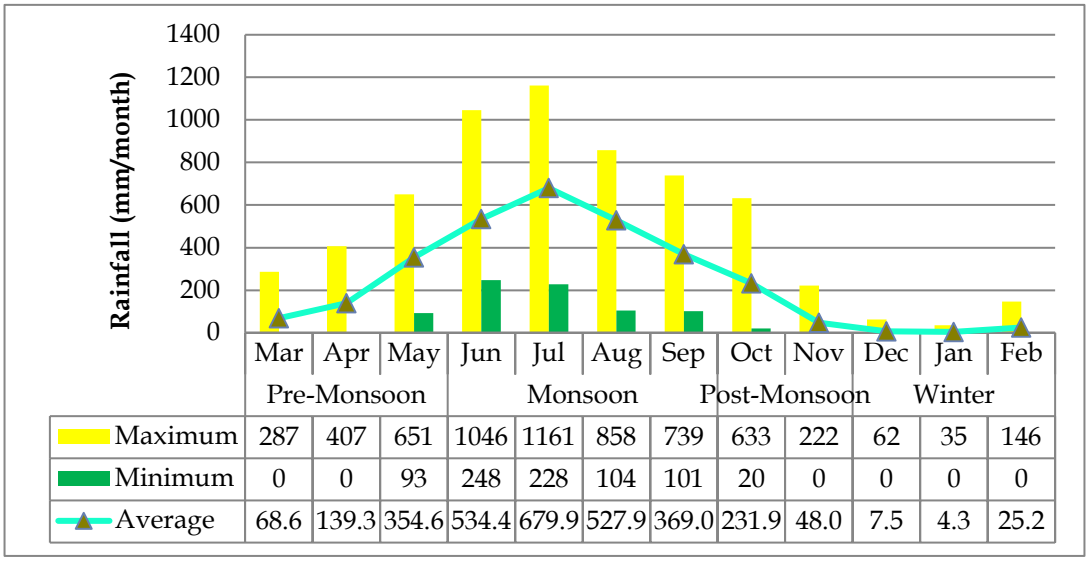
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	37.1	39.4	38.3	36.5	36.1	36.4	36.2	36.5	34.2	31.5	31.7	34.9
Minimum	12.8	10.5	8	20	21.7	21.7	21.5	18	13	7.8	6.1	9.6
Avg Max	34.7	35.6	35.8	35.1	34.3	34.6	34.7	34.7	32.7	30.0	29.2	31.5
Avg Min	15.7	18.5	20.1	22.8	23.6	23.9	23.4	20.6	15.3	11.3	9.2	11.8

Source: Bangladesh Meteorological Department

5.2.7.3 Rainfall

About 80% of the rainfall occurs during six monsoon months (May to October) with June and July getting the maximum rains. Minimum rains are reported during the months of November to February whereas average showering does occur in March, April, and November. The last 30 years data from the Tangail meteorological station which is nearest to the project location (50km far) shows that the annual average of total rainfall is recorded as 2,376 mm (93.5 in). According to the analysis of the historical data, a monthly highest average of total rainfall occurs in July 679.9 mm whereas monthly minimum rainfall is recorded 4.5 mm during the winter season (December and January). The monthly maximum, minimum and average rainfall of the last 30 years (1987-2018) of Tangail weather station which is nearest to the project location is shown in **Figure 5.14**.

Figure 5.14 Monthly Maximum, Minimum and Average Rainfall (1987-2018)



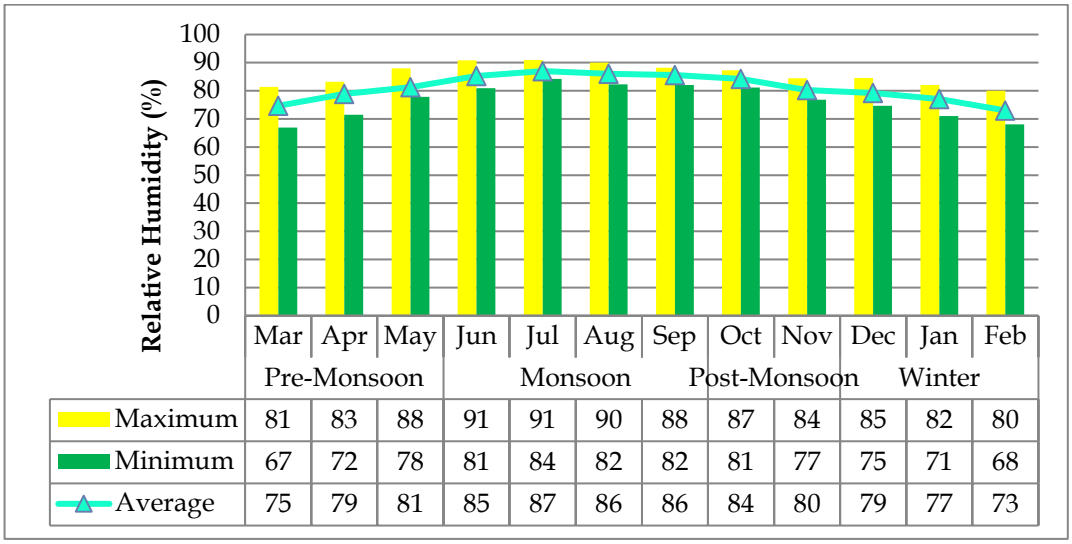
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	287	407	651	1046	1161	858	739	633	222	62	35	146
Minimum	0	0	93	248	228	104	101	20	0	0	0	0
Average	68.6	139.3	354.6	534.4	679.9	527.9	369.0	231.9	48.0	7.5	4.3	25.2

Source: Tangail Weather Station, BMD

5.2.7.4 Humidity

Due to heavy rainfall and proximity to the Bay of Bengal, the humidity levels in Bangladesh remains high. Relative humidity in the study area is generally above 80% during June to January. The month of March is the driest with relative humidity around 79%. Relative humidity normally varies in the range of 79-85% throughout the year. The monthly variation of normal humidity in Manikganj has been presented in **Figure 5.15.**

Figure 5.15 Monthly Maximum, Minimum and Average Humidity (1987-2018)



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Maximum	81	83	88	91	91	90	88	87	84	85	82	80
Minimum	67	72	78	81	84	82	82	81	77	75	71	68
Average	75	79	81	85	87	86	86	84	80	79	77	73

Source: Tangail Weather Station, BMD

5.2.7.5 Sunshine

On average, the region experiences 6.38 hours of sunshine each day. The highest sunshine hours occur during November to February, which is the coolest and has low humidity. The lowest sunshine occurs from June to September, when the cloud cover is high.

5.2.8 Ambient air quality

The objective of the ambient air quality monitoring program was to establish the baseline ambient air quality in the study area. There is no major industrial activity is reported or observed in the study area. The air quality monitoring locations were selected based on the locations of settlements and receptors within the study area. Logistic factors such as consent of villagers, mainly the house owners, power connection, accessibility, security, etc. were also taken into account in finalizing the monitoring stations.

5.2.8.1 Methodology of Air Quality Monitoring

The existing ambient air quality of the study area was monitored at two (2) locations during the monitoring period (February 2019) as part of the baseline study. The Methodology for Analysis of Ambient Air Quality adopted for this monitoring has been provided in **Table 5.3**. The calibration certificate of Air Quality monitoring instrument has been provided in **Appendix E.**

Table 5.3 Methodology for Analysis of Ambient Air Quality

S. No.	Parameter	Procedure
1	SPM	Light Scattering Nephotometer
2	PM10	Light Scattering Nephotometer
3	PM2.5	Light Scattering Nephotometer
4	SO_2	High Sensitivity Electrochemical
5	NOx	High Sensitivity Electrochemical
6	CO	High Sensitivity Electrochemical

The monitoring location details has been provided in **Table 5.4** and **Figure 5.17**.

