Chapter VII Description of Environment

7.1 Study Area

The location of the study area is shown in **Figure 7.1-1**. The study area is situated between 21º 27′ and 23º 47′ north latitude and between 90º 12′ and 92º 08′ east longitude. Proposed Meghnaghat 400kV substation is located on the northern bank of the Meghna River just off the Dhaka-Comilla highway in Sonargaon Upazila of the District of Narayanganj, Bangladesh approximately 22 km Southeast of Dhaka. Proposed Madunaghat 400kV substation is located at South Islam Nagar village of Raojan Upazila of Chittagong district in the North West side of RPCL's 25MW Power station located on the north side of Chittagong – Kaptai road.

Route of Proposed 400kV Transmission Line:

The proposed 400kV double circuit Transmission line will be drawn from the proposed Meghnaghat 400kV substation to the proposed Madunaghat 400kV substation in the 1st phase of the project. Similarly, another 400kV double circuit transmission line will be drawn from the proposed Matarbari 2x600MW Coal based power plant to the proposed 400kV Madunghat substation. Map of Bangladesh showing the proposed route of 400kV transmission line from Meghnaghat 400kV substation to Matarbari coal based power plant via Madunaghat 400kV proposed substation is given in **Figure 7.1-2.** The names of Upazilas over which the proposed 400kV Transmission lines will be drawn are given in **Table 7.1.**

Table 7.1 List of Upazilas

Sl. No.	Section	Name of Upazilas	Approximate length in km
1	Meghnaghat 400kV SS to Madunaghat 400kV SS	1. Sonaragaon, Narayanganj 2. Gazaria, Munshiganj 3. Daudkandi, Comilla 4. Kachua, Chandpur 5. Barura, Comilla 6. Laksam, Comilla 7. Nangolkot 8. Feni-Sadar, Feni 9. Chhagolnaiya, Feni 10. Mirsarai, Chittagong 11. Fatikchhari, Chittagong 12. Hathazari, Chittagong 13. Raojan, Chittagong	214
2	Madunaghat 400kV SS to Matarbari 2x600MW Coal PP	1. Boalkhali, Chittagong 2. Patiya, Chittagong 3. Anowara, Chittagong 4. Banshkhali, Chittagong 5. Pekua, Cox's Bazar 6. Moheshkhali, Cox's Bazar	100
Total		19 Upazilas under 7 districts	314

The area is well communicated with the other part of the country by railway, road and river.

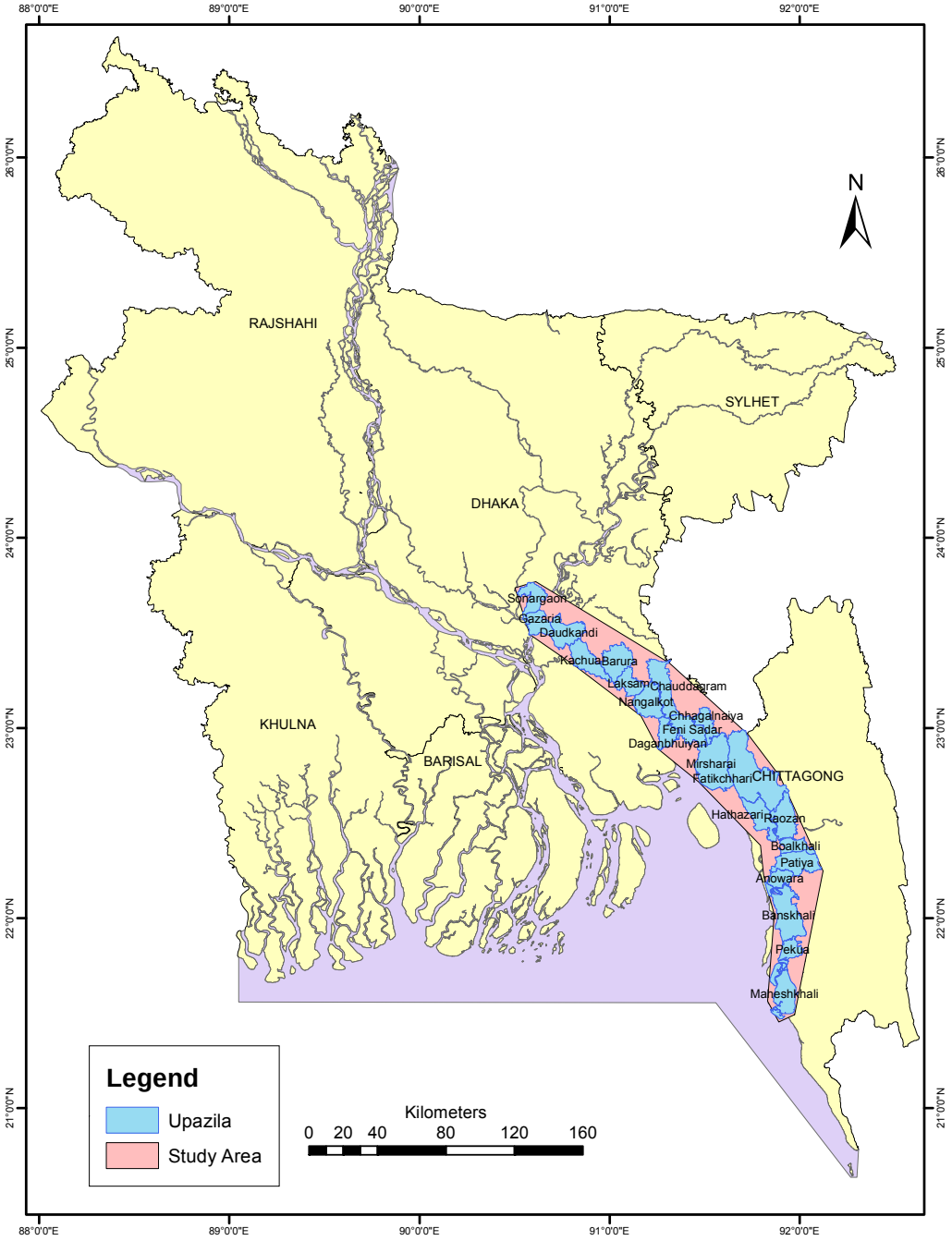


Figure 7.1-1. Location map of the study area

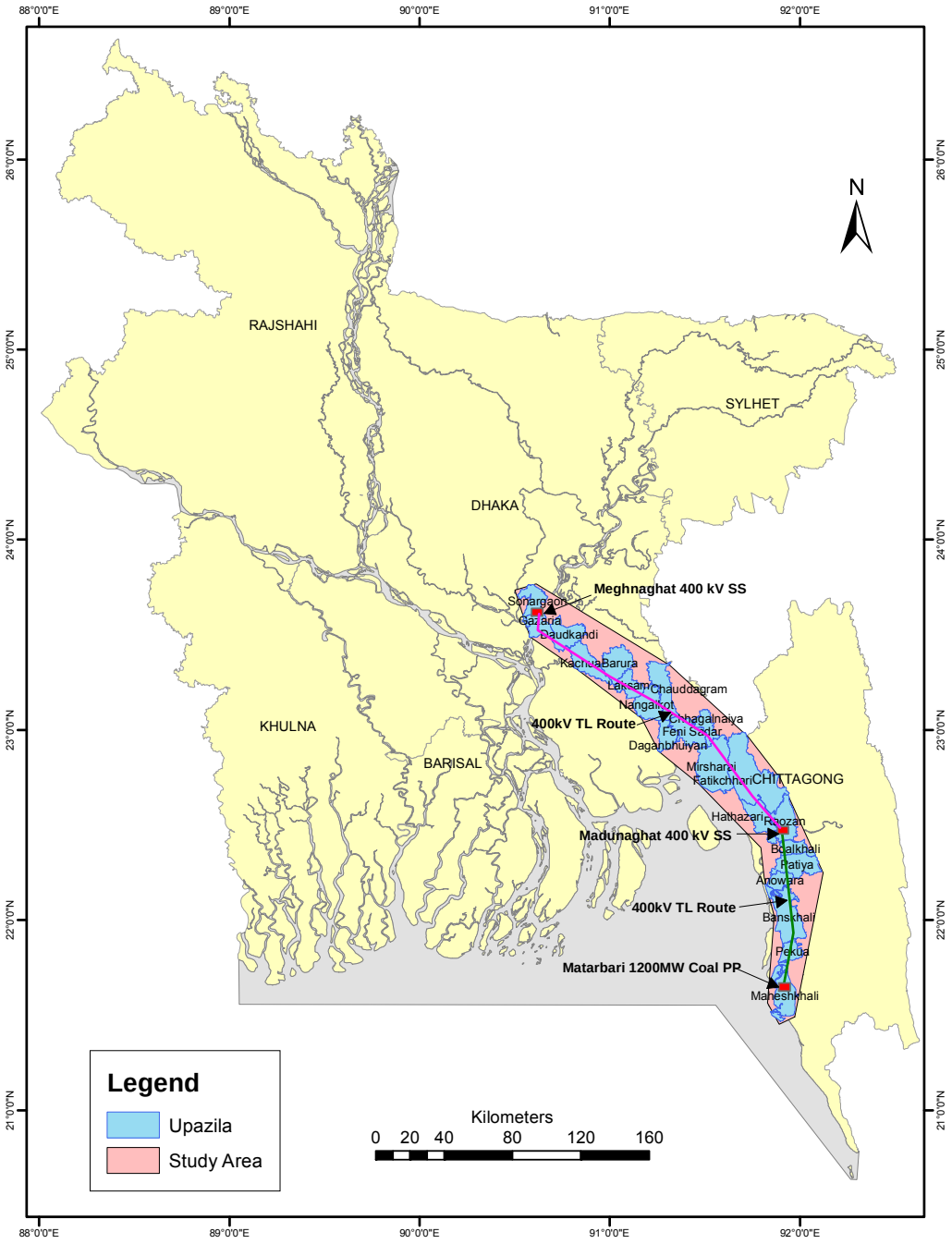


Figure 7.1-2 Route of Proposed 400kV Transmission Line.

7.2 Hydrology (Water Availability)

Hydrological environment of the study area include water bodies and river system. The study area has been divided into two distinct regions.

C. Rivers of Dhaka and Comilla region

D. Rivers of Chittagong region

Figure 7.2 gives the river system of the study area.

A. Rivers of Dhaka and Comilla region

Meghna is the biggest river in this region. Several tributaries of meghna rivers Major tributaries are the Dhaleswari, the Gumti (the name of the *Gomati* in Bangladesh), and the Feni. A river of great depth and velocity, the Meghna is sometimes split up into several channels and sandbanks of its own formation. It is navigable, but dangerous, all year. At spring tide the sea rushes upriver in a bore that may reach nearly 20 feet (6 metres).

Meghna River

Meghna has two distinct parts. Upper Meghna from Bhairab Bazar to Shaitnol is comparatively a small river. Lower Meghna below Shaitnol is one of the largest rivers in the world, because it is the mouth of Ganges-Padma and Brahmaputra-Jamuna rivers. It is a tidal reach carrying almost the entire fluvial discharge of Ganges, Brahmaputra and Upper Meghna river. The net discharge through this river varies from 10,000 cumec in the dry season to 160,000 cumec in the wet season. A little above the confluence, Meghna has a railway bridge over it. The width of the river there is three quarters of a kilometre.

Several small channels branch out from Meghna, meander through the low land bordering the marginal Tippera Surface, fed by a number of hill streams and rejoin the main river downstream. The most important of these offshoots is Titas, which takes off south of Chatalpar and after meandering through two long-bends, extending over 240 km rejoins the Meghna through two channels in Nabinagar upazila. It receives the Howrah hill stream near Akhaura. Brahmanbaria and Akhaura are both on the banks of this river. Other offshoots of the Meghna are Pagli, Katalia, Dhanagoda, Matlab and Udhamdi. Meghna and these offshoots receive the waters of a number of streams from Tripura Hills including Gumti, Howrah, Kagni, Senai Buri, Hari, Mangal, Kakri, Pagli, Kurulia, Balujuri, Sonaichhari, Handachhora, Jangalia and Durduria. All of these are liable to flash floods, but Gumti, Kakri and Howrah are the major ones. They have silted their beds to the extent that they now flow above the mean level of the land when brimful. Embankments have been built to contain them. Every other year one or the other of these streams overflow and cause considerable damage to crops, livestock and houses.

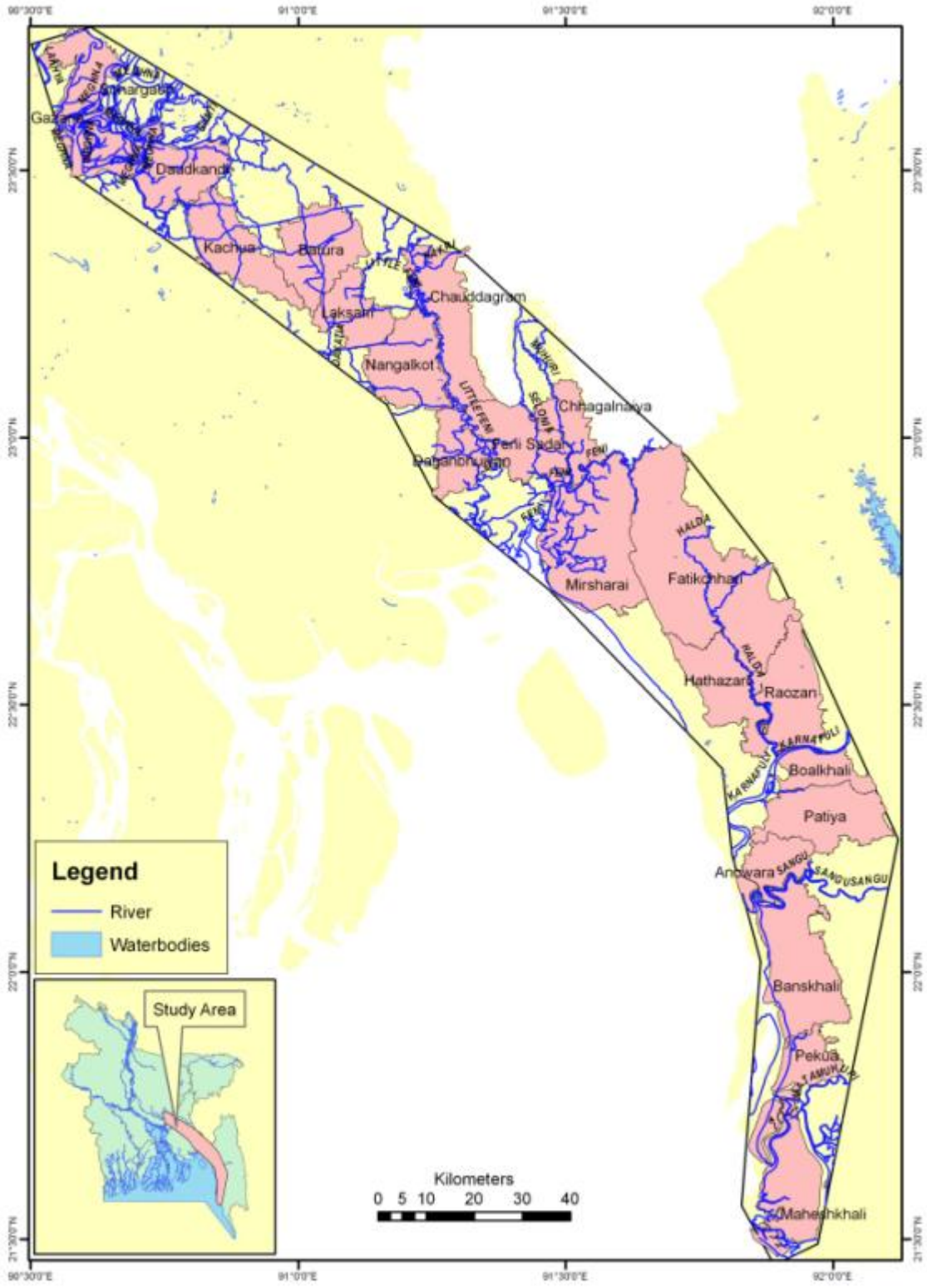


Figure 7.2 The river system of the study area.

The present deltaic Meghna, being the combination of Padma and Meghna, is the largest river in Bangladesh. From the beginning of the delta small islands create two main channels. The larger eastern channel and the smaller western channel measured five to eight kilometres and about two kilometres in width respectively. Near Muladi, Shafipur is an offshoot from the western bank.

Further south, Meghna is divided into three channels, which are, from west to east, Ilsha, Shahbazpur and Bamni. The Ilsha channel, 5-6.5 km wide, separates Bhola from the Barisal mainland. The Shahbazpur channel, 5-8 km wide, flows between Bhola and Ramgati-Hatiya islands. The Bamni, which used to flow between the islands of Ramgati, and Char Lakkhi and Noakhali mainland forming the main outlet of the Meghna, does not seem to exist now. The estuary of Meghna may be considered to be Ilsha and Shahbazpur, which together have a width of 32 km at the sea front.

Gumti falls into Meghna at Daudkandi. Another tributary from Tippera Surface is *Dakatia.* The main source of this river was Kakrai, but the *Little Feni* cuts back and captured this upper portion. Dakatia now has its source in Chauddagram khal, which connects it with Little Feni. Dakatia sends out a channel southwards, which forms the Noakhali khal. The main channel meanders westward to Shakherhat, from where the old course goes south to join Meghna at Raipur, and the new and stronger channel passes through Chandpur khal to join west of Chandpur town. For three-fourths of the year tidal currents feed the Dakatia from Meghna.

Gumti River

It originates from Dumur in the northeastern hilly region of Tripura state of India. From its source it flows about 150 km along a meandering course through the hills, turns west and enters Bangladesh near Katak Bazar (Comilla Sadar). Then it takes a meandering course again and passes through the northern side of Comilla town and east of *Mainamati.* Keeping Burichang upazila on the north, it cuts through Debidwar upazila and reaches Companiganj Bazar. The distance from Mainamati to Companiganj Bazar is about 60 km. From Companiganj it turns west and finally falls into the *Meghna* at Shapta in Daudkandi upazila. The segment between Companiganj and Daudkandi is about 50 km long. The Gumti is about 135 km long within Bangladesh. The *Dakatia* is one of the important tributaries of the Gumti and the Buri river is its distributary.

The Gumti is a hilly river having a strong current. Its flow varies from 100 to 20,000 cusec at Comilla. During the rains its average breadth is about 100m, it is full from bank to bank and the current is rapid. But during the winter it shrinks and becomes fordable at most places. In a year of normal rainfall the river rises to above 1.5m than the level of the surrounding areas. Flash floods are common phenomena of this river and it occurs at regular intervals. Previously it was known as the ‘sorrow of Comilla town’. The *Bangladesh Water Development Board* (BWDB) has taken several measures to tame the river and save Comilla town. Attempts have been made to construct flood *embankments* and 19 loop-cuts have been made to straighter the river. Despite these measures, several times Comilla town had been seriously menaced by floods. However, after the implementation of a number of BWDB projects, the Gumti appears now to be under control.

The river is not navigable by large boats. Some important places on its banks are Comilla, Mainamati, Burichang, Companiganj, Muradnagar and Daudkandi. The Gumti is influenced by tides up to Daudkandi, but upstream it is free from tidal effects.

Dakatia River

Dakatia River is one of the *trans-boundary rivers* of Bangladesh. It enters the country from India's *Tripura* state at Bagsara of COMILLA district. It is a tributary of the Meghna. The main source of flow of this river was the Kakrai, but the Little Feni cuts back and captured its upper portion. The Dakatia now has its source in Chauddagram Khal, which connects it with the Little Feni. The Dakatia sends out a *channel* southward, which forms the Noakhali Khal. The main channel meanders westward to Shekherhat, from where the old course goes south to join the Meghna at Raipur, and the new and stronger channel passes through Chandpur Khal to join the Meghna west of Chandpur town. Total length of the Dakatia is about 207 km. Tidal currents feed the Dakatia through the Meghna for three-fourths of the year.

Little Feni River

It is one of the *trans-boundary rivers* of Bangladesh, originates from the Hill Tripura in India and enters Noakhali district near Gunabati after running over the southeastern part of Comilla district. Flowing further south, the Little Feni debouches into the Bamni river in the northeast of Sandwip Channel. The river contains a lot of meanders. A number of streams eg the *Dakatia, Gumti* meet the river on its course. Little Feni follows a very tortuous course southward, and falls into Meghna estuary, southeast of Companiganj and a few kilometres from Big Feni estuary. Little Feni is a tidal river; in the rainy season its flow is around 15,000 cusec.

B. Rivers of Chittagong Region

The main rivers of Chittagong region originate in the hills. In Chittagong district the rivers are mostly at their youthful stage. They are now increasingly subject to sedimentation due to unceasing deforestation and hilly cultivation practices. The major rivers of this region are: Karnafuli and its tributaries (eg Rainkhiang, Kasalong, Halda, Ichamati etc); Bakkhali, Sangu, Matamuhuri, and Feni. Kutubdia and Maheshkhali channels are the coastal channels of the region.

The Karnafuli

It originates in the Lushai Hills of Mizoram (India), flows through Rangamati and the port city of Chittagong and discharges into the Bay of Bengal near Patenga. A number of stream flow upstream of Rangamati. The streams are: one originating near Thekamukh in Mizoram-Bangladesh border flowing through Harina, Barkal and Sublong; one originating at Marishwa through Myanmukh and Langadu till reaching Subhalong; one flowing through Dangumura to Myanmukh; and one flow through Mahalchhari to Rangamati. The streams meet near Rangamati and their combined flow is known as Karnafuli. The river is flashy and its length is about 131 km. Rainkhiang, Sublong, Thega, Kasalong, Ichamati and Halda are its main tributaries. Its major distributaries are Saylok and Boalkhali.

The only hydropower station of the country was built by constructing a dam on this river at Kaptai. The Karnafuli is navigable at Barkal and Kaptai but above Barkal it is shallow. With the construction of the Kaptai dam, this river has been blocked, and a large artificial lake has been created, and the bed of the river has also been much widened. This man-made lake provides a network of all-weather navigable routes in the area. Downstream of the dam the Karnafuli receives very little water in the dry season. The opening of the sluice gates of the dam creates water movement from the lake downstream. The river finally discharges into the Bay of Bengal. The port city of Chittagong is situated at the mouth of the river. BWDB collects water level data through its 3 hydrometric stations located at Kodala, Chittagong and Patenga.

Halda

Halda River rises from the Badnatali Hill Ranges in the *Chittagong Hill Tracts* and enters *Chittagong* district through *Fatikchhari* upazila. Then it flows southwest keeping off the higher regions to the north and then due south past Bibirhat, Nazirhat, Sattarghat and other important places of Fatikchhari, *Hathazari, Raozan* and *Kotwali* of Chittagong which form its basin. It falls into the *Karnafuli* at Kalurghat. Its total length is about 81 km, of which 29 km up to Nazirhat are navigable by big boats throughout the year; small country boats can ply further up for 16 to 24 km to Narayanhat. Forest resources like timber, bamboo, sungrass from the southern parts of *Ramgarh* upazila are floated down the river and the bulk of merchandise from Chittagong town is carried up in big cargo boats.

The Halda has a very turbulent tributary, the Dhurung river which rises in the Pakshmimura ranges in the Hill Tracts, traverses the whole of Fatikchhari upazila running almost parallel to Halda in the east, and joins it at Purba Dhalai about 48.25 km downstream. During the past century the Dhurung carved out for itself several courses. Several attempts were made to confine its current to its original bed but none proved a success. It now joins the Halda to the southwest of the Fatikchhari upazila headquarters leaving its original course of about 24.14 km to decay. The Halda also has several hill streams flowing down into it from the Chittagong Hill Tracts to its east watering and irrigating the entire Halda basin up to Kalurghat where it falls into the Karnafuli River. It is a flashy river and is 88 km long. BWDB has 13 hydrometric stations on it, and data are available since 1959.

Bakkhali

A number of small streams originating in the southeastern hills of Mizoram meets the Naikhongchhari of Bandarban district to form the Bakkhali. It flows through Naikhongchhari and Ramu of Cox's Bazar district and falls into Maheshkhali channel. This is also a flashy river and has a length of about 67 km.

Sangu

This river originates in the Arakan Hills of Myanmar and enters Bangladesh near Remarki (Thanchi upazila of Bandarban district). It flows north through Thanchi, Rowangchhari and Bandarban upazilas of Bandarban district. Then it flows west through Satkania and Banshkhali upazilas of Chittagong district to meet the Bay of Bengal near Khankhanabad (Chittagong). The length of the river is 295 km. The major tributaries of the river are Chandkhali Nadi and Dolu khal. There are 7 BWDB hydrometric stations on this river and data are available from 1965.

Matamuhuri

This is a flashy river that originates in the Moyvar hills of Alikadam (Bandarban). It flows northwest through Alikadam and Lama upazilas of Bandarban and Chakaria of Cox's Bazar. The river discharges into Maheshkhali channel near Saflapur (Chakaria, Cox's Bazar). The length of the river is 148 km. Yanchha khal and Bamu khal are its important tributaries. BWDB has 2 hydrometric stations on this river and data are available from the year 1956.

Feni

Originates in the eastern hills of Tripura and enters Bangladesh at Belchhari of Matiranga upazila of Khagrachhari district. If flows through Ramgarh (Khagrachhari), Fatikchhari (Chittagong) and then flows along the border of Chittagong (Mirsharai upazila) and Feni (Chhagalnaiya, Feni, Sonagazi upazilas) districts and discharges into the Bay of Bengal near Sonagazi. The length of the river is 108 km. BWDB has 6 hydrometric stations on the river and data are available from 1958.

Kutubdia Channel

It lies in-between the mainland of the country (Cox's Bazar) and Kutubdia Island. The length of the channel is 24 km. The channel is connected with the Bay of Bengal at its both ends.

Maheshkhali Channel

It lies between the mainland of Bangladesh (Cox's Bazar district) and Maheshkhali island. The channel carries the combined flow of the Matamuhuri and its tributaries and of other rivers such as Bharuakhali khal, Bura Matamuhuri, Mangla Khal, Manikchhari khal, etc. The length of the channel is 35 km. The channel is connected with the Bay of Bengal.

7.3 The Geology and Hydrogeology

7.3.1 Regional Geological Setting

Bangladesh lies between 20° 34′ and 26° 38′ north latitudes and 88° 01′ and 92° 41′ east longitudes. The Bengal basin is an actively evolving depositional environment comprised of unconsolidated muds and sands, which have been transported and deposited by fluvial processes. These sediments form the active channel beds, rice-cultivated floodplains, and highland terraces that make up much of the densely populated country of Bangladesh. As a function of the active tectonics of Himalayan convergence, the region□s intense monsoon climate and resultant susceptibility to seasonal flooding, the rivers that have formed this delta are sediment laden and highly mobile.

Tectonically it occupies the major part of Bengal Basin and forms the largest delta complex of the world. It is bounded in the east by the Indo-Burma ranges, in the west by the Indian shield, in the north by the Shillong Massif and the Himalayan thrust fault and in the south it is open towards the Bay of Bengal Figure 7.3.1. The delta development activities are still going on in the south by the deposition of the major river system. Quaternary sediments deposited mainly by the river Ganges, Brahmaputra and Meghna, cover about three-quarters of Bangladesh with exception of Tertiary folded belts.

Major tectonic elements of Bangladesh include (1) Indian Platform (2) Arakan Yoma folded belt (3) Bengal foredeep (Guha, 1978, Alam et al., 1990). Bengal foredeep occupies the vast area between hinge line and Arakan Yoma folded system and plays the most important role in the tectonic history of Bengal basin. Tectonically, Bengal foredeep can be divided into two major parts includes (a) Western platform flank and (b) Eastern folded flank.

The Western Platform Flank represents an area of deep subsidence, having simple structure of platform type, which sharply differs from eastern folded part of the Flank (Figure 5.3.1).

The Eastern Folded Flank is characterized by folding of intermediate or transitional type. By structural peculiarities of folds, it can be sub-divided into the following three tectonic zones;

A. The western zone:

The quietest zone of box like structures, which indicates that this folding is not yet accomplish. This zone includes Dakhin Nhila, Inani, Sitakind Maheshkhali, St. Martin's, Jaldi, and Walataung.

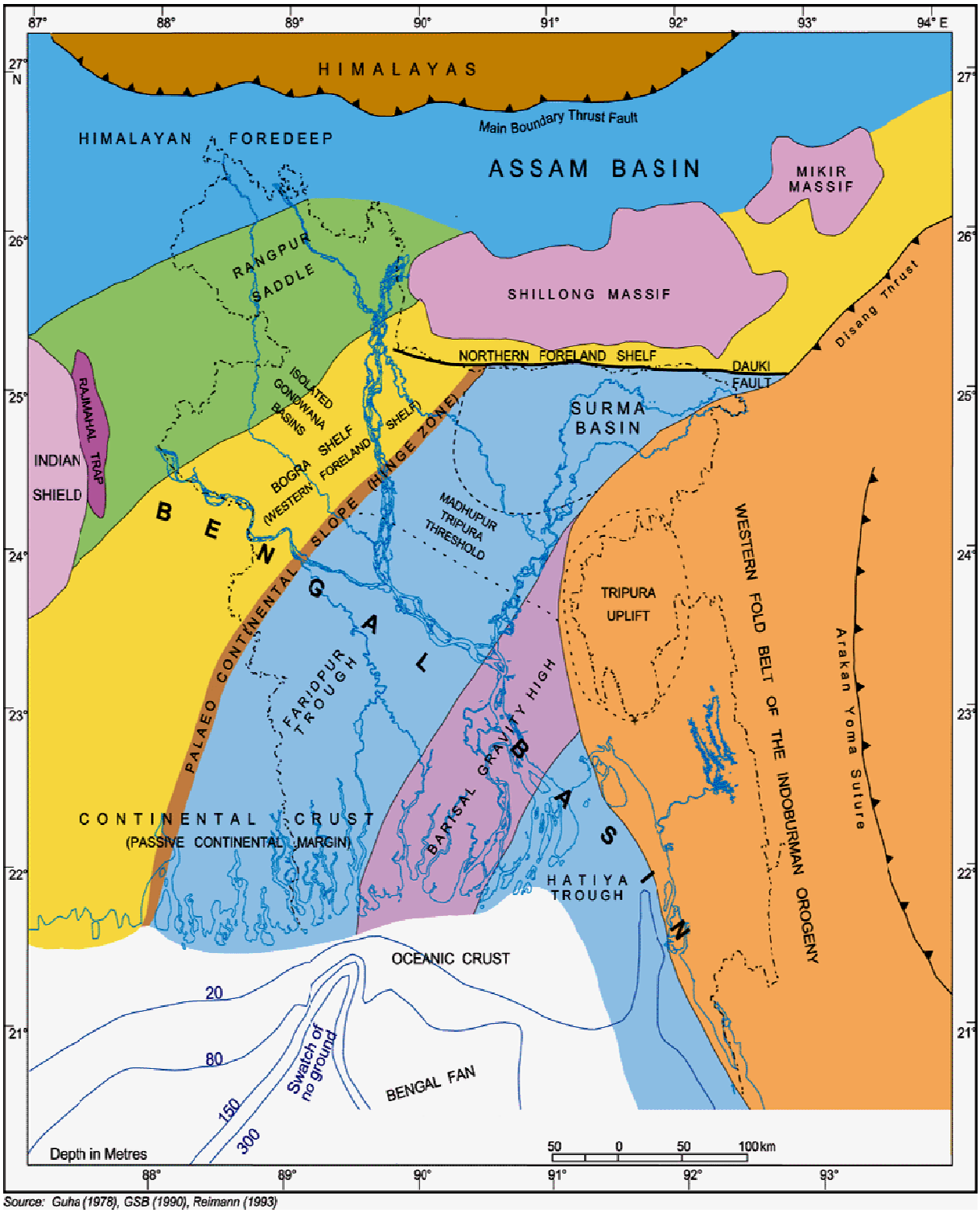
B. The middle zone:

More disturbed, predominantly asymmetrical and includes Matamuhuri, Bandarban, Gilasari, Siatpahar, and Kasalong, etc.

C. The eastern zone:

This zone includes narrow, ridge like elongated and tightly folded structures like Mowdak, Borcal, Uttar Chatra and Shisok etc.

The Chittagong part of the present study area lies in Eastern Folded Flank of the Bengal Foredeep and Feni, Comilla, Dhaka part lie on the Western Platform Flank of the Bengal Basin.



Source: Guha (1978), GSB (1990), Reimann (1993)

Figure 7.3.1 Major structural elements of the Bengal basin and its adjacent areas (modified after Guha, 1978; Reimann, 1993).

7.3.2 Stratigraphy

In the study area different geological formations are exposed to the surface. The geological age and lithology of these formations are highly variable. Table 7.3.2 gives the regional stratigraphic succession of the Bengal Foredeep (Reimann, 1993). The lithology of different geological formations is described in the Table. Figure 7.3.2

gives the geological map of Bangladesh Prepared by Geological Survey of Bangladesh (GSB 1990).

Table 7.3.2 Regional stratigraphic succession of the Bengal Foredeep (Reimann, 1993).

Era	Period	Epoch	Bengal Foredeep		Lithology
			Group	Formation	
CENOZOIC	Quaternary	Holocene	Alluvial	Alluvium	Consists of loose gravel, sand silt and clay with occasional pebbles and boulders. Peat deposits also occur locally.
		Pleistocene		Madhupur clay	Composed of mottled red and yellow clay with ferruginous and calcareous nodules.
				Dihing	Consists of yellow and grey, medium grained; occasionally pebbly sandstone and clayey sandstone with interbeds of moltted clay
	Tertiary	Pliocene		Dupitila	Upper part consists mainly of fine to medium grained, commonly silty sandstone with intercalation of a few clay horizons. Lignite and petrified wood are present. Lower part is composed of coarse grained, cross-bedded sandstone.
			Tipam	Girujan clay	Claystone, siltyshale and subordinate sandstone.
				Tipam sandstone	Grey-brown to pale grey, coarse grained, cross bedded, massive sandstone. Intercalation of grey shales occurs particularly in the upper part and conglomerate horizons occur in the lower part.
		Miocene	Surma	Bokabil	Shale, siltstone and sandstone. Upper portion is made up predominantly shaly sequence, middle portion more arenaceous.
				Bhuban	Mainly sandstone, siltstone, shaly sandstone, shales and lenticular intraformational conglomerates.
		Oligocene	Barail	Renji	Sandstone with subordinate shale
				Jenam	Siltstone, silty shale and sandstone.

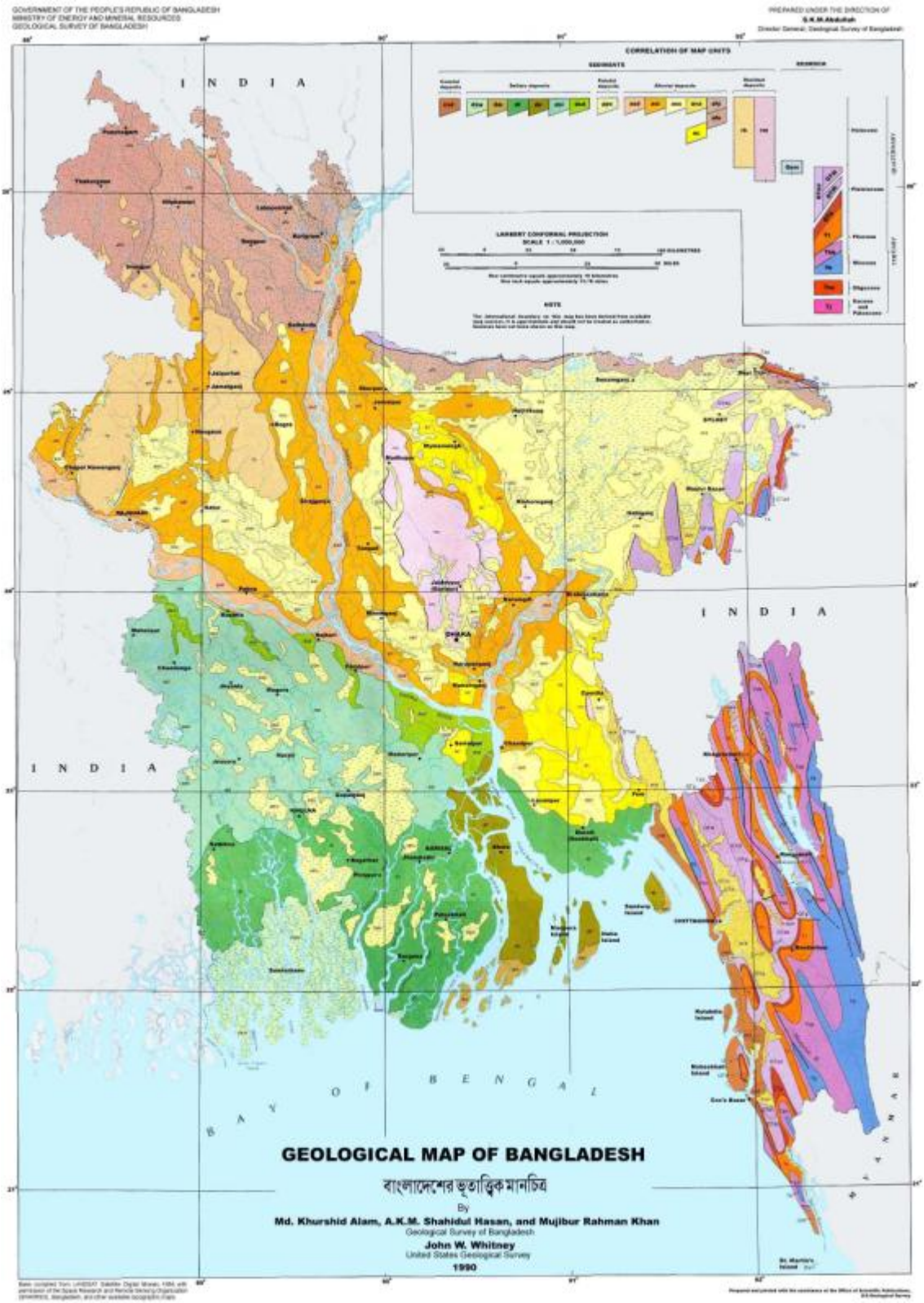


Figure 7.3.2 Geological Map of Bangladesh.