Table 5.4 Ambient Air Quality Sampling Locations

Station Code	Monitoring Location	Geographic Coordinate	Location settings
AAQ-1	In front of Subash Sarker's house, Tilochanpotti Village, Shibalaya, Manikganj	23°47'11.9"N 89°49'19.2"E	Village and rural setting
AAQ-2	In front of Aiyub Ali's house Lakshmipura Village, Shibalaya, Manikganj	23°46'40.2"N 89°49'56.9"E	Village and rural setting

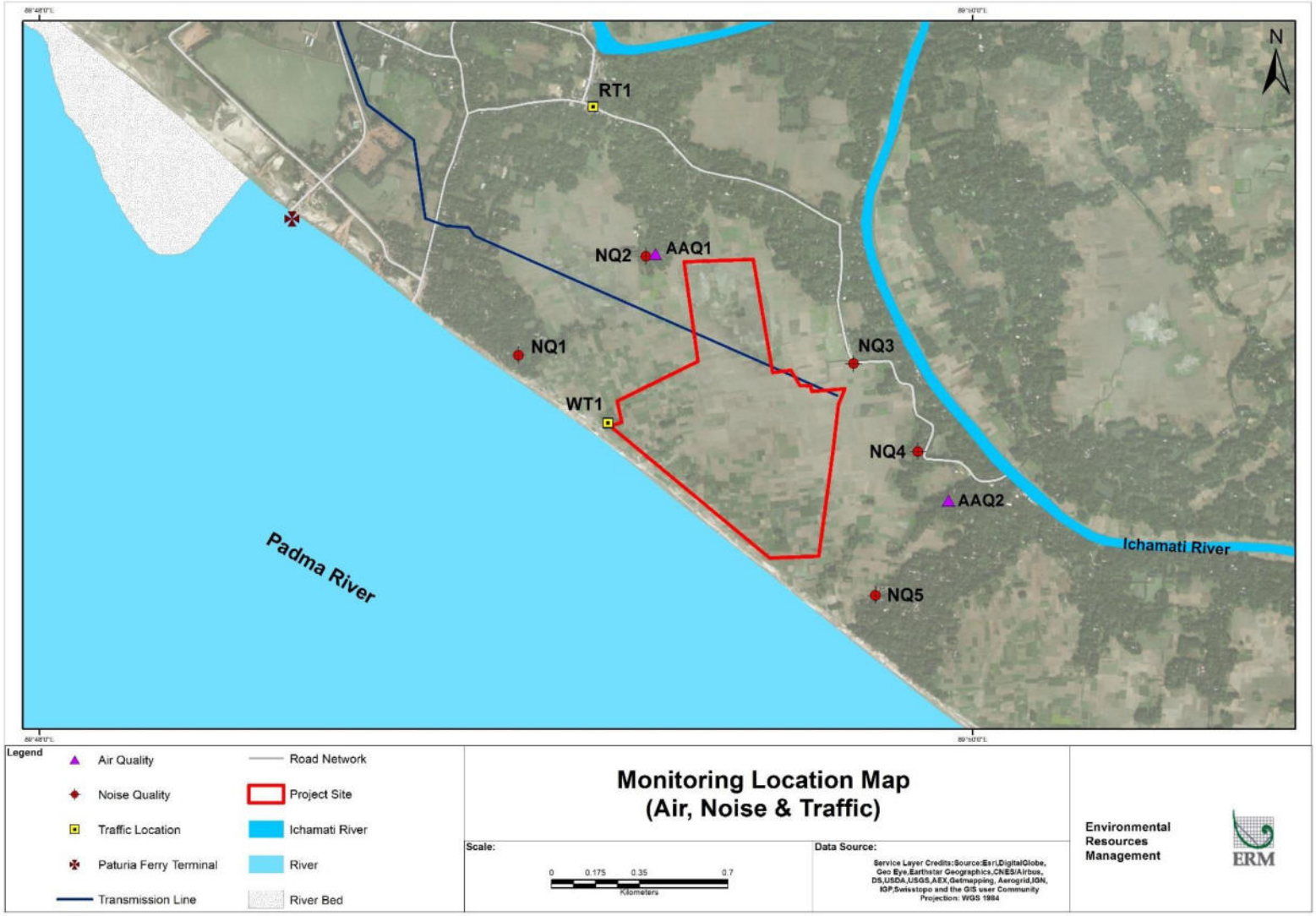
The monitoring parameters included Particulate Matter (Suspended Particulate Matter (SPM), PM_{10} and $PM_{2.5}$, Sulphur Dioxide (SO_2), Oxides of Nitrogen (NOx) and Carbon Monoxide (CO). SPM and CO were monitored for eight hour whereas rest of the parameters were monitored on 24-hourly during the duration of the study.

Figure 5.16 Photographs of Ambient Air Quality Monitoring

AQ1-In front of Subash Sarker's House, Tilochanpotti, Shibalaya, Manikganj

AQ2- In front of Aiyub Ali's House Lakshmipura, Shibalaya, Manikganj

Figure 5.17 Ambient Air, Noise & Traffic Monitoring Location Map



5.2.8.2 Monitoring Results

- Suspended Particulate Matter: The concentration of SPM in the study area varies from 172 to 186 µg/m^3. The concentrations were within the National Ambient Air Quality Standard for SPM (200 µg/m^3).
- Particulate Matter (PM_{10}): The concentration of PM_{10} in the study area varies from 64.3 to 86.8 µg/m^3. The concentrations were within the National Ambient Air Quality Standard for PM_{10} (150 µg/m^3).
- Particulate Matter ($PM_{2.5}$): The concentration of $PM_{2.5}$ in the study area varies from 47.25 to 48.17 µg/m^3. The concentrations were within the National Ambient Air Quality Standard for $PM_{2.5}$ (65 µg/m^3).
- Sulphur Di Oxide (SO_2): The concentration of SO_2 in the study area varies from 1.2 to 8.81 µg/m^3. The concentrations were within the National Ambient Air Quality Standard for SO_2 (365 µg/m^3).
- Oxides of Nitrogen (NOx): The concentration of NOx in the study area varies from 24.83 to 45.84 µg/m^3. The concentrations were within the National Ambient Air Quality Standard for NOx (100 µg/m^3).
- Carbon Mono-oxide (CO): The concentration of CO in the study area varies from 0.34 to 0.69 ppm. The concentrations were within the National Ambient Air Quality Standard for CO (9 ppm).

The monitored ambient air quality results are presented in **Table 5.5**.

Table 5.5 Ambient Air Quality Monitoring Results in the Study Area

Location	SPM (µg/m^3)	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_2 (µg/m^3)	NOx (µg/m^3)	CO (ppm)
AQ1	186	86.8	47.25	1.2	24.83	0.34
AQ2	172	64.3	48.17	8.81	45.84	0.69
Duration (hr)	8	24	24	24	24	8
ECR, 1997 and amendment in 2006 Standard (Schedule-2)	**200**	**150**	**65**	**365**	**100***	**9**
WHO Ambient Air Quality Guideline Values (2005 and 2000),	**-**	**50**	**15**	**20**	**40***	**9**

Date of Sampling: 13.02.2019 and 14.02.2019, Date of Analysis: 24.02.2019

Note * Standard for NOx is Annual

5.2.8.3 Interpretation of Results

The ambient air quality monitoring results shows that SPM, PM_{10}, $PM_{2.5}$, SO_2 and CO levels were within the National Ambient Air Quality Standard (24 hourly). However, the concentration of PM_{10}, $PM_{2.5}$ was higher than the WHO Ambient Air Quality Guideline Values (2005 and 2000) value. The concentration of NOx in the study area was within the NAAQS; however, it higher than the WHO- AQ guidelines value.

5.2.9 Noise quality

5.2.9.1 Noise Quality Monitoring

Noise levels were recorded at five (5) locations in the study area during the monitoring period February 2019. The purpose of ambient noise level measurement was to determine sound intensity at the monitoring locations. These locations were selected in such a way that a representative data could be recorded all over the project site. Noise levels were measured in the form of sound pressure levels with the help of a digital sound level meter. Noise levels were recorded in the form of A-weighted equivalent continuous sound pressure levels using Tekcoplus Data Logger SLM – 25 noise measuring instrument. Calibration certificate of noise measuring instrument is attached in **Appendix E.**

Noise level monitoring was carried out for 24 hours during monitoring period with 1-min equivalent sound pressure levels. At all the locations, measurement was taken at 1-min intervals over a 24 hour period. The equivalent noise levels have been converted to hourly equivalent noise levels. Finally, the measurements were carried out by dividing the 24 hours into two parts, i.e. daytime, which is considered from 0600 to 2100 hours and night from 2100 to 0600 hours. At each location, day time Leq has been computed from the hourly sound pressure level values measured between 0600 to 2100 hours and night time Leq has been computed from the hourly sound pressure level values measured between 2100 to 0600 hours. The details of noise monitoring locations are given in **Table 5.6** and **Figure 5.17**.