7.3.3 Geology of the study area

Tectonically, the study area lies in the Bengal Foredeep part of the Bengal basin. Figure 7.3.3-1 gives the Surface geology map of the study area. Table 7.3.3 gives the surface geological formations exposed in different Upazilas of the study area.

Bhuban Formation

This formation is a Miocene body of rock identified by lithic characteristics and stratigraphic position, and mappable at the earth's surface or traceable in the subsurface. Outcropping rocks of the Bhuban Formation occur throughout the Frontal Folded Belt and particularly in the cores of anticlinal trends in the eastern part of the Chittagong hill tracts. The lower and upper members are made up predominantly of sandstone, while the middle member usually shows a higher percentage of shale. The Bhuban in the Chittagong Hill Tracts has a thickness of about 3,500m. The unit is conformable with the overlying Boka Bil Formation and unconformable with the underlying Barail Group. The unit is a natural gas bearing horizon in Bangladesh.

Boka Bil Formation

The upper unit of the Surma Series is the Boka Bil Formation. The lithology plays an important role in identifying the Boka Bil unit and as such a Boka Bil Stage is referred to as the Boka Bil Formation, a rock unit, in Bangladesh. The formation is exposed in the hill ranges of, Chittagong district and the Chittagong Hill Tracts. It is mainly composed of alternating bluish-grey to yellowish-grey, well-bedded siltstone and shale with subordinate light yellowish-brown to brown, fine to medium-grained, bedded to massive, hard sandstone, locally calcareous and conglomeratic. Generally shale and siltstone dominate the lower and the upper parts while in the middle part the sandstone percentage is much higher. It occupies a transitional zone between the underlying dominantly sandy Bhuban Formation and overlying Tipam Sandstone Formation. The formation contains heavy minerals and is characterised by the presence of zoisite, epidote, staurolite, kyanite and hornblende.

Table 7.3.3 Surface Geological Formations of Different Upazilas

Name of Upazilas	Geological Formations Exposed on Surface
Sonaragaon Upazila, Narayanganj District	Alluvial sand and alluvial Silt
Gazaria Upazila, Munshiganj District	Alluvial sand and alluvial Silt
Daudkandi Upazila, Comilla District	Alluvial Silt and Clay; Marsh Clay and Peat
Kachua Upazila, Chandpur District	Chandina Alluvium; Alluvial Silt and Clay
Barura Upazila, Comilla District	Chandina Alluvium; Alluvial Silt and Clay
Nangalkot Upazila, Comilla District	Chandina Alluvium; Alluvial Silt and Clay
Laksam Upazila, Comilla District	Chandina Alluvium
Feni-Sadar Upazila, Feni District	Chandina Alluvium; Valley Alluvium and Colluvium
Chhagolnaiya Upazila, Feni District	Valley Alluvium and Colluvium
DaganBhuya Upazila, Feni District	Chandina Alluvium; Alluvial Silt and Clay
Mirsarai Upazila, Chittagong District	Beach and Dune Sand, Valley Alluvium and Colluvium; Tipam Sandstone, Bokabil formation and Bhuban Formation
Fatikchhari Upazila, Chittagong District	Valley Alluvium and Colluvium; Dupitila Formation, Dihing formation, Tipam Sandstone, Bokabil formation and Bhuban Formation
Hathazari Upazila, Chittagong District	Valley Alluvium and Colluvium; Dupitila Formation, Dihing formation, Tipam Sandstone, Bokabil formation and Bhuban Formation
Raojan Upazila, Chittagong District	Valley Alluvium and Colluvium; Dupitila Formation, Dihing formation,
Boalkhali Upazila, Chittagong District	Valley Alluvium and Colluvium; Dupitila Formation, Girujan clay formation, Tipam sandstone formation
Patiya Upazila, Chittagong District	Valley Alluvium and Colluvium; Dupitila Formation, Girujan clay formation, Tipam sandstone formation
Anowara Upazila, Chittagong District	Beach and Dune Sand, Valley Alluvium and Colluvium;
Banshkhali Upazila, Chittagong District	Beach and Dune Sand, Dihing and Dupitila Formation, Girujan clay formation, Tipam sandstone formation
Pekua Upazila, Cox's Bazar District	Beach and Dune Sand, Dihing and Dupitila Formation
Moheshkhali Upazila, Cox's Bazar District	Beach and Dune Sand, Dupitila Formation, Girujan clay formation, Tipam sandstone formation; Bokabil formation

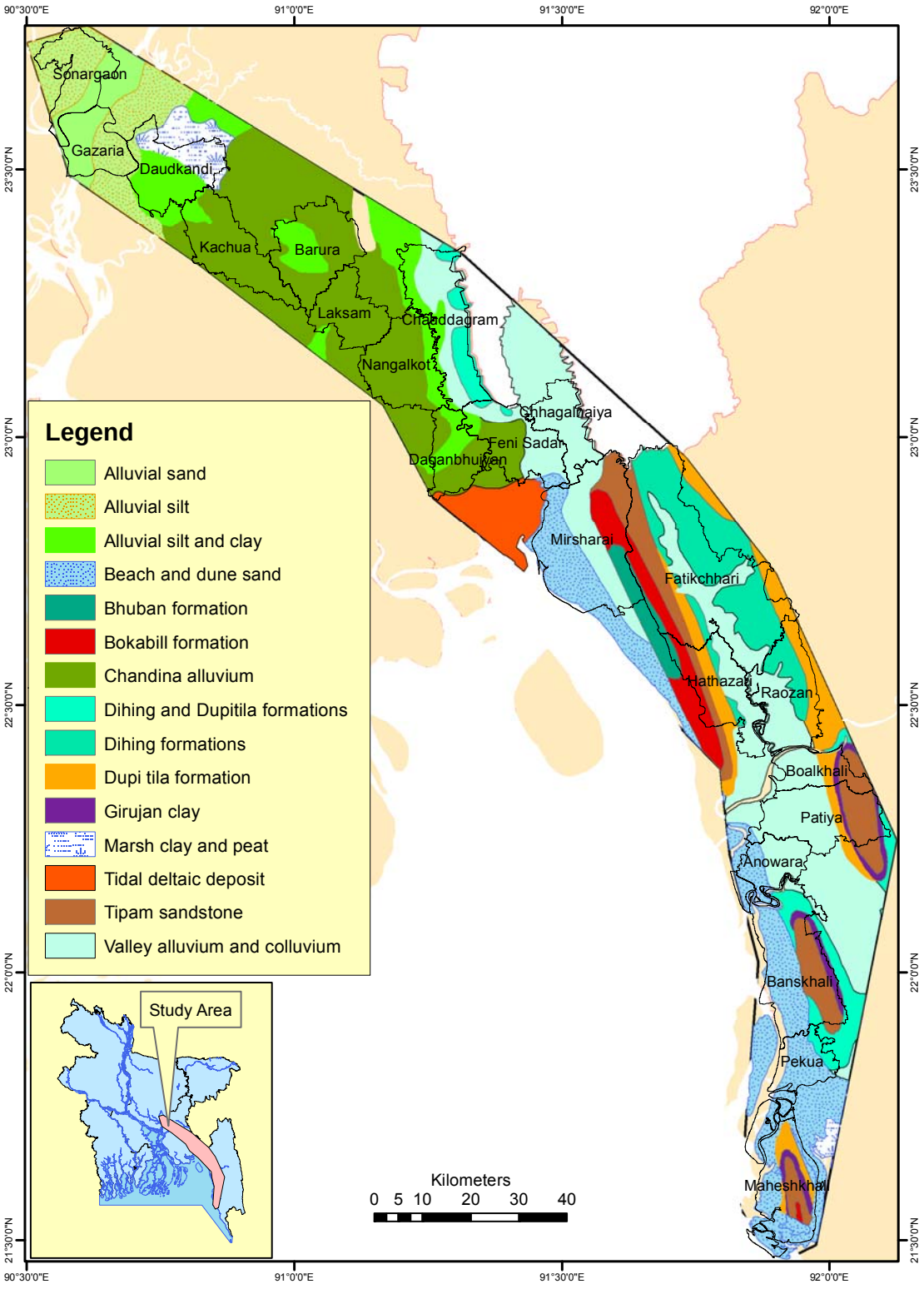


Figure 7.3.3-1 Surface Geological Map of different Upazilas in the study area.

Tipam Group

A Pliocene lithostratigraphic unit in the Bengal Basin comprising several formations. The group is subdivided into two formations: the Tipam Sandstone Formation and the Girujan Clay Formation. The Tipam Sandstone Formation is a coarse-grained sandstone sequence overlying the Boka Bil Formation. The contact between these two units is unconformable in the marginal portions of the basin as well as in the shelf areas in the west. In the deeper sections of the basin the contact is conformable. The upper contact to the Girujan Clay Formation is also conformable. In the case of absence of the Girujan Clay Formation, the Tipam Sandstone Formation is unconformably overlain by the Dupi Tila Formation.

The Tipam Sandstone Formation typically consists of grey-brown to pale-grey, coarse-grained, cross-bedded, massive sandstone. Intercalations of grey shale, conglomerate horizons, pebbles, wood fragments and petrified trunks also occur. Outcropping Tipam Sandstone deposits occur throughout the Frontal Fold Belt from the southernmost portion of the Chittagong Hill Tracts. The formation occurs regularly on the flanks of the anticlinal trends in the Frontal Folded Belt area, forming steep cliffs.

The name **Girujan Clay Stage** was given by P Evans after a small stream at Digboi in Assam. The formation develops conformably and gradationally from the underlying Tipam Sandstone. The arenaceous deposits of the Dupi Tila Formation unconformably overlie it. It is composed mainly of mottled clay with subordinate mottled sandy clay, sandstone with subordinate ferruginous sandstone. Fossil wood and lignite are also present in the unit. Its deposits are preserved mainly in the large valleys coinciding with major synclinal trends of the fold belt. The thickness of the formation is 168m in the Sitakunda, 107m near Cox's bazar. The Girujan Clay Formation represents lacustrine floodplain and overbank deposits. The sedimentation took place under subaerial conditions.

Dupi Tila Formation

It is a Pliocene-Pleistocene mappable body of rock in the Bengal Basin. It is exposed in Chittagong division. The unit unconformably overlies the Tipam Group and is in turn overlain either by the Dihing Formation or by Recent alluvial deposits.

In Chittagong, the Dupi Tila Formation consists of yellowish-brown to brown, fine to medium grained pebbly and cross-bedded sandstone with subordinate claystone and siltstone. In the subsurface of northern Bangladesh the formation consists of pebble beds, coarse to fine-grained sandstone and shale of grey colour.. In the Chittagong-Cox's Bazar area the unit contains pockets of white clay.

Dihing Formation

A Pleistocene mappable body of rock. It has scattered occurrence in the Bengal Basin and is merely of local importance. The formation has a patchy distribution within Bangladesh. The thickness of 24m as observed in Cox's Bazar district .The formation consists of yellow and grey, medium-grained, occasionally pebbly sandstone and clayey sandstone with interbeds of mottled clay. The rocks are in most part poorly consolidated. The unit lies unconformably between Dupi Tila and alluvium. At places the unit is reported to contain white clay at the base.

Chandina Alluvium

Chandina Deltaic Plain generally level land that lies between the uplifted Lalmai deltaic plain and the Meghna floodplain (Bakr 1977). It is made up of silt, silty loam, silty clay and clay and has been named the Chandina formation. The sediments are similar to the recent Meghna floodplain deposits except for being comparatively more compact and oxidised.

Recent Alluvial Sediments

Recent alluvium includes detrital material deposited during a comparatively recent geologic time by rivers or streams or found on alluvial fans, floodplains, etc. Alluvium consists of gravel, sand, silt, and clay and often contains organic matter that makes it a fertile soil. Alluvial sand, alluvial silt and alluvial silt and clay are floodplain deposit of Recent age which comprises fine grained sediments. These alluviums are unconsolidated and non-homogeneous in age, texture and mineralogy, and deposited under diverse conditions like estuarine, tidal, piedmont and meander floodplains. Alluvial sand deposit comprises mostly of fine sand and very fine sand. They generally occur in area near to the rivers. During heavy rainfall in the catchments high flow rate allows sand and silt to be carried to the floodplain area forming alluvial silt and sand. Alluvial silt and clay deposit occur as floodplain deposits. Silty clay with abundant organic debris, i.e. humus is the main constituent of the alluvium.

Under riverine condition, floodplains are enriched with new alluvium every year. But as the river changes its course, the floodplain remains cut off from new alluvium. Some floodplains of the country received little or no new alluvium for the last few hundred years. The rivers have changed their courses in the past; thus parts of the floodplains are abandoned and reoccupied. As a result, alluviums of different ages are added in different parts of the floodplains.

Valley Alluvium and Colluvium

In hilly area valley alluvium and colluvium deposits are formed by small streams and small alluvial fan. Sand, silt and clay constitute the most dominant rock types of the alluvium. Boulders and pebbles of all sizes and carbonaceous wood intermix with the sand. The sand is mostly composed of quartz with subordinate ferromagnesian minerals and feldspar. As the floodplain slopes away from the base of the piedmont, the sand becomes finer and finer, loses its ferromagnesian minerals and feldspar and grade into very fine sand, silt and clay in the delta. The colour of the sand changes from yellowish and brownish to grey.

Marsh Clay and Peat

Marsh clay and peat deposits occur in the deeper part of the flood plain where peaty clay, clayey peat and peat are deposited. Freshwater marshes are more or less shallow water bodies lying at the back-slope of floodplains. In most cases, these are old or abandoned river courses, having tall reeds and grasses mixed with thickets of floating vegetation. Generally, clay and organic sediments are deposited in this environment to march clay and peat layers.

7.3.4 Hydrogeology

Groundwater is one of the major natural resource of Bangladesh. It has been developed advantageously as a source of domestic, industrial and irrigation supplies. UNDP (1982) studied the hydrogeology of Bangladesh with a view to increase development of groundwater and to make a general appraisal of the groundwater resources of Bangladesh including collection, compilation, processing and analysis of existing data.

UNDP (1982) divided Bangladesh into 15 zones for groundwater developments. Each zone has been classified and rated as to its development potential in relation to the other zones. Figure 7.3.4 gives the Hydrogeological Classification of the study area (UNDP 1982). The study area constitutes Zone G, Zone L and Zone N. The description of different zones area given below:

Zone G

Zone G includes the southwestern section of Comilla district and the northern part of Noakhali district. It includes Sonaragaon Upazila, Narayanganj district, Gazaria Upazila, Munshiganj district; Daudkandi, Barura, Laksam and Nagalkote Upazila of Comilla district; Kachua of Chandpur district.

The sediments consist primarily of floodplain deposits of the Meghna River. The main aquifer is at depths ranging from 16 to 100 metres below ground surface with an average depth for the zone of 60 metres. This zone should be considered for only deep tubewell development with discharges of up to 56.6 lit/sec (2 cusecs). Special attention should be given to the development of areas adjacent to the coastal zone and the lower Meghna River owing to the possibility of increased saline water intrusion

ZONE L

Zone L covers the piedmont deposits of Chittagong District and the Meghna estuarine floodplains of Noakhali District. It includes Feni Sadar and Daganbhuyan Upazilas of Feni district; Mirsarai, Fatikchhari, Hathazari, Raojan, Boalkhali, Patiya, Anowara, Banshkhali Upazilas of Chittagong district.

The area is not considered favourable for extensive ground-water development. Aquifers in the area are generally confined. At places, semi-confined conditions exist but leakage from the overlying water-bearing formations is negligible. Transmissivities average about 400 m^2/day.

Hydrogeological analyses indicate that well discharge of 28.3 lit/sec (1 cusec) is considered as maximum with optimum values ranging from 14.2 to 21.2 lit/sec (0.5 to 0.75 cusecs).

Zone N

Zone N covers the coastal areas of Noakhali and Chittagong districts. Daganbhuyan Upazila of Feni district; Mirsarai, Boalkhali, Patiya, Anowara, Banshkhali of Chittagong district; and Moheshkhali of Cox's Bazar district.

It comprises the floodplains of the Ganges-Padma and Meghna Rivers as well as the Chittagong coastal plain. Groundwater conditions are highly variable and development is highly impaired by the low quality of water affected by the intrusion of brackish and saline water. The development of the main and composite aquifers is limited to isolated fresh water areas. The ground water potential of the coastal zone depends upon the development of the deep aquifer. The potential of the deep aquifer is relatively unknown but there are indications that fresh water may be encountered.

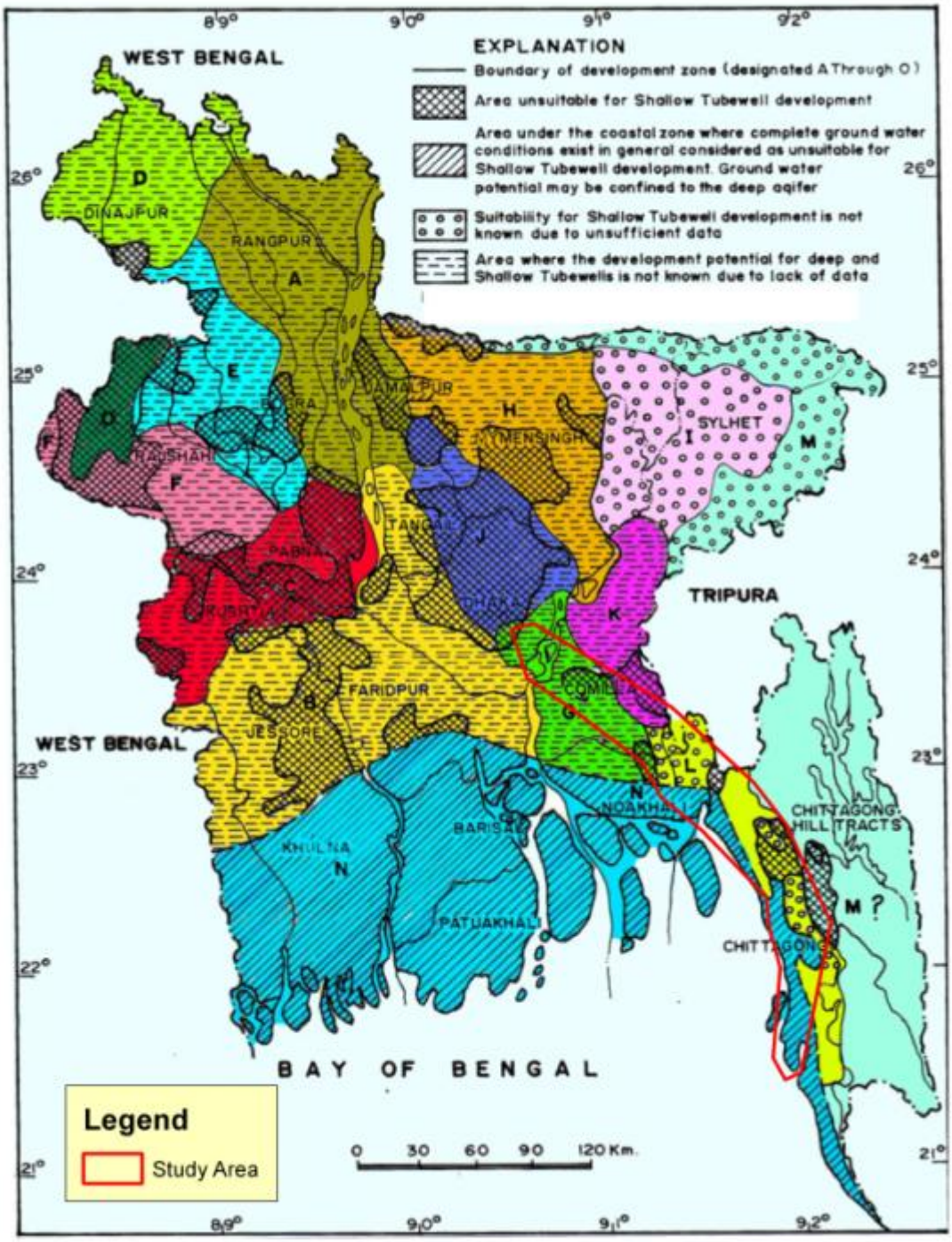


Figure 7.3.4 Hydrogeological Classification of the study area (UNDP 1982)

7.4 Meteorology

7.4.2 Climate

7.4.2.1 Ambient Air Temperature

The proposed transmission line and substations lie in the south-eastern part of Bangladesh, where monsoon comes in July and recede in late October. Bangladesh Meteorological Department (BMD) is responsible for monitoring the climate data at different stations in Bangladesh. There are 7 stations namely, Dhaka, Comilla, Feni, Chittagong, Chittagong (Ambagan), Kutubdia and Cox's Bazar in the project area. The maximum and minimum average temperature recorded in the above seven stations for the last 10 years from 2004 to 2013 are given in **Table-7.4.2.1**

Table 7.4.2.1: Monthly Max. & Min. Av. Temperature in 7 stations during 2004-2013

Station	Dhaka	Comilla	Feni	Chittagong	Chittagong (Ambagan)	Kutubdia	Cox's Bazar
Maximum Average temperature in deg. Celsius	35.5	34.4	33.5	33.7	34.2	33	34.1
Minimum Average temperature in deg. Celsius	12.2	10.9	10.9	12.7	12.7	13.5	13.9

The details of ambient temperature recorded in the above seven stations for the last 10 years from 2004 to 2013 are given below:

Dhaka Station:

The monthly maximum and minimum average temperature at Dhaka are given in Table 7.4.2.1-1 and Table-7.4.2.1-2 respectively. In the last 10 years the monthly maximum average temperature in Dhaka area was 35.5 deg Celsius and the monthly minimum average temperature was 12.2 deg Celsius.

Table 7.4.2.1-1: Monthly Maximum Average Temperature at Dhaka, 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	23.5	28.3	32.8	32.6	35.1	32.7	31.5	32.3	30.4	31	29.5	27
2005	24.5	29.1	32.2	24.4	33.2	33.4	31.5	32.1	32.8	30.6	29.1	27.1
2006	25.3	31.3	33.2	33.7	33.7	32.4	32.4	32.5	31.9	32.5	29.7	26.9

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	24.6	27.1	31.5	33.7	34.8	32.5	31.4	32.5	32.1	31.5	29.1	25.8
2008	24.5	26.1	31.7	34.5	34.7	32.4	31.8	32.1	32.7	31.4	29.8	25.6
2009	25.9	29.7	33.3	35.1	34.6	34.5	32.4	32.5	32.8	32.2	32.2	32.2
2010	23.8	28.9	34.1	35.5	34.2	33	33	33.1	32.5	32.4	30	26
2011	23.7	28.7	32	33.4	33.4	32.6	32.3	31.1	32.4	32.6	29.7	24.9
2012	24.1	28.5	33	33.5	34.6	33.2	32.5	32.5	32.8	32.3	28.7	24
2013	24.2	28.9	33.4	34.2	31.7	33.7	32.7	32.0	32.6	31.5	30.2	26.3

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-2: Monthly Minimum Average Temperature at Dhaka, 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	14	16	22.4	23.9	26.3	25	25.4	26.5	25.5	23.3	18.6	16.2
2005	14.2	18.3	22.4	24.1	24.2	26.8	25.8	26.7	26	24.4	19.8	15.7
2006	18.2	19.4	22	23.8	25	26.1	26.7	26.5	25.8	24.7	20.1	15.8
2007	12.5	16.8	19.6	23.7	25.9	25.5	25.9	26.4	26.5	23.8	19.9	15
2008	14.5	15.2	22	24.5	24.9	26.3	26.4	26.5	26.2	23.8	19	16.9
2009	14.8	17.3	21.5	25.9	25.2	26.7	26.7	26.3	26.3	24.2	20.2	15.3
2010	12.8	16.2	23.3	26.4	25.9	26.7	27.4	27	26.6	25	20.9	15.4
2011	12.2	16.9	21.5	23.2	24.6	26.2	26.7	26.5	26.3	24.7	19.1	15
2012	14.5	16	22.1	23.7	25.8	26.9	26.7	26.6	26.8	24.3	19.1	14.5
2013	12.3	17.5	22.1	24.4	24.8	27.2	27.0	26.2	26.3	24.4	18.5	15.6

Source: Bangladesh Meteorological Department (BMD)

Comilla Station:

The monthly maximum and minimum average temperature at Comilla are given in Table 7.4.2.1-3 and Table-7.4.2.1-4 respectively. In the last 10 years the monthly maximum average temperature in Comilla area was 34.4 deg Celsius and the monthly minimum average temperature was 10.9 deg Celsius.

Table 7.4.2.1-3: Monthly Maximum Average Temperature at Comilla, 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	24.2	27.8	30.8	31.6	34.4	32.2	31.5	32.6	31.1	30.8	29.9	27.2
2005	24.7	28.6	30.7	33.5	33.2	33.4	31.8	31.5	32.5	31	29.3	27.8
2006	25.6	30.2	31.9	33.9	33.1	32.8	32	32.9	32.2	32	29.2	27
2007	24.4	26.9	30.1	31.8	33.7	32.2	30.7	32.3	31.7	31.7	29	26
2008	25.2	26.3	30.5	33.7	33.8	31.6	31.1	31.8	32.6	31	29.9	26.5
2009	26	28.9	31.8	33.8	33.9	33.4	32	32.8	33	33	32.2	32.2
2010	24.5	28.1	32	33.2	33.4	31.8	32.7	33.3	32.7	32.3	30.1	26.3
2011	24	28.2	30.7	32.5	33.1	32.2	31.9	31.3	32.2	32.6	29.6	25.1
2012	24.3	28.1	31.5	32.2	33.6	32.8	31.2	32.3	32.4	31.5	28.7	24.1
2013	24.5	28.8	31.9	32.9	30.7	33.5	32.3	31.8	32.4	31.2	29.9	26.5

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-4: Monthly Minimum Average Temperature at Comilla, 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	12.9	14.8	20.9	22.2	25.7	24.9	25.5	25.3	25	32.2	17.1	14.7
2005	12.3	16.4	21.1	22.7	23.7	26.2	25.5	25.5	25.4	24.2	18	14
2006	12.1	18.5	20.2	22.9	24.4	25.7	25.8	25.6	25.2	24.2	19.2	13.4
2007	11.1	14.7	18	22.7	24.8	25.3	25.5	26.5	25.4	23.8	19.9	14.2
2008	12.9	13.7	20.5	22.9	23.9	23.5	25.5	25.6	25.3	23.2	18.1	16
2009	13.6	15.7	20.4	24.2	24.3	25.9	25.5	25.9	25.7	32.1	18.8	13.4
2010	10.9	14.7	21.9	25.1	24.7	26	26.3	26.3	25.6	24.7	19.9	13.8
2011	11.3	15.8	19.7	22	24	25.9	25.9	25.6	25.6	23.9	18.1	14.4
2012	12.9	14.6	21.7	24.3	25	25.8	25.9	25.9	25.9	23.4	18.6	13.4
2013	10.9	15.8	20.5	23.4	24.2	26.5	26.1	25.9	25.7	24.1	17.8	14.2

Source: Bangladesh Meteorological Department (BMD)

Chittagong Station:

The monthly maximum and minimum average temperature at Chittagong are given in Table 7.4.2.1-5 and Table-7.4.2.1-6 respectively. In the last 10 years the monthly maximum average temperature in Chittagong area was 33.7 deg Celsius and the monthly minimum average temperature was 12.7 deg Celsius.

Table 7.4.2.1-5: Monthly Maximum Average Temperature at Chittagong, 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	2.64	29.4	31.4	31.5	33.6	31.8	30.5	31.8	31.1	32	30.9	29
2005	27.5	30.6	30.9	33.4	33.5	32.9	31.5	30.6	32.6	33	30.8	29
2006	28.1	30.8	33.7	33.4	32.8	32.6	31.3	32.5	32.3	32.8	31.1	28.3
2007	26.8	28.7	32.3	31.6	32.9	31.6	29.6	30.9	32.2	30.8	28.7	25.8
2008	25.1	26	29.9	32.2	32.2	30.7	29.8	30.1	30.9	30.7	29.7	26.7
2009	25.6	29	31.7	32	32.5	32.1	30.2	30.6	31.8	31.2	29.9	31.2
2010	26.5	29	31.6	32	32.5	32	30.1	30.6	31.4	31.2	29.9	26.2
2011	25	28.8	30.5	31.1	31.4	30.5	31.1	30.3	30.6	31.1	28.8	25.1
2012	25.3	29.6	30.3	31.3	31.4	31	30.2	31.1	31.7	31.1	28.8	24.7
2013	25.0	29.3	31.1	31.9	30.4	31.7	31.3	30.2	31.3	29.9	28.7	26.0

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-6: Monthly Minimum Average Temperature at Chittagong, 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	14.9	16.3	21.9	23.8	25.8	25.6	25.3	25.6	25.1	23.7	18.7	16.3
2005	14.5	18.4	22.2	24.8	24.7	26.9	25.6	32.9	25.5	24.7	19.5	17.2
2006	14.8	190	21.9	24.8	24.8	26.2	26	25.7	25.5	25.2	21.4	15.9
2007	13.5	17.7	19.6	23.6	25.8	25.6	25.5	25.6	25.7	23.8	21.9	16.6
2008	15.2	15.7	21.9	24.2	25.1	24.7	25.2	25.4	25.3	24	19.6	17.7
2009	14.9	16.9	21.6	25.3	25	25.6	25.5	25.8	25.4	24	21.1	15.9
2010	14.9	16.8	21.5	25.3	24.9	25.5	25.4	25.7	25.4	24	21	15.8

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	13.2	16.7	20.2	23.9	24.6	25.5	25.5	25.1	25.1	24.4	19.2	16.1
2012	15.3	16.3	22	22.7	25.4	25.5	25.5	25.7	25.8	24.2	20.5	14.5
2013	12.7	16.9	20.9	24.4	24.5	26.1	26.0	25.7	25.8	24.5	20.1	16.2

Source: Bangladesh Meteorological Department (BMD)

Chittagong (Ambagan) Station:

The monthly maximum and minimum average temperature at Chittagong (Ambagan) are given in Table 7.4.2.1-7 and Table-7.4.2.1-8 respectively. In the last 10 years the monthly maximum average temperature in Chittagong area was 34.2 deg Celsius and the monthly minimum average temperature was 12.7 deg Celsius.

Table 7.4.2.1-7: Monthly Maximum Average Temperature at Chittagong (Ambagan) , 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	26.2	29.4	31.4	31.5	33.6	31.8	30.5	31.8	31.2	32.0	30.9	29.0
2005	27.4	30.6	30.9	33.4	33.5	32.8	31.4	30.6	32.6	33.0	30.6	29.1
2006	28.2	30.7	33.7	33.5	32.8	32.5	31.4	32.5	32.3	32.7	31.1	28.3
2007	26.8	28.7	32.3	32.3	33.1	32.0	30.6	32.0	31.5	32.2	31.0	28.4
2008	27.3	28.0	31.4	34.2	33.6	31.6	30.6	31.2	32.0	32.2	31.1	27.9
2009	28.1	30.5	33.0	33.1	33.8	32.8	30.9	31.3	32.3	32.6	31.4	28.2
2010	27.0	30.4	33.0	33.4	33.3	31.9	32.4	32.3	32.7	33.0	32.0	28.6
2011	26.9	30.1	32.0	32.3	32.8	31.5	31.7	31.0	31.5	32.7	31.1	27.3
2012	27.3	30.8	31.8	32.2	33.5	32.1	30.9	32.0	32.6	32.4	30.4	27.1
2013	26.9	31.3	32.6	33.3	30.9	32.6	31.5	31.4	32.1	31.2	31.6	28.1

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-8: Monthly Minimum Average Temperature at Chittagong (Ambagan), 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	14.9	16.3	22.0	23.9	25.9	25.5	25.4	25.6	25.2	23.7	18.4	16.3

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	14.5	18.4	22.2	24.5	24.7	26.9	25.6	25.5	25.5	24.7	19.5	17.1
2006	14.6	19.1	21.8	24.7	24.6	25.9	25.7	25.6	25.4	24.6	20.6	15.8
2007	13.5	17.1	19.6	23.6	25.7	25.6	25.3	25.4	25.4	23.3	21.2	15.9
2008	15.0	15.2	21.6	23.8	24.4	25.2	25.1	25.3	25.5	24.1	19.5	17.3
2009	15.0	17.6	21.7	25.6	25.0	25.8	25.6	25.7	25.6	23.7	20.5	15.6
2010	13.8	16.9	22.7	26.0	25.5	25.7	26.1	25.8	25.7	24.9	21.2	16.0
2011	13.5	16.9	20.7	23.7	25.0	25.8	25.6	25.3	25.4	24.3	19.2	16.0
2012	14.9	16.5	21.9	23.6	25.2	25.6	25.5	25.6	25.7	23.8	20.0	14.3
2013	12.7	16.7	21.1	24.4	24.6	26.0	25.8	25.7	25.5	24.0	19.1	15.8

Source: Bangladesh Meteorological Department (BMD)

Feni Station:

The monthly maximum and minimum average temperature at Feni are given in Table 7.4.2.1-9 and Table-7.4.2.1-10 respectively. In the last 10 years the monthly maximum average temperature in Chittagong area was 33.5 deg Celsius and the monthly minimum average temperature was 10.9 deg Celsius.

Table 7.4.2.1-9: Monthly Maximum Average Temperature at Feni , 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	24.3	28.3	30.6	30.7	33.5	31.1	30.9	31.5	30.1	30.5	29.2	27.4
2005	25.1	29.0	***	32.7	32.0	32.6	30.8	30.3	32.3	31.2	29.3	27.5
2006	26.0	30.0	32.3	32.8	32.6	31.7	30.7	31.7	31.1	31.7	29.5	27.0
2007	25.2	27.2	31.0	31.8	32.7	31.1	30.1	31.3	30.8	31.0	29.3	26.2
2008	25.1	26.2	30.8	33.2	33.3	30.7	29.8	30.6	32.0	31.0	30.0	26.3
2009	26.3	29.1	31.8	33.2	33.0	32.2	30.5	30.9	31.6	31.5	30.1	26.3
2010	24.8	28.6	31.9	32.5	32.3	30.7	31.3	31.8	31.4	31.9	30.4	26.4
2011	24.2	29.0	31.3	32.7	32.5	31.1	31.3	30.5	31.4	32.4	30.0	26.1
2012	24.9	29.1	31.9	31.8	33.4	31.5	30.7	31.6	31.9	31.3	29.2	25.1

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	25.3	29.4	32.6	33.3	30.1	32.8	31.6	31.4	32.0	31.0	30.1	26.7

*** Missing data

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-10: Monthly Minimum Average Temperature at Feni, 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	13.5	14.5	20.9	22.9	25.6	25.0	25.5	25.3	24.9	23.3	17.1	15.0
2005	12.7	16.6	***	22.9	23.9	26.4	25.6	25.5	25.7	24.4	19.2	14.8
2006	13.6	18.2	20.8	23.4	24.8	25.9	25.6	25.6	24.9	24.3	19.4	14.2
2007	11.6	16.4	18.4	23.1	25.2	25.6	25.5	26.0	25.6	23.5	21.0	15.0
2008	14.0	14.8	21.6	23.4	24.6	25.3	25.4	25.4	25.4	23.4	18.3	16.1
2009	13.6	16.2	21.0	24.9	24.6	25.8	25.7	25.6	25.5	23.3	19.4	13.8
2010	11.7	15.1	22.6	25.7	25.3	25.6	26.1	26.0	25.5	24.6	20.3	14.6
2011	11.4	15.9	19.7	22.6	24.2	25.5	25.6	25.3	25.3	24.2	18.1	14.6
2012	13.0	14.6	21.2	22.7	25.2	25.1	25.3	25.5	25.5	23.2	18.5	13.2
2013	10.9	15.3	20.4	23.8	24.3	26.2	25.7	25.5	25.2	23.8	17.8	14.3

*** Missing data

Source: Bangladesh Meteorological Department (BMD)

Kutubdia Station:

The monthly maximum and minimum average temperature at Kutubdia are given in Table 7.4.2.1-11 and Table-7.4.2.1-12 respectively. In the last 10 years the monthly maximum average temperature in Kutubdia area was 33.0 deg Celsius and the monthly minimum average temperature was 13.5 deg Celsius.

Table 7.4.2.1-11: Monthly Maximum Average Temperature at Kutubdia , 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	25.2	27.2	30.2	31.2	33.0	31.6	29.8	30.9	30.8	31.1	29.8	28.1

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	26.0	28.4	30.1	32.6	33.0	32.2	30.9	30.2	31.8	32.0	30.0	27.9
2006	26.7	29.1	31.4	32.6	32.3	31.6	30.4	31.0	31.2	31.7	30.3	27.4
2007	25.4	27.1	29.5	31.3	32.0	31.6	30.2	31.1	30.6	31.0	29.7	***
2008	25.6	26.1	29.6	32.4	32.8	31.2	29.9	30.6	31.2	31.7	30.3	27.4
2009	26.7	28.5	30.7	32.1	33.0	32.1	30.2	30.8	31.6	31.7	30.4	27.0
2010	24.6	27.6	31.2	32.9	32.9	31.6	31.5	31.7	31.7	31.9	31.0	27.3
2011	25.0	28.1	30.0	31.3	31.9	30.5	30.6	30.6	30.8	32.0	30.1	26.2
2012	25.5	28.1	30.7	32.1	32.9	31.4	30.0	31.3	32.0	32.3	29.9	26.0
2013	25.0	27.8	30.3	31.8	30.9	31.7	31.3	31.0	31.6	31.0	30.2	27.3

*** Missing data

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-12: Monthly Minimum Average Temperature at Kutubdia, 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	15.7	16.5	22.0	24.3	26.3	26.0	25.7	25.8	25.5	24.4	19.3	17.2
2005	15.5	19.1	22.0	24.8	25.7	27.1	26.1	25.9	25.9	25.5	20.4	18.3
2006	15.5	19.4	21.9	24.9	25.5	26.4	26.0	25.2	26.0	25.4	21.5	16.6
2007	14.5	18.0	20.2	23.5	26.0	26.5	25.6	25.8	25.7	24.0	22.0	***
2008	15.8	16.1	22.1	24.5	25.5	26.2	25.3	25.6	25.7	25.1	20.4	18.0
2009	15.5	17.8	22.2	25.5	25.6	26.3	25.8	25.8	25.8	24.5	21.2	16.3
2010	15.2	17.2	23.1	26.3	26.4	26.3	26.2	26.2	25.9	25.5	21.3	17.0
2011	14.6	17.7	20.7	24.2	25.3	26.0	26.0	25.7	25.5	24.8	19.3	16.4
2012	15.2	16.6	21.9	24.4	25.8	25.8	25.3	25.7	25.8	24.4	20.5	14.7
2013	13.5	17.5	21.3	24.3	24.6	25.6	25.1	25.3	24.8	23.8	19.0	15.8

*** Missing data

Source: Bangladesh Meteorological Department (BMD)

Cox's Bazar Station:

The monthly maximum and minimum average temperature at Cox's Bazar are given in Table 7.4.2.1-13 and Table-7.4.2.1-14 respectively. In the last 10 years the monthly maximum average temperature in Cox's Bazar area was 34.1 deg Celsius and the monthly minimum average temperature was 13.9 deg Celsius.

Table 7.4.2.1-13: Monthly Maximum Average Temperature at Cox's Bazar, 2004-2013

Year	Monthly Maximum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	27.1	29.4	32.0	32.2	34.1	32.4	31.1	31.3	31.8	31.7	31.2	29.6
2005	27.2	30.1	31.9	33.9	33.9	32.5	31.1	30.5	32.1	32.5	30.4	28.6
2006	27.9	30.6	33.6	33.5	32.5	31.8	30.8	31.3	31.6	32.4	31.2	28.5
2007	26.8	28.7	32.0	32.2	32.7	31.9	30.3	31.5	31.3	31.5	30.8	28.2
2008	27.3	28.1	31.5	34.0	33.7	31.4	30.0	30.8	31.7	32.5	31.3	28.8
2009	28.6	30.8	32.9	33.4	33.9	32.9	30.7	31.3	32.5	32.8	31.7	28.3
2010	27.2	30.4	33.0	34.0	33.7	32.2	31.8	32.3	32.2	32.3	31.7	28.4
2011	27.0	30.3	32.3	32.9	32.5	31.3	31.2	30.9	31.1	32.1	30.7	27.6
2012	27.6	30.5	31.2	32.8	33.5	31.9	30.5	31.4	32.2	32.4	30.6	27.2
2013	26.8	30.7	32.2	33.8	31.8	32.4	31.6	31.2	31.9	31.3	31.2	28.4

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.1-14: Monthly Minimum Average Temperature at Cox's Bazar, 2004-2013

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	16.3	16.8	22.1	24.4	26.0	25.7	25.3	25.4	25.4	24.6	19.7	17.4
2005	15.9	19.2	22.3	24.8	25.9	26.5	25.5	25.4	25.4	25.1	20.8	19.4
2006	15.9	19.0	22.3	25.1	25.2	25.7	25.5	25.3	25.1	25.0	21.8	16.6
2007	14.6	17.9	20.3	23.5	25.7	26.0	25.2	25.4	24.9	24.0	22.6	17.5
2008	16.0	16.5	21.8	24.6	25.0	25.2	24.8	25.0	25.2	24.8	20.8	18.0
2009	15.9	17.9	21.9	25.3	25.3	25.6	25.5	25.3	25.2	24.6	21.7	16.6
2010	15.3	17.5	23.3	26.3	26.1	26.0	25.8	25.7	25.3	25.4	21.7	17.5
2011	14.9	17.8	20.9	24.1	24.7	25.4	25.5	25.1	24.9	23.9	19.5	17.0

Year	Monthly Minimum Average Temperature in Degree Celsius											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	15.8	17.1	21.4	24.3	25.8	25.4	25.1	24.9	25.4	24.4	21.5	15.5
2013	13.9	18.2	21.4	24.5	24.7	25.8	25.1	25.5	25.6	24.5	21.3	17.1

*** Missing data

Source: Bangladesh Meteorological Department (BMD)

7.4.2.2 Humidity

The relative humidity along the route of the proposed 400kV transmission line are recorded at 7 stations namely, Dhaka, Comilla, Chandpur, Feni, Chittagong (Ambagan), Kutibdia and Cox's Bazar respectively by BMD. The maximum and minimum average relative humidity at the above seven stations during the last 10 years from 2004 to 2013 are given in **Table-7.4.2.2.**

Table 7.4.2.2: Max. & Min. Average Relative Humidity at 7 stations during 2004-2013

Station	Dhaka	Comilla	Chandpur	Feni	Chittagong (Ambagan)	Kutubdia	Cox's Bazar
Maximum Average Relative Humidity in %	85	88	89	90	90	92	90
Minimum Relative Humidity in %	52	68	67	68	56	67	62

The detailed monthly average relative humidity at the above seven stations are given in **Table-7.4.2.2-1 through Table-7.4.2.2-7** respectively.

Table 7.4.2.2-1: Monthly Average Relative Humidity at Dhaka Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	73	60	62	72	67	81	81	78	85	74	69	70
2005	68	60	66	66	73	79	81	82	81	80	72	66
2006	69	65	53	67	72	81	80	77	80	76	68	69
2007	68	68	54	69	70	81	84	80	80	78	77	69

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	69	61	67	64	70	80	83	81	81	77	69	79
2009	72	55	53	66	72	74	80	82	81	73	66	69
2010	71	56	59	67	71	79	77	78	79	74	68	66
2011	69	54	57	64	76	80	79	82	77	73	67	73
2012	66	52	57	69	70	77	79	78	79	71	68	77
2013	65	55	55	63	78	76	77	80	81	78	66	72

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.2-2: Monthly Average Relative Humidity at Comilla Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	82	74	79	83	78	85	85	83	86	79	77	77
2005	77	76	82	79	79	84	85	87	85	84	80	76
2006	78	79	72	78	79	85	85	83	84	83	80	78
2007	77	76	71	81	82	86	88	84	85	82	81	79
2008	79	73	81	77	79	86	86	86	82	83	77	83
2009	78	73	75	78	80	83	86	86	83	82	76	79
2010	78	71	76	80	80	86	83	83	85	82	78	76
2011	75	68	74	78	82	85	84	85	84	80	76	81
2012	77	70	75	81	79	84	85	83	85	82	78	83
2013	74	68	75	78	85	81	83	85	84	85	78	81

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.2-3: Monthly Average Relative Humidity at Chandpur Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	82	74	80	85	80	87	87	86	89	84	79	79
2005	80	73	79	80	81	84	87	88	86	85	80	78
2006	79	76	70	76	79	86	86	85	86	82	81	79
2007	78	76	67	78	79	86	88	85	87	82	81	78
2008	77	72	76	74	77	86	88	86	84	83	76	83
2009	80	69	68	76	79	82	86	86	85	82	77	79
2010	81	72	71	77	79	87	84	83	85	81	78	77
2011	77	71	70	76	82	86	85	87	86	80	76	81
2012	78	67	71	79	78	84	85	85	85	81	77	83
2013	77	70	70	76	85	82	85	86	85	84	75	79

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.2-4: Monthly Average Relative Humidity at Feni Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	81	74	78	82	77	85	86	84	88	84	79	78
2005	78	74	***	78	80	83	87	89	86	85	81	79
2006	78	78	72	77	81	85	87	83	86	84	82	78
2007	78	75	68	80	81	86	89	86	86	83	82	79
2008	79	73	79	78	80	85	88	87	84	85	79	84
2009	79	73	75	79	80	83	88	88	84	83	79	79
2010	80	70	77	82	84	90	86	85	86	84	80	80
2011	76	71	75	82	87	88	86	88	86	82	79	82
2012	79	70	77	82	80	87	89	85	86	85	81	83
2013	77	70	72	76	86	83	85	86	86	86	79	80

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.2-5: Monthly Average Relative Humidity at Chittagong (Ambagan) Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	78	66	76	78	79	84	87	84	86	83	76	75
2005	69	66	76	75	77	82	86	90	86	86	82	79
2006	76	77	66	74	83	89	87	81	84	83	78	75
2007	73	73	64	80	82	87	89	85	87	85	83	76
2008	76	69	79	74	78	83	87	86	84	84	80	84
2009	73	62	70	79	77	81	86	86	84	81	76	74
2010	70	59	69	76	78	86	82	84	82	83	78	74
2011	67	66	69	76	79	85	84	88	86	82	77	81
2012	74	64	77	82	79	87	88	85	82	84	77	80
2013	69	56	70	72	82	83	82	84	85	85	75	77

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.2-6: Monthly Average Relative Humidity at Kutubdia Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	77	74	77	80	79	82	86	85	85	83	74	71
2005	70	74	81	78	77	82	85	88	84	82	76	74
2006	73	80	72	75	78	84	86	83	84	82	75	73
2007	73	74	72	80	80	82	87	85	86	83	82	73
2008	75	70	81	75	76	83	87	85	84	81	76	77
2009	71	71	80	80	76	81	86	86	84	79	74	70
2010	73	69	78	77	76	84	83	83	82	82	75	71
2011	67	70	73	79	80	86	87	87	87	82	75	77
2012	70	68	79	83	86	89	92	91	87	83	82	81

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	81	80	81	87	87	89	89	88	88	89	77	76

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.2-7: Monthly Average Relative Humidity at Cox's Bazar Station, 2004-2013

Year	Monthly Average Relative Humidity in %											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	79	72	76	81	80	85	88	88	86	83	75	71
2005	70	71	78	76	75	84	87	90	86	82	76	77
2006	72	75	68	72	80	86	89	86	85	81	74	73
2007	72	72	67	76	79	83	89	86	86	83	80	71
2008	72	66	78	71	76	85	89	87	86	81	74	75
2009	70	66	73	76	75	82	89	88	85	80	73	71
2010	71	64	74	75	77	86	85	84	85	84	76	74
2011	67	67	69	77	80	87	85	88	87	82	74	77
2012	66	62	77	77	79	86	89	87	85	82	76	77
2013	70	66	75	77	85	85	86	86	85	83	73	73

Source: Bangladesh Meteorological Department (BMD)

7.4.2.3 Rainfall

During the monsoon (June to September), wind direction from the southwest brings moisture laden air from the Bay of Bengal, when the heaviest rainfall occurs. Average monthly rainfall values at Dhaka, Comilla, Chandpur, Feni, Chittagong (Ambagan), Kutubdia and Cox's Bazar stations are given in **Table 7.4.2.3-1 through Table-7.4.2.3-7** respectively in the last 10 years from 2004 to 2013. In the last 10 years (2004-2013), the maximum annual rainfalls recorded at the above stations are given in **Table-7.4.2.3.**

Table 7.4.2.3: Maximum annual Rainfall in mm at 7 stations during 2004-2013

Stations	Dhaka	Comlla	Chandpur	Feni	Chittagong (Ambagan)	Kutubdia	Cox's Bazar
Maximum Annual Rainfall in mm	2885	2497	2545	3543	4340	4677	4440
Year	2007	2007	2013	2007	2007	2012	2011

Table 7.4.2.3-1: Monthly Rainfall data in mm at Dhaka station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	0	9	167	162	476	295	191	839	208	0	0	2347
2005	1	3	155	91	291	259	542	361	514	417	3	0	2637
2006	0	0	0	181	185	326	331	167	663	61	5	0	1919
2007	0	30	11	163	185	628	753	505	179	320	111	0	2885
2008	23	56	45	91	205	577	563	319	279	227	0	0	2385
2009	1	1	43	14	168	170	676	482	298	74	4	0	1931
2010	0	48	22	37	177	308	167	340	169	174	0	81	1523
2011	0	0	20	123	235	314	356	409	207	112	0	0	1776
2012	10	1	37	269	137	175	226	282	81	38	68	5	1329
2013	0	8	26	32	378	325	302	212	172	131	0	4	1590

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.3-2: Monthly Rainfall data in mm at Comilla station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	4	6	175	186	654	311	183	686	218	1	0	2424
2005	6	2	249	157	193	259	403	410	395	349	0	1	2424
2006	0	0	0	117	607	402	151	226	300	94	1	0	1898
2007	0	20	21	179	153	548	654	221	339	280	82	0	2497

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2008	30	11	26	34	282	330	457	375	247	265	0	0	2057
2009	0	0	3	48	295	235	573	427	145	98	0	0	1824
2010	0	13	30	23	343	417	94	125	241	277	0	15	1578
2011	0	0	28	76	351	346	273	501	233	76	0	0	1884
2012	16	1	13	195	209	442	282	373	178	115	102	3	1929
2013	0	3	30	28	467	214	276	243	255	124	0	3	1643

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.3-3: Monthly Rainfall data in mm at Chandpur station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	0	9	104	101	374	312	334	845	302	0	2	2383
2005	7	0	122	91	115	31	344	318	149	360	0	2	1539
2006	0	0	0	27	260	336	348	309	410	24	0	0	1714
2007	0	57	40	51	226	399	782	180	266	228	109	0	2338
2008	39	22	64	67	240	193	649	320	213	333	0	0	2140
2009	0	1	5	56	220	177	431	312	146	195	3	0	1546
2010	0	23	3	17	191	541	233	204	229	303	6	15	1765
2011	0	1	35	145	424	410	291	403	291	128	0	0	2128
2012	12	12	30	194	121	279	298	452	137	128	92	2	1757
2013	0	3	15	135	670	497	225	331	502	167	0	0	2545

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.3-4: Monthly Rainfall data in mm at Feni station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	0	0	177	185	468	499	104	708	254	0	0	2395
2005	11	0	0	188	331	292	784	615	279	346	22	0	2868
2006	0	0	0	52	577	390	439	188	388	52	0	0	2086
2007	0	73	4	128	282	509	970	402	601	499	75	0	3543

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2008	29	16	30	16	285	505	788	687	249	269	0	0	2874
2009	0	1	20	36	506	371	854	682	234	226	55	0	2985
2010	0	36	6	62	338	728	444	348	321	383	20	23	2709
2011	0	10	55	58	437	599	576	832	402	225	0	0	3194
2012	2	0	28	388	138	723	568	390	274	356	18	0	2885
2013	0	3	26	17	533	493	382	468	373	193	0	0	2488

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.3-5: Monthly Rainfall data in mm at Chittagong (Ambagan) station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	0	6	165	275	638	905	142	590	203	0	0	2924
2005	5	0	57	121	148	233	596	654	386	100	23	8	2331
2006	0	0	0	50	859	288	495	138	438	91	16	0	2375
2007	0	49	4	223	263	953	930	589	512	635	182	0	4340
2008	56	13	14	1	272	618	962	809	266	216	43	0	3270
2009	0	0	2	125	360	408	1025	589	261	321	39	0	3130
2010	0	9	50	50	282	916	245	392	86	301	52	22	2405
2011	0	0	35	117	355	454	613	748	740	66	0	0	3128
2012	0	0	31	231	114	1268	662	300	221	445	3	0	3275
2013	0	1	5	58	469	504	391	243	305	403	0	0	2379

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.3-6: Monthly Rainfall data in mm at Kutubdia station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	0	4	134	167	539	559	461	528	149	0	0	2541
2005	4	0	102	139	218	433	507	853	251	189	16	15	2727
2006	0	0	0	25	626	488	899	344	502	81	2	0	2967

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2007	0	117	0	104	365	483	709	416	481	325	162	0	3162
2008	52	6	10	1	253	441	1256	659	305	181	7	0	3171
2009	0	0	2	87	180	410	1067	448	308	125	31	0	2658
2010	0	2	10	4	464	666	517	466	120	403	0	50	2702
2011	5	0	22	118	316	952	803	856	597	224	0	1	3894
2012	0	0	37	135	251	1178	1688	527	260	554	47	0	4677
2013	0	1	0	85	1088	1058	818	642	296	215	0	0	4203

Source: Bangladesh Meteorological Department (BMD)

Table 7.4.2.3-7: Monthly Rainfall data in mm at Cox's Bazar station, 2004-2013

Year	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Year Total
2004	0	0	1	204	250	705	751	686	438	247	0	0	3282
2005	6	0	27	113	178	848	608	957	342	257	23	25	3384
2006	0	0	0	114	800	662	802	385	678	78	10	0	3529
2007	0	65	0	100	373	640	1274	526	409	492	127	0	4006
2008	15	50	4	0	244	1318	1275	664	387	184	3	0	4144
2009	0	0	0	130	241	324	971	944	485	130	58	0	3283
2010	0	0	15	12	717	982	496	501	257	375	15	68	3438
2011	11	0	4	123	296	926	877	1226	692	280	0	5	4440
2012	0	0	109	148	254	1102	1130	801	302	263	14	0	4123
2013	0	0	0	54	700	876	772	1000	237	420	0	0	4059

Source: Bangladesh Meteorological Department (BMD)

7.4.2.4 Wind

Wind speeds and directions are recorded by BMD at seven weather stations located at Dhaka, Comiila, Chandpur, Feni, Chittagong (Ambagan), Kutubdia and Cox's Bazar respectively along the proposed 400kV transmission line from Meghnaghat to Matarbari via Modunaghat. Monthly wind speed and direction at the above seven

stations for the last 10 years from 2004 to 2013 are given in **Table 5.1.2.4-1 through Table-7.4.2.4-7** respectively. From the tables, it is found that wind directions along the proposed route of transmission line are mostly from the south and southeast. During November to February the wind directions are from north or northwest and from March to October from south or southeast.

From **Table 7.4.2.4-1 through Table-7.4.2.4-7,** it was observed that the maximum wind speed of **9.4 knots** from South-East prevailed during October, 2007 at Chittagong (Ambagan) station. from South-East.

Table-7.4.2.4.-1: Monthly Prevailing Wind speed in knots and direction (2004-2013), Dhaka Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2004	3.50	W	3.90	W	5.60	S	5.90	S	5.50	S	3.60	S	4.30	SE	4.10	SE	6.30	E	4.20	SE	3.20	W	2.50	NW
2005	4.10	NNW	4.30	W	4.60	S	4.50	S	4.40	S	4.40	SE	4.60	SE	3.50	S	4.60	SE	4.80	SE	3.40	NW	3.70	NNW
2006	3.00	N	3.60	S	5.00	NNW	3.80	S	3.80	S	2.10	S	2.20	SE	4.50	SE	5.40	SE	2.30	N	2.00	W	2.40	NW
2007	2.90	NW	3.10	NW	4.20	NW	3.80	S	3.50	S	3.10	S	3.10	S	3.10	S	3.20	S	4.10	NE	5.50	NE	2.90	NW
2008	3.01	S	2.82	S	3.92	S	3.22	NNW	3.14	S	3.85	S	3.50	S	2.73	S	2.54	SE	3.08	S	2.25	S	2.84	S
2009	3.25	W	3.75	W	3.80	W	4.58	S	4.23	S	3.51	S	3.48	SE	2.74	S	2.18	CLM	1.71	CLM	1.61	CLM	1.91	NW
2010	2.72	NW	2.84	W	3.14	S	4.12	S	3.19	S	2.93	S	2.69	S	2.15	S	2.62	S	2.02	NE	2.11	N	2.24	NW
2011	2.20	W	2.31	W	2.82	S	2.48	S	2.72	S	2.81	S	2.15	SE	2.02	SE	2.20	SE	1.42	CLM	1.25	CLM	1.92	NW
2012	2.20	W	2.71	W	2.58	S	2.54	S	2.27	S	2.61	S	2.61	S	1.76	SE	1.84	S	1.71	S	2.00	NW	1.44	CLM
2013	1.56	NW	2.12	NW	2.37	W	2.74	S	2.97	E	2.42	S	2.51	SE	2.48	S	1.76	S	1.80	CLM	1.70	CLM	1.59	W

Source: BMD; 1knots =1.85325kms

Table-7.4.2.4.-2: Monthly Prevailing Wind speed in knots and direction (2004-2013), Comilla Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir
2004	3.3	N	3.8	N	6.5	S	8.5	S	6	S	5.1	S	6.4	S	5.2	S	4.1	S	7.1	S	3.8	N	3.4	N
2005	3.9	N	6.8	S	5.6	S	4.4	S	4.6	S	4.5	S	4.6	S	4.2	S	3.5	S	3.3	S	3	N	2.9	NW

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir	Spd	dir
2006	4	N	6	S	3.2	S	4.7	S	4.7	S	4.9	S	3.6	S	3	S	2.8	S	2.2	N	2.3	N	2.4	N
2007	2.4	N	2.8	S	3	NW	4	S	3.7	S	3.8	S	3.2	S	2.8	S	2.7	S	3.7	S	2.3	N	2.2	N
2008	2.3	N	2.5	NW	2.7	S	3.4	S	3.5	S	3.9	S	4.4	S	3.1	S	2.8	S	3.3	N	1.9	N	1.8	NW
2009	2.1	NW	2.6	NW	2.5	S	3.0	S	2.8	S	2.4	S	2.4	S	2.1	S	2.0	S	1.7	NW	1.7	N	1.6	NW
2010	1.9	NW	2.0	NW	2.9	S	3.9	S	2.6	S	2.7	S	2.0	S	1.7	S	1.7	S	1.6	NW	1.3	NW	1.6	NW
2011	1.8	NW	1.8	NW	2.7	S	1.9	S	2.0	S	2.1	S	1.9	S	2.0	S	1.9	S	1.9	N	1.4	NW	1.8	NW
2012	1.8	NW	2.0	NW	2.2	S	1.9	S	2.1	S	2.3	S	2.3	S	1.9	S	1.9	S	2.0	N	1.5	N	1.6	N
2013	1.6	N	2.1	N	1.9	S	2.4	S	3.0	S	2.5	S	2.6	S	2.5	S	2.2	S	2.0	NW	1.8	N	1.7	N

Source: BMD; 1knots =1.85325kms

Table-7.4.2.4.-3: Monthly Prevailing Wind speed in knots and direction (2004-2013), Chandpur Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2004	2.4	N	1.9	NW	1.5	S	2.4	S	2.2	S	2.1	SE	2.4	SE	2.5	SE	3.7	SE	3	SE	2.2	N	1.5	NW
2005	2	N	2.7	NW	3.1	S	2.4	S	2.1	S	2.3	S	2.4	SE	2	SE	2.1	SE	1.7	NW	2.1	NW	2.2	NW
2006	1.9	NW	2.2	S	2	N	2.5	S	2.4	S	2.3	S	2.4	SE	3.6	SE	3.4	SE	2.1	NW	2.5	N	2.1	N
2007	2.3	N	2.4	NW	2.3	NW	3.4	S	2.9	S	2.7	S	2.5	S	3	S	2.8	SE	2.5	SE	1.7	NW	2.2	N
2008	1.8	N	1.6	N	1.6	S	2.0	S	2.4	S	2.2	S	1.9	S	1.8	S	2.1	SE	1.9	NW	1.3	N	0.8	CLM
2009	1.0	CLM	1.7	N	1.7	NW	2.8	S	2.7	S	2.2	S	2.4	S	2.2	S	2.3	S	1.9	S	1.8	N	2.2	N

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2010	2.8	N	2.5	N	3.3	S	3.5	S	2.7	S	2.6	S	2.6	S	2.5	S	2.5	S	2.4	NW	1.9	N	2.1	N
2011	2.2	N	2.2	N	2.9	S	2.4	S	2.2	S	2.3	S	2.1	S	2.1	S	2.2	S	2.1	NW	1.5	N	2.1	N
2012	2.2	N	1.9	N	2.5	S	2.7	S	2.3	S	2.9	S	2.6	S	2.4	S	2.3	S	2.6	N	2.3	N	2.3	N
2013	2.5	N	2.6	N	2.1	S	2.8	S	3.0	S	2.3	S	2.2	S	2.4	S	2.1	S	1.9	NW	2.3	N	2.0	N

Source: BMD; 1knots =1.85325kms

Table-7.4.2.4.-4: Monthly Prevailing Wind speed in knots and direction (2004-2013), Feni Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2004	2.4	NW	2.7	SW	4.1	S	6	S	3.7	S	2.9	S	3.6	S	3.4	S	2.7	S	3.3	S	2.3	NW	3	NW
2005	2.2	NW	3.1	S	****	***	2.8	S	2.7	S	3.3	S	2.9	S	2.9	S	2.4	SE	3.1	SE	2.7	S	2.2	N
2006	2.2	NW	2.6	S	2.2	S	3.1	S	2.9	S	3.3	S	3.1	S	3.9	S	2.9	S	2.5	SE	2.7	N	2.4	N
2007	2.4	NW	2.6	S	3.1	NW	3.5	S	3.5	S	3.2	S	2.8	S	2.6	S	2.7	SE	2.4	SE	2.2	NE	1.9	NNW
2008	1.9	NW	2.1	NNW	3.0	S	2.9	S	2.7	S	3.0	S	2.5	S	2.8	S	2.4	SE	1.9	CLM	1.1	CLM	1.4	CLM
2009	1.6	CLM	2.3	W	2.4	S	2.9	S	2.8	S	3.0	S	2.7	S	2.3	S	2.3	S	1.2	CLM	1.4	CLM	1.4	NW
2010	1.7	NW	1.6	CLM	3.2	S	3.6	S	2.8	S	2.7	S	2.6	S	2.2	S	2.0	S	1.2	CLM	0.9	CLM	1.2	CLM
2011	1.6	NW	1.9	CLM	2.7	S	2.5	S	2.5	S	2.6	S	2.4	S	2.3	S	2.3	S	1.0	CLM	0.6	CLM	1.3	CLM
2012	1.5	NW	1.8	NW	2.4	S	2.9	S	2.7	S	3.1	S	3.2	S	2.4	S	2.2	SSE	1.1	CLM	0.6	CLM	1.0	CLM
2013	1.2	CLM	1.9	NW	2.2	S	2.9	S	3.8	S	2.7	S	3.3	S	3.1	S	2.1	S	1.3	CLM	0.7	CLM	0.5	CLM

Source: BMD Note: *** means Missing Data. 1knots =1.85325kms

Table-7.4.2.4.-5: Monthly Prevailing Wind speed in knots and direction (2004-2013), Chittagong (Ambagan) Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2004	1.9	N	2.4	N	3.8	S	5.6	S	2.9	S	2.8	S	3.1	S	2.5	S	2.6	S	2.9	S	2.3	NW	2.9	SW
2005	2.7	N	6.2	S	5.3	S	4.4	S	4.7	S	3.3	S	3.1	S	2.6	S	2.6	S	2.6	S	2	N	2	N
2006	2.5	N	3.9	S	2	S	3.8	S	3.3	S	3.4	S	2.6	S	2.6	S	2	SE	1.5	SE	1.9	NW	1.9	N
2007	2.9	NW	2.4	NNE	3.4	W	4.3	S	3.9	S	3.4	S	3	S	5.8	S	6.3	S	9.4	SE	3.2	N	2.7	N
2008	3.8	NW	3.3	W	4.4	W	5.5	SW	4.7	S	4.1	S	4.1	S	4.1	S	3.6	SE	3.5	W	2.6	NW	2.6	W
2009	3.2	W	3.3	NW	3.2	W	5.0	S	4.7	S	3.4	S	4.5	S	3.2	S	3.8	W	3.2	S	3.1	W	2.9	N
2010	4.2	NW	4.0	NNE	6.0	S	6.2	S	4.2	S	4.3	S	4.1	S	3.1	S	3.3	S	2.7	NW	2.5	NW	2.8	N
2011	2.8	NW	2.9	NW	4.1	S	3.2	W	4.0	S	3.6	S	4.0	S	4.0	S	3.5	S	2.9	W	2.8	NW	2.5	N
2012	3.3	NW	3.4	NW	3.5	S	4.1	S	3.8	S	3.9	S	3.3	S	3.5	S	3.4	S	3.2	W	2.7	NW	2.7	NNW
2013	3.0	NNW	3.0	NW	3.8	S	3.9	S	3.9	S	3.5	SSE	3.6	S	3.2	S	2.8	S	2.4	W	2.2	NW	2.3	W

Source: BMD Note: *** means Missing Data. 1knots =1.85325kms

Table-7.4.2.4.-6: Monthly Prevailing Wind speed in knots and direction (2004-2013), Kutubdia Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2004	3.3	NW	3.3	N	3.9	S	3.9	S	3.3	S	3.1	S	3.5	S	3.8	S	2.9	S	2.6	S	1.8	N	2.2	NW

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2005	2.4	NW	3.1	NW	4.2	S	3.3	S	3.4	S	5.4	S	5.1	S	4.3	S	3.2	S	2.9	SE	2.0	NE	2.5	NE
2006	2.8	NE	2.8	NW	2.7	NW	4.3	SSW	4.0	SSW	4.1	S	5.2	S	4.6	S	3.3	SSE	2.0	NNW	2.5	NNW	2.3	NNW
2007	2.2	NNW	3.3	NW	3.6	NW	3.6	SSE	3.7	SSE	4.1	SE	3.8	SSE	3.3	SSE	2.8	SSE	2.9	NNW	2.7	NW	2.5	NNW
2008	2.5	NNW	2.8	WNW	2.4	NW	2.5	WSW	3.0	SSW	4.3	S	4.1	SE	4.2	S	3.5	SE	2.7	NW	2.1	NW	2.1	NW
2009	2.3	NW	2.0	NNW	1.9	W	3.2	S	3.3	S	2.0	S	2.7	S	2.3	S	2.3	S	1.8	NW	1.5	N	1.7	NNW
2010	1.9	NNW	1.5	NNW	2.7	S	3.9	S	2.3	S	2.3	S	2.6	S	1.8	S	1.8	S	1.7	S	1.4	NNW	1.6	NNW
2011	1.8	NNW	1.5	NNW	2.0	S	1.6	W	2.9	S	2.6	S	2.2	S	2.4	S	2.3	S	1.2	S	1.4	NW	1.6	NW
2012	1.7	NW	1.7	NW	1.6	S	2.5	SW	2.1	NW	2.8	S	2.7	S	1.7	S	0.0	CLM	0.0	CLM	0.0	CLM	0.0	CLM
2013	0.9	CLM	1.3	NW	1.2	NW	1.6	SW	2.4	SW	1.8	SE	2.2	SE	2.0	SE	1.7	SE	1.4	SE	1.4	NW	1.1	NW

Source: BMD Note: *** means Missing Data. 1knots =1.85325kms

Table-7.4.2.4.-7: Monthly Prevailing Wind speed in knots and direction (2004-2013), Cox's Bazar Station

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2004	4.2	N	5.2	W	6.2	S	6.1	S	4.9	S	4.7	S	5.5	S	6.2	S	4.7	S	4.5	S	2.9	CLM	1.3	CLM
2005	5.1	N	5.7	NNW	6.5	S	6.9	W	5.5	S	6.8	S	6.0	S	6.8	S	5.4	S	4.4	SSW	3.9	NNW	3.6	NNE
2006	4.3	N	4.2	W	5.0	N	6.3	SSW	5.7	S	6.2	S	5.8	S	5.3	S	4.8	S	3.5	W	3.7	N	3.8	N
2007	3.7	N	4.2	NNW	4.7	N	4.3	SSW	4.6	S	4.9	S	5.1	S	5.7	S	5.0	S	4.5	NNW	4.0	NNE	3.5	NNE
2008	3.9	NNE	5.1	NNW	3.4	WSW	4.9	SSW	4.2	SSW	5.2	S	4.1	S	4.5	S	3.6	SSE	4.3	NNW	2.9	NNW	2.2	CLM

Year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir	Spd	Dir
2009	3.0	NNE	4.6	NNW	3.9	WNW	6.0	S	4.9	SSW	5.1	S	4.8	SSE	3.9	S	3.7	S	3.1	NNW	2.2	N	2.8	CLM
2010	4.0	NNW	4.1	N	4.5	S	5.5	S	4.1	SSW	4.6	S	4.1	S	3.3	S	3.1	S	2.5	S	2.6	NNE	2.9	NNE
2011	3.7	NNW	3.7	NNW	4.3	NNW	3.4	W	4.2	S	3.7	S	3.8	S	3.6	S	2.9	S	2.1	CLM	1.9	CLM	1.5	CLM
2012	2.8	N	3.0	NNW	2.9	SSW	4.0	SSW	3.8	S	4.9	S	4.5	S	4.1	S	3.7	S	3.8	S	3.7	NNE	3.9	NNE
2013	4.6	NNE	4.4	NNE	3.5	NNW	3.4	SSW	4.3	S	2.9	S	2.9	S	2.9	S	2.6	S	1.7	CLM	1.1	CLM	1.3	CLM

Source: BMD Note: *** means Missing Data. 1knots =1.85325kms

7.4.3 Natural Hazards

7.4.3.1 Cyclones

The southeastern region of Bangladesh is cyclone prone area. Severe cyclones like cyclones in 1970. 1991 can damage the structures. Enough protection against cyclones is required to avoid accidents. The list of major cyclonic storms in Bangladesh from 1960 to 2013 is given in **Table 7.4.3.1.**

Table-7.4.3.1: List of Major Cyclonic Storms in Bangladesh from 1960 to 2013

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in km/hr.	Tidal Surge Height in ft.	Central Pressure (hPa)
1	2	3	4	5	6
11.10.60	Severe Cyclonic Storm	Chittagong	160	15	-
31.10.60	Severe Cyclonic Storm	Chittagong	193	20	-
09.05.61	Severe Cyclonic Storm	Chittagong	160	8-10	-
30.05.61	Severe Cyclonic Storm	Chittagong (Near Feni)	160	6-15	-
28.05.63	Severe Cyclonic Storm	Chittagong- Cox's Bazar	209	8-12	-
11.05.65	Severe Cyclonic Storm	Chittagong-Barisal Coast	160	12	-
05.11.65	Severe Cyclonic Storm	Chittagong	160	8-12	-
15.12.65	Severe Cyclonic Storm	Cox's Bazar	210	8-10	-
01.11.66	Severe Cyclonic Storm	Chittagong	120	20-22	-
23.10.70	Severe Cyclonic Storm of Hurricane intensity	Khulna-Barisal	163	Mode-rate	-
12.11.70	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	224	10-33	-
28.11.74	Severe Cyclonic Storm	Cox's Bazar	163	9-17	-
10.12.81	Cyclonic Storm	Khulna	120	7-15	989
15.10.83	Cyclonic Storm	Chittagong	93	-	995
09.11.83	Severe Cyclonic Storm	Cox's Bazar	136	5	986
24.05.85	Severe Cyclonic Storm	Chittagong	154	15	982
29.11.88	Severe Cyclonic Storm with a	Khulna	160	2-14.5	983

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in km/hr.	Tidal Surge Height in ft.	Central Pressure (hPa)
1	2	3	4	5	6
	core of hurricane wind				
18.12.90	Cyclonic Storm (crossed as a depression)	Cox's Bazar Coast	115	5-7	995
29.04.91	Severe Cyclonic Storm with a core of hurricane wind	Chittagong	225	12-22	940
02.05.94	Severe Cyclonic Storm with a core of hurricane wind	Cox's Bazar-Teknaf Coast	278	5-6	948
25.11.95	Severe Cyclonic Storm	Cox's Bazar	140	10	998
19.05.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	232	15	965
27.09.97	Severe Cyclonic Storm with a core of hurricane wind	Sitakundu	150	10-15	-
20.05.98	Severe Cyclonic Storm with core of hurricane winds	Chittagong Coast near Sitakunda	173	3	
28.10.00	Cyclonic Storm	Sundarban Coast near Mongla	83	-	-
12.11.02	Cyclonic Storm	Sundarban Coast near Raimangal River	65-85	5-7	998
19.05.04	Cyclonic Storm	Cox's Bazar Coast between Teknaf and Akyab	65-90	2-4	990
15.11.07	Severe Cyclonic Storm with core of hurricane winds	Khulna-Barisal Coast near Baleshwar river	223	15-18	942

Date of Occurrence	Nature of Phenomenon	Landfall Area	Maximum Wind Speed in km/hr.	Tidal Surge Height in ft.	Central Pressure (hPa)
1	2	3	4	5	6
	(SIDR)				
25.5.2009	Cyclonic Storm (AILA)	West Bengal-Khulna Coast near Sagar island	70-90	4 -6	987
16-05-2013	Cyclonic Storm (CS) 'MAHASEN'	The cyclonic storm Mahasen completed crossing Noakhali-Chittagong coast .	100 kph, NW'ly	-	-
16-05-2013	Cyclonic Storm (CS) 'MAHASEN'	The cyclonic storm Mahasen completed crossing Noakhali-Chittagong coast .	100 kph, NW'ly	-	-

Source: Bangladesh Meteorological Department (BMD)

7.4.3.2 Seismicity

Bangladesh and northeast Indian states have long been one of the seismically active regions of the world, and have experienced numerous large earthquakes during the past 200 years at an average rate in every 30 years.