Table 5.6 Details of Ambient Noise Monitoring Locations

Location Code	Stations	Distance from Project Boundary	Geographical Location	Location Setting
NQ1	In front of Sabor Uddin's House, Baruria Village, Shibalaya, Manikganj.	420 m	23°46'58.9''N 89°49'01.6''E	Residential Area
NQ2	In front of Dulal's House Tilochanpotti Village, Shibalaya, Manikganj.	160 m	23°47'11.6''N 89°49'18.0''E	Residential Area
NQ3	In-front of Project gate, Dorikandi Village, Shibalaya, Manikganj.	110 m	23°46'57.8''N 89°49'44.7''E	Mixed Area
NQ4	In front of Sahajudi's House Lakshmipura Village, Shibalaya, Manikganj.	310 m	23°46'46.5''N 89°49'53.0''E	Residential Area
NQ5	In front of Saidul Uddin's House Nayakandi Village, Shibalaya, Manikganj	280 m	23°46'28.0''N 89°49'47.5''E	Residential Area

Figure 5.18 shows the pictures of ambient noise quality sampling locations.

Figure 5.18 Photographs of Ambient Noise Quality Monitoring

NQ1- Baruria Village, Shibalaya, Manikganj.

NQ2- Tilochanpotti Village, Shibalaya, Manikganj

NQ3- Project gate, Dorikandi Village, Shibalaya, Manikganj

NQ4- Lakshmipura Village, Shibalaya, Manikganj.

NQ5- Nayakandi Village, Shibalaya, Manikganj

NQ5- Nayakandi Village, Shibalaya, Manikganj.

5.2.9.2 Monitoring Results

The recorded noise level in the project study area during the monitoring period is summarized in **Table 5.7**.

Table 5.7 Noise Levels in the Study Area

Location Code	Location Settings	Noise Level dB(A)		Bangladesh Standard dB(A)	
		Leq day	Leq night	Day	Night
NQ1	Residential Area	50.87	41.04	55	45
NQ2	Residential Area	51.55	40.19	55	45
NQ3	Mixed Area	54.48	49.45	60	50
NQ4	Residential Area	46.97	37.02	55	45
NQ5	Residential Area	52.74	40.58	55	45

5.2.9.3 Interpretation

The daytime equivalent noise levels observed at different residential areas ranged between 46.97 to 52.74 dB(A) in the study area and the night time equivalent noise levels ranged between 37.02 to 41.04 dB(A). These noise levels were in compliance to the Bangladesh ambient day time and night time noise standards [55dB(A) and 45 dB(A) respectively] for residential areas.

5.2.10 Traffic & Transport

5.2.10.1 Site Approach Road

The approach road from Dhaka-Paturia highway to the plant site is near about 3km. The entire road is metalled road having the average width of 7.5m with pavement. The materials used for the approach road is Black Indian Stone chips. The thickness of base course is 150mm, whereas it is 52mm for wire courses. According to the civil engineer of roads and highways department (RHD), the entire 3km road has the carrying capacity of 35 tons. There are three 90 degree turns exist on the approach road (see below figure). The average width of those turns is 8m. On every turns of the approach road, the safety barrier posts exist. A culvert is situated near the entry gate of the site. The length of the culvert is 3m and width is 8.5m with the carrying capacity 50 tons. In the Nali bazaar intersection, the width of the road is 10m. Safety cautions and speed breakers exist before the Nali bazaar intersection where local market, schools and madrasa situated. The existing electricity distribution wire hanging at 15-20 feet height was observed during traffic survey at Nali Bazaar intersection. Roads and Highways Department (RHD) is the in-charge of the construction and maintenance of the road.

Table 5.8 Condition of the Approach Road

S. No.	Status	Details
1.	Status	Metalled Road
2.	Length of the Approach Road	3km from the Dhaka-Paturia Highway (NH5)
3.	Average Width	7.5m (with pavement)
4.	Materials Used	Black Indian Stone chips
5.	Thickness	Base Course-150mm, Wire Courses- 52mm
6	Weight Capacity of the Road	35 Ton
7.	Culvert Length and Width	Length- 3 meter; 7.5 meter
8.	Weight Capacity of the Culvert	50 Ton
9.	Safety Barriers (in Turnings)	Available in most of the turnings
10.	In-charge of construction and maintenance	Roads and Highways Department (RHD)

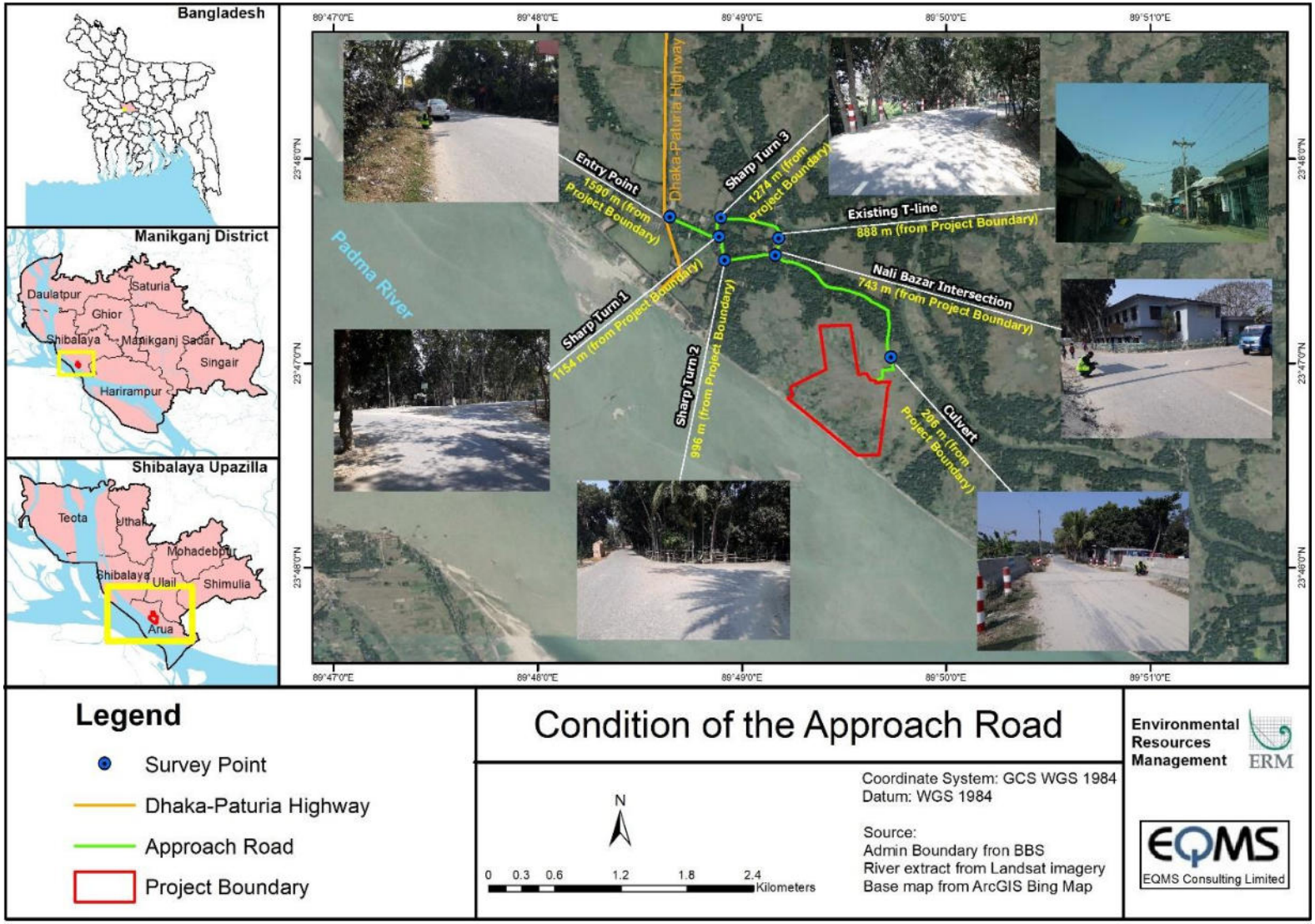
5.2.10.2 Traffic Survey

Total two primary traffic surveys were conducted during 12th – 13th February 2019 of which one was on the access road and other one river traffic for the Padma River. The traffic surveys were conducted for 24 hours. Road traffic survey was conducted during the survey period on the Dhaka-Paturia Highway to Nayakandi bazaar passing through the Nali bazaar on the north side of the project and the project site from the north-eastern side. The route of Dhaka-Paturia Highway to Nayakandi bazaar through Nali bazaar road is selected for the road traffic survey to understand the traffic load as the road will be used for carrying the construction material. River traffic survey was also conducted at one location; near Baruria village situated on the right bank of the river Padma. The details of the road and water traffic have been shown in **Table 5.9** and **Figure 5.17**.

Table 5.9 Details of Road and River Traffic Survey

Location Code	Location	Geographical Coordinates
RT1	Dhaka-Paturia Highway to Nayakandi bazaar	23°47'30.88"N; 89°49'11.19"E
WT1	Near Baruria village situated on the right bank of the river Padma	23°46'50.24"N; 89°49'13.18"E

Figure 5.19 Condition of the Approach Road



Road Traffic

The road traffic survey was conducted for 24 hours, once during the study period at one location (shown in the Figure 26) at the approach road to the proposed project. The traffic survey was conducted for both way movement of vehicles and categorization as a Medium vehicle (tractor/power tiller), light vehicle (private car, auto rickshaw, CNG, motorcycle) and non-motorized vehicle (rickshaw, cycle etc.).

Total no. of vehicles recorded on the road for 24 hours are 151 including 15 medium vehicles, 104 light vehicles, and 32 non- motorized vehicle. Maximum traffic volume of 17 vehicles in an hour was recorded between 3.00 pm to 4.00 pm. The frequency of the medium vehicle (9.93%), light vehicle (68.87%) and non-motorized vehicle (21.19%) respectively.

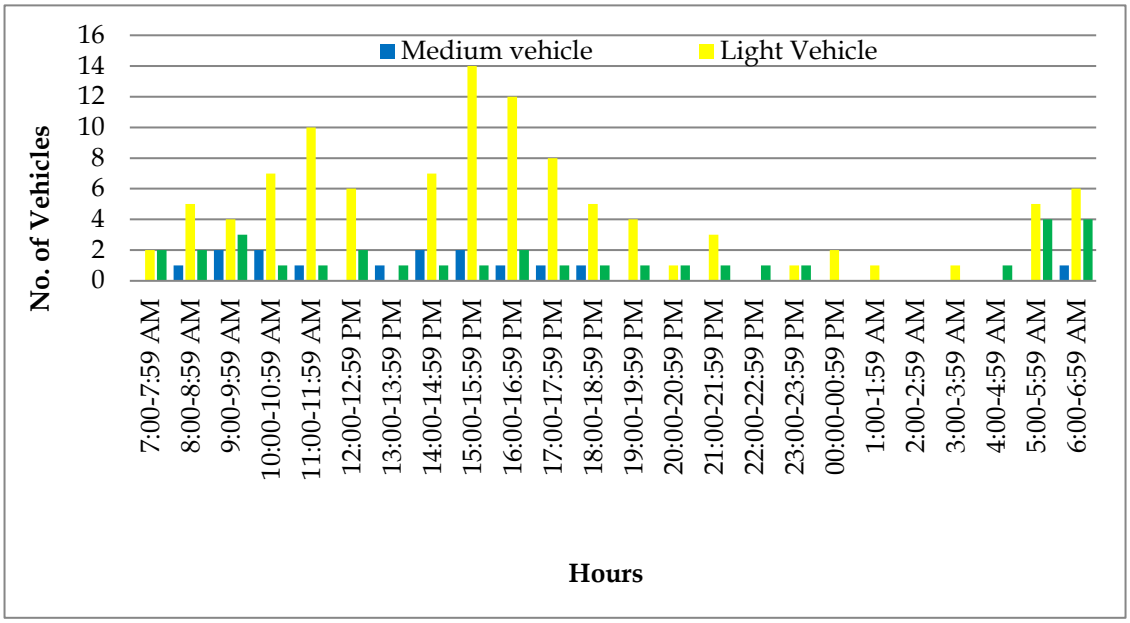
A summary of traffic survey results is presented in **Table 5.10** and hourly movements of vehicles are presented in **Figure 5.20**.

Table 5.10 Status of Road Traffic

S. No.	Vehicle Type	Numbers/ Time
1	Total traffic volume (Nos)/24 hr	151
2	Average traffic volume/hr	6.3
3	Max Traffic volume (Nos)/hr	17
4	Min traffic volume (Nos)/hr	0
5	Minimum traffic flow hours	2.00 am to 2.59 am
6	Maximum traffic flow hours	15.00 pm to 15.59 pm

Movement of man, material, and machinery to the site is expected during the construction and operation stages of the project. This is likely to result in an increase in traffic movement on the project surrounding the area. It is understood that equipment can be transported to the project site by existing road.

Figure 5.20 Hourly Road Traffic Volume



River Traffic

The river traffic survey was conducted continuously for 24 hours, once during the study period at one location in the Padma River near Baruria village. The river traffic survey was done for both way movement of river traffic and categorized as a fishing boat (motorized), trawler (goods carrying), passenger service boat (large), fishing boat (Non- motorized).

The river port/Paturia ferry Ghat adjacent to proposed power plant is a major inland port and trading center. Various developments in the region continue to increase this port's importance to fishing boats, passenger boats, and trawlers. The Padma River and connecting waterways will be relied upon for heavy construction equipment transportation as well as being used for power station cooling and general water uses. The river traffic survey was conducted near to the project location on the bank of the Padma River.

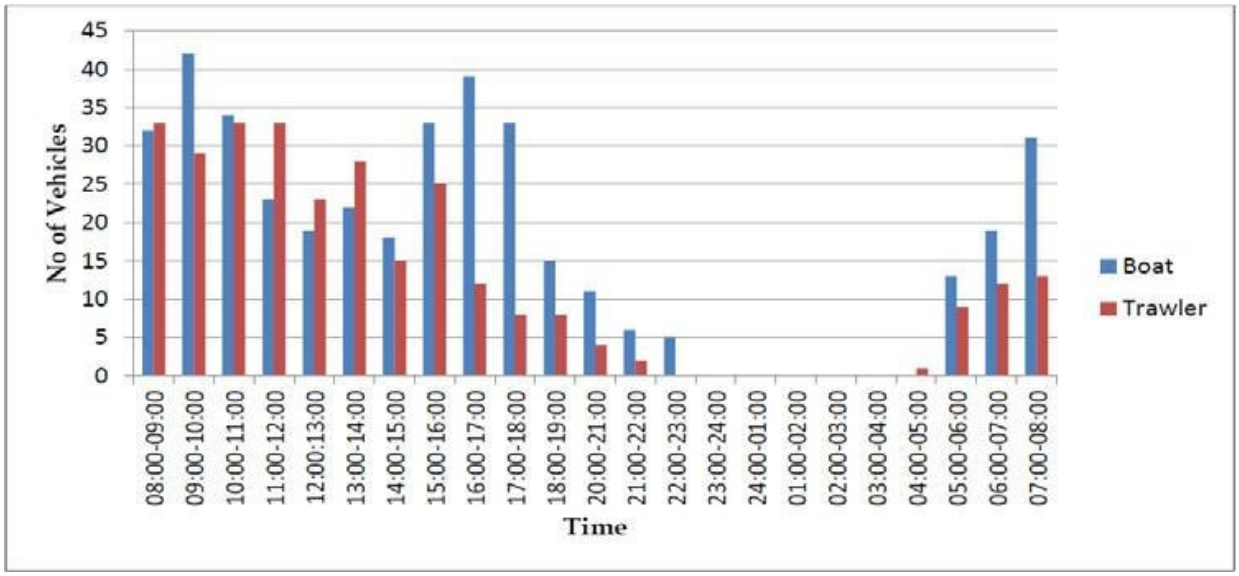
People from the both sides of the river travel every day from one side to the other for their livelihood, business or travel purpose. A number of trawlers and boats travel in the river. River traffic survey was implemented 24 hours one time, during the study period at one location.

Table 5.11 Status of River Traffic

S. No.	Description	River Traffic Number			
		Boat	Barge	Cargo vessel	Trawler
1	Total traffic/24 hrs	385	4	2	280
2	Average Traffic Flow/Hr	16	0	0	12
3	Max Traffic Flow (nos)/Hr	40			31
4	Min Traffic Flow (nos)/Hr	0	0	0	0
5	Max Traffic Flow (Time)	09:00-10:00			08:00-09:00 10:00-11:00 11:00-12:00

It is observed that the Padma River is a navigation network with an average of 16 boats across per hour at project location. Major traffic was boats and trawlers.