Seismo-tectonic studies have been undertaken by various workers in the area comprising the Indo-Burma ranges and their western extension and in northern India a complete list of reference of which is provided in Haque (1990) using data from various source. A seismicity map of Bangladesh and its adjoining areas has also been prepared by Mominuddin (1991). Bangladesh has been classified as falling into seismic zones with zone-III the most severe and zone-I the least, prepared by BGS.

Based on the seismicity, Bangladesh has been divided into three seismic zones as follows:

Zone-I : Severe (Seismic Factor - 0.08g)

Zone-II: Moderate (Seismic Factor – 0.05g

Zone-III: Minor (Seismic Factor – 0.04g)

Seismic Zones of Bangladesh are shown in **Figure 7.4.3.2.**

Figure 7.4.3.2 Seismic Zones of Bangladesh

The proposed site falls under Zone-II (Moderate Damage), whose Seismic Factor is 0.05g.

Earthquake data of in and around Bangladesh from 1918 to 2014 are given in **Annex-7.4.3.2.**

7.5 Ambient Air and Noise Quality

The secondary data of air quality and noise level in different upazilas along the proposed 400kV transmission line have been collected from **BUET, CUET, Environmental Science (CU), DU and BCSIR.** Sampling locations were in the urban or semi-urban area. Air quality and Noise level in the study area is given in **Table-7.5** It was found that air quality in most of the upazilas were found within standard limit except noise levels were above the standard limit because of having sampling location near industrial area. However, the proposed transmission line is located in the rural area where the air quality and noise level are assumed to be within standard limit.

Table-7.5 Air quality and Noise Level in the study area

Date	Upazila	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound dBA	Remarks
11/07/2009	Potiya	BSCIC, Potiya	219	8.5	14.4	74.5	Urban area
30/09/2010	Mirsarai	Dhaka – Ctg Road Side	223	9.0	16.3	75.3	Urban area
12/07/2010	Boalkhali	Bazar road side	86	4.0	7.0	69.7	Urban area
20/11/2011	Anowara	Beside Kafco R/A.	73	ND	ND	69.4	Urban area
15/08/2008	Banshkhali	In front of Upzila office	124	4.2	7.3	64.2	Urban area
14/07/2012	Laksam	North side	78	ND	ND	67.5	Urban area
23/04/10	Chandpur	Beside Rail Station	182	6.0	8.5	74.2	Urban area
23/04/10	Chandpur	BesideBus Stop	209	8.5	12.6	77.3	Urban area
Bangladesh Standard			200	80	100	60	

Note:- 1, SMP- Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3.SOx- Oxides of Sulphur. 04. dBA-Decible. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

The detailed analysis sheets of air quality and Noise level at different upazilas are given in **Annex-7.5**

7.6 Water Quality

7.6.1 Surface water:

The secondary data of surface water quality in different upazilas along the proposed 400kV transmission line have been collected from **BUET, CUET, Environmental Science (CU), DU and BCSIR.** Sampling locations were in the major water bodies such as river, Khal, pond etc. Surfeace water quality in the study area is given in **Table-7.6.1.** It was found that surface water quality in most of the

upazilas were found within standard limit. However, the proposed transmission line is located in the rural area where the surface water quality is assumed to be within standard limit.

Table-7.6.1: Surface water Quality of the Study Area

Upazila	Sample Location	Date	Temperature ^{0}C	PH	EC .µS/cm	Chloride mg/1	TDS mg/1	SS mg/1	DO mg/1	BOD mg/1	COD mg/1	Salinity %	Oil & Grease mg/1	Arsenic mg/1	Note
Chandpur	Dakatia River Side,Notun Bazar, Chandpur	14/07/07	30.5	7.1	132	11	66	67	5.2	4	1	-			
	Dakatia River Middle,Notun bazar,Chandpur	14/07/07	30.6	7	126	10	63	41	5.6	0.3	1	-	-		
Banshkhali	Sangu River, Under Toylardip Bridge, Baskhali, Chittagong	15/08/08	30.1	7.32		23	98	2.39	5.4	0.4	0	0.02	3.1	0	-
Raozan	Canal Water under Bridge Gohira, Raozan	24/10/10	30.5	7.22		9	76	11	5.3	0.3	0	0.02	2.5	0	-
Mirsarai	Surface water of Canel (Khal), Mirarsharai, Ctg.	16/02/07	24	7.61		112	251	32	5.4	0.4	0	0.26	3	0	-
Laksam	Canal (Khal)Beside NoakhaliRoad, Laksam,Comilla	20/05/06	30.2	7.24		41	116	35	5.2	0.5	0	0.07	2.8	0	-
Boalkhali	Karnafully River water Char Khidirpur,Boalkhali Side,Ctg.	11/6/2010	30.5	7.62		1254	2710	179	5.5	0.4	135	2.26	4	0	Jhoar
	Karnafully River water Charkhidirpur, Boalkhali Side,Ctg.	11/6/2010	31.1	7.21		36	154	153	5.3	0.5	31	0.06	3.5	0	Vata
Daudkandi	Water Body Beside Daudkandi Bus Stand Comilla.	13/07/10	30	7.12	122	7	56	9	5	0.5	1	-	-		

Upazila	Sample Location	Date	Temperature ^{0}C	PH	EC. µS/cm	Chloride mg/1	TDS mg/1	SS mg/1	DO mg/1	BOD mg/1	COD mg/1	Salinity %	Oil & Grease mg/1	Arsenic mg/1	Note
Feni	Feni River Under Bridge.Bishow Road,Feni.	16/06/07	30	7.24		19	86	213	5.5	0.3	0	0.01	3.2	0	-
Fatickchari	Pond water of Paharica Farm Ltd. Nannupur,Fotickchari, Chittagong	13/08/11	31	7.14		15	114	23	5.2	0.5	0	0.03	2.2	0	-
Potiya	Waste Water of Middie, Shikalbaha Khal, Potiya, Chittagong.	11/7/2009	29.7	7.6	154	21	87	63	5.4	0.3	3	0.03	-		
Anowara	Karnafully River water CUFL Side, Anowara, Ctg..	11/7/2009	31	7.8		10890	18540	357	5.4	0.5	467	19.6	5.5	0	Jhoar
	Karnafully River water CUFL Side, Anowara, Ctg..	11/7/2009	31.4	7.34		1246	2614	315	5.2	0.6	139	2.24	4.1	0	Vata
Standard Limit			40	6.5-8.5	1200	150-600	2100	100	4.5-8.5	50	200	-	-		

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

The detailed analysis sheets of ground water quality at different upazilas are given in **Annex-7.6.1**

7.6.2 Ground water:

The secondary data of ground water quality in different upazilas along the proposed 400kV transmission line have been collected from **BUET, CUET, Environmental Science (CU), DU and BCSIR.** Sampling locations were in the urban or semi-urban area. Ground water quality in the study area is given in **Table-7.6.2.** It was found that ground water quality in most of the upazilas were found within standard limit. However, the proposed transmission line is located in the rural area where the ground water quality is assumed to be within standard limit.

Table-7.6.2: Ground water Quality of the Study Area

Upazila	Sample Location	Date	Temperature ^{0} C	P^{H}	Chloride mg/1	TDS mg/1	SS mg/1	Arsenic mg/1	Fe mg/1	Coli Form n/100 ml	Salinity %	DO	BOD^{5}	COD mgl1	Note
Chandpur	Deep Tubewell of Mohammadia Jame Mosque Puran Bazar, Chandpur	7/4/2010	30	8	1284	4175	3	0.18	2.2	0	2.31	3.7	0.3	1	-
	Deep Tubewell of Hotel Taj, Mukti Sharoni Road, Chandpur	7/4/2010	30.1	7.8	371	1208	2	0.1	1.6	0	0.67	4	0.3	0	-
Banshkhali	Deep Tubewell of Jioldi Bazar Area Bashkhali, Chittagong	16/03/06	27.2	6.7	113	277	2	0.03	2.6	0	0.21	3.6	0.4	0	-
Raozan	Deep Tubewell of Gohira Bazar, Raozan Chittagong	12/07/13`	29.3	6.7	77	152	2	0	0.32	0	0.13	3.8	0.4	0	-
Mirsarai	Deep Tubewell Water Mosque of Sona Pahar Area, Mirsharai,Chittagong	16/02/10`	28.3	7.56	302	457	4	0.04	3.1	0	0.54	3.7	0.2	0	-
Laksam	Deep Tubewell Beside Railway Station, Laksam, Comilla.	14/07/12`	29.2	7.34	73	169	2	0.02	0.56	0	0.13	4	0.1	0	-
Boalkhali	Deep Tubewell of Char khidirpur,Boalkhali,Chittagong.	12/7/2010	29.5	6.9	92	214	1	0	0.23	0	0.08	4	0.2	0	-
Daudkandi	Goripore Bazar area.Daudkandi, Comilla.	20/05/09	29.4	7.62	86	263	3	0.03	1.52	0	0.14	3.6	0.3	0	-
Feni Sadar	Deep Tubewell of Mohipal Zame Mosque, Feni.	30/07/09	28.5	6.94	153	307	2	0.03	0.95	0	0.24	3.8	0.2	0	-
Fatickchari	Deep Tubewell of Nannupur, Fotickchari, Chittagong..	13/08/11	29.1	6.82	63	138	1	0	0.27	0	0.12	3.8	0.4	0	-

Upazila	Sample Location	Date	Temperature ^{0} C	PH	Chloride mg/1	TDS mg/1	SS mg/1	Arsenic mg/1	Fe mg/1	Coli Form n/100 ml	Salinity %	DO	BOD^{5}	COD mgl1	Note
Potiya	Deep Tubewell of Shatirhat,Potiya, Chittagong. ..	10/1/2010	29.3	6.82	65	134	1	0.01	0.69	0	0.11	3.9	0.2	0	-
Anowara	Deep Tubewell water Beside Korean EPZ. Dangerchar, Anowara, Ctg	20/11/2011	29.2	6.83	2564	720	1282	4	0.06	0.92	0	3.8	0.2	0	-
Standard Limit			40	6.5-8.5	150-600	1000	10	0.05	1	200	-	4.5-8.5	2	4	-

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

The detailed analysis sheets of ground water quality at different upazilas are given in **Annex-7.6.2**

7.7 Soil Quality

7.7.1 Introduction

Bangladesh has a wide range of environmental conditions. Environmental diversity occurs not only at national and regional levels, it also occurs at the Upazila and village levels. Besides considerable year to year variability in moisture, the temperature and flood regimes create major problems for planning program on environment and agricultural research, extension and development activities.

In Bangladesh total thirty agro-ecological regions and 88 sub-regions have been identified by considering factors on the physical environment which are relevant for land use and assessing agricultural potential. These factors are:

- Physiography (land forms and parent materials)
- Soils and their characteristics
- Depth and duration of seasonal flooding
- Length of the rainfed kharif and rabi growing periods
- Length of the pre-kharif period of unreliable rainfall
- Length of the cool winter period and frequency of occurrence of extremely low (below 0.4^{0}C) winter temperature.
- Frequency of occurrence of extremely high (> 40^{0}C) summer temperature.

Figure 7.7.1 shows the distribution of 30 agro-ecological regions in Bangladesh (BARC, 2005; CIMMYT, 2007 and FAO/UNDP 1988).

Most of the study area is included the following agro-ecological zones:

1. AEZ 16. Middle Meghna River Floodplain

2. AEZ 19. Old Meghna Estuarine Floodplain
3. AEZ 23. Chittagong Coastal Plains
4. AEZ 29. Northern and Eastern Hills

Small part of the study area included the following agro-ecological zones:

5. AEZ 9. Old Brahmaputra Floodplain
6. AEZ 18. Young Meghna Estuarine Floodplain
7. AEZ 22. Northern and Eastern Piedmont Plains

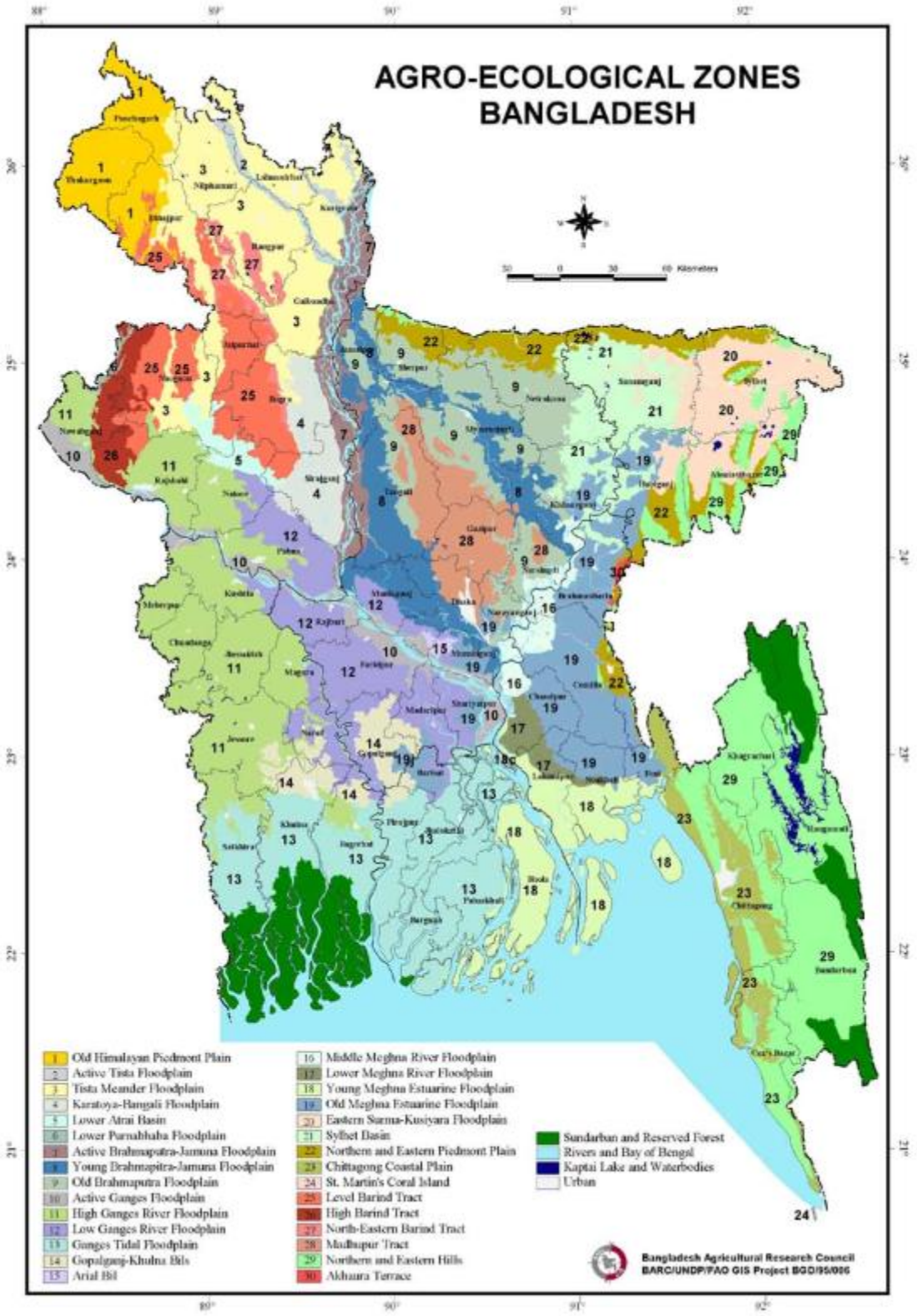


Figure 7.7.1 Agro-ecological Zones of Bangladesh (BARC/UNDP/FAO GIS project BGD/95/006).

Table 7.7.1. Area, locations and land types of agro ecological zones

AEZ Name	Area		Major land types & extent		Locations (Upazila & districts)
	km^2	ha	Type	Extent (%)	
AEZ 16 Middle Meghna River Floodplain	1555	155464	MLL LL VLL	29	Sonaragaon, Narayanganj Gazaria, Munshiganj Daudkandi, Comilla
AEZ 19. Old Meghna Estuarine Floodplain	7740	774026	MHL MLL LL	24 33 21	Daudkandi, Comilla Kachua, Chandpur Barura, Comilla Laksam, Comilla Nagalkote, Comilla Choddagram, Comilla Feni Sadar, Feni Daganbhuyan, Feni
AEZ 23. Chittagong Costal Plains	3720	372007	HL MHL MLL	17 43 13	Feni Sadar, Feni Chhagolnaiya, Feni Mirsarai, Chittagong Fatikchhari, Chittagong Hathazari, Chittagong Raojan, Chittagong Boalkhali, Chittagong Patiya, Chittagong Anowara, Chittagong Banshkhali, Chittagong Pekua, Cox's Bazar Moheshkhali, Cox's Bazar
AEZ 29. Northern and Eastern Hill	18172	1817172	HL	92	Mirsarai, Chittagong Fatikchhari, Chittagong Hathazari, Chittagong Raojan, Chittagong Boalkhali, Chittagong Patiya, Chittagong Banshkhali, Chittagong Pekua, Cox's Bazar Moheshkhali, Cox's Bazar
AEZ 9. Old Brahmaputra Floodplain	7230	723037	HL MHL MLL	28 35 20	Sonaragaon, Narayanganj
AEZ 18. Young Meghna Estuarine Floodplain	9269	926885	MHL	45	Dagaonbhuyan, Feni, Mirsarai, Chittagong,
AEZ 22. Northern and Eastern Piedmont Plains	4038	403758	HL MHL MLL	31 31 16	Choddagram, Comilla

HL = Highland, MHL =Medium Highland, MLL = Medium Lowland LL = Lowland, VLL = Very Lowland

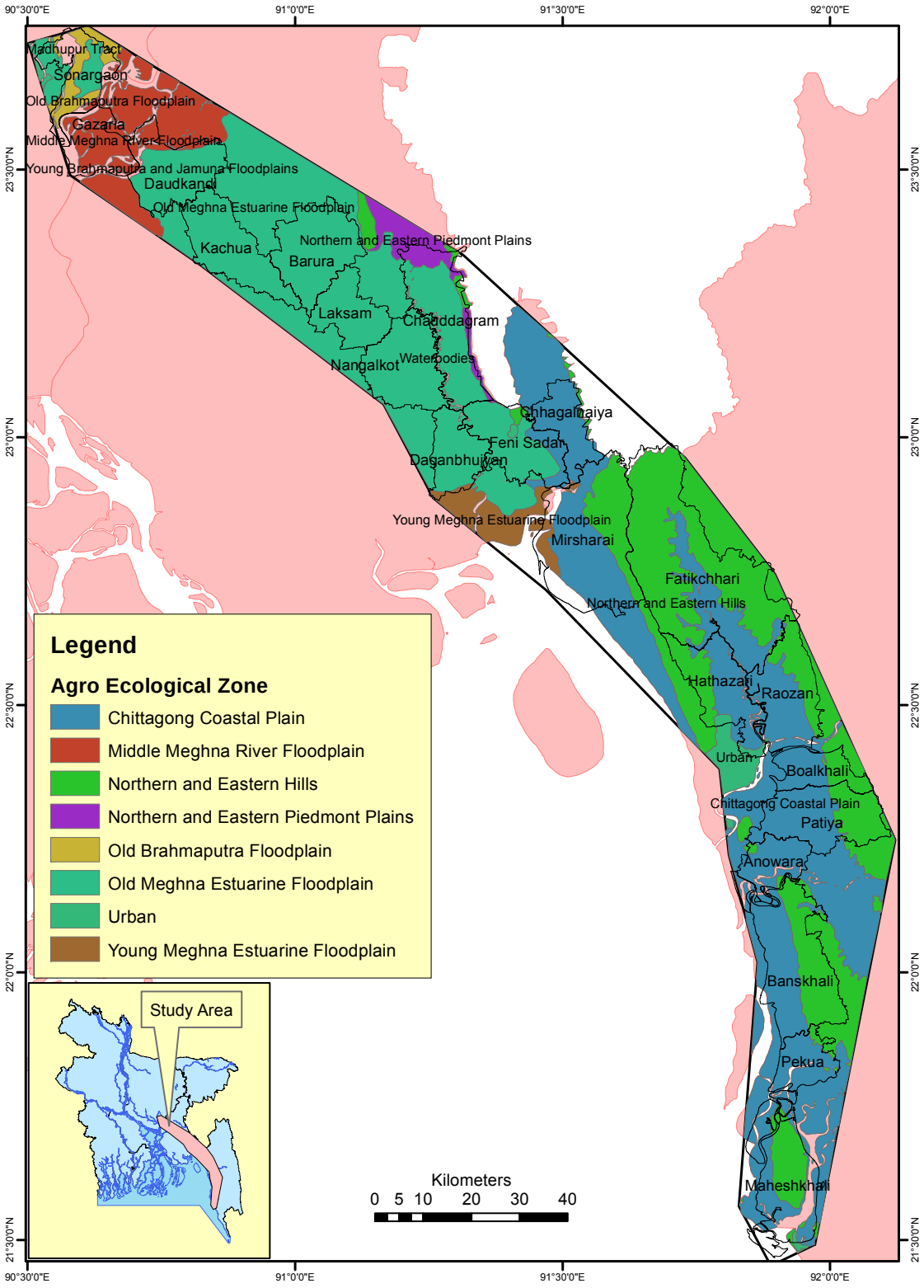


Figure 7.7.2 Agro-ecological Zones of the study area.

7.7.2 Agro-Ecological Zones

AEZ 16. Middle Meghna River Floodplain

The **Meghnaghat 400kV SS** at Sonaragaon Upazila of Narayanganj District is situated in this zone. Gazaria Upazila of Munshiganj and part of Daudkandi Upazila of Comilla District are included in this zone

Physiography

This region occupies abandoned channel of the Brahmaputra river on the border between the greater Dhaka and Comilla districts. This region includes islands – former Brahmaputra chars, within the Meghna river as well as adjoining parts of the mainland. It comprises various kinds of relief. The Meghna river banks are mainly stable. But bank erosion occur on a small scale locally.

Climate

Mean annual rainfall is about <2000 mm in the centre and 2200-2300mm in the north and south.

Mean annual temperature is about 26.0°C.

Land type and soil type

Land type	Percentage
Highland	<1
Medium highland	8
Medium lowland	29
Lowland	23
Very lowland	11
Homestead, water	27

Three main kinds of soil occur-

i) Grey loams and clays on ridge and basin site in area of Meghna alluvium.

ii) Grey loamy ridge soil and dark grey basin soils in old Brahmaputra alluvium

iii) Grey sands to loamy sands in Old Brahmaputra char. Organic matter content is low

Soils of the area are grey, loamy on the ridges and grey to dark grey clays in the basins. Grey sands to loamy sands with compact silty topsoil occupy areas of Old Brahmaputra char. Dominant General Soil type is Noncalcareous Grey Floodplain soils. Topsoils are strongly acidic and subsoils moderately acidic to slightly alkaline. General fertility level is medium with low N and organic matter contents. The P, Zn

and B levels are low to medium.

Major land type	Soil pH	Soil OM	Nutrient status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium lowland (29%)	4.9-7.0	LM	L	LM	L	MOpt	Opt	MOpt	LM	LM	Opt
Lowland (25%)	4.1-6.8	M	L	LM	L	MOpt	Opt	MOpt	LM	LM	Opt
Very lowland (11%)	4.6-5.5	M	L	LM	L	MOpt	Opt	MOpt	LM	LM	Opt

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

Ample surface water exists in the Meghna channels to irrigate the whole region and groundwater probably is readily available for use by tubewells if needed to supplementation surface water supplies.

Present land use

Mainly deep water aman, or mixed aus and aman. Local boro paddy in flooded area and HYV boro in higher margin of basin. Rabi crops are chilli, mustard, wheat, kheshari etc.

Major cropping patterns

Veg(R)/Wheat/Potato/mustard/pulse- B.aus/Jute-T.aman

Chillies-B.aus/Jute-Fallow

Mustard-Boro-Fallow

Boro-Fallow-Fallow

Development constraints

a) Early rise of flood water, deep flooding and slow drainage

b) Poor communications.

c) Sandy soils and irregular relief.

River bank erosion along parts of the main Meghna channel

AEZ 19. Old Meghna Estuarine Floodplain

It includes Daudkandi, Barura, Laksam, Nagalkote and Choddagram Upazilas of Comilla District; Kachua Upazila of Chandpur District; and Feni Sadar and Daganbhuyan Upazilas of Feni District.

Physiography

The area is smooth, almost level, floodplain ridges and shallow basin. This region occupies a large area, mainly low lying between the south of the Surma-Kushiyara Floodplain and the northern edge of the Young Meghna Estuarine Floodplain. It comprises smooth, almost level, floodplain ridges and shallow basins.

Climate

Mean annual rainfall is about 2000mm over most of the region, but exceeds 2500mm in north east and exceeds 3000mm in the extreme south-east.

Mean annual temperature is about 26^{o}C.

Land type and soil type

Land type	Percentage
High land	2
Medium highland	24
Medium lowland	33
Lowland	21
Very lowland	3
Homestead, water	17

Silty soils predominate but silty clay and clay also found. Organic matter contents in the cultivated layer range from 1-2.5 percent in ridges and 2-5% in depression. Moisture holding capacity is high. Silt loam soils predominate on highlands and silty clay to clay in lowlands. A noncalcareous Dark Grey Floodplain soil is the only

General Soil Types of the area. Organic matter content of the soils is moderate. Moisture holding capacity is medium. Topsoils are moderately acidic, but subsoils neutral in reaction. General fertility level is medium. Status of K is low in uplands and low to moderate in lowlands. Levels of P, S, Zn and B are low to medium.

Major land type	Soil pH	Soil	Nutrient status								
		OM	N	P	K	S	Ca	Mg	Zn	B	Mo
Medium highland (24%)	4.4-7.8	LM	VLL	LM	LM	LM	Opt	Opt	LM	LM	Opt
Medium lowland (33%)	5.5-7.7	M	VLL	LM	LM	LM	Opt	Opt	LM	LM	Opt
Lowland (21%)	5.7-6.9	M	L	LM	LM	LM	Opt	Opt	LM	LM	Opt

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

Surface water that could be used for irrigation is widely available from the Meghna, Sitalakhya, Dhaleswari or Ganges distributaries. Ground water apparently is readily available for use by tubewell.

Present land use

On highland and medium highlands- aus, T.aman, HYV boro rice, mustard and rabi crops are grown.

On medium lowland-mixed aus and aman, jute, wheat, mustard, potato, chilli, kaon, sesame, kheshari etc. are grown. In the lowland- Local variety of boro are widely grown.

Major cropping patterns

Mustard/wheat/grasspea/potato/cucurbits-B.aus-T.aman

Boro-Fallow-T.amam

Sugarcane

B.aus-Fallow

Mustard-Jute-Fallow

Development constraints

a) Moderately deep or deep seasonal flooding over most of them.

b) Slow drainage of most of the soil after rainy season.

c) Very silty soils which are difficult to use for kharif dry land crops.

d) Exposure to cyclone in the south.

e) Saline groundwater in the south of the region.

AEZ 23. Chittagong Coastal Plains

This region occupies the plain land in greater Chittagong district and the eastern part of Feni district. Feni Sadar and Chhagolnaiya Upazilas of Feni District, Mirsarai, Fatikchhari, Hathazari, Raojan, Boalkhali, Patiya, Anowara and Banshkhali Upazilas of Chittagong District; and Pekua, and Moheshkhali Upazilas of Cox's Bazar are included in this zone.

Proposed sites of **Madunaghat 400kV substation and Matarbari 2x600MW Coal based power plant** are located in this zone.

Physiography

The region includes 6 physiographic unit namely piedmont plains, river floodplain, old tidal floodplain, young tidal floodplain, mangrove tidal floodplain and old beach ridges. It is a compound unit of piedmont, river, tidal and estuarine floodplain landscapes. The major problem in these soils is high salinity during dry season (October to May).

Climate

Mean annual rainfall is about 2500mm in the centre and 3500mm in the south. Mean

annual temperature is about 25.8°C..

Land type and soil type

Land type	Percentage
Highland	17
Medium highland	43
Medium lowland	13
Lowland	<1
Homestead, water	27

Soils conditions are relatively uniform over most of the area, with grey, near neutral, silt loams and silty clay loams predominating. Acid sulphate soils occur on mangrove tidal floodplain. OM status is low. Grey silt loams and silty clay loam soils are predominant. Acid Sulphate soils which are potentially extremely acidic occur in mangrove tidal floodplains. Noncalcareous Grey Floodplain soils, Noncalcareous Alluvium and Acid Sulphate soils are the major components of the General Soil Types of the area. General fertility level of the soils is medium, and N and K are limiting. Status of S is high. Organic matter content is low to moderate and the status of Zn and B is medium.

Major land type	Soil pH	Soil OM	Nutrient status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Highland (17 %)	4.3-6.0	LM	L	VLL	LM	MOpt	LM	LM	LM	LM	M
Medium highland (43%)	4.4-6.2	LM	L	VLL	LM	MOpt	LM	LM	LM	LM	M
Medium lowland (13%)	4.6-6.0	M	L	VLL	LM	MOpt	LM	LM	LM	LM	M

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

Limited amount of water available in the rivers and streams in the dry season and is already fully exploited for irrigation. Ground water supplies scatteredly available.

Present land use

Broadcast and transplant aus, T.aman is the main crop. Deepwater aman is grown in basin. Dry land rabi crops are grown in the highest loamy soils. Within irrigation HYV boro is grown.

Major cropping patterns

Fallow-T.aus-T.aman

Fallow-B.aus-T.aman

Boro-Fallow-T.aman

Development constraints

a) Heavy monsoon rainfall, severe flash floods and exposure to cyclones.

b) Extremely acid soils in some region.

c) Dry season soil salinity in some region.

Unstable course of the Matamuhuri river, causing bank erosion, washout of road embankments and bridges.

AEZ 29. Northern and Eastern Hills

Part of Mirsarai, Fatikchhari, Hathazari, Raojan, Boalkhali, Patiya, and Banshkhali Upazilas of Chittagong District; and Pekua, and Moheshkhali Upazilas of Cox's Bazar are included in this zone.

Physiography

This region includes the country's hill areas. Relief is complex. Hills have been dissected to different degrees over different rocks. In general slopes are very steep (more than 45%), but more rolling relief occurs locally and a few low hills have flat summits.

Climate

Mean annual rainfall exceeds 40000mm in the north and 200-25000mm in the west. Mean annual temperature is about 25.0^{o}C.

Land type and soil type

Land type	Percentage
Highland	92
Medium highland	2
Medium lowland	<1
Lowland	<1
Very low land	<1
Homestead, water	5

The major hill soils are yellow-brown to strong brown, permeable, friable, loamy; very strongly acidic and low in moisture holding capacity. Top soils contain 2-5% organic matter under forest, they generally have <2% in soils used regularly for shifting (Jhum) cultivation. However, soil patterns generally are complex due to local differences in sand, silt and clay contents of the underlying sedimentary rocks and in the amount of erosion that has occurred. Brown Hill soils are the predominant General Soil Types of the area. Organic matter content and general fertility level are low.

Major land type	Soil pH	Soil OM	Nutrient status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Highland (92 %)	4.1-7.1	LM	VLL	L	LM	LM	LM	LM	LM	LM	LM

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

Only limited amount of surface water exist in perennial rivers. Cross dams are built seasonally on some hill rivers and streams to divert water into gravity irrigation channels. Ground water supplies in valleys apparently are erratic, artesian supplies exist locally.

Present land use

Most hill land is under scrub thicket, grassland or bamboos forested area covers a relatively small area. Shifting (Jhum) cultivation is widely practised in Chittagong hill tracts. Ginger and local varieties of banana is widely grown. Pineapple is extensively cultivated. Tea is grown in some area other tree crops, including rubber, grown locally. In traditional Jhum cultivation, crops are aus type paddy, Comilla cotton, sesamum, pulses gourds, vegetables and maizes.

Major cropping patterns

Mixed evergreen and deciduous forest

Thicket and grasses

Boro-Fallow-T.aman

Rubber

Tea.

Development constraints

a) Steep slopes on most of the land

b) Difficult communications in most areas because long linear, hill ranges with steep slopes. Roads are expensive to build and to maintain.

c) Low soil fertility especially in areas used for Jhum cultivation.

d) Heavy monsoon rainfall

e) Flash floods in valleys

f) Tribal land ownership or illicit land ownership by people

AEZ 9: Old Brahmaputra Floodplain

Most part of Sonaragaon Upazila of Narayanganj District is included in this zone.

Physiography

Most areas have broad ridges and basins. The differences in elevation between ridge top and basin centre usually 2-5 meters. This region occupies a large area of Brahmaputra sediments before the river was diverted to its present Jamuna channel about 200 years ago.

Climate

Mean annual rainfall is about 2000mm in the west and 4000mm in the north west.
Mean annual temperature ranging from 25.3^{o}C to 26.5^{o}C

Length of minimum cool winter temperature is 50-70 days in the east and 100 days to the north west.

Land type and soil type

Land type	Percentage
High land	28
Medium high land	55
Medium low land	20
Low land	7
Very low land	<1
Homestead, water	10

Dark grey floodplain soil generally predominates. Reaction of the cultivated layer is usually medium to very strongly acidic. Organic matter in the cultivated layer ranges from about 1-1.5 percent in the ridge soil to 2-5 percent in basin soil. Soils of the area are predominantly silt loams to silty clay loams on the ridges and clay in the basins. General Soil Types predominantly includes Dark Grey Floodplain soil. Organic matter content is low on the ridges and moderate in the basins, top soils moderately acidic and sub soils neutral in reaction. General fertility level is low. However, the status of P and CEC is medium and the K status is low.

Major land type	Soil pH	Soil OM	Nutrient status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Highland (28 %)	4.5-7.4	L	VLL	LM	L	LM	Opt	Opt	LM	LM	Opt
Medium highland (35%)	4.7-7.2	L	VLL	LM	L	LM	Opt	Opt	LM	LM	Opt
Medium lowland (20%)	4.5-7.2	L	VLL	LM	L	LM	Opt	Opt	LM	LM	Opt

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

A limited amount of surface water is available for irrigation mainly in the Old Brahmaputra and Sitalakhya river.

Present land use

Permeable soils on high ridges: aus, jute, groundnut, sugarcane; with irrigation-wheat, potato, tobacoo, rabi vegetables and spices.

Medium lowland and lowland basin: mainly mixed aus and aman or jute and broadcast aman on lowland. With irrigation, mainly HYV boro.

Major cropping patterns

Mustard-Aus/Jute-Fallow

Vegetable(R) – B.aus – Fallow

Sugarcane

Boro-Fallow-T.aman

Fallow-Jute-T.aman

Development constraints

a) High rainfall and flash flood.

b) Risk of easily flooding in basin elsewhere.

c) Uncertain depth of flooding from year to year.

d) Heavy clay basin soil which is difficult to cultivate.

e) Droughty soil on ridge tops.

f) Irregular relief near river channel.

AEZ 18. Young Meghna Estuarine Floodplain

Small part of Dagaonbhuyan Upazila Feni District and Mirsarai Upazila of Chittagong District are located in this zone.

Physiography

This region occupies young alluvial land in and adjoining the Meghna estuary. It is almost level with very low ridges and broad depressions. Shifting channels constantly erode land and deposit new char formations.

Climate

Mean annual rainfall is about <2500mmin north and >3000mm in the centre and south.

Mean annual temperature is about 25.7^{o}C.

Land type and soil type

Land type	Percentage
Highland	<1
Medium highland	45
Medium lowland	7
Homesteads, water	47

Soils are mainly grey to olive, deep, silt loams and silty clay loams. Organic matter contents is medium. The major soils are grey to olive, deep, calcareous silt loam and silty clay loams and are stratified either throughout or at shallow depth. Calcareous Alluvium and Noncalcareous Grey Floodplain soils are the dominant General Soil Types. The soils in the south become saline in dry season. Top soils and subsoils of the area are the dominant General Soil Types. The soils in the south become saline in dry season. Top soils and subsoils of the area are mildly alkaline. General fertility is medium but low in N and organic matter. Sulphur status is medium to high.