Figure 5.21 Hourly movement of River Traffic near Baruria Transit



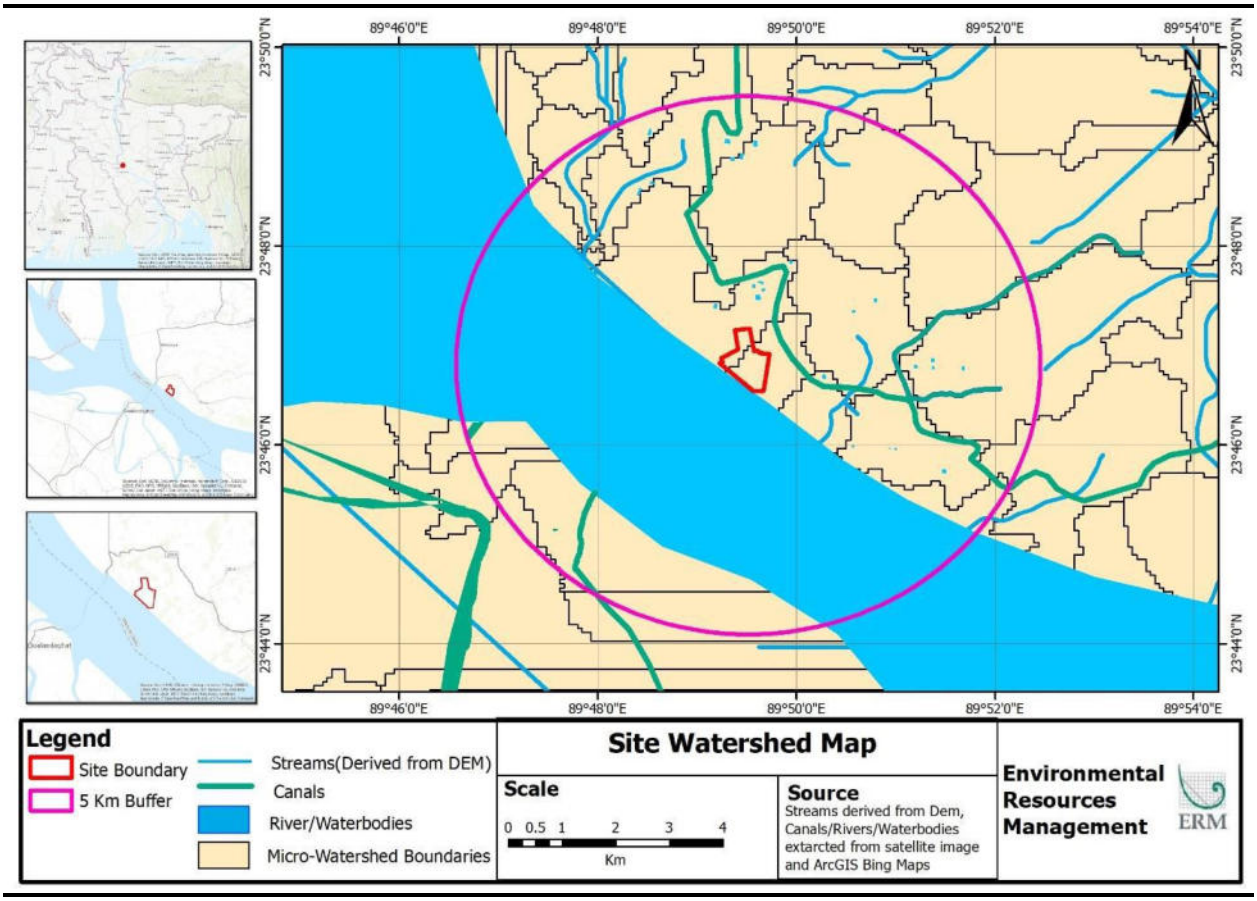
Note that the river traffic survey was carried out during dry season, so that the movement of large vessels found negligible due to the shallow water flow in the Padma River.

5.2.11 Hydrology

5.2.11.1 Drainage of the Watershed/Catchment

The study area falls within the watershed of Padma River. Padma River flows north- west to south-east within the study area at a nearest distance of 0.05 km west of the site. The micro-watershed within which the Site is located was delineated based on the topography and drainage pattern. The micro-watershed area admeasures ~7.6 km^2, predominantly occupied by Padma River as presented in **Figure 5.22**. The Site is located close to the edge of the catchment[1], almost along the river bank. The natural drainage of the micro-watershed is from north to south and southeast, while within the Site area is from west to northeast direction. The ground slope leads the drainage from the Site area to natural drainage channel, low lying areas located in east of the Site and ultimately to the Padma River in the downstream. Though, the Padma river is located adjacent the Site (southwest to the Site), the gradient is towards northeast of the Site due to presence of levee.

Figure 5.22 Catchment Area of Micro-watershed within which the Site is Located



5.2.11.2 Surface Water Bodies & Natural Drainage Channels within the Catchment

Key surface water bodies and natural drainage channels within the region include Padma River, Jamuna River, Dhaleshwari River, Kaliganga River, and Ichamati River. Padma River and Jamuna River merge near Aricha Port. The Site is located on the left bank of the Padma River ~5 km downstream from the confluence point. Dhaleshwari and Kaliganga Rivers are distributaries of Jamuna River which are located

[1] Catchment is a topographically defined area, draining surface water to a single outlet point. It may frequently include an area of tributary streams and flow paths as well as the main stream.

> 20 km NE from the Site. Ichamati River is a distributary of Jamuna River which passes through the study area.