Major land type	Soil pH	Soil OM	Nutrient status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Medium highland (45%)	4.8-8.4	LM	VLL	LM	MOpt	MOpt	OptH	OptH	LM	Opt	Opt

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

Small amount of sweet water occur at a shallow depth in floodplain ridges, but they are fully required for domestic use. Salinity gradually increases northward in the dry season.

Present land use

Most areas grow a single crop of T.aman rice followed by kheshari or lentils.HYV aus or aman are grown in some area. Chillies also grown as rabi crops. Coconut betlnut, sugarcane also grown.

Major cropping patterns

Fallow-B.aus-T.aman

Fallow-Sesame-T.aman

Fallow-T.aus-T.aman

Coconut Betlnut Sugarcane.

Development constraints

a) Poor communication, both by water and by road.

b) Dry season soil salinity in Barisal, Chittagong, Noakhali.

c) Lack of fresh surface water or groundwater for dry season irrigation in most areas.

d) Very silty soils low in organic matter

e) Constant bank erosion and new char formation.

Location in the cyclone zone and susceptible to high storm surges.

AEZ 22. Northern and Eastern Piedmont Plains

Only small part of Choddagram Upazila of Comilla District is located in this zone.

Physiography

This is a discontinuous region occurring as a narrow strip of land at the foot of the northern and eastern hills. The area comprises merging alluvial fans which slope gently outward from the foot of the hills, into smooth, low lying basin. Locally, the relief is irregular close to rivers and streams crossing the region.

Climate

Mean annual rainfall is about 2000 mm in the west and exceed 5000mm in the north.

Mean annual temperature varies from 24.7°C to 26.0°C.

Land type and soil type

Land type	Percentage
Highland	33
Medium highland	31
Medium lowland	16
Lowland	9
Very lowland	1
Homestead, water	10

The greater part of the area is occupied by soils with sandy loam to silty clay texture Organic matter content is medium (1.7-3.4%). The plot varies from 4.5 to 5.5. Grey Piedmont soils and Noncalcareous Grey Floodplain soils are the major General Soil Types of the area. Soils of the area are loams to clays in texture having slightly acidic to strongly acidic reaction. General fertility level is low to medium.

Major land type	Soil pH	Soil OM	Nutrient status								
			N	P	K	S	Ca	Mg	Zn	B	Mo
Highland (33%)	4.2-6.1	VLL	VLL	L	L	L	LM	LM	M	LM	L
Medium highland (31%)	4.2-6.1	VLL	VLL	L	L	L	LM	LM	M	LM	L
Medium lowland (16%)	4.2-6.0	L	VLL	L	L	L	LM	LM	M	LM	L

OM	=	Organic matter			
VL	=	Very low	Opt	=	Optimum
L	=	Low	H	=	High
M	=	Medium	VH	=	Very high

Water resources

Dry season surface water supplies in rivers or streams are limited and are mainly fully used, either within erratic in occurrence. Artesian supplies occur locally.

Present land use

Mainly broadcast or transplanted aus followed by T.aman and irrigated HYV/local boro paddy is grown. Non irrigated basin clays remain under ground in the dry season. Tea is grown on some high Old piedmont fans in the north or Sylhet and Moulavi Bazar.

Major cropping patterns

Boro-Fallow-T.aman

Fallow-T.aus-T.aman

Boro-Deepwater –T.aman

Development constraints

a) Flash flood in all land types; early and deep flood in basins.

b) Heavy monsoon rainfall and cloudiness, which hamper the harvesting, drying and storage of boro and aus paddy.

c) Compact top soil and ploughpan in most ridge and basin soils.

Low moisture holding capacity of both ridge and basin soils.

7.7.3 Soil Salinity

CIMMYT (2007) and SRDI (2009) prepared soil salinity map of Bangladesh of Bangladesh. A reconnaissance soil survey was carried out in the coastal areas of Bangladesh excluding Sunderbans by SRDI in 2009. Soil association maps, ULSRU Guides, topomaps, aerial photographs, soil and landform maps, soil salinity map (2000) were used as base materials. A total of 2500 soil samples were collected. Detailed soil survey data were recorded. EC, pH, N, P, organic carbon, S, B, Cu, Mn, Fe, Zn, CaCO3 and CEC were measured. Eighteen (18)districts viz., Cox's Bazar, Chittagong, Noakhali, Feni, Laxmipur, Bhola, Barisal, Jhalakathi, Pirojpur, Patuakhali, Borguna, Bagerhat, Khulna, Satkhira, Jessore, Narail, Gopalgonj, Madaripur were found affected by different degrees of salinity. The survey led to "Saline Soils of Bangladesh: 2009" report with a salinity map of 1:2.8 million scale. The report focused on fairly detailed characteristics of coastal saline soils. Land characteristics, constraints, hydrology and present cropping patterns in coastal ecosystem were presented in the report. Saline area increased by 0.0354 ha from 2000 measuring 1.056 million ha at present.

Figure 7.7.3 gives the soil salinity map of the study area. Soil salinity is higher (Electrical conductivity 4–8 MMHOS/cm)in some parts of Moheshkhali, Pekua and Banshkhali Upazila in the coastal area of Cox's Bazar and Chittagong District. For most of the study area the soil salinity is low (Electrical conductivity <2 MMHOS/cm).

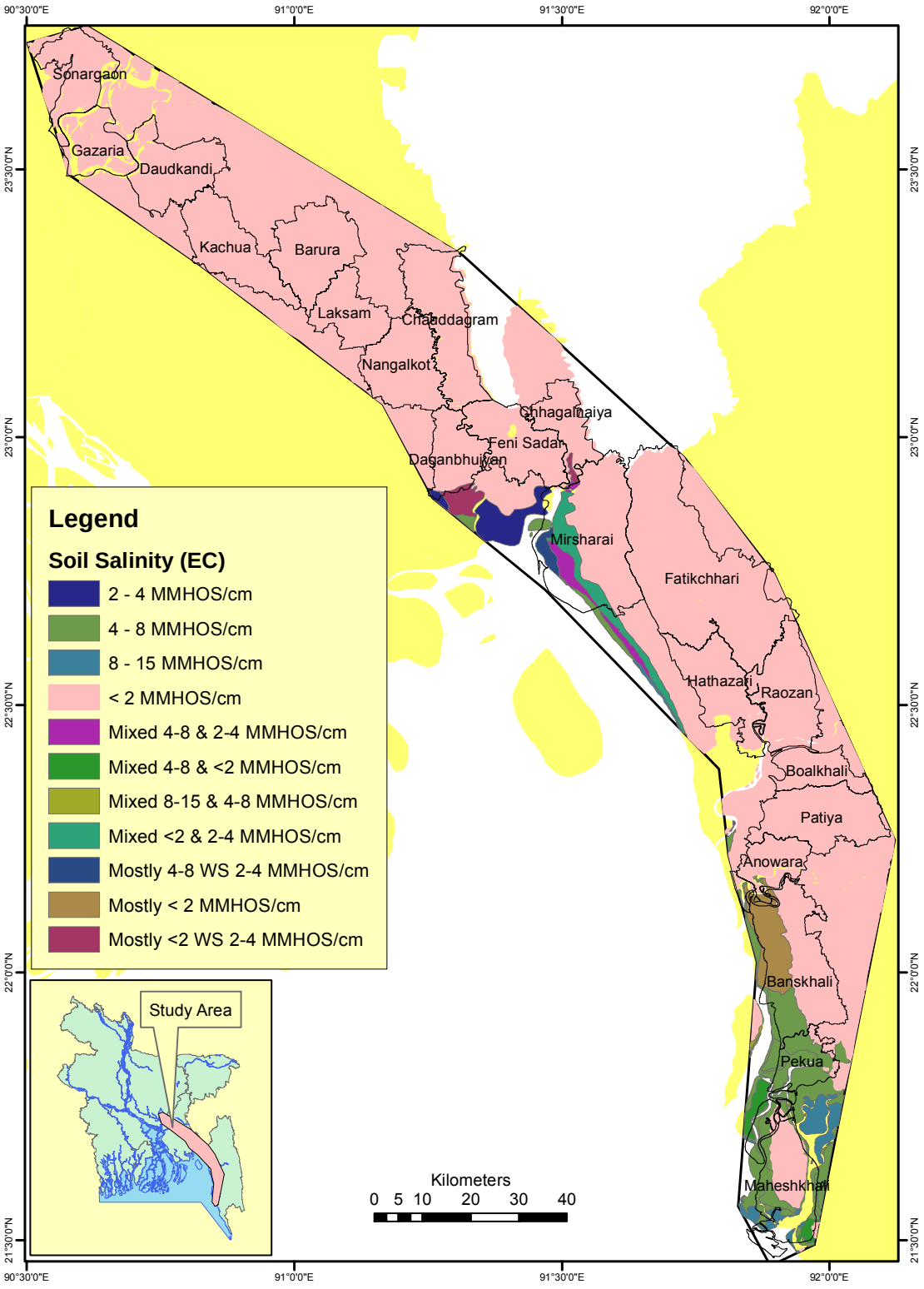


Figure 7.7.3 Soil Salinity map of the study area.

7.7.4 Soil Texture

Figure 7.7.4 gives the soil texture map of the study area. The major soil texture of the study area includes clay, clay loam, loam and sandy loam. Clay loam and loam soil predominantly occur in Sonaragaon, Narayanganj district, Gazaria, Munshiganj district; Daudkandi, Barura, Laksam, Nagalkote and Choddagram of Comilla district; Kachua of Chandpur district; Feni Sadar, and Daganbhuyan of Feni district; Mirsarai, Fatikchhari, Hathazari, Raojan, Boalkhali, Patiya, Anowara, Banshkhali of Chittagong district; and Moheshkhali of Cox's Bazar district.

Soil texture of Pekua, of Cox's Bazar district is mostly clay.

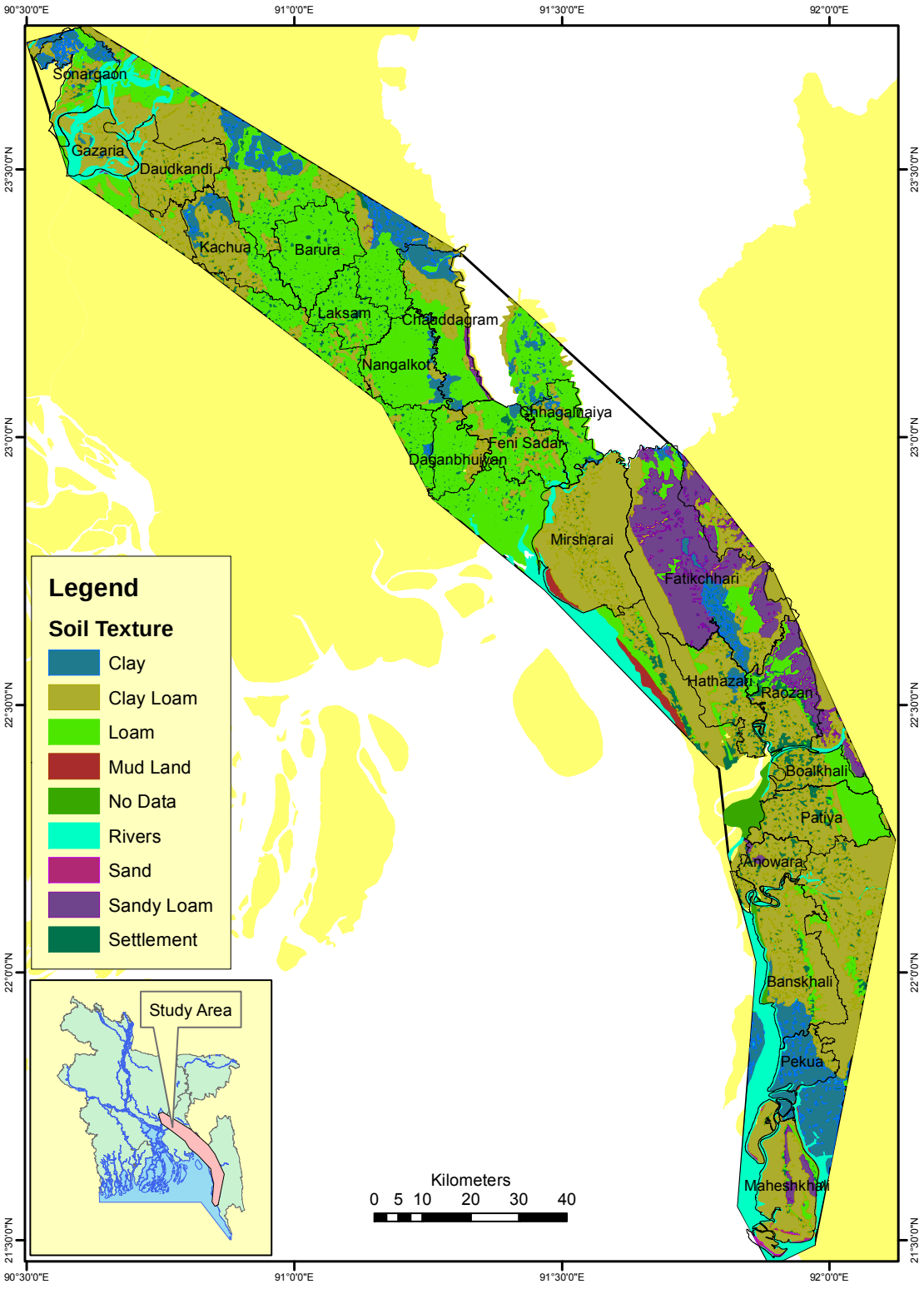


Figure 7.7.4 Soil texture map of the study area.

7.8 Ecology

7.8.1 Forests

Diversity of the study areas is very poor because maximum lands are cultivated (Paddy field), swamp, marshy and water logging condition during rainy season. There are some small and scattered forests (not dense) and vegetable field adjacent to the paddy field. There are some trees are planted along road side viz: *Albizia saman (*Rain tree), *Eucalyptus globulus* (Eucalyptus), *Acacia mangium* (Wattle) etc. There are few houses near the transmission line. Around these houses some ornamental, vegetables, trees are planted.

A section of about 13km of the proposed 400kV transmission line lies in Mirsarai reserved forest having total area of 32,900acres under Bangladesh Forest Department. A part of this reserved forest is being used for Rubber cultivation by Bangladesh Forest Industries Development Corporation (BFIDC). A map of Bangladesh showing the locations of hill forests over which the proposed 400kV transmission line has been drawn is given in **Figure 7.8.1.**

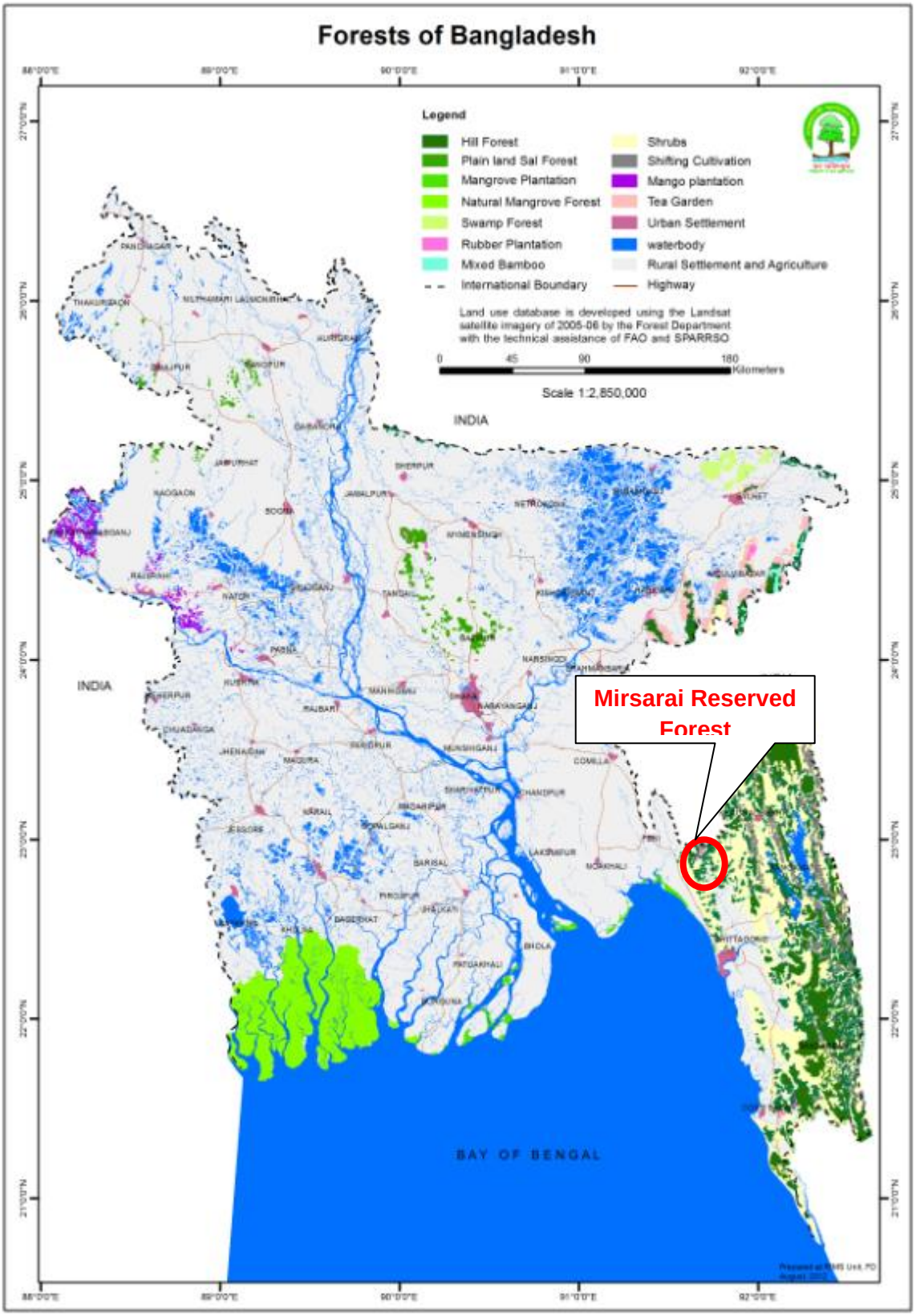


Figure 7.8.1: Map of Bangladesh showing Mirsarai Reserved Forest

7.8.2 Flora & Fauna:

Survey of flora and fauna at seven points along the proposed 400kV transmission line and proposed Modunaghat substatios was conducted in August 2014 (wet season) and in October-November 2014 (dry season) respectively. Report on this survey of flora and Fauna is given under **Annex-7.8.2.** The summary of survey results in the wet season and dry season are given below:

c) Wet Season:

Flora:

A total of 152 species in 121 genera under 69 families were recorded from the study site. There were some common plant species, which were present in every survey site. Viz.: *Achyranthes aspera, Alternanthera philoxeroides* etc. According to IUCN category, three threatened plant species were recorded from the study areas. Viz.: *Borassus flabellifer, Dipterocarpus turbinatus, Swietenia mahagon*

Threatened species observed in Project Sites

Taxa	No.	Scientific Name (English)	Season (Rainy)	Conservation Status		Remarks
				IUCN (2013)	Local Law	
Flora	1	*Borassus flabellifer* L.	○	EN	○	The species is common in some parts of Bangladesh
	2	*Dipterocarpus turbinatus* Gaertn.	○	CR	○	The species is very common in the forest of South-east Bangladesh
	3	*Swietenia mahagoni* (L.) Jacq.	○	EN	○	This is a introduced species. It is widely cultivated in roadsides, homestead forests throughout Bangladesh
Total	03					

Fauna

A total of 184 species were observed, from seven sampling points, including 62 insects, 11 amphibians, 31 reptilians, 61 birds and 19 mammalian species. These 62 insect were belong to 29 families of 10 orders. All the 11 amphibians were from

Order Anura and five Families. The highest six species were recorded under family Dicroglossidae, while one species from each of the following families, viz., Bufonidae, Ranidae and Rhacophoridae. Furthermore, two species recorded from the family Microhylidae. A total of 12 lizards and 19 snake species were recorded, where only one were included in CITES appendix I and three were in appendix II. 19 mammalians taxa were recorded of 6 orders and 11 families. Four mammals were included in CITES appendix III and three in appendix I. None of the observed insect, amphibian and birds taxa found to be enlisted in CITES appendices. All observed insect, amphibian, reptilian and birds were Least Concern of IUCN category whereas only 4 species of mammals (*Panthera pardus* Linnaeus 1758; *Arctonyx collaris* F.G.Cuvier 1825; *Lutra lutra* Linnaeus 1758; *Viverra zibetha* Linnaeus 1758) – were included into Near Threatened category.

d) Dry Season:

Flora:

A total of 145 species in 116 genera under 66 families were recorded from the study site. There were some common plant species, which were present in every survey site. Viz.: *Achyranthes aspera, Alternanthera philoxeroides* etc. According to IUCN category, three threatened plant species were recorded from the study areas. Viz.: *Borassus flabellifer, Dipterocarpus turbinatus, Swietenia mahagoni*.

Fauna:

A total of 132 species were observed, from seven sampling points, including 47 insects, 07 amphibians, 12 reptilians, 53 birds and 13 mammalian species. These 47 insects were belonging to 31 families of 12 orders. All the 7 amphibians were under order of Anura and three Families. The highest four species were recorded under family Dicroglossidae, while two species from Microhylidae and one species from Bufonidae. A total of 12 reptile species were recorded, where only one was included in CITES appendix I. 13 mammalians taxa were recorded of 4 orders and 9 families. Three mammals were included in CITES appendix III and one in appendix I. None of the observed insect, amphibian and birds taxa found to be enlisted in CITES appendices. All observed insect, amphibian, reptilian and birds were Least Concern of IUCN category whereas only 3 species of mammals (*Arctonyx collaris* F.G.Cuvier 1825; *Lutra lutra* Linnaeus 1758; *Viverra zibetha* Linnaeus 1758) – were included into Near Threatened category.

7.9 Demography Profile and Occupational Pattern

Demographic profile and occupational pattern of upazillas along the proposed 400kV transmission line is given in **Table-7.9.**

Table-7.9 Demographic profile and occupational pattern of upazillas along the proposed 400kV TL

Division	District	Upazilla	No. of successful Interview	No. of Family Member	Sex		Occupation											Average Monthly income	Average Monthly expenditure
					M	F	Farmer	Business	Service	student	House wife	Agriculture Laborer/ Day Laborer	Unemp loyed	Teacher	Retired/ Old man	Driver	others		
Chittagong	Chittagong	Anowara	35	177	101	76	10	13	2	1	6		3					20085.71	15700
Chittagong	Chittagong	Banskhali	31	164	77	87	9	8	3		4	5		1		1	0	9612.90	8548.38
Chittagong	Chittagong	Raozan	27	115	64	51	5	2	1		12	1				2	4	10518.51	8703.7
Chittagong	Comilla	Laksam	29	130	67	63	5	6	1		11	1			2	2	1	9517.24	8862.06
Dhaka	Munshigonj	Gozaria	32	133	78	55	6	17	3		1	1			1		3	14937.5	13406.25
Dhaka	Narayangonj	Sonargaon	30	125	67	58	3	13	7		1				4		2	12950	12233.33
Total =			184	844	454	390	38	59	17	1	35	8	3	1	7	5	10	68008.96	67453.72

Others: Mosque Imam -1, Carpenter-2, Fuiller-1, Meson-1, Rickshaw Puller-2, Quack doctor-1, Village Police-1, Boatman-1

7.10 Land use and Cropping Pattern

Land use and cropping pattern of upazillas along the proposed 400kV transmission line is given in **Table-7.10.**

Table-7.10 Land use and cropping pattern of upazillas along the proposed 400kV TL

Division	District	Upazilla	No. of respondents	Land use		Land Price (per decimal)		Paddy production		Selling price of paddy		Remark
				Homestead	Agriculture	Homestead	Agriculture	Unit yield of paddy per season in average (kg per decimal)	Annual cropping intensity (%)	Normal quality (BDT/kg)	High quality (BDT/kg)	
Chittagong	Chittagong	Anowara	35	159.75	586.5	12605000	14440000	30	300%	18.75	23.75	
Chittagong	Chittagong	Banskhali	31	237	493	6981000	8620000	24	200%	18.75	23.75	
Chittagong	Chittagong	Raozan	27	148	136	17850000	5550000	24	100%	19.50	22.50	
Chittagong	Comilla	Laksam	29	327.5	611	29935000	28780000	42	300%	21.25	25.00	
Dhaka	Munshigonj	Gozaria	32	347	600	120200000	55000000	36	100%	22.50	26.25	
Dhaka	Narayangonj	Sonargaon	30	211	321	44300000	19400000	36	200%	22.50	26.25	
		Total =	184	1430.25	907.5	231871000	131790000	192	1200%	123.25	147.5	

* Average per upazilla No. of intrview 30.66, No. of homestead Land use 238.37, No. of Agriculture land 151.25,Price of homestead land per decimal value 386451. 67, Value of Agriculture land per decimal per upazilla 21965000, paddy production per decimal per upazilla 32kg, Annual cropping intensity 200%, selling price of paddy per upazilla normal quality 20.54 per kg and High quality 24.58 per kg

7.11 Socio-economic Scenario

Questionnaire survey was conducted in six Upazillas (Anowara, Banskhali, Raozan, Laksam, Gozaria and Sonargaon) along the proposed 400kV transmission line. Total 184 household heads have been interviewed,

Occupation:

32.07% of the respondents were businessmen, **20.65%** Farmers, **19.022%** housewife, **9.24%** Service holder, **4.35%** day labourer, **3.8%** retired persons and **10.87%** others.

Family Size:

The average size of the family is **4.64.**

Monthly Income:

The average monthly incomes of the respondents are as follows:

21.74%	-	Tk. 612
39.67%	-	Tk. 9075
11.41%	-	Tk. 12047
12.50%	-	Tk. 14913
14.67%	-	Tk. 34703

Houses :

The roofs of **84.7%** houses are made of Tin, **6.5%** of Concrete and **8.8%** of thatch/ hay. The walls of **45.66%** houses are made of Tin, **25%** of Clay, **18.47%** of Concrete and **10.87%** of Bamboo. Similarly, the floors of **79.34%** are made of clay, **19.02%** of concrete and **1.64%** of bamboo.

Source of Drinking Water:

The main source of drinking water for the 100% households is tube well water. Besides, ponds and river water are also used in various purposes like, bathing, cooking, cleaning etc.

Electricity:

76.09% households are electrified with grid system and **2.17%** with sloar system. The remaining houses are not electrified.

Fuels for cooking:

83.7% of households use wood for cooking purpose, **13.04%** LP Gas / Natural gas, **7.61%** cow dung, **7.07%** leaves and **5.43%** natural garbage.

Medical Treatment:

The most of the respondents used to go to Govt. Hospital for their medical treatment. Some of the respondents used to go to different places to seek medical attention, namely, private clinic, quack doctor, MBBS Doctors etc.

Chapter VIII Environmental Impacts

8.1 Identification of impacts

The environmental impacts of transmission lines and substations during construction and operation stage have been identified.

8.1.1 Transmission Lines:

The environmental impacts of Transmission lines during construction and operation stage are given in **Table-8.1.1.**

Table 8.1.1 Environmental Impacts of Transmission Lines

Item	No.	Impact	Rating		Result
			construction Phase	Operation Phase	
Pollution mitigation measure	1	Air pollution	B-	D	**Construction phase:** Generation of dust by land preparation and other construction work is expected, but the impact will be temporary. Generation of air pollutants (SOx, NOx, and others) from operation of heavy machines and trucks is predicted, but the impact will be limited only to within the surrounding area. **Operation phase:** No specific air pollution is anticipated.
	2	Water pollution	B-	B-	Soil runoff may occur from the exposed soil of the embankment and cut slope and water pollution of the downstream area of the surrounding river is predicted.
	3	Waste	B-	D	**Construction phase:** General waste and hazardous waste generated by the construction work is predicted. **Operation phase:** No general waste and hazardous waste is anticipated.
	4	Noise and Vibration	B-	D	**Construction phase:** Impact of noise and vibration is predicted caused by operation of heavy machines and trucks, but will be limited to the surrounding area. **Operation phase:** No specific noise or vibration is anticipated.
Natural environment	5	Natural reserve	B-	D	**Construction phase:** There is a possibility that the transmission line passes by the Ecologically Critical Area, and the impact of air pollution, noise and vibration due to construction work is anticipated. **Operation phase:** No specific impact on the natural reserve is predicted.
	6	Ecosystem	B-	B-	**Construction phase:** There is a possibility that the transmission line passes by the Reserved Forest, and the impact of air pollution, noise and vibration due to construction work is anticipated on the terrestrial ecosystem. **Operation phase:** Bird-strike and other impacts are anticipated.
	7	Geography and geology	C	C	The impact is unknown (it will be identified in further site survey).

Item	No.	Impact	Rating		Result
			construction Phase	Operation Phase	
Social environment	8	Land Acquisition and Resettlement	C	D	**Construction phase:** No land acquisition for towers will be required. Settlements and houses were avoided when the route map was prepared based on the available secondary information and site survey. The social survey has identified the land owners of the tower locations and crop patterns along the transmission line. Only crop compensation will be required. **Operation phase:** N/A
	9	Disturbance to Poor People	C	C	The extent of the impact is unknown at this stage.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	C	C	The proposed construction site of the transmission line is located close to the Chittagong Hill Tracts (CHT), where the indigenous population is related to neighboring Myanmar, and there is a possibility that ethnic minority groups and indigenous people live within the surrounding hill area. The social survey identified that no ethnic minority gropus and indigenous people are available along the route of transmission line. No impact has been predicted.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	C	C	The extent of the impact is unknown at this stage.
	12	Land Use and Utilization of Local Resources	C	C	The extent of the impact is unknown at this stage.
	13	Disturbance to Water Usage, Water Rights etc	C	C	In general, soil runoff may occur from the exposed soil of the embankment and cut slope, resulting in water pollution of the downstream area of the surrounding river and alteration of water use. The extent of the impact is, however, unknown at this stage.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	**Construction phase:** Increased traffic is predicted. **Operation phase:** No specific adverse effect is predicted on the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	C	D	**Design phase:** The extent of the impact is unknown at this stage. **Operation phase:** No specific impact is predicted concerning the social infrastructure and local decision-making institutions.
	16	Misdistribution of Benefits and Damages	C	D	**Design phase:** The extent of the impact is unknown at this stage. **Operation phase:** No specific impact is predicted.

Item	No.	Impact	Rating		Result
			construction Phase	Operation Phase	
	17	Local Conflicts of Interest	C	D	**Design phase:** The extent of the impact is unknown at this stage. **Operation phase:** No specific impact is predicted.
	18	Cultural Heritage	C	C	The extent of the impact is unknown at this stage.
	19	Landscape	C	C	The extent of the impact is unknown at this stage.
	20	Gender	C	C	The extent of the impact is unknown at this stage.
	21	Children's Rights	C	C	The extent of the impact is unknown at this stage.
	22	Infectious Diseases such as HIV/AIDS	B-	D	**Construction phase:** A temporary influx of migrant labor during construction period may increase the risk of transmitted diseases. **Operation phase:** There is no specific negative impact anticipated.
	23	Working Conditions (including working safety)	B-	B-	**Construction phase:** In general, a high risk of accidents is predicted in construction work. **Operation phase:** There is a risk of accidents such as electric shocks and falls during maintenance work.
	24	Others	C	C	The extent of the impact is unknown at this stage.
Others	25	Accidents	B-	B-	Accidents may occur including soil runoff caused by floods, and break-down of towers by cyclones.
	26	Cross-boundary impact and climate change	D	D	Cross boundary and CO_2 emission concerning the transmission line are not anticipated.

(Source: developed by the JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

8.1.2 Substations:

The environmental impacts of substations during construction and operation stage are given in **Table-8.1.1.**

Table 8.1.2 Environmental Impacts of Substations

Item	No.	Impact	Rating		Result
			construction Phase	Operation Phase	
Pollution	1	Air pollution	B-	D	**Construction phase:** Generation of dust through land preparation

Item	No.	Impact	Rating		Result
			Design / construction Phase	Operation Phase	
					and other construction work is expected, but the impact will be temporary. Generation of air pollutants (SOx, NOx, and others) from operation of heavy machines and trucks is predicted, but the impact will be limited only to within the surrounding area. **Operation phase:** No specific air pollution is anticipated.
	2	Water pollution	B-	B-	Soil runoff may occur from the exposed soil of the embankment and water pollution of the surrounding waterway for paddy fields is predicted.
	3	Waste	B-	B-	**Construction phase:** General waste and hazardous waste generated by the construction work is predicted. **Operation phase: G**eneral waste and hazardous waste is anticipated.
	4	Noise and Vibration	B-	D	**Construction phase:** Impact of noise and vibration is predicted caused by operation of heavy machines and trucks, but will be limited to the surrounding area. **Operation phase:** No specific noise or vibration is anticipated.
Natural environment	5	Natural reserve	D	D	N/A
	6	Ecosystem	D	D	No specific adverse effect is predicted on the ecosystem of the site and its surrounding area.
	7	Geography and geology	C	C	The impact is unknown (it will be identified in further site survey).
Social environment	8	Land Acquisition and Resettlement	B-	D	**Design phase:** As much as 220 acres of land, which is presently owned by BPDB, has already been secured and is available for the future development of Meghnaghat SS. BPDB and PGCB will take all official procedures for transferring the ownership. Whereas, it is anticipated that 20 acres of paddy field land is to be acquired for Madunaghat SS. The extent of the impact is, however, unknown at this stage. No resettlement is anticipated. **Operation phase:** N/A
	9	Disturbance to Poor People	B- / C	B-/ C	**Construction phase:** Sharecroppers (*bargadars*) at Madunaghat SS site may lose their means of livelihoods temporarily during the construction phase. The extent of the impact is, however, unknown at this stage. **Operation phase:** Poverty resulting from losses of livelihood means may occur if appropriate measures are not taken.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	D	D	No ethnic minority groups or indigenous people live at the sites for Meghnaghat SS and Madunaghat SS.

Item	No.	Impact	Rating		Result
			Design / construction Phase	Operation Phase	
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	B-/C	B-	**Construction phase:** Sharecroppers (*bargadars*) at Madunaghat SS site may lose their means of livelihoods temporarily. The extent of the impact is, however, unknown at this stage. **Operation phase:** Sharecroppers at Madunaghat SS site may lose their means of livelihoods permanently.
	12	Land Use and Utilization of Local Resources	B-	B-	**Construction phase:** It is anticipated that 20 acres of paddy field land is to be acquired for Madunaghat SS. **Operation phase:** Land use will change permanently.
	13	Disturbance to Water Usage, Water Rights etc	C	C	The extent of the impact is unknown at this stage.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	**Construction phase:** Increased traffic is predicted. **Operation phase:** No specific adverse effect is predicted on the existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	**Design phase:** It is the Deputy Commissioner's Office of the District that takes the initiative in conducting local consultations and the detailed measurement surveys for land acquisition, which will cause certain impact on the social infrastructure and local decision-making institutions. **Operation phase:** No specific impact is predicted.
	16	Misdistribution of Benefits and Damages	C	C	The extent of the impact is unknown at this stage.
	17	Local Conflicts of Interest	C	C	The extent of the impact is unknown at this stage.
	18	Cultural Heritage	D	D	There is no cultural, historical or traditional heritage in the substation sites. No specific impact is thus predicted.
	19	Landscape	D	D	No specific impact is predicted.
	20	Gender	D	D	There is no specific negative impact anticipated.
	21	Children's Rights	D	D	There is no specific negative impact anticipated.
	22	Infectious Diseases such as HIV/AIDS	B-	D	**Construction phase:** A temporary influx of migrant labor during construction period may increase the risk of transmitted diseases. **Operation phase:** There is no specific negative impact anticipated.
	23	Working Conditions (including working safety)	B-	B-	**Construction phase:** A high risk of accidents is predicted in construction work.

Item	No.	Impact	Rating		Result
			Design / construction Phase	Operation Phase	
					Operation phase: There is a risk of accidents such as electric shocks and falls during maintenance work.
	24	Others	C	C	The extent of the impact is unknown at this stage.
Others	25	Accidents	B-	B-	Accidents may occur including soil runoff caused by floods, and break-down of towers by cyclones.
	26	Cross-boundary impact and climate change	D	D	Cross boundary and CO_2 emissions are not anticipated.

(Source: developed by the JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Chapter IX Evaluation of Impacts

9.1 Evaluation of Impacts

This Section describes the results of predictions and impact evaluations of the major environmental impact items for the proposed transmission line, substation and access road. There is no item evaluated as “A” (significant positive/negative impact is expected).

These predictions and impact evaluations have been made studying mitigation measures for avoiding or mitigating impacts with respect to various forms of environmental items.

9.1.1 Transmission Lines

9.1.1.1 Pre-construction Phase and Construction Phase

a) Pollution control

(i) Air Pollution

Dust is expected from land preparation and other construction work, but the impact will be temporary. Generation of air pollutions (SO_2, NO_2,) from the operation of heavy machinery and trucks is predicted, but the impact will be limited to within the surrounding area. Watering the road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken in order to reduce dust.

There will be periodic maintenance and management of all construction machinery and vehicles to reduce exhaust discharged from such machinery and vehicles.

(ii) Water Pollution

There may be soil runoff from the exposed soil of the embankments and cut slopes, and water pollution of the downstream area of the surrounding river is predicted.

The transmission line route shall avoid using steep sloping land, and any slopes used shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

(iii) Waste

Waste generated from the construction work will include metal chips, waste plastic, wood shavings, waste glass and waste oil. Furthermore, household waste discarded from the camping ground of the workers will include cans, bottles and garbage. If such waste is inadequately handled, river water and underground water may be contaminated, and sanitation problems may arise.

To separate waste collection, recycling and reuse of waste will be promoted and non-recyclable waste will be disposed at appropriate sites according to related regulations. Hazardous waste will be treated under the related regulations. To reduce the amount of solid waste discharged from the workers during the construction work, efforts will be taken to employ local workers wherever possible, so that the amount of household waste at the site will be minimized. These measures will be taken to ensure that water pollution or sanitary problems resulting from waste will not arise.

(iv) Noise and Vibration

Noise and vibration are expected to be caused by the operation of heavy machinery and trucks, but will be limited to the surrounding area.

In the actual construction work, schedule management will be performed to maintain constant amounts of construction work and low noise/low vibration equipment will be used as much as possible.

Construction work will be performed during daytime, especially piking work.

Measures for reducing the generation of noise, such as speed reduction of vehicles in residential areas will be taken, whereby minimizing vehicle noise and vibration impacts.

b) Natural Environment

(i) Natural Resources

The transmission line route through over reserved forest*[4] area named of *Mirsarai* with 13,160 ha, in which partially planted teak tree or rubber tree, near Chittagong Hill Tracts.

About 13km length of T/L will pass through over these forest and 35 towers will be constructed with affecting a total of 1.4ha forest for tower sites. 20 towers, occupying 0.8 ha , out of 35 towers will be constructed after cutting trees of the site, in which 96 trees of teak and 64 rubber trees and scattered shrub will be cut.

Compensation for the affected trees will be paid for once on their initial removal.

(ii) Ecosystem

The transmission line route bypasses the protected area, and will use land used for rice fields and other agricultural activity, and not any primeval forests or tropical rain forests. Very few trees, which are commonly seen in project sites, will be cut down accompanied with construction activities.

There is no habitat of precious species of Fauna, which is designated as threatened species by IUCN, but some of Flora which is designated as threatened species by IUCN is founded at where not near the transmission line route and then not will be affected directly from construction activities.

(iii) Topography and Geology

There may be soil runoff from the exposed soil of the embankments and cut slopes.

The transmission line route shall avoid using steep sloping land, and any slope used shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

[4] The category of "reserved forest " by Forest law in Bangladesh does not mean the forest should be protected but prompted forest of its forestry activities economically.

c) Social Environment

(i) Land Acquisition and Resettlement

Construction of one tower base for 400kV requires: i) 2m2 of land for suspension tower (approximately 550 nos), and; 2) 3m2 of land for tension tower (approximately 250 nos). The total area is approximately not more than 2,000 m2. And construction of one tower base for 230kV requires: iii) 1m2 of land for suspension tower (approximately 20 nos), and; iv) 1m2 of land for tension tower (approximately 15 nos). It is approximately required not more than 100 m2 in total.

Such permanent land acquisition for the above tower bases shall be conducted on the basis of compensation at replacement cost. Trees within clearance distance from cables will be removed. Standing crops and trees will be compensated at market price. However, given an informed consent, the land owners have the right to fully exercise their power of choice: to voluntarily or involuntarily provide their land for tower bases. If PGCB does not purchase the land under the proposed transmission towers, PGCB shall restore the land to its original conditions after construction of the transmission towers.

In addition to the permanent acquisition, farm activities will be disturbed due to temporary land acquisition during construction period too. It is approximately estimated that 800m2 per tower bases (for construction, parking vehicle and storing material, temporary access road, and place for engine and drum) will be blocked exclusively for the construction, where farm activities will be disturbed for 30 days. That depends on which month the construction takes place, but 30 days is long enough for farmers to lose their standing crops for one season.

(ii) Disturbance to Poor People

Livelihood means of sharecroppers will be temporary lost during construction period due to the blockage of farm land for the construction purpose. Sharecroppers work on daily basis and they are not well-paid. Compensation for their income for one season shall be offered to them in order for them to sustain their living and find other job opportunities.

(iii) Disturbance to Ethnic Minority Groups and Indigenous People

According to the results of Population Census of 2011 and interview survey conducted during JICA survey, no ethnic minority groups or indigenous people have been identified along the transmission line route.

(iv) Deterioration of Local Economy such as Losses of Employment and Livelihood Means

Land owners and sharecroppers will temporarily lose their means of livelihood during construction period due to the construction blockage of farm land. The period for such blockage will last for 30 days, and in the worst scenario their loss can last for the whole season. Compensation for such income loss for

one season shall be offered for sustaining their living and seeking other job opportunities.

(v) Land Use and Utilization of Local Resources

Farm activities will be disturbed temporarily due to the construction work. It is approximately estimated that 800m2 per tower bases will be blocked exclusively for the construction, where farm activities will be disturbed for 30 days, which may affect their standing crops for a whole season. However, the transmission line construction area will be reused for farming after the completion of the transmission tower, except the tower bases, and adverse effects on income will be therefore very limited.

(vi) Disturbance to Water Usage, Water Rights, etc.

Transmission line route has been selected avoiding any steep sloping land. Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

(vii) Infectious Diseases such as HIV/AIDS

Local people will be put priority as laborers for simple work during construction period, which will help lower the risk of infectious diseases brought by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).

(viii) Work Conditions (Including Work Safety)

The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those as provision of protective equipment, etc.

(ix) Right of Way (ROW)

Temporary disturbance to the local land use will occur in the ROW due to the blockage during construction of tower bases and transmission line extension. Proper compensation shall be given to them for the period their activities are affected.

(x) . Accidents

Accidents can occur at any time which does harm to local residents living in surrounding areas and workers involved in construction work. As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

9.1.1.2 Operation Phase

a) Pollution control

(i) Air Pollution

Air Pollution is not expected caused by operation of Transmission line.

(ii) Water Pollution

Water Pollution is not expected as embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

(iii) Noise and Vibration

Noise and Vibration is not expected caused by operation of Transmission line.

b) Natural Environment

(i) Ecosystem

Birds striking caused by the transmission line are expected. Bird species inhabiting areas along the proposed transmission line route is mainly sandpipers and plovers, and their flight altitude is relative low, therefor, the possibilities of bird strikes are small.

However, installing sign to prevent birds striking to the transmission line is considered necessary.

(ii) Topography and Geology

Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff.

c) Social Environment

(i) **Disturbance to Water Usage, Water Rights, etc.**

Transmission line route has been selected avoiding any steep sloping land. Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

(ii) **Accidents**

Accidents can occur at any time which does harm to local residents living in surrounding areas and workers involved in construction work. As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

9.1.2 Substation (Modunaghat)

9.1.2.1 Pre-construction Phase and Construction Phase

a) Pollution control

(i) Air Pollution

Dust is expected from land preparation and other construction work, but the impact will be temporary and limited area. Generation of air pollutions (SO2, NO2,) from the operation of heavy machinery and trucks is predicted, but the impact will be limited to within the surrounding area. Watering the road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken in order to reduce dust.

There will be periodic maintenance and management of all construction machinery and vehicles to reduce exhaust discharged from such machinery and vehicles.

(ii) Water Pollution

There may be soil runoff from the exposed soil of the embankments, and water pollution of the downstream area of the surrounding river is predicted.

Any slopes of embankments shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

Site of Substation shall be surrounded by gutter made of concrete to avoid leaking directly turbid water to outside of the site.

(iv) Noise and Vibration

Noise and vibration are expected to be caused by the operation of heavy machinery and trucks, but will be limited to the surrounding area.

In the actual construction work, schedule management will be performed to maintain constant amounts of construction work and low noise/low vibration equipment will be used as much as possible.

Construction work will be performed during daytime.

Measures for reducing the generation of noise, such as speed reduction of vehicles in residential areas will be taken, whereby minimizing vehicle noise and vibration impacts.

b) Natural Environment

(i) Ecosystem

The site for substation will be constructed at rice field by landfill activity.

Habiting plants and small animals in site are commonly seen broadly and impacts of the project on these habitats are expected to be insignificant from the point of ecosystem.

(ii) Topography and Geology

There may be soil runoff from the exposed soil of the embankments.

Any slope of embankment shall be reinforced with concrete, plantation or other means to minimize soil runoff.

c) Social Environment

(i) **Land Acquisition and Resettlement**

Approximately 7 ha of farm land will be required for the construction of new Madunaghat substation in Raozan Upazila of Chittagong District. Land acquisition will be conducted on the basis of compensation at replacement cost. Trees within clearance distance from cables will be removed. And standing crops and trees will be compensated at market price. It is the Deputy Commissioner of Chittagong District who will conduct land acquisition and payment of compensation in accordance with the Ordinance 1982. PGCB will pay to DC Office when the budget is allocated from the Government of Bangladesh.

(ii) **Disturbance to Poor People**

Livelihood means of sharecroppers will be permanently lost. Sharecroppers work on daily basis and they are not well-paid. Compensation for their income shall be offered to them in order for them to sustain their living and bridging support shall be given until they find other job opportunities.

(iii) **Disturbance to Ethnic Minority Groups and Indigenous People**

According to the results of Population Census of 2011 and interview survey conducted during JICA survey, no ethnic minority groups or indigenous people have been identified in the substation site of Raozan Upazila.

(iv) **Deterioration of Local Economy such as Losses of Employment and Livelihood Means**

Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood. Compensation for such income loss shall be offered at replacement cost for their losses, sustaining their living and seeking other job opportunities. As mitigation measures, employing as many local residents as possible, and using the services and products offered by the local community.

(v) **Land Use and Utilization of Local Resources**

Farm activities will be disturbed permanently due to the permanent acquisition of land as large as 7 ha at new Madunaghat substation site. Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood. Compensation for such losses shall be offered, sustaining their living and seeking other job opportunities.

(vi) **Social Institutions such as Social Infrastructure and Local Decision-making Institutions**

The Deputy Commissioner's Office of Chittagong District will take responsibility for initiatives to conduct local consultations concerning compensation in accordance with the Ordinance 1982, on top which compensation at replacement cost shall be added according to the resettlement policy framework as agreed between PGCB and JICA.

(vii) **Misdistribution of Benefits and Compensation**

Equality of compensation and fair treatment among the project affected people must be assured. Landowners and other affected people must be legitimately identified for proper payment of compensation.

(viii) **Local Conflicts of Interest**

In case equality of compensation and fair treatment among the project affected people is not assured, disputes and conflicts among them can occur at any time. Regulations of Bangladesh stipulate that public consultation must be held in the land acquisition process, and their complaints or suggestions must stay heard for immediate action.

(ix) **Infectious Diseases such as HIV/AIDS**

Local people will be put priority as laborers for simple work during construction period, which will help lower the risk of infectious diseases

brought by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).

(x) **Work Conditions (Including Work Safety)**

The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those as provision of protective equipment, etc.

(xi) **Accidents**

Accidents can occur at any time which does harm to local residents living in surrounding areas and workers involved in construction work. As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

9.1.2.2 Operation Phase

a) Pollution control

(i) Air Pollution

Air Pollution is not expected caused by operation of Substation.

(ii) Water Pollution

Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

(iii) Noise and Vibration

Low frequency sound and vibration will occur. However, the impact is limited as the facilities will be kept inside the site so that no noise and vibration is expected outside the substation.

b) Natural Environment

.(i) Ecosystem

Impacts to ecosystem are not expected by operation of Substation.

(ii) Topography and Geology

Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff.

c) Social Environment

(i) Disturbance to Poor People

Sharecroppers who permanently lost their means of livelihood during construction work may not be able to find other job opportunities in the surrounding area even after the construction work. Bridging support shall be given to them until they find new jobs.

(ii) **Deterioration of Local Economy such as Losses of Employment and Livelihood Means**

Sharecroppers who permanently lost their means of livelihood during construction work may not be able to find other job opportunities in the surrounding area even after the construction work. Bridging support shall be given to them until they find new jobs.

(iii) Electromagnetic Field

Negative impact of electromagnetic fields on human health is not anticipated if local residents keep out of the substation complex.

(iv) Work Conditions (Including Work Safety)

The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those as provision of protective equipment, etc.

(v) Accidents

Accidents can occur at any time which does harm to local residents living in surrounding areas and workers involved in construction work. As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

9.1.3 Access Road

The access road will be constructed by expanding of existing farm road with 3.5 meter to 5.0 meter width and 1,000 meter length.

Its small scale expansion shall be developed by landfill activity of adjacent rice field, and then no serious impact to the natural and social environment nearby is estimated by the project.

9.1.3.1 Pre-construction Phase and Construction Phase

a) Pollution control

i) **Air Pollution**

Dust is expected from land preparation and other construction work, but the impact will be temporary. Generation of air pollutions (SO2, NO2,) from the operation of heavy machinery and trucks is predicted, but the impact will be limited to within the surrounding area. Watering the road and construction site, especially in the dry season, and using cover sheets on trucks for the transportation of soil will be undertaken in order to reduce dust.

(ii) **Water Pollution**

There may be soil runoff from the exposed soil of the embankments, and water pollution of the downstream area of the surrounding river is predicted.

Embankments of slope will be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

(iii) **Noise and Vibration**

Noise and vibration are expected to be caused by the operation of heavy machinery and trucks, but will be limited to the surrounding area.

In the actual construction work, schedule management will be performed to maintain constant amounts of construction work and low noise/low vibration equipment will be used as much as possible.

Construction work will be performed during daytime.

b) Natural Environment

(i) Ecosystem

The site for expansion of road will be used adjacent rice field after landfill activity.

Habiting plants and small animals in site are commonly seen broadly and impacts of the project on these habitats are expected to be insignificant from the point of ecosystem.

(ii) Topography and Geology

There may be soil runoff from the exposed soil of the embankments.

Any slope of embankment shall be reinforced with plantation or other means to minimize soil runoff.

c) Social Environment

(i) Land Acquisition and Resettlement

The existing road will be expanded for 2m for 1,000m up to the new substation, for which approximately 2,000m2 of land will be required and acquisition will be conducted on the basis of compensation at replacement cost. Trees within clearance distance from cables will be removed. And standing crops and trees will be compensated at market price. It is the Deputy Commissioner of Chittagong District who will conduct land acquisition and payment of compensation in accordance with the Ordinance 1982. PGCB will pay to DC Office when the budget is allocated from the Government of Bangladesh.

(ii) Disturbance to Poor People

Livelihood means of sharecroppers will be permanently lost. Sharecroppers work on daily basis and they are not well-paid. Compensation for their income shall be offered to them in order for them to sustain their living and bridging support shall be given until they find other job opportunities.

(iii) Disturbance to Ethnic Minority Groups and Indigenous People

According to the results of Population Census of 2011 and interview survey conducted during JICA survey, no ethnic minority groups or indigenous people have been identified in the substation site of Raozan Upazila.

(iv) Deterioration of Local Economy such as Losses of Employment and Livelihood Means

Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood. Compensation for such income loss shall be offered at replacement cost for their losses, sustaining their living and seeking other job opportunities. As mitigation measures, employing as many local residents as possible, and using the services and products offered by the local community.

(v) Land Use and Utilization of Local Resources

Land acquisition for road expansion may hinder specific activities at homesteads and farm land along the road. Land owners will permanently lose their land and their sharecroppers will permanently lose their means of livelihood. Compensation for such losses shall be offered, sustaining their living and seeking other job opportunities.

(vi) Social Institutions such as Social Infrastructure and Local Decision-making Institutions

The Deputy Commissioner's Office of Chittagong District will take responsibility for initiatives to conduct local consultations concerning compensation in accordance with the Ordinance 1982, on top which compensation at replacement cost shall be added according to the resettlement policy framework as agreed between PGCB and JICA.

(vii) Misdistribution of Benefits and Compensation

Equality of compensation and fair treatment among the project affected people must be assured. Landowners and other affected people must be legitimately identified for proper payment of compensation.

(viii) Local Conflicts of Interest

In case equality of compensation and fair treatment among the project affected people is not assured, disputes and conflicts among them can occur at any time. Regulations of Bangladesh stipulate that public consultation must be held in the land acquisition process, and their complaints or suggestions must stay heard for immediate action.

(ix) Infectious Diseases such as HIV/AIDS

Local people will be put priority as laborers for simple work during construction period, which will help lower the risk of infectious diseases brought by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc).

(x) Work Conditions (Including Work Safety)

The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those as provision of protective equipment, etc.

(xi) Accidents

Accidents can occur at any time which does harm to local residents living in surrounding areas and workers involved in construction work. As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

9.1.3.2 Operation Phase

a) Pollution control

(i) **Air Pollution**

Air Pollution is not expected caused by operation of access road as the numbers of vehicle using access road will be limited just only to operation vehicle of substation.

(ii) **Water Pollution**

Embankments of slope will be reinforced with plantation or other means to minimize soil runoff and turbid water generation.

(iii) Noise and Vibration

Noise and Vibration is not expected caused by operation of access road.

b) Natural Environment

(i) Ecosystem

Impacts to ecosystem are not expected by operation of access road.

(ii) **Topography and Geology**

Embankments of slope will be reinforced with plantation or other means to minimize soil runoff.

c) Social Environment

(i) Work Conditions (Including Work Safety)

The contractor shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on such aspects as safety training, etc., and those as provision of protective equipment, etc.

(ii) Accidents

Accidents can occur at any time which does harm to local residents living in surrounding areas and workers involved in construction work. As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.

9.2 Summary of Environmental Impact Assessment

9.2.1 Transmission Line

Summary of Results of environmental impacts assessment for Transmission Line is given in **Table-9.2.1.**

Table 9.2.1 Results of Environmental and Social Evaluation (Transmission Line)

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air pollution	B-	D	B-	D	**Construction phase:** - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. **Operation phase:** - No specific air pollution is expected.
	2	Water pollution	B-	B-	B-	D	**Construction and Operation phase:** - The transmission line route was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
	3	Waste	B-	D	B-	D	**Construction phase:** - General waste and hazardous waste are generated by the construction work. **Operation phase:** - No General waste and hazardous waste are expected.
	4	Noise and Vibration	B-	D	B-	D	**Construction phase:** - Construction machinery and vehicles will be maintained regularly. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							Operation phase: - No specific noise and vibration is expected.
Natural Environment	5	Natural reserve	B-	D	D	D	**Construction phase:** - Transmission line route was selected avoiding any protected areas. **Operation phase:** - No specific impact on Natural reserve areas is predicted.
	6	Ecosystem	B-	B-	D	C-	**Construction phase:** - Transmission line route was selected avoiding any protected areas. - There are no flora species listed in the IUCN Red list under the transmission line route. - Precious species of insects, amphibians, reptiles, mammals and birds designated by IUCN are not observed under/along the transmission line route. **Operation phase:** - Birds striking the lines and other impacts are expected to be insignificant.
	7	Topography and Geology	C	C	B-	D	**Construction and Operation phases:** - Transmission line route was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
Social Environment	8	Land Acquisition and Resettlement	C	D	B-	D	**Pre-construction phase:** - Construction of one tower base for 400kV requires 2m^2 of land for suspension tower (approximately 550 nos) and 3m2 of land for tension tower (approximately 250 nos). It is approximately required not more than 2,000 m2 in total. - Construction of one tower base for 230kV requires 1m^2 of land for suspension tower (approximately 20 nos) and 1m2 of land for

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							tension tower (approximately 15 nos). It is approximately required not more than 100 m2 in total. - Land acquisition will be conducted on the basis of compensation at replacement cost. - Trees within clearance distance from cables will be removed. - Standing crops and trees will be compensated at market price. - During construction period, certain part will be blocked exclusively for the construction, where farm activities will be disturbed.
	9	Disturbance to Poor People	C	C	B-	D	**Pre-construction and Operation phases:** - Sharecroppers are among vulnerable groups. Their livelihood means will be temporary lost during construction period.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	C	C	D	D	**Pre-construction and Operation phases:** - No ethnic minority groups or indigenous people were identified along the transmission line route.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	C	C	B-/B+	D	**Pre-construction and Construction phases:** - During construction period, certain part will be blocked exclusively for the construction, where farm activities will be disturbed. - As mitigation measures, employing as many local residents as possible, and using the services and products offered by the local community. **Operation phase:** - The transmission line construction area can be reused for farming after the completion of the transmission tower construction, except for the land for tower bases, therefore adverse effects on income will be very limited.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	12	Land Use and Utilization of Local Resources	C	C	**B-**	**D**	**Pre-construction phase:** - During construction period, certain part will be blocked exclusively for the construction, where farm activities will be disturbed. **Operation Phase:** - The transmission line construction area can be reused for farming after the completion of the transmission tower construction, except for the land for tower bases, therefore adverse effects on income will be very limited.
	13	Disturbance to Water Usage, Water Rights, etc.	C	C	**B-**	**B-**	**Construction and Operation phases:** - Transmission line route has been selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	D	D	**Construction phase:** - Since the volume of increased traffic will be small, no significant impact is anticipated. **Operation phase:** - No specific adverse effects is predicted for existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	C	D	D	D	**Pre-construction phase:** - PGCB will, together with the contractor of the transmission lines, inform the land owners of their possible land use for the tower base, duly take into account the land owners' responses and conclude agreements in writing with the land owners with regard to the land use for the tower base. Upon such communication with the land owners, PGCB will duly inform the land owners that they have the right to express objection to the possible land use. If PGCB does not purchase the land under the proposed transmission towers, PGCB shall restore the land to its original conditions after construction of the transmission towers.

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							Operation phase: - No specific impact is predicted concerning social infrastructure and local decision-making institutions.
	16	Misdistribution of Benefits and Compensation	C	D	D	D	No specific impact is predicted concerning the misdistribution of benefits and compensation.
	17	Local Conflicts of Interest	C	D	D	D	No specific impact is predicted concerning local conflicts of interest.
	18	Cultural Heritage	C	C	D	D	- No specific impact is predicted concerning cultural heritage.
	19	Landscape	C	C	D	D	- Transmission line route has been selected avoiding any protected and scenic areas to the maximum extent.
	20	Gender	C	C	D	D	No specific negative impact expected.
	21	Children's Rights	C	C	D	D	No specific negative impact expected.
	22	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**Construction phase:** - Local people will be recruited for simple work to maximum extent possible, which will help lower low risk of infectious diseases being transmitted by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc). **Operation phase:** - No specific negative impacts are expected.
	23	Work Conditions (Including Work Safety)	B-	B-	B-	B-	**Construction phase:** - The construction company shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc). **Operation phase:** - The work safety plan shall be established including mitigation measures on soft aspects

Item	No.	Impact	Evaluation based on scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							(safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc).
	24	Right of Way (ROW)	B-	D	B-	D	**Construction phase:** - Temporary disturbance to the local land use due to the blockage during construction period. **Operation phase:** - No specific impact is anticipated.
Others	25	Accidents	B-	B-	B-	B-	**Construction and Operation phase:** - As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.
	26	Cross-boundary Impact and Climate Change	D	D	D	D	- Cross boundary and CO2 emissions are not anticipated in relation to the transmission line.

(Source: developed by the JICA Survey Team)

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)

D: No impact is expected.

9.2.2 Substations

Summary of Results of environmental impacts assessment for Substations is given in Table-9.2.2.

Table 9.2.2 Results of Environmental and Social Evaluation (Substation)

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air pollution	B-	D	B-	D	**Construction phase:** - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. **Operation phase:** - No specific air pollution is expected.
	2	Water pollution	B-	B-	D	D	**Construction and Operation phase:** - The site of Substation was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
	3	Waste	B-	B-	B-	B-	**Construction phase:** - General waste and hazardous waste are generated by the construction work. **Operation phase:** - General waste is generated.
	4	Noise and Vibration	B-	D	B-	D	**Construction phase:** - Construction machinery and vehicles will be maintained regularly. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area. **Operation phase:** - Noise and vibration will be borne due to the operation of substation. However, it will be absorbed within the site, so that no specific impact is anticipated outside.
Natural	5	Natural reserve	D	D	D	D	**Pre-construction and Operation phases:**

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Environment							- The site of Substation was selected in rice field, so that Natural resources are not existed.
	6	Ecosystem	D	D	D	D	**Construction phase:** - The site of Substation was selected avoiding any protected areas. - There are no flora species listed in the IUCN Red list in/around site of Substation. -Precious species of insects, amphibians, reptiles, mammals and birds designated by IUCN are not observed in/around site of Substation. **Operation phase:** - Birds striking the lines and other impacts are not expected.
	7	Geography and Geology	C-	C-	D	D	**Construction and Operation phases:** - The site of Substation was selected avoiding any steep sloping land. - Any slopes shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.
Social Environment	8	Land Acquisition and Resettlement	B-	D	B-	D	**Pre-construction phase:** - Approximately 7 ha of farm land will be required for the construction of Madunaghat substation. - Land acquisition will be conducted on the basis of compensation at replacement cost. - Trees within clearance distance from cables will be removed. - Standing crops and trees will be compensated at market price.
	9	Disturbance to Poor People	B-/C-	B-/C-	B-	B-	**Pre-construction and Operation phases:** - Sharecroppers are among vulnerable groups, and they may lose their livelihood means permanently.
	10	Disturbance to Ethnic Minority	D	D	D	D	**Pre-construction and Operation phases:**

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
		Groups and Indigenous People					- No ethnic minority groups or indigenous people were identified.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	B-/C-	B-	B-/B+	B-	**Pre-construction and Construction phases:** - Sharecroppers may lose their livelihood means permanently. - As mitigation measures, employing as many local residents as possible, and using the services and products offered by the local community. **Operation phase:** - Sharecroppers may lose their livelihood means permanently.
	12	Land Use and Utilization of Local Resources	B-	B-	B-	D	**Pre-construction phase:** - 7 ha of farm land will be permanently lost.
	13	Disturbance to Water Usage, Water Rights, etc.	C	C	D	D	N/A
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	D	D	**Construction phase:** - Since the volume of increased traffic will be small, no significant impact is anticipated. **Operation phase:** - No specific adverse effects is predicted for existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	B-	D	**Pre-construction phase:** - The Deputy Commissioner's Office will take responsibility for initiatives to conduct local consultations concerning compensation by law. On top of that, compensation at replacement cost shall be added according to the resettlement policy framework as agreed between PGCB and JICA. **Operation phase:** - No specific impact is predicted concerning social infrastructure and local decision-making institutions.

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
	16	Misdistribution of Benefits and Compensation	C	C	B-	D	**Pre-Construction phase:** Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** No specific impact is predicted concerning the misdistribution of benefits and compensation.
	17	Local Conflicts of Interest	C	C	B-	D	**Pre-Construction phase:** Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** No specific impact is predicted concerning local conflicts of interest.
	18	Cultural Heritage	D	D	D	D	- No specific impact is predicted concerning cultural heritage.
	19	Landscape	D	D	D	D	- Substation site has been selected avoiding any protected and scenic areas to the maximum extent.
	20	Gender	D	D	D	D	No specific negative impact expected.
	21	Children's Rights	D	D	D	D	No specific negative impact expected.
	22	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**Construction phase:** - Local people will be recruited for simple work as much as possible and there is a low risk of infectious diseases being transmitted by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc). **Operation phase:** - No specific negative impacts are expected.
	23	Work Conditions (Including Work Safety)	B-	B-	B-	B-	**Construction phase:** - The construction company shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc) and hard aspects

Item	No.	Impact	Evaluation based on Scoping drafts		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							(provide workers with appropriate protective equipment, etc). **Operation phase:** - The work safety plan shall be established including mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc).
	24	Electromagnetic Field	D	B-	D	D	**Construction phase:** - No specific impact is anticipated. **Operation phase:** - No exceeding impact bigger than the present condition.
Others	25	Accidents	B-	B-	B-	B-	**Construction and Operation phase:** - As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.
	26	Cross-boundary Impact and Climate Change	D	D	D	D	- Cross boundary and CO2 emissions are not anticipated in relation to the Substations due to small scale facility.

(Source: developed by the JICA Survey Team)

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)

D: No impact is expected.

9.2.3 Road Expansion to Modunaghat Substation

Summary of Results of environmental impacts assessment for Road Expansion to Modunaghat substation is given in Table-9.2.3.

Table 9.2.3 Results of Environmental and Social Evaluation (Road Expansion to Modunaghat Substation)

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
Pollution Control	1	Air pollution	B-	D	B-	D	**Construction phase:** - Prevention measures for dust dispersion will be taken by spraying water. - Maintenance of machinery will be conducted regularly, resulting in reducing exhaust gas emissions. **Operation phase:** - No specific air pollution is expected as the length of road is only about 1,000m.
	2	Water pollution	B-	B-	D	D	**Construction :** - Increased turbidity will occur within a short period. **Operation phase:** - Any slopes shall be covered with vegetation or other means to minimize soil runoff and turbid water generation.
	3	Waste	B-	B-	B-	D	**Construction phase:** - General waste and hazardous waste are generated by the construction work. **Operation phase:** - No General waste and hazardous waste are expected.
	4	Noise and Vibration	B-	D	B-	D	**Construction phase:** - Construction machinery and vehicles will be maintained regularly. - Low-noise/ low-vibration machinery will be used. - Noise levels generated from construction machinery will meet noise level standards at the nearest residential area. **Operation phase:** - No specific noise and vibration is expected.
Natural Environment	5	Natural reserve	D	D	D	D	**Pre-construction and Operation phases:** - The expanding road will be constructed by using slope of existing road covered with grass or man-planted trees and rice field, so that Natural resources are not seen.
	6	Ecosystem	D	D	D	D	**Construction phase:** - The each side of road was paddy field and no any protected areas near. - There are no flora species listed in the IUCN Red list in/along the road. -Precious species of insects, amphibians, reptiles, mammals and birds designated by IUCN are not observed in/along the road. **Operation phase:** - Flora and Fauna along the road are observed widely.
	7	Geography and Geology	C-	C-	D	D	**Construction and Operation phases:** - The site of road was selected avoiding any steep sloping land. - Any slopes shall be covered with vegetation to

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
							minimize soil runoff and turbid water generation.
Social Environment	8	Land Acquisition and Resettlement	B-	D	B-	D	**Pre-construction phase:** - Expansion of road will require 1,000m x 2m = 2,000m^2 of land. - Land acquisition will be conducted on the basis of compensation at replacement cost. - Trees within clearance distance from cables will be removed. - Standing crops and trees will be compensated at market price.
	9	Disturbance to Poor People	B-/C-	B-/C-	B-	D	**Pre-construction:** - Sharecroppers may lose their livelihood means temporarily or partially.
	10	Disturbance to Ethnic Minority Groups and Indigenous People	D	D	D	D	**Pre-construction and Operation phases:** - No ethnic minority groups or indigenous people were identified.
	11	Deterioration of Local Economy such as Losses of Employment and Livelihood Means	B-/C-	B-	B-/B+	D	**Pre-construction and Construction phases:** - Sharecroppers may lose their livelihood means temporarily during construction period. - As mitigation measures, employing as many local residents as possible, and using the services and products offered by the local community.
	12	Land Use and Utilization of Local Resources	B-	B-	B-	D	**Pre-construction phase:** - Land acquisition for road expansion may hinder specific activities at homesteads and farm land along the road.
	13	Disturbance to Water Usage, Water Rights, etc.	C-	C-	D	D	N/A
	14	Disturbance to the Existing Social Infrastructure and Services	B-	D	D	D	**Construction phase:** - Since the volume of increased traffic will be small, no significant impact is anticipated. **Operation phase:** - No specific adverse effects is predicted for existing social infrastructure.
	15	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	B-	D	B-	D	**Pre-construction phase:** - The Deputy Commissioner's Office will take responsibility for initiatives to conduct local consultations concerning compensation. On top of that, compensation at replacement cost shall be added according to the resettlement policy framework as agreed between PGCB and JICA. **Operation phase:** - No specific impact is predicted concerning social infrastructure and local decision-making institutions.
	16	Misdistribution	C-	C-	B-	D	**Pre-Construction phase:**

Item	No.	Impact	Evaluation based Scoping		Evaluation based on survey results		Results
			Pre- / construction Phase	Operation Phase	Pre- / construction Phase	Operation Phase	
		of Benefits and Compensation					-Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** -No specific impact is predicted concerning the misdistribution of benefits and compensation.
	17	Local Conflicts of Interest	C-	C-	B-	D	**Pre-Construction phase:** -Landowners and other affected people must be legitimately identified for proper payment of compensation **Operation phase:** -No specific impact is predicted concerning the misdistribution of benefits and compensation.
	18	Cultural Heritage	D	D	D	D	- No specific impact is predicted concerning cultural heritage.
	19	Landscape	D	D	D	D	- Road expansion will not harm scenic areas.
	20	Gender	D	D	D	D	No specific negative impact expected.
	21	Children's Rights	D	D	D	D	No specific negative impact expected.
	22	Infectious Diseases such as HIV/AIDS	B-	D	B-	D	**Construction phase:** - Local people will be recruited for simple work as much as possible and there is a low risk of infectious diseases being transmitted by external workers. Pre-employment and periodic medical check-ups will be conducted for external workers (technical workers, etc). **Operation phase:** - No specific negative impacts are expected.
	23	Work Conditions (Including Work Safety)	B-	B-	B-	B-	**Construction phase:** - The construction company shall establish a work safety plan and submit it to PGCB to obtain approval. The work safety plan shall stipulate mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc). **Operation phase:** - The work safety plan shall be established including mitigation measures on soft aspects (safety training, etc) and hard aspects (provide workers with appropriate protective equipment, etc).
	24	Others	C-	C-	D	D	N/A
Others	25	Accidents	B-	B-	B-	B-	- As prevention measures for land traffic accidents, observation of traffic regulations, installation of traffic signs and training and education on safe driving will be implemented.
	26	Cross-boundary Impact and Climate Change	D	D	D	D	- Cross boundary and CO2 emissions are not anticipated in relation to access road due to a short length of road.

(Source: developed by the JICA Survey Team)

A+/-: Significant positive/negative impact is expected.

B+/-: Positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact may be clarified as the study progresses.)

D: No impact is expected.

Chapter X Mitigation of Impacts

10.1 General:

In this section, Mitigation Measures for Transmission Line, Substation and Access Road etc. have been discussed.

10.2 Mitigation Measures

10.2.1 Implementation system

a) Construction phase

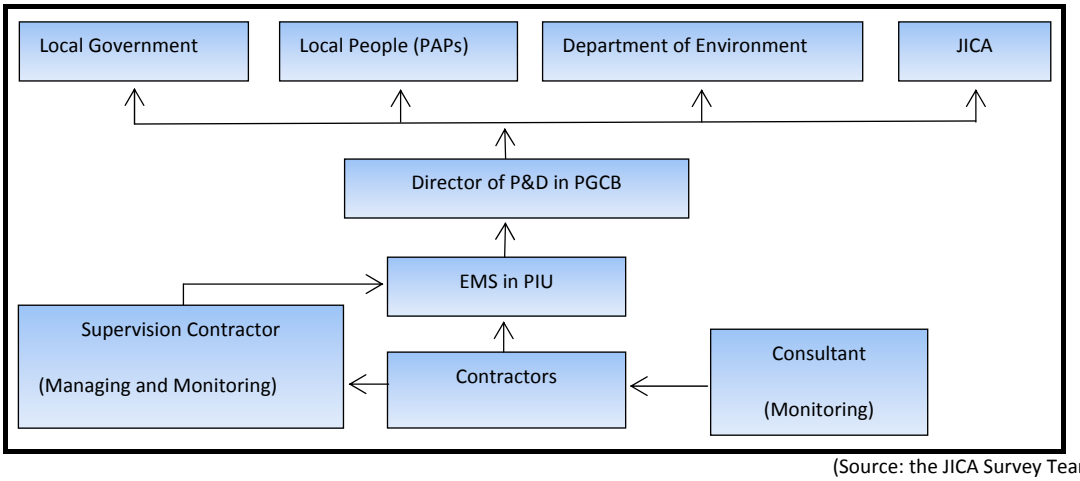
At the construction stage, the **Project Implementation Unit (PIU) of PGCB**, shall carefully monitor all construction activities with the supervision consultant, and encourage the contractor to fully understand the necessary mitigation measures and to implement them.

In this regard, an Environmental Management Section shall be organized in PIU prior to construction activities and some members of PIU of P&D in PGCB shall be designated as an environmental management administrator.

During the construction activity, in which a large inflow of workers and vehicles is predicted, the Environmental Management Section shall encourage the understanding of the surrounding community about the contents and schedule of the construction activity and mitigation measures, and obtain local people's opinions and change the mitigation measures as appropriate.

The Environmental Management Administrator shall regularly hold explanation sessions with the local people and submit reports to the Department of Environment of MOEF in Bangladesh, JICA and other relevant organizations about the implementation status of the environmental management, in addition to the environmental monitoring.