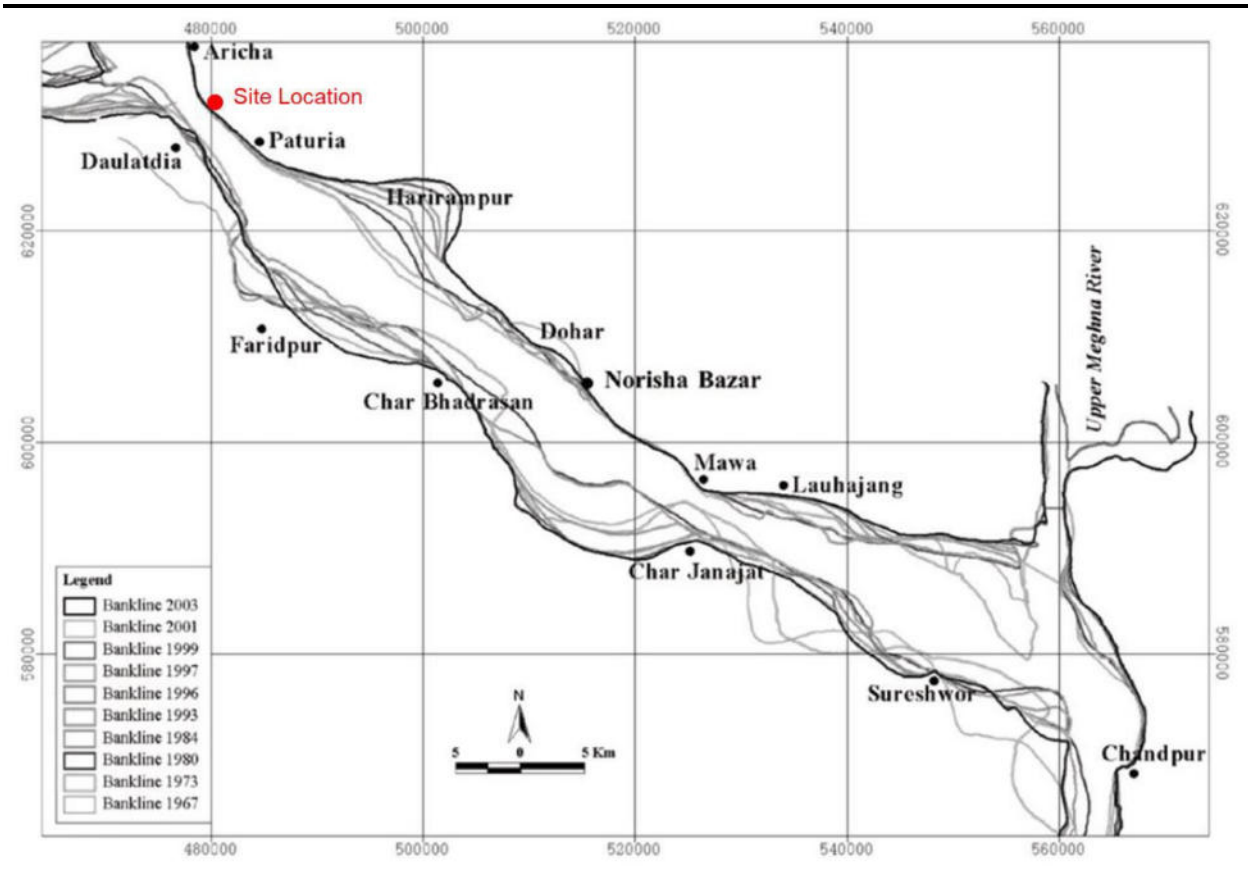
Padma River

The Padma is the second longest river of Bangladesh (Hossain et al., 2005). It is the main distributary of the Ganga, which originates in the Gangotri glacier of the Himalayan. The part of the Ganga in Bangladesh is known as the Padma which enters Bangladesh from India (Murshidabad district) at Shibganj Upazila (Manakosha and Durlavpur unions) of Chapai Nawabganj district. Its length in Bangladesh is 366 kilometers (Hossain et al., 20052). The Padma is joined by the mighty Jamuna (Lower Brahmaputra) and the resulting combination flows with the name Padma further east, to Chandpur. At this point, the widest river in Bangladesh, the Meghna, merges with the Padma, continuing as the Meghna to the south, before finally discharging in the Bay of Bengal. Padma River channel extends over 3.25 km wide area near the Site and has clearly defined banks on both sides of the river. Submergence area of the river channel varies depending on the season.

Based on satellite imagery, the river is observed to show considerable erosion and siltation which in turn alter the water course within the river channel on a frequent basis. Owing to combined flow from both Padma and Jamuna rivers, Padma experiences frequent flooding and is known to have caused some of the most prominent floods in Bangladesh in the past, both in terms of scale and magnitude

The Site is located on the left bank of Padma River, south to the Paturia Ferry terminal (approximately one km). Being located at the bank of the river and morphologically at riverine lands are prone to erosion/accretion, which alter the flow direction and intensity of the storm water. Based on the research articles, Padma River banks are prone to large scale erosion. However, the patch of the bank, where the Site is located is less prone compared to other areas of the bank (**Figure 5.23**).

Figure 5.23 Historical Bank Positions of Padma River



Ichamati River

Ichamati River at Manikganj is a distributary of The Brahmaputra River (aka Jamuna), which originates ~ 14 km north and upstream from the Site and discharges into river Padma, ~10.5 km southeast and downstream from the Site. It meanders through a total length of ~21 km before merging with Padma River. The River is perennial in nature with an average water level of ~5.5 m during monsoon and ~1 m during pre-monsoon period. Ichamati River is located ~270 m east of the Site at the nearest point. Surplus surface runoff from the Site and surrounding area drain into this river. High water level in Ichamati is likely to cause backflow, inundation and waterlogging near Site and surround area.

5.2.12 Geo-hydrology

Rain water is the principal source of groundwater recharge in Bangladesh. Flood water which overflow the river and stream banks also infiltrates into the groundwater. Water from permanent water bodies (rivers, canals, wetlands, ponds, irrigated fields etc.) that lie above the water table also percolates to the groundwater. In the Pleistocene terraces, the recharge occurs through the incised antecedent drainage channels that cut through near-surface clays into the underlying sands. The greatest scope of recharge is within the coarse grained sediments and the least is within the fine grained sediments like clay.

In line with the above paragraph, the main sources of groundwater of the project site are shallow and deep tube wells. There are 3 tube wells with the depth of 50 feet have been installed in the project site to meet the water requirements for pre-construction phase. These tube wells are also used for drinking purposes and for other activities. The proponent has planned to install 2 more wells or boreholes in the project site to meet the water requirements for construction and operation phase. There are 20 existing boreholes situated around to the entire project boundaries. These boreholes are mainly used for irrigation purposes and also drinking purposes for the nearby villagers.

5.2.13 Surface Water Quality

Surface water was monitored at three different locations from the study area. Samples were collected to understand the potential impact due to proposed project activities.

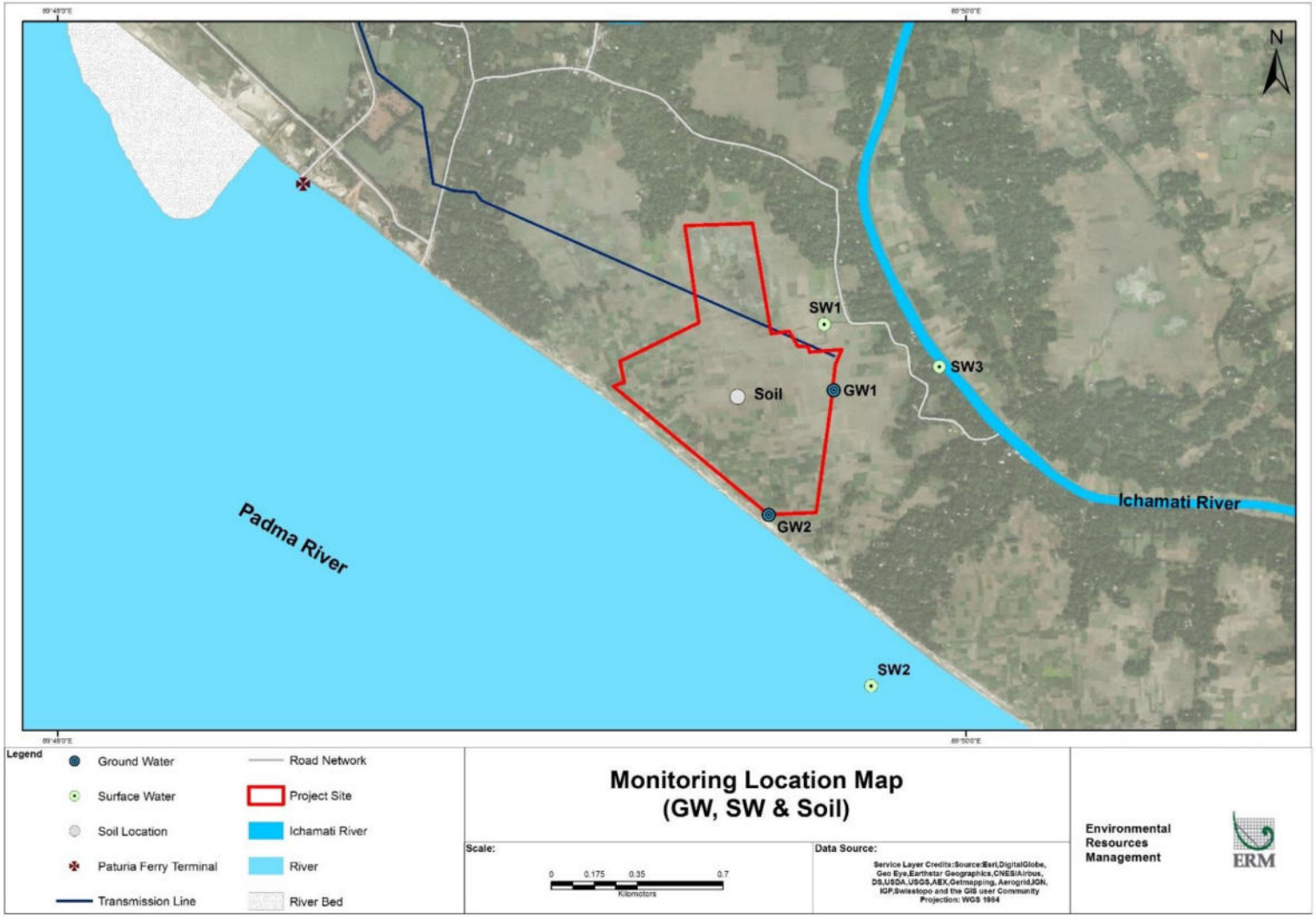
5.2.13.1 Surface Water Monitoring Locations

Two samples were collected upstream and downstream of the local drainage channel confluence point at Ichamati River. Another sample was collected from a stream (Surface water body near project site) that meets joins with local drainage channel. The surface water quality monitoring details has been provided in **Table 5.12** and **Figure 5.24**.