The following figure describes the environmental management and monitoring implementation structure with the reporting flow during the construction phase.



(Source: the JICA Survey Team)

Figure 10.2.1-1 Environmental Management and Monitoring Implementation Structure in construction phase

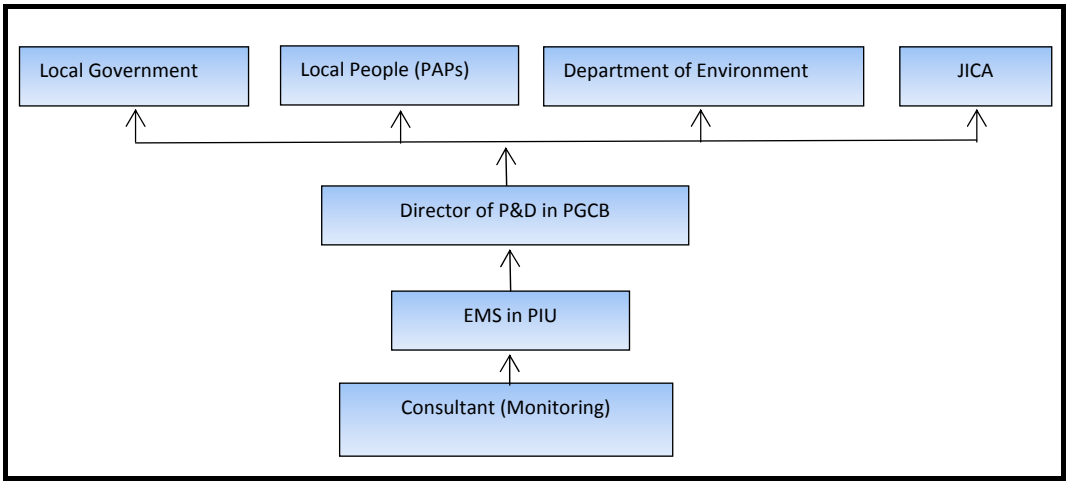
b) Operation phase

The Environmental Management Section shall report the contents and implementation status of the environmental management plan and the environmental monitoring plan to the director of the P&D in PGCB, with the director taking final responsibility.

Environmental Management Section also shall regularly provide explanations to the local people and submit reports to the Department of Environment of DOE, JICA and other relevant organizations about the implementation status of the environmental management, in addition to the environmental monitoring.

The Environmental Management Section shall also play a role of function as a grievance organization to understand and address any grievances from local people during operation phase, and conduct appropriate mitigation measures.

The following figure describes the environmental management and monitoring implementation structure with the reporting flow during the operation phase.



(Source: the JICA Survey Team)

Figure 10.2.1-2 Environmental Management and Monitoring Implementation Structure in operation phase

Chapter XI Environmental Management Plan (EMP)

11.1 EMP during Construction Phase

Table-11.1 shows Environmental Managgemnet Plan (EMP) during pre-construction and construction phase.

Table 11.1 Environmental Manegement Plan during Pre-construction and Construction Phase

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
Pre-construction Phase									
1	Land acquisition	- Loss of land at tower bases - new Madunaghat substation	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Consideration for land owners, sharecroppers and compensation for standing agriculture products	- Towers are constructed in non-residential areas - Land acquisition should be conducted in compliance with relevant laws and regulations - Cost related to relocation (if any) will be given to the relocated residents	- Tower bases - Site of Madunaghat Substation	- During land acquisition process	- Office of the Deputy Commissioner - PGCB	Expenses to be paid by PGCB
2	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- Changes in people's thinking through interacting with local government officers, local	-----	- Consideration to affected peoples' emotions	- Compensation should be conducted in compliance with relevant laws and regulations	- Tower bases - Site of Substation	- Prior to the start of construction	- Office of the Deputy Commissioner - PGCB	Expenses to be paid by PGCB

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
		residents and others in the land acquisition procedure							
Construction Stage									
1	Air Quality	1) Dust resulting from construction work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment 3) Air pollution arising from incineration of construction materials and waste	1) - 3) - Ambient Air Quality Standard	1) - 3) - Prevention of air pollution in the surrounding construction area	1) Dust prevention - Watering access roads and construction site, especially in the dry season - Using cover sheet on trucks for the transportation of soil 2) Gas emission prevention - Periodic maintenance and management of all	1) - 3) - Construction area	1) - 3) -During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					construction machinery and vehicles 3) Waste management - Prohibit open burning and illegal dumping				
2	Water Quality	1) Run off water from construction area 2) Domestic wastewater of workers 3)Inappropriate disposal of waste	1) -3) - Wastewater standards	1) - 3) - Prevention of water pollution in the surrounding construction area	1) Run off water - Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of the construction area with concrete, as necessary based on geological survey 2) Domestic	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB / Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					wastewater - Install wastewater treatment facility for workers, such as septic tanks 3) Waste management - Prohibit illegal waste disposal				
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rule	1) - 3) - Prevention of inappropriate waste disposal	1), 2) Construction and domestic waste - Conduct separate waste collection and promote recycling and reuse - Appropriate disposal of non-recyclable waste according to rules	1) - 3) - Construction area	1) - 3) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					3) Hazardous waste - Hazardous waste should be treated under the related regulations				
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for mobilization of equipment and workers	1), 2) - Noise level standards	1), 2) - Reduction of noise level from construction activities	1) Construction machinery - Optimizing construction schedule - Perform construction work during daytime, especially piling work -Using low-noise/ low vibration equipment, as much as possible 2) Mobilization - Limit truck speed, especially	1), 2) - Construction area	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					around residential areas				
5	Ecosystem	1) Removal of vegetation 2) Loss of protected species	1) Cover of vegetation and trees 2) Existence of protected species	1), 2) - Mitigation of environmental impact on the loss of vegetation and protected species	1) Vegetation - Tower construction area should be re-vegetated with native plants 2) Protected species - Consult with specialists about moving individual animals if any protected species are discovered	1), 2) - Transmission line route	1), 2) - During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
6	Topography and Geology	- Soil runoff	-Soil runoff	-Prevention of soil runoff	- Transmission line route was selected avoiding any steep sloped areas - Preventing soil	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					loss by stabilizing any slopes of construction areas with concrete, as necessary based on geological survey			Supervision Consultant	
7	Deterioration of Local Economy such as Losses of Employment and Means of Livelihood	- Loss of farmlands, being kept out of construction zones	- Employment of local residents	- Consideration of local residents' feelings	- Employ as many local residents as possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the local community	- Villages along the transmission line route and substation	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
8	Land Use and Utilization of Local Resources	- Changing the traditional land usage patterns and utilization of local resources	- Employment of local residents	- Consideration of local residents' feelings	- Employ as many local residents possible - Use the services (i.e., laundry and catering services, etc.) and products offered by the	- Villages along the transmission line route and substation	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					local community			Consultant	
9	Disturbance to Water Usage, Water Rights, etc.	- Water pollution caused by soil runoff	-----	- Prevention of water pollution in downstream areas	- Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of construction areas with concrete, as necessary based on geological survey -Re-greening in construction areas	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
10	Cultural Heritage	- Further destruction of buried cultural heritage due to engineering work	- Loss of cultural heritage	- Protect cultural heritage	- Stop construction work if any cultural heritage area is discovered and immediately	- Construction area	- During construction phase	- Implementation: Contractor/ Environmental Consultant - Supervisor:	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					consult with specialists			PGCB/ Supervision Consultant	
11	Infectious Diseases such as HIV/AIDS	- Temporary influx of migrant labor during construction may increase risk of infection	-----	- Consideration of sanitation of local residents	- Establish medical center and implementation of periodic medical check-ups - Education and training on workers' health care	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor
12	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any	- Construction area	- During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate during the construction period - Use facilities and equipment that protects against electric shocks				
13	Accidents	1) Traffic accidents 2) Soil runoff and tower breakages	1) Traffic accidents - Land traffic 2) Soil runoff and tower breakages	1) Prevention of traffic accidents 2) Prevention of soil runoff	1) Traffic accidents - Observation of traffic regulations, installation of traffic signs and education on	1) Construction area 2) Roads near the construction area	1), 2) - During construction phase	- Implementation: Contractor - Supervisor: PGCB	Expenses included in contract cost by Contractor

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					safe driving - Training safe operation of vehicles 2) Soil runoff and tower breakages - Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of the construction area with concrete, as necessary based on geological survey				

11.2 EMP during Operation Phase

Table-11.2 shows Environmental Managgemnet Plan (EMP) during Operation phase.

Table 11.2 Environmental Manegement Plan during OperationPhase

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
1	Water Quality	- Run-off water from tower bases and substation	------	- Prevention of water pollution in the surrounding construction area	- Re-vegetation of the tower bases and slopes in substation site	- Tower bases -Substation	- During the inspection work	PGCB	PGCB
2	Waste	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3	Ecology	- Birds striking the lines	- Birds striking	- Prevention of birds striking	- Installation of lights and signs, etc., if needed	- Along the transmission line route	- During the inspection work	PGCB	PGCB
4	Topography and Geology	- Soil runoff	- Soil runoff	-Prevention of soil runoff	- Transmission line route was selected avoiding any steep sloped areas - Preventing soil loss by stabilizing any slopes of construction area with concrete, as necessary based on geological	- Along the transmission line route -Inside Substation site	- During the inspection work	PGCB	PGCB

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					survey				
5	Work Conditions (including work safety)	Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Prevention measures against labor accidents, accidents, and health problems	- Prepare a manual for labor accident prevention including safety education and training - Provide workers with appropriate protective equipment - Inspect and ensure that any lifting devices, such as cranes, are appropriate for expected loads - Keep lifting devices well maintained and perform maintenance checks as appropriate during the construction	- Along the transmission line route	- During the inspection work	PGCB	PGCB

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					period - Use facilities and equipment that protects against electric shocks				
6	Accidents	1) Traffic accidents 2) Soil runoff and tower breakages	1) Traffic accidents - Land traffic 2) Soil runoff and tower breakages	1) Prevention of traffic accidents 2) Prevention of soil runoff	1) Traffic accidents - Observation of traffic regulations, installation of traffic signs and education on safe driving - Training safe operation of vehicles 2) Soil runoff and tower breakages - Transmission line route was selected avoiding any steep sloped areas	1) Roads near the construction area 2) Along the transmission line route	- During the inspection work	PGCB	PGCB

No	Potential Impact to be Managed	Sources of Potential Impact	Standard of Impact	Objectives	Management Effort	Management Location	Period of Management	Management Institution	Cost
					- Preventing soil loss by stabilizing any slopes of the construction area with concrete, as necessary based on geological survey				

(Source: the JICA Survey Team)

Chapter XII Risk Assessment

12.1 Introduction

The problem of protecting human health and the environment may best be defined as the management of risk. The failure to manage risk effectively and to establish priorities rationally translates ultimately into a failure to protect health, safety, and the environment. Through the use of risk assessment, concerned authorities can estimate the relative level of risks posed by different substances, products and activities and can establish priorities in determining whether, and how, to regulate.

Risk assessment is the technical process for estimating the level of risks posed by operational processes or products, i.e. the probability that a given harm will occur as a result of the processes or products. Risk assessment is applied to a substance, proceeds in four major steps:

Hazard identification: determining what kinds of adverse health effects a substance, product or activity can cause

- Dose - response assessment: predicting the degree of adverse effects at a given exposure level
- Exposure assessment: estimating the amount of exposure, and
- Risk characterization: combining the foregoing into a numerical range of predicted deaths or injuries associated with actual exposure event

Risk management options are then evaluated in a proposed solution to provide reduction of risk to the exposed population. Specific actions that are identified and selected may include consideration of engineering constraints as well as regulatory, social, political and economic issues related to the exposure. Quantitative assessment of risks associated with hazard identification, dose-response assessment, exposure estimation and risk characterization were beyond the scope of the present study. However, this study takes a qualitative approach to identify common hazards within the power plant and recommends measures for managing these risks with accidents and external threats.

12.2 Substation Risks Assessment

In the substation, there are buses, protective devices, transformers etc. Transformers are filled up with mineral oil. Due to high fault current and malfunction of protective devices, the power transformer can burst with fire. . Apart from risks associated with emissions, noise generation, solid waste, hazardous waste and wastewater disposal as a result of construction and operation, substations put human beings and the environment inside and outside of the substation to a certain degree of risk of accident and sometime loss of life. It is therefore essential that a risk management plan should be devised in order to both reduce risk of accident and to take the correct action during accidents. Important risks of accidents in substation disasters or emergency situations may occur during following events:

- Risks during emergency: Fire, Explosion, Oil/acid spillage, Toxic chemical spillage, Electrocution

- Risks due to natural disasters: Flood, Cyclone, Earthquake, Storm, Lightning,
- Risks due to external threats: Sabotage, War situation, Water/food poisoning

In substation, accidents can occur at two different levels. First, these may occur due to fires, explosions, oil or chemical spillage and spontaneous ignition of inflammable materials. In such events, operators working inside the substation and at various strategic hazard locations will be affected.

Second, risks are also associated with external threats of sabotage. Failure of automatic control/warning systems, failure of mineral oil storage tanks and chemical release from acid and alkali stores and handling also pose great degree of associated risks.

12.3 Managing the Risks

As mentioned earlier, in order to reduce the risks associated with accidents, internal and external threats, and natural disasters, a risk management program is essential. Risk management planning can be done during design and planning stage of the substation as well as during substation operation. While risk management is mainly preventive in nature during the substation operation stage, the design and planning stage of the substation can incorporate changes in basic engineering to include safety design for all processes, safety margins for equipment, and substation layout. The following steps among others are important in managing the risks mentioned.

- Oil storage is to be designed with adequate precautions in respect of fire hazard control.
- Storage of hazardous substances such as acids and alkalis should be sited in protected areas.
- With respect to plant operation, safe operating procedures should be laid down and followed to ensure safety, optimum operation and economy.
- A fire fighting group with adequate manpower and facilities such as water tank of sufficient capacity, C02 tank, foam tank, portable fire extinguishers should be provided and facilities located at strategic locations e.g. Transformer area, high voltage panel, control rooms etc.
- Regular checks on safe operating practices should be performed.

In order to achieve the objective of minimizing risks at Meghnaghat and Modunaghat substation, the unit will be trained to act in a very short time in a pre- determined sequence to deal effectively and efficiently with any disaster, emergency or major accident to keep the loss of life, human injury, material, plant machineries, and impacts on the environment to the minimum.

12.4 Emergency Response Plan

Emergency response plans are developed to address a range of plausible risk scenarios and emphasize the tasks required to respond to a physical event. The emergency response plan (ERP) for the proposed substation and transmission lines has been developed listing various actions to be performed in a very short period of time in a pre-determined sequence if it is to deal effectively and efficiently with any emergency, major accident or natural disaster.

The primary objective of the plan is to keep the loss of life, material, machinery/equipment damage, and impacts on the environment to minimum.

12.4.1 Emergency Response Cell

It is highly recommended that an Emergency Response Cell (ERC) adequately equipped with highly trained manpower and appropriate gears is established within the substation in order to effectively implement the emergency response plan. The main functions of the emergency response cell should include the following.

- Identification of various types of emergencies
- Identification of groups, communities, and areas those are vulnerable to different kinds of emergencies
- Preparing service teams for various operations within the organization through extensive training
- Establishment of early detection system for emergencies
- Developing reliable, instant information and communication system
- Mobilizing all units in the plant within a very short time to address any emergency

12.4.2 Emergency Preparedness

The ERC headed by a trained Manager should establish an Emergency Control Room with links to all substation control rooms and all other services.

The team will be responsible for preparing and executing a specific emergency response plan for the substation. The team should meet at regular intervals to update the plan, based on plant emergency data and changes in support agencies.

The team should undertake some trial runs, e.g. fire drill, in order to be fully prepared and to improve upon the communication links, response time, availability and workability of emergency gears and other critical factors.

Upon receiving information about an accident, the ERC team will assemble in the Emergency Control Room within the shortest possible time and formulate emergency control procedure.

12.4.3 Fire Fighting Services

The Fire Officer will be the commanding officer of the fire fighting services. The FO will head a fire fighting team of trained officers and workers. Adequate fire fighting equipment e.g. fire extinguishers of different types appropriate for different strategic locations must be planned according to requirements of substations.

Depending on the scale of emergency, the fire fighting team will work in close association with security and maintenance personnel of plant. Additional assistance may also be sought from outside fire stations when required.

Preparedness is extremely important for efficient and effective fire fighting services at the time of emergency. This can be better achieved by organizing fire drills at regular intervals, e.g. once every two weeks during dry summer, months and once every two months during wet months involving all team members, all other service groups, all staff of the power plant, and utilizing all fire fighting gears.

12.4.4 Emergency Medical Services

The Medical Officer will be responsible for providing medical services within the substation at the time of any emergency. The services should also be rendered to people living in the close vicinity of the substation and affected by any accident within the substation.

The Medical room of the substations must be equipped with adequate medical personnel and equipment for providing emergency services in addition to normal Medicare services to population of the plant.

A team of well trained Medical Officers specializing in burn injury, orthopedics, electrocution, chemical toxicity or poisoning, and shock treatment must be available at substation Medical room. The number of officers may be determined considering the total number of staff and their family members in the plant. Special attention must be given to child injury treatment.

The following services must be on alert at all times in the substation.

First aid services for attending patients on the spot. The Medical room should provide training on first aid services to some designated staffs of important areas of operationfor immediate attention to the injured.

Ambulance services should be available for transport of casualties from spot to Medical room of the substation, and from Medical room to outside hospital, as necessary. Facilities for transportation of fatalities to appropriate hospital or to relatives or to the police following prescribed procedure should be available.

All potential areas for emergency/ accidents in the substation must have an information chart including contact phone numbers of relevant services.

12.4.5 Rescue Services

Without going for additional manpower, the rescue team can be formed with potential staffs of the substation, e.g. from medical services, security services and fire fighting services, for conducting rescue operations following an emergency. A senior member can be designated Rescue Officer who will be responsible for formulating rescue plan and guiding the team.

12.4.6 Security Services

Meghnaghat and Modunaghat substations will have a strong independent security team headed by the Chief Security Officer and will be responsible for the overall security of the substation , its equipment, machineries, buildings, utilities. The security office shall maintain liaison with other emergency services at the time of emergency and during normal hours.

12.4.7 Public Relations Services

The Public Relations Officer (PRO) of the substation will be responsible for communicating emergency related information to concerned officials within the substatin outside agencies.

The PRO will be responsible for warning people in and around the plant against potential fire hazards, or possible chemical contamination of water.

The PRO will keep close contact with outside local community and provide direction, and participate along with management team in the welfare services for the affected communities.

12.5 Concluding Remarks

Apart from the services mentioned above, the Environmental Management Unit and the Emergency Response Cell must ensure that all staffs working within the substations are oriented, through orientation programs, about the dos and don'ts during emergencies as well as overall environmental aspects and issues related to power plant operations.

It is however, to be emphasized that the emergency response plan (ERP) outlined above is to be used as guide only and that the Environmental Management Unit and the Emergency Response Cell shall develop their own environmental management system (EMS) following ISO 14001 and the emergency response plan (ERP) respectively in consultation with and involving the substations and the PGCB Management.

Chapter XIII Environment Monitoring Plan

13.1 Environmental Monitoring Plan

An Environmental Monitoring Plan will be prepared to provide guidelines for an environmental management plan during the construction and operation activities of the Transmission Line and substation. The environmental components that will be monitored are those that will be positively or negatively affected, or expected to be affected, by the construction activities. **Table 13.1** shows Envoromental Monitoring Plan for Transmission line and substation.

An Environmental Monitoring Plan has been discussed only for Transmission Line and substation. Other projects of construction for Access Road have not been discussed because of its scale of facility or expansion is very small and not to give significant impacts to surroundings.

For monitoring, environmental monitoring forms for transmission lines, substation and access road have been developed. The environmental monitoring forms are givern under **Annex-13.1.**

Table 13.1 Environmental Monitoring Plan

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
Pre-Construction									
1	Land acquisition	- Loss of land at tower bases - Kept out of the construction zone - Trees will be removed if they are within clearance distance	- the Acquisition and Requisition of Immovable Property Ordinance 1982 - JICA Guidelines for Environmental and Social Considerations (2010)	- Confirmation of compensation process	- Attendance of compensation payment	- Areas for compensation	- During land acquisition process	- Deputy Commissioner's Office - PGCB	PGCB
2	Social Institutions such as Social Infrastructure and Local Decision-making Institutions	- Changing peoples` thinking through interacting with local government officers, local residents and others in the	-----	- Confirmation of affected peoples' feelings	- Interviewing affected people	- Affected people	- Once after compensation	PGCB	PGCB

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		land acquisition procedure							
3	Misdistribution of Benefits and Compensation	- Can occur among residents, workers, government officers, and local politicians	-----	- Same as those addressed in Land acquisition	- Same as those addressed in Land acquisition	- Same as those addressed in Land acquisition	- Same as those addressed in Land acquisition	PGCB	PGCB
4	Local Conflicts of Interest	- Can occur among residents, workers, government officers, and local politicians	-----	- Same as those addressed in Social institutions	- Same as those addressed in Social institutions	- Same as those addressed in Social institutions	- Same as those addressed in Social institutions	PGCB	PGCB
Construction Phase									
1	Air Quality	1) Dust resulting from construction	PM_{10} Ambient Air Quality	Evaluation of effect of the mitigation measures	Collecting samples and analyzing at a	4 points Construction sites and	Once every three months	- Implementation: Contractor/ Environmental	Expenses included in contract cost by

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		work 2) Exhaust gas from construction machinery and vehicles used for mobilization of equipment	Standard SO2,NO2	towards air pollution	lab.	surroundings, especially residential areas.		Consultant - Supervisor: PGCB/ Supervision Consultant	Contractor
2	Water Quality	1) Run off water from construction site 2) Domestic wastewater of workers 3) Inappropriate disposal of waste 4) Leakage of oil and chemical materials from construction	PH, BOD, SS, Oil, Coliforms, Wastewater standards Ambient water quality standards	Evaluation of effect of the mitigation measures towards water pollution	Collecting samples and analyzing at a lab	(Substation) 1 point- Foreside of the drain outlet. 3 points- Construction sites and surroundings, especially residential areas.	Once every three months	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		activity							
3	Waste	1) Construction waste from construction work 2) Domestic waste from workers 3) Hazardous waste such as dry batteries, etc.	1) - 3) - Waste Management Rules	1) - 3) - Evaluation of effect of the mitigation measures for waste	1) - 3) - Record of kinds and quantity of waste, and the disposal method	1) - 3) - Construction area	1) - 3) - Continuous records	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
4	Noise and Vibration	1) Noise and vibration caused by construction machinery 2) Noise caused by vehicles used for	Noise level Noise level standards	Evaluation of effect of the mitigation measures towards noise level	Measurement using noise level meter	7 points- Construction sites and surroundings, especially residential areas. (sampling sites of	Once every three months	Expenses included in contract cost by Contractor	Expenses included in contract cost by Contractor

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
		mobilization of equipment and workers				survey for environment)			
5	Ecosystem (Endangered Species)	- Existence of endangered species	Species, Number - Bangladesh Wild Life (Preservation) (Amendment) Act, 1974 - JICA Guideline (2010)	- Confirmation of endangered species existence	1), 2) - Observation	lines - Near rivers and Forest Hill	- Once a week in migration season	- Implementation: Contractor/ Environmental Consultant - Supervisor: PGCB/ Supervision Consultant	Expenses included in contract cost by Contractor
6	Work Environment (Including Work Safety)	- Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor: CPGCBL	Expenses included in contract cost by Contractor
7	Accidents	- Traffic accidents	- Land traffic	- Evaluation of effect of traffic schedule	- Record of accidents	- Contractor's office	- Once a year	- Implementation: Contractor - Supervisor:	Expenses included in contract cost by Contractor.

No	Significant Impact to be Monitored	Source of Significant Impact	Monitored Parameter	Purpose of the Monitoring	Monitoring Method			Responsible Organization	Cost
					Method of Collecting and Analyzing Data	Location	Duration and Frequency		
								CPGCBL	
Operation Stage									
1	Ecosystem (Endangered species)	- Existence of the towers and cable	**Species, Number** - Migratory birds	- Confirmation of bird strikes	- Observation	5 lines - Near rivers and Forest Hill	- Once a month in migration season	- PGCB/ Environmental Consultant	PGCB
2	Work Environment (Including Work Safety)	1) Labor accidents	- Handling heavy loads - Working at heights - Electric shocks	- Evaluation of effect of the work safety plan	- Record of accidents	- PGCB office	- Once a year	PGCB	PGCB

(Source: the JICA Survey Team)

Chapter XIV Work Plan

14.1 Work Plans and Schedules

14.1.1 Construction Phase

Before starting the construction work, the Project Director (PD) of PGCB is required to give sufficient consideration to the details of the construction work, and to make sure that the required EMP and Monitoring Plans are thoroughly understood by the contractor.

Thus, the Project Director (PD) of PGCB is required to form the required organization.

Especially, there is an active inflow of the workers and many construction-related vehicles during the construction. The details of the construction work, schedule and mitigation measures should be sufficiently explained to the communities in the surrounding area. The countermeasures should be altered as appropriate, based on the correct understanding of the views of the residents.

The following are the major environmental impacts during the construction work.

- Inflow of workers and an increase in the number of construction-related vehicles
- Generation of construction wastes
- Generation of dust particles, and gas emission from vehicles and machinery
- Generation of noise from vehicles and machinery
- Occurrence of muddy water in the excavation area

Employing workers from local areas during the construction phase will have a favorable impact on the local economy. Sufficient consideration must be given to the local employment, including implementation of the preliminary education and training program of the workers.

The EMP and monitoring plan should be worked out by sufficient discussions between PGCB and the contractor. To confirm the implemented plan and to study further measures, a report schedule should be worked out in such a way that the contractor will report the current situation of implementation in the form of a written statement. This report should be submitted to the DoE for further discussion.

14.1.2 Operation Phase

During the operation phase, the PGCB is responsible to form a required organization for environmental management. This organization is responsible for receiving the complaints from the residents of the surrounding area during the operation phase and to take appropriate measures, so that the complaints of the residents will be correctly understood and necessary measures will be taken.

The basic idea is to establish a relationship with the local communities. It is important to sufficiently explain the environmental management procedures taken at the substation. It is also important to invite the residents and school children to observe the substation.

The following describes the major environmental impacts during the operation phase.

- Generation of waste water
- Generation of noise from operating machinery
- Generation of solid waste from operation

The operation workers are required to have specialized knowledge. It will be difficult to hire workers from the local area. However, employing local workers will have a favorable impact on the local economy. For the comparatively easy work, sufficient consideration must be given to local employment, including implementation of the preliminary education and training programs for workers.

PGCB should prepare a report on the implementation of the EMP and monitoring plan and should submit it to DoE and related organizations for further discussion.

Chapter XV Public Consultation

15.1 Introduction

Public consultation forms an important part of the EIA study. The main objective of the consultation process is to apprise the local inhabitants about the proposed project and to seek their opinions regarding the possible impacts of the project. It was recognized that their opinions would be more useful as they are accustomed to construction and operation of a number of power plant units in the locality in last few years.

Public involvement is a fundamental principle of any environmental assessment study. The inclusion of the views of the affected and interested public helps to ensure that the decision making process is equitable and fair and leads to more informed choice and better environmental outcomes. The findings from the public consultations carried out as a part of the EIA study were utilized in the development of the EMP (presented in Chapter 11), especially in identifying the significant impacts of the proposed project and developing the corresponding mitigation measures.

15.2 Approach and Methods

Within the framework of the present study, public consultation process has been initiated with an explicit objective to ensure people's participation. More specifically this was aimed at improving the study, taking into account opinions from the people of the study area.

The consultation sessions included Focused Group Discussions (FGD). Fourteen FGDs were held at 7 sampling points along the 400kV Transmission line from Meghnaghat to Matarbari. Two FGDs were held at each sampling point – one FGD for male group and another for female group. Similarly, Four FGDs (Land owner group, mixed group, agriculture labour group and one female group) were held around Madunaghat sunbstation.

Formal and informal meetings in terms of FGD with different groups and interviews with Key Informants (KIs) of the area were held with the primary objective to understand the people's perceptions regarding relevant issues. Discussion mainly centered on problems of the area relevant to the proposed project and suggested solutions.

Apart from Focus Group Discussion, In-depth interviews were conducted with the different officials and local elites of 18 upazilas along the 400kV transmission line r upazila to grasp their views and opinions. Similarly, In-depth interviews were conducted with the local elites of East Gujra Union of Rauzan upazila around Madunaght substation.

The study also took into consideration the findings of questionnaire survey carried out as part of the EIAs conducted for other power plants, (positive and negative impacts), the socio-economic and political situation and peoples' perception about the project.

Consultation was undertaken at early stages of the EIA study so that potentially affected groups/people could provide meaningful input to the EIA. The dialogue, both

formal and informal, was continued throughout the period. All consultations and meetings were documented including responses to the questionnaire.

15.3 Public Consultations

15.3.1 General:

Survey has been conducted in the seven sampling points along the proposed 400kV transmission and in and around the proposed Madunaghat 400kV substation in two ways – i. Quantitative approach and ii. Qualitative approach. For quantitative approach, standard questionnaire (socio economic and environmental issues) has been used for interviewing randomly selected respondents in the proposed area. On the other hand, for qualitative approach, focus group discussion guidelines have been followed.

For Quantitative approach, **184 respondents** have been randomly selected from the seven sampling points along the proposed 400kV Transmission line and **36 respondents** (affected land owners) in the proposed Madunaghat 400kV substation.

For Qualitative approach, **14 Focus Group Discussions** in seven sampling points along the proposed transmission line and **4 Focus Group Discussions** in the proposed Madunaghat substation were conducted. Apart from FGDs, in-depth interviews were also conducted with local administrative authorities and public representatives of different upazilas along the proposed transmission line and substation..

15.3.2 General Interview:

a) Transmission Line

For Quantitative approach, 184 respondents have been randomly selected in the seven sampling points along the proposed 400kV transmission line. The Comments of the respondents were as follows:

- The respondents were not familiar with 400kV transmission line But they were optimistic to get electricity in their area if this 400kV transmission line is constructed.
- They were very concerned about the damage of their crops during construction of the transmission line.
- They are also concerned about whether they will get any compensation for the land to be used for tower footings and crops to be damaged during construction.
- They were in favour of the construction of the transmission line for transmitting power all over the country, which will result the industrial development of the country.

b) Sub-station

For Quantitative approach, 36 respondents (affected land owners) have been randomly selected around the proposed Madunaghat substation area. The Comments of the espondents were as follows:

- The respondents expressed their unhappiness about compensation during construction of RPCL's 25MW power plant adjacent to the proposed substation.
- They were reluctant to give their land for the substation unless the propoer compensation for their land and crops are ensured.
- After motivationg them, they were in favour of the construction of this project for

transmitting power all over the country, which will expedite the industrial development of the country.

15.3.3 Focus Group Discussion (FGD)

a) Transmission Line:

14 FGDs were conducted at seven sampling points along the proposed 400kV transmission line. 2 FGDs (one for Male group and other for Female group) were conducted in each sampling point. The findings of the FGDs are given below:

- Most of the participants were not aware of usefullness of 400kV transmission line. They have gladly accepted the construction of 400kV transmission line through their area after they were fully briefed about the project.
- They were in favour of implementation of this project for the national interest.
- But they were very much concerned about the social and environmental impact of the transmission line. They apprehanded that he land for tower footing and crops along the line will be damaged during construction of the transmission line.
- They requested the relevant authorities to provide proper compensation for the damaged land and crops as well.
- They also requested to take necessary mitigation measures of the negative impacts of the transmission line during contruction and operation phase.
- The participants from hilly area raised that they are all deprived from grid electricity. They are dependent on the solar home systems only, which are very costly. So, they requested the relevant authorities to provive them with grid electricity supplied by BREB or BPDB

b) Sub-station:

4 FGDs (Female group, land owners group, mixed group and agriculture labour group) were conducted in the Madunaghat substation area. The participants of the FGDs wer annoyed to participate in the group discussions as they have very bad experience with RPCL about compensation during construction of RPCL's 25MW power plant located near the proposed substation site. However, the local administrative authority and local elites motivated all the villagers in Gabullah para and Gochi under East Gujra union and finally they participated in the FGDs. The findings of the FGDs are given below:

- All affected land owners for the proposed substation reuested to give propoer compenstation of the land as the value of lanfd in that area is very high.
- They also demanded the crop compensation during land acquisition for the substation
- Priority of Employement in the substation during construction and operation phase should be given to local people.
- Proper mitigation measures should be undertaken by the authority to avoid negative impacts of the substation construction.

15.3.4 In Depth Interview:

a) Transmission LIne

In Depth interviews were conducted with **81 local administrative officials, local elites** of 18 upazilas along the proposed transmission line. The list of local administrative officials, local elites is given below:

Division	District	Upazilla	UNO	Land Officer	Fisheries Officer	Agri. Officer	Statistical Officer	Education Officer	NGO Worker	UP.Chairman/ UP Member	P.H.E	Total
Dhaka	Narayangonj	Sonergaon	1	-	-	1	1	1	-	-	1	5
	Munshigonj	Gozaria	1	1	1	1	-	1	1	1	1	8
Chittagong	Chadpur	Kachua	-	1	1	1	-	1	1	-	-	5
	Comilla	Doudkandi	-	-	1	1	1	-	1	-	1	5
		Barura	-	1	1	1	-	-	1	-	-	4
		Laksham	-	-	1	-	-	1	1	-	1	4
		Nangalkot	1	-	1	1	1	1	-	1	-	6
	Feni	Feni Sadar	-	1	1	1	-	1	-	1	1	6
		Dagonbhuyen	-	1	1	1	1	1	1	-	-	6
		Chhagalnaiya	1	-	-	1	1	1	1	-	-	5
	Chittagong	Mirsarai	-	-	1	1	-	1	-	1	1	5
		Fatikchhari	-	-	-	1	-	-	-	-	-	1
		Hathazari	-	-	1	1	1	-	-	-	-	3
		Raozan	-	-	1	1	1	1	1	-	-	5
		Boalkhali	-	-	-	1	1	-	1	-	-	3
		Patiya	1	-	1	-	-	-	-	-	-	2
		Anowara	-	1	1	1	-	1	-	1	-	5
		Banshkhali	-	-	1	1	1	-	-	-	-	3
Total=			**5**	**6**	**14**	**16**	**9**	**11**	**9**	**5**	**6**	**81**

The findings of in depth interviews are given below:

Under the 2 Zillas of Dhaka Division (Narayanganj and Munshiganj), and 4 Zillas of Chittagong division (Chittagong, Comilla, Feni, Chandpur); in total of 18 Upazillas a 400kV transmission line from Meghnaghat to Matarbari of Moheshkhali Upazilla this transmission line will be established. So, information has been collected through discussion from the in charge officials of these 2 divisions. During this course, many of the officials refrained from attending the conversation sessions and from giving information, since they did not receive any official letter from their respective ministries. However, since many of the official members were out spending their leaves and also many official members were absent from their workplace, it was not

possible to record their opinion and collect information accordingly. As a result, under this transmission line, in total of 18 Upazillas, 81 members of different hierarchy were interviewed and their opinions were taken in to our respective account. We nonetheless, showed our gratitude to all the members who gave their opinions regarding this topic from their busy schedule and precious time. The members from these two divisions were interviewed and their vital opinions and input on the establishment of the transmission line were recorded mainly focusing on two aspects; the benefits that they will receive in the future from this transmission line and the likely environmental hazards that may be resulted from this transmission line.

b) Substation:

In depth interview with Chairman and one member of East Gujra Union Council, one school teacher, one journalist and one Moaque imam of East Gujra union were conducted.

The findings of in depth interviews are given below:

Positive perceptions:

- Bangladesh will be developed
- Agricultural sector will be benefited
- Education system of Bangladesh will be benefited
- Employment opportunities will be created in the project area
- Load shedding will decrease/power shortage will decrease
- Industrial sector will flourish with job opportunities and increase the number of job vacancies
- The lifestyle of local people will be improved
- The demand of everyday electricity consumption will be fulfilled
- It will further improve the technological aspect of this country
- Social development will be achieved.

Negative perceptions:

- The establishment of the transmission line/Sub-Station may result in cutting down of many trees
- Many birds may lose their lives from electrical short-circuit
- Some Crops may be damaged
- Day by day Agricultural lands will decrease
- Environment will be polluted due to rapid industrialization
- The natural habitat of mammalian / birds will be affected

Balanced Perceptions:

As the 400 kV Transmission Line/ Sub-Station will go over the populated villages, it has to be kept in mind that its establishment does not create any negative social, economic and environmental impact. The health issues of the population have to be prioritized and focused so that they do not become a victim from the project. If there is damage to the land acquired trees, houses, proper compensation has to be provided.

Chapter XVI Conclusion, Recommendation, Commitments

16.1 Conclusion

a) Transmission Lines:

The routes of all transmission lines have been selected avoiding households, trees and protected areas. Some part of 400kV transmission line will pass through reserved forest area only. As per Electricity Act, no land acquisition will be required for construction of transmission lines. Construction area for the transmission line can be reused for farming after the completion of the construction, except for the $2m^2$ x 4 = $8m^2$ of land for tower bases, and any adverse effects on income will be very limited.