Table 5.12 Details of Surface Water Quality Monitoring Location

Location Code	Location	Geographical Coordinates	Selection Criteria
SW-1	Surface Waterbody near project site	23°46'57.9"N; 89°49'41.3"E	Assess the existing water quality; assess the impact on surface runoff
SW-2	Upstream of Ichamati River	23°46'10.2"N; 89°49'47.5"E	Assess the existing water quality.
SW-3	Downstream of Ichamati River	23°46'52.3"N; 89°49'56.5"E	Assess the existing water quality; assess the impact on surface runoff

Figure 5.24 Surface Water, Ground Water and Sediment Quality Monitoring Location Map



5.2.13.2 Interpretation of Surface Water Quality Results

The surface water quality monitoring results has been provided in **Appendix F**. The surface water quality has been compared with ECR, 97 Standard for inland surface Water.

The pH of the surface water samples varied from 7.58 to 7.81; within the inland surface water standard for category a, b, c, d, e & f[1] use category. The DO levels at all locations exhibited values ranging from 5.6 to 6.1 mg/l, indicating favourable conditions for the growth and reproduction fish and other aquatic organisms in these water bodies, indicating water was fit for category b, d, e and f use category. Biochemical Oxygen Demand (BOD) values of the sample collected from upstream of Ichamati River and surface waterbody near site was found to be < 2.0 mg/l. The other samples reveal BOD values of 3.8 mg/l. Such low BOD values confirmed the presence of low concentrations of biologically oxidizable organic matter in the receiving water bodies; indicating the water was fit for b, c, d, e and f use category.

Presence of contaminants in the form of oil and grease in all surface water samples was found to be negligible (<1.4 mg/l).

The total Coliform count of the surface water samples found between <1.8 to 2 MPN/100 ml, indicating for use category a, b, c. d. e and f.

Concentrations of heavy metal like lead (<0.005 mg/l), chromium (<0.01 mg/l), cadmium (<0.001 mg/l), mercury (<0.001 mg/l), arsenic (<0.005 mg/l) and vanadium (<0.2 mg/l) were found to be below detection limits in the surface water sample.

5.2.14 Ground Water Quality

Primary monitoring of ground water quality was considered important in order to understand the probable impacts of the proposed project activities on the sub surface aquifers.

5.2.14.1 Groundwater Sampling Locations

Groundwater samples were collected from 2 different locations. Groundwater was collected from shallow deep tube wells of the study area Refer **Table 5.13** and **Figure 5.24.** The samples were analysed for physicochemical and bacteriological parameters and results were compared with ECR drinking water standard drinking water standards to identify and interpret any deviation in the statutory limits set for parameters under this standard.

Table 5.13 Details of Ground Water Quality Monitoring Location

Location Code	Location	Geographical Coordinates	Selection Criteria
GW-1	Tube well within the site- SE side	23°46'49.2"N 89°49'42.5"E	Assess the existing water quality; assess the impact on ground water
GW-2	Tube well within the site- Eastern side	23°46'32.7"N 89°49'33.9"E	Assess the existing water quality; assess the impact on ground water

5.2.14.2 Analysis Results of Ground Water Quality

The ground water quality monitoring results has been provided in **Appendix G.**

[1] a- Source of drinking water for supply only after disinfecting: b. Water usable for recreational activity; c. Source of drinking water for supply after conventional treatment; d. Water usable by fisheries: e. Water usable by various process and cooling industries; f. Water usable for irrigation

pH of the groundwater samples were found in the range of 7.21 to 7.33; were found to be within the drinking water standard (6.5-8.5).

The concentration of TSS were found to be 23 to 44 mg/l; were found to be above the drinking water standard (10 mg/l).

With respect to drinking water standard of chloride is 150 mg/l (acceptable limit) while the permissible limit of the said parameter is 600 mg/l. The chloride concentration in the ground water samples (17 to 34 mg/l) was found to be in compliance to the acceptable limit.

Hardness of water is considered to be an important parameter in determining the suitability of water for domestic uses particularly washing. Total hardness of water is correlated to the presence of bivalent metallic ions viz. calcium and magnesium. Total hardness in the groundwater samples varied from 252-411 mg/l and were incompliance to the acceptable limit of 200 -500 mg/l.

Iron is considered to be an important ground water parameter since at higher concentration it interferes with laundering operations and imparts objectionable stains. Concentration iron in ground water sample ranged from 5.2 to 22 mg/l. Iron concentration in all the samples were in non- compliance with drinking water standard (0.3 to 1.0 mg/l).

Fluoride concentration of the samples varied between 0.31-0.38 mg/l, which is in compliance to the drinking water standards (1.0 mg/l).

Nitrate and sulphate contents of the groundwater samples varied between <0.5-3.9 mg/l and <1.0-18.0 mg/l and were in compliance to the drinking water standard for nitrate (10 mg/l) and sulphate (400 mg/l).

Mercury, cadmium, lead, nickel, arsenic, total chromium, hexavalent chromium and vanadium contents in all ground water samples were found to be below detection limits and in compliance to the drinking water standard.

The concentration of TPH and Zn were found to be below detection limit for all the samples.

Coliform are indicators of contamination from sewage and faecal matter. Total coliforms contents of all the samples were found to be <2.0 MPN/100 ml, above the drinking water standard (0 /100 ml).

5.2.15 Sediment Quality

The project site and its surrounding area is a rural area; there is no industrial activity in the 2km area of influence. Mechanised boat and vessels are only operated in the Padma River. However, operation of mechanised boat was not observed in the Ichamati River. To assess the sediment quality in the river primary monitoring was carried out in three representative locations in surface water body near project site and up-stream and down-stream of Ichamati River. The sediment quality monitoring location details has been provided in **Table 5.13** and **Figure 5.24**.

Table 5.14 Details of Sediment Quality Monitoring Location

Location Code	Location	Geographical Coordinates	Selection Criteria
SW-1	Surface Waterbody near project site	23°46'57.9"N; 89°49'41.3"E	Assess the existing water quality; assess the impact on surface runoff
SW-2	Upstream of Ichamati River	23°46'10.2"N; 89°49'47.5"E	Assess the existing water quality.
SW-3	Downstream of Ichamati River	23°46'52.3"N; 89°49'56.5"E	Assess the existing water quality; assess the impact on surface runoff

Analysis of Results

The sediment monitoring results are provided in **Appendix H**

Toxic Metal: The concentration of Cadmium, cadmium, chromium in all the monitoring locations were observed <2.0 mg/kg. The concentration of Arsenic varied from 0.48 to 0.88 mg/kg. The concentration of Lead varied from 9.6 to 13 mg/kg. The concentration of mercury in all the monitoring locations were <0.1 mg/kg. The mercury (inorganic and organic) in all the monitoring locations were <0.1 mg/kg.

The concentration of Cr, Cd and Pb were well below the Dutch intervention values for these metals (Dutch intervention value: Cd 13 mg/kg, Cr(III)- 180 mg/kg, Cr (VI)-78 mg/Kg, Pb- 530 mg/kg). It was found that concentration of Co, Cu, Ni and Zn were well below the Dutch intervention values for these metals. (Dutch targeted and intervention value: Co - 190 mg/kg, Cu- 190 mg/kg, Ni-100 mg/kg, Zn- 720 mg/kg).

5.3 Ecological environment

In order to understand the ecological environmental condition of the study area, a survey was conducted for five (05) days covering the study area of the project from 11th to 15th February 2019. The study area for ecological survey includes a buffer area considering 05 km radius from the estimated Centre of the proposed project location. The biodiversity component of the study, focused on a few groups of biological components comprising of flora (tree, herbs, shrubs & climbers) and fauna (birds, reptiles, amphibians, mammals, butterflies, Fish) as well as the surrounding ecosystems.

The objective of the survey was as follows:

- Identification of various habitat in the study area;
- Identification of critical habitat in the study area;
- Identification of floral species (terrestrial and aquatic), endangered species, if any;
- Identification of faunal species (terrestrial and aquatic), endangered species, if any;
- Identification of areas which are important or sensitive for ecological reasons.

5.3.1 Methodology for ecology & biodiversity survey

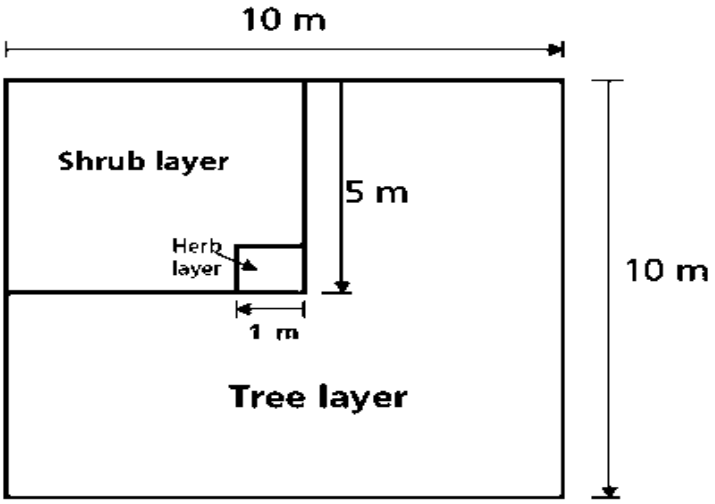
Different methods were applied for assignment of various forms of biodiversity within the study area.

5.3.1.1 Methodology for floral survey

Micro level approach involved mainly the field based primary data collection on different components of the project objectives/scope of work using well established and accepted ecological methods in different habitats identified within the study area.

The primary data collection of different components of the study area conducted by using well established and accepted ecological methods in the different habitats. Quadrat sampling method has been used for the counting the vegetation structure in and around the study area. A quadrat is a frame that is laid down to mark out a specific area of the community to be sampled. Within the quadrat frame, the occurrence of plants is recorded using an appropriate measure of abundance. The quadrat method can be used in virtually any vegetation type to quantify the plant community. IUCN didn't assess the floral diversity in Bangladesh yet, so that the Conservation significance of the floral diversity within the study area was studied according to the IUCN global Red list. Furthermore the ecologist studied the different floral aspect within the study location and also categorized them into different local availability status. Methods of quadrate layout is presented in **Figure 5.25**.

Figure 5.25 Quadrat study layout of sampling of floral species



5.3.1.2 Methodology for faunal survey

Different methods were applied for assignment of various forms of faunal diversity within the study area.

Avifauna

Survey of birds are followed by using line transect method, point count method and opportunistic bird sightings. By using bird vocal sounds and photographs, the species were identified in consultation with ornithologists. This methods involves identifying all the birds; it has been seen or heard while standing at a series of points along with transect (Straight line through the site). Bird's counts were conducted at the start of first light which is before sunrise. This time was when birds vocalized most, and is known as the "Dawn Chorus". It is also time of maximum bird movement as birds through the bush to begin feeding. A systematic search in the study area (over a fixed area and/ or for a fixed time) such as the method specified here has been the added advantage of providing an index of the abundance of individuals and species. The reliability of the abundance index can be reduced by either overestimates or underestimates of bird numbers. To reduce overestimates, particularly when a member is observing, try to ensure that each individual bird is recorded only once. Hence, ensure that a least one member of the team was watching at all times. Focus Group Discussion (FGD) with local people (including villagers, school teachers, Mosque Imam) to get information of the local species available in the study area.

Amphibians and reptiles

Amphibians and reptilian's groups are known as herpetofauna. Amphibians and Reptiles have been assessed on an opportunistic basis by the team. For this inventory, it has been used a combination of diurnal and nocturnal time-recorded visual encounter surveys ("general surveys"), road driving with capturing digital image from the spot. Interviews were held with local people in the area to assess the presence of game species. Focus Group Discussion (FGD) with local people (including villagers, school teachers, Imam) to get information of the local species available in the study area.

Mammals

For mammal's inventory, it is generally huge challenging, time consuming as well as costly. During the inventory of this study area with the stipulated short time, it has been followed "Observational methods" including imaging record by digital camera, identification of dung or feces, tracks and others signs. Focus Group Discussion (FGD) and consultation with local people also consider during this inventory of the study area.

5.3.2 Bio-ecological zone

As per IUCN classification based on physiographic and biological diversity the study area falls under Ganges Floodplain and Major Rivers. Basic information on the study site bio-ecological zone is

summarized in **Table 5.15** and **Table 5.16**. The Bio-Ecological Zone of Bangladesh and the study area is shown in **Figure 5.26**.

Table 5.15 Information on Project site Bio-Ecological Zone

Features	Information
Location	$21^0$50'-$24^0$15' N and $88^0$20'-$90^0$30' E
Relevant admin headquarter	Rajshahi, Pabna, Rajbari, Faridpur, Shariatpur, Barishal, Meherpur, Chuadanga, Jhenaidah, Magura, Jessore
Physiography	Ganges river floodplain and Ganges tidal floodplain
Soil	Calcareous dark grey floodplain soils & calcareous brown floodplain Soils
Rainfalls	1270-1780 mm
Temperature	Maximum 37^0C, Minimum 11^0C
Flooding depth	H-MH, MH-H, MH-L
Land use	Rabi-B, aus-Fallow (1c), Fallow-Aus_T, Aman (3a), Rabi-Mixed B, Aus & Aman (7b), Fallow-B, Aman (8a), Boro-Fallow (9d)

5.3.2.1 Ganges Floodplain

Floral diversity:

- **Herbs & Shrubs:** Chakunda (Cassia tora); Assam lata (Mikania scandens); Ban crolon (Croton bonplandianum).
- **Planted Trees:** Khejur (Phoenix sylvestris); Narikel (Cocos nucifera), Amra (Spondias pinnata); Supari (Arcea catechu).
- **Plants near water:** Hijal (Barringtonia acutangula); Barun (Crataeva nurvala); Jiban (Trema orientalis); Mandar (Erythrina indica)
- **Aquatic plants:** Sada shapla (Nymphaea nouchali); Singra (Trapa bispinosa); Kachuripana (Eichhornia crassipes); Panchuli (Nymphoides indicum), Hogla (Typha elephantina).

Faunal Diversity

- **Mammals:** Hanuman langur (Senmopithecus entellus); Five-striped palm squirrel (Funambulus pennanti), Smooth-coated otter (Lutra perspicillata); Rufous-tailed hare (Lepus nigricollis)
- **Birds:** Water cock (Gallicrex cinerea), Bank myna (Acridotheris ginginianus), Asian paradise-flycatcher (Terpsiphone paradisi), Brahminy kite (Haliastur indus); River tern (Sterna aurantia).
- **Reptiles:** Yellow monitor (Varanus flavescens); Common vine snake (Ahaetulla nasutus); Binocellate cobra snake (Naja naja); Painted roofed turtle (Kachuga kachuga).
- **Amphibians:** Boulenger's frog (Rana alticola); Balloon frog (Uperodon globulosus).

Table 5.16 Bio-ecological Zone 11: Major Rivers

Features	Information
Location	$22^0$55'-26°15' N and 88°10'-90°37' E
Relevant admin headquarter	Rajshahi, Kustia, Faridpur, Shariatpur, Chandpur, Narayanganj, Manikganj, Tangail, Sirajganj, Kurigram, Rangpur.
Physiography	Young Brahmaputra floodplain, Ganges river floodplain
Soil	Calcareous alluvium (non-saline); Noncalcareous alluvium Soils

Features	Information
Rainfalls	1270-2290 mm
Temperature	Maximum 37^0C, Minimum 9^0C
Flooding depth	MH, & ML
Land use	Rabi-Aus-T, Aman (2a), Rabi-Mixed B, Aus & Aman (7a), Rabi-B, Aus-Fallow (1e)

Floral diversity:

- **Plants:** Binna ghash (Vetveria zizaniodes); Kash (Saccharum spontaneum), Ghagra (Xanthium indicum); Ban Palang (Rumex maritimus).

Faunal Diversity

- **Mammals**: Ganges River Dolphin (Platanista gangetica); Bengal fox (Vulpes bengalensis), Greater bandicoot rat (Bandicota indica).
- **Birds**: River lapwing (Vanellus duvaucelii), Black-bellied tern (Sterna acuticauda), Sand lark (Calandrella raytal), Spot billed duck (Anas poecilorhyncha); Small prantincole (Glareola tentoria).
- **Reptiles**: Bibron's softshell turtle (Pelochelys bibroni); Gangetic gharial (Gavialis gangeticus); Ganges softshell turtle (Aspideretes gangeticus); Median roofed turtle (Kachuga tentoria).
- **Amphibians**: Jerdon's bull frog (Hoplobatrachus crassus); Skipper frog (Euphlyctis cyanoplyctis).

Figure 5.26 Bio Ecological Zone of Bangladesh and Project Location