As the land to be acquired for each transmission tower is small, it is not expected that there will be any semi-permanent loss of livelihood means. Also, all standing crops and trees lost by the land owners will be compensated with a market price.

The transmission line route has been selected to avoid steep sloping land, and any slopes used shall be reinforced with concrete, plantation or other means to minimize soil runoff and turbid water generation.

Installing lights or signs will be considered in order to prevent birds from striking the transmission lines.

c) Sub-stations:

The proposed Meghnaghat 400kV substation and old Madunghat 230kV substation will be located within the PGCB's own land already acquired and developed. So, no land acquisition will be required for these two substations. However, the proposed madunaghat 400kV substation will require land acquisition causing loss of livelihood of affected land owners. It was suggested to compensate the affected land owners with adequate compensation for land and standing crops etc.

The study reveals that the adverse impacts of construction of transmission lines and substations on natural and social environment are very low. These could be offset or minimized if the mitigation measures are adequately implemented.

16.2 Recommendation

The environmental assessment carried out for the proposed 400kV transmission line from Meghnaghat to Matarbari via Madunaghat and the proposed 400kV and 230kV substations suggests low scale of adverse impacts, which can be reduced to acceptable level through recommended mitigation measures as mentioned in the Environmental Management Plan. It is therefore recommended that the proposed transmission lines and substations may be installed, provided the suggested mitigation measures are adequately implemented. It is also recommended that the environmental monitoring plan be effectively implemented in order to identify any changes in the predicted impacts and take appropriate measures to off-set any unexpected adverse effects.

Annex-1.1: DoE letter for Exemption of IEE and Approval of TOR for EIA

Government of the People's Republic of Bangladesh
Department of Environment
Head Office, E-16 Agargaon
Dhaka-1207
www.doe.gov.bd

Memo No: DoE/Clearance/5339/2014/ 229 Date: 11 /09/2014

Subject: Exemption of IEE and Approval of Terms of Reference (TOR) for EIA of Meghnaghat-Madunaghat-Matarbari 400KV Transmission Line Project.

Ref: Your Application dated 08/07/2014.

With reference to the above, the undersigned is directed to convey the exemption of IEE and approval of the Terms of Reference (TOR) for Environmental Impact Assessment (EIA) of Meghnaghat-Madunaghat-Matarbari 400KV Transmission Line Project.

I. Power Grid Company of Bangladesh Ltd. shall submit a comprehensive Environmental Impact Assessment (EIA) considering the overall activity of the proposed Rural Electricity Transmission and Distribution activity in accordance with the TOR and time schedule submitted to the Department of Environment (DOE).

II. The EIA shall incorporate the following components/items in addition to the issues mentioned in the proposed TOR for EIA.

(a) There shall be a new Section on 'Analysis of Suitability for Alternative Routes' this analysis shall be performed, among other approaches, in a GIS based Spatial Decision Support System (SDSS) presenting the suitability of different options for both the interventions;

(b) Refer to Section-8; a detail technical and financial proposal shall be included for developing an in-house environmental monitoring system to be operated by the proponent's own resources (equipments and expertise);

(c) Specific formats for Environmental monitoring shall be included under Section 8.

III. Without approval of EIA report by the Department of Environment, Power Grid Company of Bangladesh Ltd. shall not be able to open L/C in favor of importable machineries.

IV. Without obtaining Environmental Clearance, Power Grid Company of Bangladesh Ltd. shall not be able to start the physical activity of the project.

1

V. Power Grid Company of Bangladesh Ltd. shall submit the EIA along with a filled-in application for Environmental Clearance in prescribed form, the applicable fee in a treasury chalan, the no objection certificates (NOCs) from the local authority, NOCs from forest department (if it is required in case of cutting any forested plant, private or public) and NOC from other relevant agencies for operational activity etc. to the Head Office of DOE with a copy to concerned Divisional offices of DOE.

11.09.2014

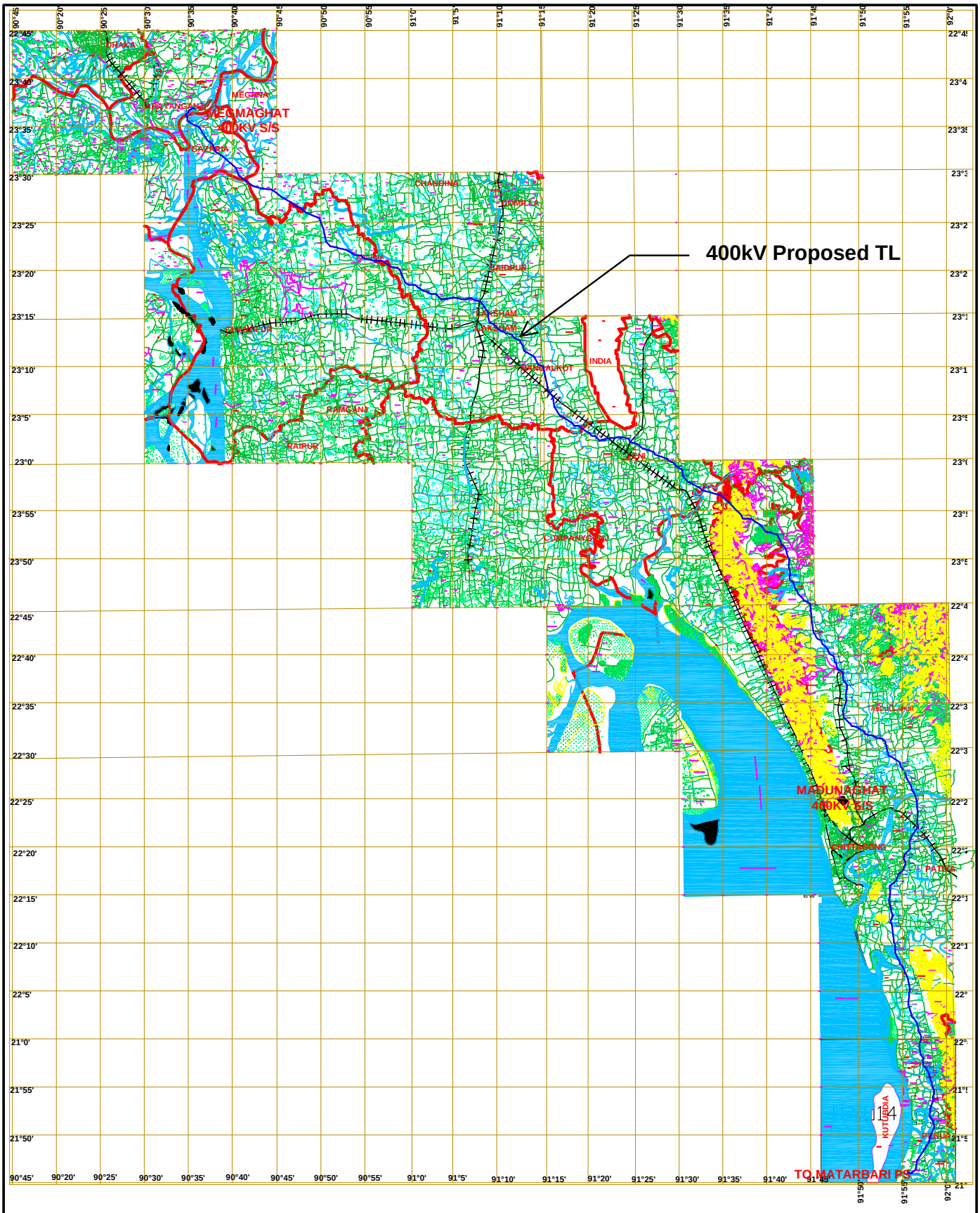
(**Syed Nazmul Ahsan**)
Deputy Director (Environmental Clearance)
and
Member Secretary
Environmental Clearance Committee
Phone # 8181778

Project Director
Meghnaghat-Madunaghat-Matarbari 400KV Transmission Line Project
Power Grid Company of Bangladesh (PGCB) Ltd.
Institution of Engineers Bangladesh (IEB) Bhaban (New) 3rd & 4th Floor
Ramna, Dhaka-1000

Copy Forwarded to :

1) Private Secretary to the Hon'ble Secretary, Ministry of Environment and Forests, Bangladesh Secretariat, Dhaka.
3) Director, Department of Environment, Dhaka/Chittagong Divisional Office, Dhaka/Chittagong.
4) Assistant Director, Office of the Director General, Department of Environment, Head Office, Dhaka.

Annex-5.3: Geographic Map of Bangladesh showing the selected Route of TL



LEGEND	CONSULTANT	TITLE OF DRAWING	
Highway Road, ... Railway Line ..... Boundary International,Demarcated..... Building, ... Bridge, Culvert ..... River, Canal..... Forest/Tree ..... GRASS, Cane,Bamboo Plantain.....	ENGINEERS ASSOCIATES LTD. Flat No. A-3, (3rd Floor - South Side) House No.1/3, Asad Gate Road Mohammadpur Housing Estate Dhaka - 1207	GEOGRAPHIC MAP SHOWING THE PROPOSED ROUTE OF 400KV TL FROM MEGHNAGHAT TO MATARBARI VIA MODUNAGHAT	SCALE N

Annex-7.4.3.2.: Earthquake Data of in and around Bangladesh from 1918 to 2014

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

BANGLADESH METEOROLOGICAL DEPARTMENT

(CLIMATE DIVISION)

METEOROLOGICAL COMPLEX , AGARGAON ,

DHAKA-1207.

Sub : Earthquake data of in and around Bangladesh from 1918 to 2014 .

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
08-07-1918	-	-	-	24	30	91	00	7.6	Major
09-09-1923	-	-	-	25	18	91	00	7.1	Major
02-09-1930	-	-	-	25	30	90	00	7.1	Major
24-03-1932	-	-	-	25	00	90	00	7.4	Major
27-03-1932	-	-	-	24	30	92	00	7.4	Major
09-11-1932	-	-	-	26	30	92	00	7.4	Major
06-03-1933	-	-	-	26	00	90	30	7.6	Major
21-05-1935	-	-	-	28	48	89	18	6.3	Strong
21-01-1941	-	-	-	27	00	92	00	6.8	Strong
23-02-1954	-	-	-	28	30	91	30	6.5	Strong
22-02-1959	-	-	-	28	30	91	30	5.7	Moderate
18-02-1964	-	-	-	27	30	91	06	5.6	Moderate
06-11-1965	-	-	-	27	12	91	36	4.8	Light
06-09-1967	-	-	-	24	06	91	42	5.0	Moderate
15-09-1967	-	-	-	27	24	91	48	5.8	Moderate
14-11-1967	-	-	-	25	00	91	30	5.1	Moderate
27-12-1968	-	-	-	24	06	91	36	5.2	Moderate
05-11-1969	-	-	-	27	42	90	12	5.0	Moderate
25-07-1970	-	-	-	25	42	88	30	5.2	Moderate
28-08-1970	-	-	-	24	42	91	42	4.9	Light
02-02-1971	-	-	-	23	48	91	48	5.4	Moderate
31-10-1971	-	-	-	26	12	90	42	4.6	Light
06-11-1972	-	-	-	27	00	88	42	4.8	Light
21-09-1974	-	-	-	25	42	90	54	4.7	Light
23-06-1976	-	-	-	21	24	88	42	5.3	Moderate
21-05-1984	09	59	35	23	42	91	30	5.3	Moderate
30-09-1984	21	35	24	25	24	91	30	5.4	Moderate
03-05-2007	16	52	44	25	40	91	00	4.1	Light
08-05-2007	23	16	55	25	21	90	10	3.6	Minor
18-05-2007	18	39	43	28	05	90	12	4.7	Light
20-05-2007	20	18	16	27	15	88	44	5.3	Moderate
25-06-2007	06	19	30	22	57	91	52	2.8	Very Minor
11-08-2007	20	36	04	26	27	89	24	4.9	Light
31-08-2007	18	06	33	23	04	90	45	3.9	Minor
19-09-2007	01	48	59	25	18	90	59	4.6	Light
13-03-2008	21	42	40	27	46	91	00	4.5	Light
20-03-2008	19	15	50	24	42	90	38	4.4	Light
09-05-2008	04	20	51	23	51	91	47	3.6	Minor
24-05-2008	15	41	53	27	59	89	15	3.2	Minor
29-05-2008	16	35	16	26	24	91	46	4.9	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
05-07-2008	22	56	19	26	07	91	39	5.1	Moderate
06-07-2008	09	05	38	26	56	88	46	4.0	Light
20-09-2008	17	16	23	23	50	91	07	4.8	Light
20-09-2008	17	42	45	23	19	90	50	3.3	Minor
20-09-2008	17	51	41	23	41	91	03	4.6	Light
20-09-2008	18	00	52	23	33	91	01	4.8	Light
20-09-2008	18	21	30	23	48	91	06	4.3	Light
21-09-2008	07	55	19	23	28	90	56	3.0	Minor
21-09-2008	08	29	37	23	48	91	03	2.9	Very Minor
21-09-2008	09	13	06	23	19	90	56	2.8	Very Minor
26-09-2008	10	00	12	24	25	90	24	3.3	Minor
26-09-2008	10	00	15	23	25	89	54	3.1	Minor
01-10-2008	07	01	24	24	23	90	13	3.5	Minor
04-10-2008	08	46	45	24	24	90	20	2.8	Very Minor
09-11-2008	13	15	21	26	32	88	21	3.6	Minor
19-11-2008	05	00	49	24	17	90	47	4.1	Light
19-11-2008	05	15	20	24	27	90	25	4.0	Light
19-12-2008	17	52	48	21	00	90	43	4.4	Light
25-12-2008	06	26	37	27	04	88	15	4.5	Light
05-01-2009	13	03	54	27	22	90	53	4.8	Light
06-01-2009	22	03	22	24	11	89	25	4.7	Light
29-01-2009	06	34	57	23	33	88	54	3.6	Minor
09-02-2009	04	58	45	23	58	91	21	3.1	Minor
16-02-2009	01	36	00	26	15	90	01	4.0	Light
27-02-2009	16	42	40	20	29	89	31	4.8	Light
14-04-2009	03	11	23	24	09	91	29	3.7	Minor
19-04-2009	12	33	26	25	37	91	28	3.4	Minor
25-04-2009	20	29	26	26	24	91	42	4.1	Light
05-05-2009	14	40	50	26	32	89	01	3.4	Minor
15-05-2009	15	59	47	25	36	91	56	3.0	Minor
26-06-2009	19	51	47	23	15	91	10	3.7	Minor
13-07-2009	14	39	13	26	09	89	39	4.5	Light
21-09-2009	15	53	02	27	40	91	36	6.4	Strong
21-09-2009	16	16	53	27	21	91	28	4.9	Light
21-09-2009	16	38	41	27	20	91	13	4.7	Light
21-09-2009	17	22	22	27	43	91	14	4.6	Light
21-09-2009	21	34	07	27	31	91	25	4.4	Light
22-09-2009	04	45	49	27	30	91	25	3.9	Minor
23-09-2009	09	01	31	26	15	89	24	4.3	Light
30-10-2009	00	00	28	27	29	91	36	5.2	Moderate
30-10-2009	02	56	59	26	40	90	01	4.2	Light
08-11-2009	06	00	35	26	43	88	10	4.6	Light
18-11-2009	07	49	06	27	35	90	01	4.4	Light
19-11-2009	16	03	03	26	03	90	53	3.9	Minor
15-12-2009	12	45	05	21	42	91	56	3.4	Minor
31-12-2009	16	57	26	27	31	91	15	5.4	Moderate
10-03-2010	13	38	55	24	50	90	38	4.1	Light
12-06-2010	22	13	05	23	59	91	24	4.0	Light
21-07-2010	08	57	22	27	12	91	10	4.5	Light
31-07-2010	06	15	41	23	09	90	36	3.7	Minor
10-09-2010	22	39	58	23	09	90	29	3.6	Minor
10-09-2010	23	24	19	23	14	90	45	4.8	Light
11-09-2010	13	02	09	25	52	90	39	5.2	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
15-09-2010	03	33	19	23	12	90	40	3.9	Minor
21-09-2010	13	57	29	24	48	94	45	4.4	Light
21-10-2010	14	08	48	22	23	94	20	4.5	Light
18-11-2010	07	21	29	23	50	94	17	4.1	Light
24-11-2010	02	34	05	23	15	94	00	4.3	Light
12-12-2010	07	40	02	24	42	93	27	4.8	Light
19-12-2010	14	47	14	24	19	94	31	4.0	Light
29-12-2010	20	04	01	25	53	92	03	3.5	Minor
01-01-2011	16	15	04	22	57	88	35	3.9	Minor
18-01-2011	08	15	54	24	35	95	05	4.8	Light
27-01-2011	12	10	39	23	55	93	14	4.4	Light
28-01-2011	04	40	06	24	07	94	03	4.6	Light
01-02-2011	14	52	48	23	51	91	35	4.3	Light
04-02-2011	19	53	48	24	51	94	35	6.4	Strong
10-02-2011	09	51	53	26	41	88	28	4.0	Light
12-02-2011	16	22	42	23	28	91	15	4.3	Light
13-02-2011	22	42	10	22	45	94	40	4.4	Light
13-02-2011	23	51	23	27	26	87	12	4.5	Light
15-02-2011	05	44	34	26	44	95	46	4.5	Light
23-02-2011	04	57	13	24	48	94	43	4.2	Light
24-02-2011	03	38	42	23	50	93	25	4.0	Light
24-02-2011	11	36	36	23	20	91	18	4.3	Light
24-02-2011	14	28	14	19	26	94	03	5.0	Moderate
28-02-2011	06	54	55	20	02	95	13	4.4	Light
06-03-2011	06	18	10	23	43	94	05	4.5	Light
08-03-2011	23	48	28	22	52	94	00	4.5	Light
20-03-2011	23	31	37	23	25	94	08	4.6	Light
24-03-2011	19	55	12	20	07	99	49	6.8	Strong
24-03-2011	21	52	45	20	30	99	47	5.4	Moderate
25-03-2011	06	23	25	20	48	99	48	5.0	Moderate
03-04-2011	14	48	10	25	21	90	35	3.0	Minor
07-04-2011	16	34	41	22	16	94	24	4.6	Light
08-04-2011	11	39	40	21	55	94	14	4.6	Light
19-04-2011	09	34	01	24	35	94	18	4.5	Light
24-04-2011	08	23	10	28	17	88	07	4.6	Light
25-04-2011	23	00	35	25	30	93	10	4.2	Light
03-05-2011	20	38	56	23	34	91	02	4.6	Light
05-05-2011	02	56	19	30	21	80	36	5.0	Moderate
07-05-2011	07	47	17	23	18	94	35	4.6	Light
14-05-2011	16	21	17	36	03	70	56	4.8	Light
15-05-2011	03	07	05	36	41	70	59	5.9	Moderate
24-05-2011	09	14	15	25	19	92	28	3.3	Minor
26-05-2011	19	25	46	21	22	94	24	4.5	Light
31-05-2011	19	15	41	25	42	98	42	4.5	Light
01-06-2011	00	45	03	24	32	94	41	4.3	Light
03-06-2011	06	53	22	27	44	88	17	4.9	Light
03-06-2011	13	27	00	09	41	92	53	5.6	Moderate
09-06-2011	13	34	24	23	26	89	44	4.5	Light
20-06-2011	12	27	06	30	24	79	32	4.9	Light
20-06-2011	16	17	36	24	59	98	50	5.3	Moderate
21-06-2011	10	50	59	23	24	90	52	4.0	Light
23-06-2011	18	39	36	23	46	91	41	4.5	Light
26-06-2011	05	40	39	23	43	93	49	4.6	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
01-07-2011	03	45	33	25	50	93	25	3.6	Minor
03-07-2011	06	15	10	25	28	92	01	3.6	Minor
10-07-2011	06	40	25	21	10	93	08	4.8	Light
11-07-2011	05	16	08	21	14	94	21	4.2	Light
14-07-2011	18	15	14	22	38	92	35	3.2	Minor
16-07-2011	01	59	37	27	51	87	47	4.4	Light
22-07-2011	06	58	49	24	21	92	03	4.1	Light
28-07-2011	23	53	39	25	02	88	58	4.4	Light
01-08-2011	06	26	08	24	05	93	42	4.0	Light
09-08-2011	17	50	00	24	48	98	44	5.0	Moderate
15-08-2011	19	14	37	24	36	94	29	3.7	Minor
24-08-2011	12	17	25	23	47	91	38	4.0	Light
27-08-2011	06	56	00	23	26	90	54	4.0	Light
31-08-2011	20	53	26	26	33	89	25	3.8	Minor
04-09-2011	21	18	19	24	42	90	04	3.2	Minor
05-09-2011	02	52	47	25	14	94	06	4.2	Light
16-09-2011	19	31	06	25	45	94	14	4.5	Light
18-09-2011	18	40	49	27	48	88	17	6.8	Strong
18-09-2011	19	11	58	27	31	88	41	5.3	Moderate
18-09-2011	19	54	20	27	19	88	24	4.6	Light
19-09-2011	01	20	49	25	54	91	01	4.1	Light
19-09-2011	14	04	09	24	06	94	39	3.7	Minor
22-09-2011	20	17	30	23	41	94	53	4.8	Light
23-09-2011	19	23	16	24	39	93	45	4.2	Light
16-10-2011	06	53	32	22	56	93	55	3.7	Minor
20-10-2011	23	18	38	21	32	70	09	5.1	Moderate
21-10-2011	20	40	29	24	43	93	59	4.6	Light
02-11-2011	14	57	36	23	23	90	53	4.1	Light
04-11-2011	16	15	31	24	05	92	59	4.3	Light
05-11-2011	10	45	06	24	45	90	22	4.1	Light
07-11-2011	17	59	12	36	28	71	00	5.5	Moderate
11-11-2011	15	57	34	26	43	89	01	4.5	Light
21-11-2011	09	15	38	24	49	95	03	5.9	Moderate
28-11-2011	21	06	58	25	14	97	38	5.1	Moderate
29-11-2011	19	37	41	22	06	93	13	4.5	Light
01-12-2011	01	42	27	07	39	93	54	5.3	Moderate
03-12-2011	01	37	35	07	31	93	57	5.4	Moderate
11-12-2011	07	28	42	23	44	92	29	3.2	Minor
13-12-2011	21	09	04	25	12	91	18	3.5	Minor
16-12-2011	14	49	04	23	31	92	43	3.3	Minor
1-01-2012	08	35	20	23	28	91	45	4.1	Light
12-01-2012	04	23	10	25	05	95	02	4.3	Light
10-02-2012	21	43	02	26	43	93	57	4.4	Light
25-02-2012	14	45	56	26	18	88	42	3.8	Minor
26-02-2012	21	55	31	24	42	93	42	4.4	Light
06-03-2012	08	32	39	08	21	93	28	5.5	Moderate
12-03-2012	12	06	40	36	13	73	03	5.7	Moderate
18-03-2012	08	56	10	23	41	90	12	4.6	Light
28-03-2012	05	40	13	26	03	87	54	4.8	Light
29-03-2012	06	23	13	21	37	94	42	4.5	Light
11-04-2012	14	38	30	02	03	92	26	8.7	Great
11-04-2012	16	43	09	00	41	92	27	8.1	Great
13-04-2012	16	11	43	25	08	94	59	4.3	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
14-04-2012	21	16	54	06	17	91	51	5.4	Moderate
15-04-2012	11	57	36	02	34	92	06	6.2	Strong
21-04-2012	05	14	23	01	40	93	12	6.1	Strong
25-04-2012	13	42	24	08	59	93	08	5.7	Moderate
27-04-2012	17	12	36	24	24	93	11	3.8	Minor
30-04-2012	14	00	06	01	45	89	16	5.7	Moderate
30-04-2012	19	07	00	15	02	93	11	5.4	Moderate
09-05-2012	05	12	47	20	55	94	09	4.1	Light
11-05-2012	18	41	36	25	52	92	59	5.3	Moderate
25-05-2012	01	39	13	14	07	93	10	4.9	Light
27-05-2012	21	01	32	26	33	91	31	4.4	Light
28-05-2012	11	25	25	23	14	94	24	3.8	Minor
30-05-2012	15	28	06	24	34	95	09	4.5	Light
11-06-2012	11	02	10	35	16	68	56	5.4	Moderate
11-06-2012	11	29	07	36	09	69	18	5.6	Moderate
12-06-2012	23	02	10	23	41	94	17	4.7	Light
01-07-2012	10	13	53	25	31	94	42	5.5	Moderate
08-07-2012	18	53	18	21	44	92	45	3.6	Minor
10-07-2012	02	13	09	25	38	96	08	5.2	Moderate
10-07-2012	19	03	31	26	25	93	08	4.4	Light
12-07-2012	20	00	14	36	07	70	36	5.8	Moderate
15-07-2012	01	55	10	25	29	94	29	5.6	Moderate
17-07-2012	05	16	27	26	09	95	34	4.4	Light
17-07-2012	12	00	45	24	04	92	27	3.9	Minor
19-07-2012	13	36	28	37	25	71	59	5.7	Moderate
22-07-2012	08	11	10	25	16	96	09	5.2	Moderate
29-07-2012	08	21	15	23	06	94	12	5.6	Moderate
02-08-2012	19	17	03	20	53	90	17	4.7	Light
03-08-2012	01	05	51	26	29	96	31	5.1	Moderate
05-08-2012	12	36	44	24	30	98	59	4.3	Light
19-08-2012	15	24	43	26	35	92	31	4.9	Light
22-08-2012	16	23	36	23	48	91	14	3.4	Minor
23-08-2012	22	30	15	28	17	82	51	5.0	Moderate
07-09-2012	00	27	10	24	02	91	42	3.8	Minor
11-09-2012	17	09	22	23	50	94	24	4.5	Light
13-09-2012	01	29	16	36	45	71	43	5.1	Moderate
23-09-2012	02	43	16	25	21	96	51	4.7	Light
25-09-2012	14	32	55	36	46	69	17	5.2	Moderate
29-09-2012	17	23	40	06	10	92	46	5.3	Moderate
03-10-2012	00	37	33	26	51	92	48	5.1	Moderate
16-10-2012	05	43	35	36	14	69	47	5.0	Moderate
26-10-2012	07	50	20	24	08	92	46	3.8	Minor
03-11-2012	03	31	49	24	28	94	58	4.5	Light
11-11-2012	07	12	48	23	47	95	55	6.6	Strong
11-11-2012	16	54	42	22	47	95	43	5.7	Moderate
12-11-2012	00	19	41	23	13	95	59	5.7	Moderate
14-11-2012	00	28	19	23	31	95	47	4.9	Light
15-11-2012	04	10	00	23	20	91	31	3.6	Minor
19-11-2012	23	25	45	23	01	96	04	4.8	Light
23-11-2012	16	24	21	22	42	96	01	4.2	Light
25-11-2012	12	01	42	23	36	91	26	4.3	Light
30-11-2012	09	51	57	25	10	96	00	4.2	Light
01-12-2012	01	39	35	27	20	88	28	4.6	Light

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
03-12-2012	17	55	25	23	11	95	47	4.5	Light
13-12-2012	14	41	53	25	48	90	35	3.7	Minor
13-12-2012	16	05	15	22	47	92	43	3.8	Minor
14-12-2012	08	17	48	22	41	96	00	4.7	Light
17-12-2012	18	47	49	24	44	92	24	3.5	Minor
18-12-2012	17	51	58	25	23	96	29	4.6	Light
22-12-2012	22	41	47	22	24	94	36	5.5	Moderate
26-12-2012	19	59	46	22	49	95	32	4.8	Light
26-12-2012	21	14	43	22	39	93	42	4.0	Light
26-12-2012	21	20	46	22	19	95	46	4.0	Light
30-12-2012	14	16	39	24	00	91	56	4.1	Light
03-01-2013	11	47	28	24	25	93	49	4.3	Light
09-01-2013	07	41	52	25	20	94	57	5.9	Moderate
15-01-2013	17	16	59	23	54	94	26	4.5	Light
20-02-2013	03	05	22	25	24	89	00	4.5	Light
27-02-2013	18	26	56	26	29	90	31	3.8	Minor
02-03-2013	07	30	43	24	14	92	00	5.4	Moderate
04-03-2013	22	05	24	26	17	91	21	4.1	Light
05-03-2013	02	15	44	25	01	93	04	3.9	Minor
06-03-2013	22	50	01	28	18	82	04	5.0	Moderate
01-04-2013	02	04	54	23	24	95	58	5.0	Moderate
03-04-2013	22	35	45	18	43	95	03	5.8	Moderate
04-04-2013	21	16	25	19	18	95	44	5.7	Moderate
11-04-2013	09	47	03	19	29	95	56	5.2	Moderate
16-04-2013	07	23	25	25	53	91	49	4.5	Light
16-04-2013	14	34	03	28	49	95	08	5.3	Moderate
22-04-2013	01	35	24	23	08	94	07	4.7	Light
25-04-2013	20	54	53	24	29	92	28	3.2	Minor
07-05-2013	02	19	46	20	07	99	35	4.8	Light
01-06-2013	19	28	34	22	08	88	19	3.6	Minor
03-06-2013	12	40	41	24	07	91	31	3.3	Minor
18-06-2013	06	57	50	23	59	91	24	3.5	Minor
20-06-2013	08	41	40	24	51	90	11	3.9	Minor
08-07-2013	09	44	29	23	47	91	24	4.4	Light
20-07-2013	15	14	13	21	59	94	04	4.7	Light
02-08-2013	18	04	24	24	05	94	40	5.2	Moderate
09-08-2013	05	59	17	20	34	94	10	4.9	Light
11-08-2013	14	24	08	25	15	91	43	3.5	Minor
17-08-2013	20	41	14	11	24	93	18	4.8	Light
04-09-2013	08	43	36	23	47	92	22	3.4	Minor
14-09-2013	21	53	25	23	46	93	04	3.4	Minor
03-10-2013	12	12	35	27	16	88	24	5.5	Moderate
30-10-2013	00	09	13	27	21	91	01	4.4	Light
06-11-2013	10	16	19	26	12	93	04	5.5	Moderate
13-11-2013	01	52	09	24	30	94	18	4.0	Light
04-12-2013	19	05	12	26	24	88	20	4.5	Light
07-12-2013	10	41	52	23	55	91	32	3.6	Minor
17-12-2013	14	30	17	23	42	91	14	3.6	Minor
17-12-2013	14	56	31	23	38	91	20	4.2	Light
20-12-2013	09	04	37	15	13	93	20	4.8	Light
23-12-2013	16	41	26	24	05	92	36	3.6	Minor
26-012014	18	38	46	23	26	95	38	4.9	Light
29-01-2014	19	46	48	23	52	93	42	5.2	Moderate

Date	Time of Occurrence (BST)			Location of Epicentre				Magnitude in Richter's Scale	Intensity
				Latitude (^{0}N)		Longitude (^{0}E)			
	Hrs.	Mts.	Secs.	Deg.	Mts.	Deg.	Mts.		
30-01-2014	18	17	16	22	53	94	02	4.7	Light
14-02-2014	19	10	48	25	04	89	45	4.1	Light
23-02-2014	23	05	03	26	20	90	21	4.5	Light
27-02-2014	02	58	47	24	10	93	42	4.1	Light
28-02-2014	19	11	27	23	53	91	07	3.6	Minor
22-03-2014	14	35	23	22	59	94	18	4.6	Light
28-03-2014	09	10	11	26	28	95	52	4.4	Light
01-04-2014	23	45	05	26	21	92	28	4.4	Light
04-04-2014	12	57	03	23	03	93	07	4.0	Light
18-04-2014	05	57	57	24	24	90	31	3.6	Minor
21-05-2014	22	21	58	18	08	87	50	6.1	Strong
28-05-2014	09	19	11	24	44	94	41	4.7	Light
29-05-2014	09	23	47	24	21	94	07	4.3	Light
30-05-2014	12	37	10	26	38	90	27	4.4	Light
04-06-2014	13	20	19	23	08	93	07	4.3	Light

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH
BANGLADESH METEOROLOGICAL DEPARTMENT
(CLIMATE DIVISION)
METEOROLOGICAL COMPLEX , AGARGAON ,
DHAKA-1207.

Sub :- Historical Earthquake Record .

Location of Epicenter	Date of Occurrence	Magnitude in Richter Scale
Dispur , Assam , India	893	-
West Bengal , India	1737	-
Arakan , Myanmar	1762	8.4
Tibet , China	16-08-1833	8.0
Kachar , Assam , India	10-01-1869	7.5
Eastern Province , Nepal	14-07-1885	7.0
Shilang , Meghalaya , India	12-06-1897	8.8
Dauki , Meghalaya , India	08-07-1918	7.6
Assam , India	09-09-1923	7.1
Dhubri , Assam , India	02-07-1930	7.1
Eastern Province , Nepal	15-01-1934	8.4
Assam , India	1935	7.5
Tibet , China	15-08-1950	8.6
Arunachal , India	15-08-1950	8.5
Manipur , India	15-08-1950	8.0
Arunachal , India	16-08-1950	7.0
Manipur , India	16-08-1950	6.6
Assam , India	16-08-1950	6.7
Assam , India	26-08-1950	7.0
Assam , India	13-09-1950	7.0
Arunachal , India	30-09-1950	6.7
Arunachal , India	08-10-1950	6.6
Assam ,India	07-04-1951	6.8
Assam , India	21-03-1954	7.2
Assam , India	01-07-1957	7.2
Assam , India	22-03-1958	6.5
Tibet , China	29-07-1960	6.5
Myanmar	12-07-1964	6.7
Dauki , Meghalaya , India	08-05-1997	6.0
Arakan , Myanmar	21-11-1997	8.5
Arakan , Myanmar	22-07-1999	5.2
South-East Bay of Bengal	10-08-2009	7.8
North-East Bhutan	21-09-2009	6.4
Arakan , Myanmar	21-09-2009	5.4
South-East Bay of Bengal	07-04-2010	7.8
Andaman Islands , India	01-06-2010	6.3
Nicobar Islands , India	13-06-2010	7.7
South-West Pakistan	19-01-2011	7.2
Myanmar-India Border	04-02-2011	6.4
Myanmar	24-03-2011	6.8
Sikkim , India	18-09-2011	6.8

Annex-7.5: Analysis Sheets of Air Quality & Noise Level

Analyisis Sheet of Ambient Air Sample Beside BSCIC, Potiya, Chittagong.

Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound dBa	Remarks
11/07/2009	BSCIC, Potiya	219	8.5	14.4	74.5	-
Standard Limit	-	200	80	100	60	-

Note:- 1, Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3. SOx-Oxides of Sulphur.

04. dBa-Decibel. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

Analysis Sheet Ambient Air & Sound Sample of Main Road Mirsarai, Chittagong.

Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound Level	Remarks
30/09/2010	Dhaka –Ctg Road Side	223	9.0	16.3	75.3 dBa	-
Standard Limit.	-	200	80	100	60	-

Note:- 1, Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3. SOx-Oxides of Sulphur.

04. dBa-Decibel. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

Analyisis Sheet of Ambient Air Sample Bazar side of Shakpura, Boalkhali, Chittagong.

Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound dBa	Remarks
12/07/2010	Bazar road side	86	4.0	7.0	69.7 dBa	-
Standard Limit.	-	200	80	100	60	-

Note:- 1, Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3. SOx-Oxides of Sulphur.

04. dBa-Decibel. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

Analysis Sheet Ambient Air & Sound Sample of Beside Korean Export Processing Zone, Anowara, Chittagong.

Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound Level dBa	Remarks
20/11/2011	Beside Kafco R/A.	73	ND	ND	69.4 dBa	-
Standard Limit.	-	200	80	100	60	-

Note:- 1, Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3. SOx-Oxides of Sulphur.

04. dBa-Decibel. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

Analyisis Sheet Ambient Air & Sound Sample of Joldi Bazar, Bashkhali, Chittagong.

Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound Level dBa	Remarks
15/08/2008	In front of Upzila office	124	4.2	7.3	64.2 dBa	-
Standard Limit	-	200	80	100	60	-

Note:- 1, Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3. SOx-Oxides of Sulphur.

04. dBa-Decibel. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

Analysis Sheet of Ambient Air & Sound Sample of Beside Rail Station, Laksam, Comilla.

Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound Level dBa	Remarks
14/07/2012	North side	78	ND	ND	67.5 dBa	-
Standard Limit.	-	200	80	100	60	-

Note:- 1, SMP- Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3.SOx-Oxides of Sulphur.

04. dBa-Decobel. 5. ND-Not Detectable

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR

Analysis Sheet of Ambient Air & Sound Sample of Chandpur City Area.

Sl.No	Date	Sampling Location	SPM µg/m3	SOx µg/m3	NOx µg/m3	Sound Level	Remarks
01	23/04/10	Beside Rail Station	182	6.0	8.5	74.2 dBa	-
02	23/04/10	BesideBus Stop	209	8.5	12.6	77.3dBa	-
Standard Limit		-	Below200	Below 80	Below100	Below 60 dBa	-

Note:- 1, SMP- Suspended Particulate Matter. 2. NOx- Oxides of Nitrogen. 3.SOx- Sulphur-di-Oxide. 4.dBa- Decibel.

Source : BUET, CUET, Environmental Science (CU), DU and BCSIR