ROADS AND HIGHWAYS DEPARTMENT
MINISTRY OF ROAD TRANSPORTATION AND BRIDGES
THE PEOPLE'S REPUBLIC OF BANGLADESH

PREPARATORY SURVEY
ON
WESTERN BANGLADESH
BRIDGES IMPROVEMENT PROJECT

FINAL REPORT

VOLUME 1: MAIN REPORT

APRIL 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
KATAHIRA & ENGINEERS INTERNATIONAL

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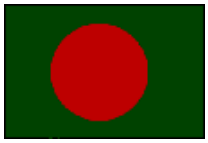
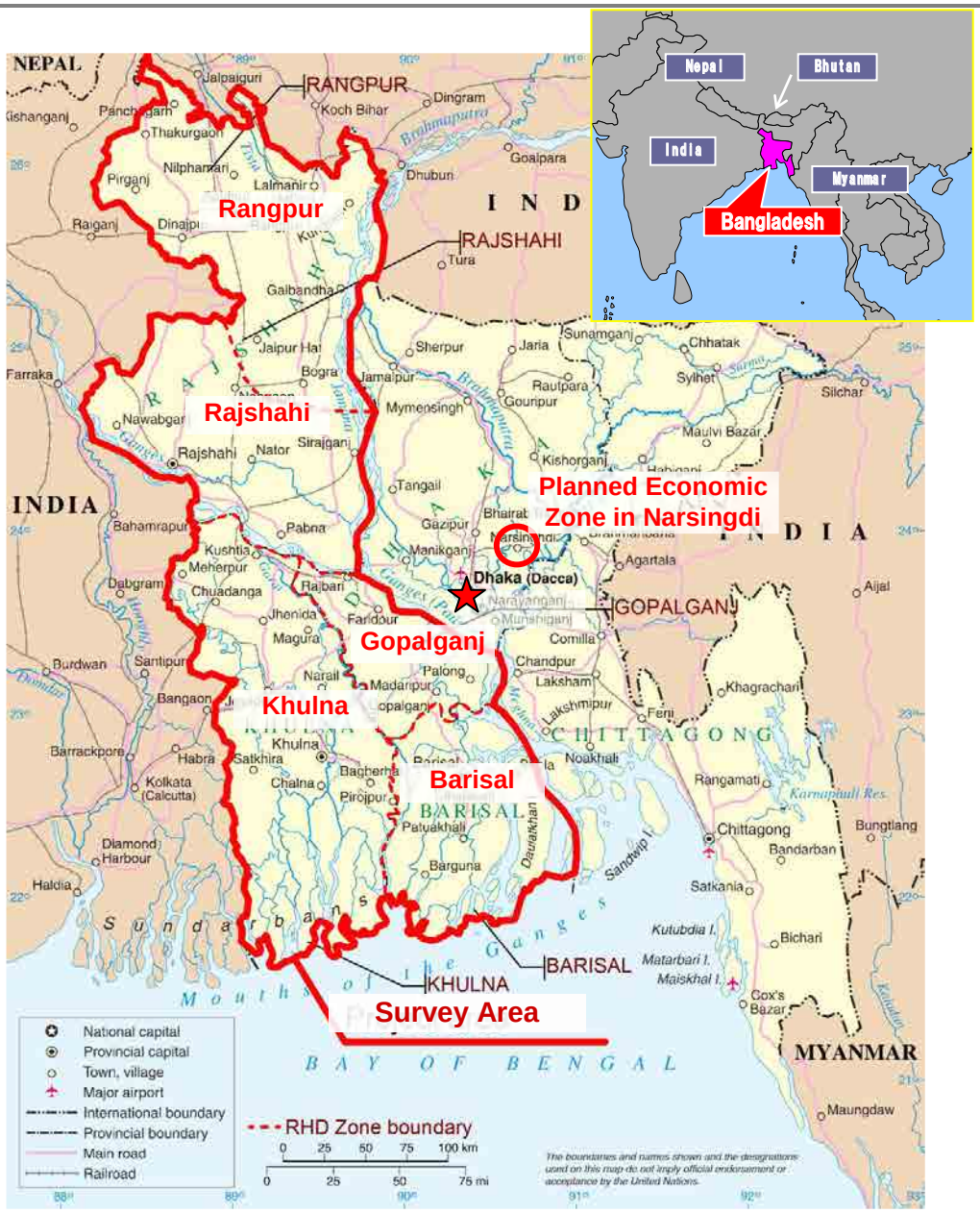
The exchange rates applied in this study are;

USD 1.0= BDT 77.9 = JPY 119.0

BDT: Bangladesh TAKA



People's Republic of Bangladesh



■Area: 144 thousand km2 (About 0.4 times of Japan)

■Population: 152.5million(2013）

■Capital: Dhaka

■Ethnic: Bangalese

■Language: Bengali

■Religion: Muslim (89.7%), Hinduism (9.2%), Buddhism (0.7%), Christianity (0.3%)

■Major industry: Clothing goods, Sewing

■GDP: USD 766.5（2012）

■Price Escalation:　7.97%（2012）

■Economic growth:　6.3%(2012）

■Trade (2012)

(1)Export: USD23.9billion

(Knitwear, Clothing goods)

(2)Import: USD33.3billion

(Petroleum products, Fiber, Chemical product, Mechanical component)

■Exchange rate: USD1＝BDT 77.5(2012)

■ODA Performance of GOJ(2011)

(1)Government loans：JPY 59.97 billion

(2)Grant aid:：JPY 12.67billion

(3)Technical assistance:：JPY 29.04billion

Veiw of Steel-I Girder Bridge

Veiw of PC-I Girder Bridge

Outline of the Project

1. Country: The People'S Republic of Bangladesh

2. Project Name: Preparatory Survey on Western Bangladesh Bridges Improvement Project

3. Execution Agency: Roads and Highways Department under Ministry of Road Transport and Bridges

4. Survey Objectives:

The Objective of the Survey is to obtain all the data and information required for appraisal of the Project as Japanese ODA loan project, such as defining the project objectives and preparing project summary, project cost, implementation structure, implementation schedule, implementation method (procurement, construction), implementation plan, operation and maintenance plan, environment and social considerations, etc.

5. Survey Contents:

[Stage 1] Affirmation of the Project and Selection of Project Bridges

Phase 1: Understanding of Basic Information, Study on Framework of the Project, and Selection of Candidate Bridges

[Stage 2] Study on Main Content of the Project

Phase 2: Site Survey and Determination of Bridge Type

Phase 3: Preliminary Design

Phase 4: Selection of Project Bridges, Preparation for Appraisal of Japanese ODA Loan

[Stage 3] Reporting and Support for JICA Appraisal Mission

Phase 5: Reporting and Support for JICA Appraisal Mission

6. Conclusions and Recommendations:

(1) Conclusions

- The Project is technically and economically feasible and environmentally sound.
- Hence, it is justified to implement the Project for national and people's benefits.
- The Project is comprised of 60 small- and middle-size bridges in Western Bangladesh and the EZ Bridge and Road.
- Confidential
- Three types of bridges are constructed in the Project, namely, PC-I girder bridge, steel-I girder bridge, and steel-box girder bridge.
- Weathering steel is applied for steel bridges.

(2) Recommendations

- Asphalt pavement was selected as a general pavement type in the preliminary design. Adoption of other pavement types such as concrete pavement or stone mastic asphalt (SMA) shall be considered, especially for some sections of the EZ approach road in the detailed design, since a number of heavy vehicles will utilize the EZ Bridge and Road.
- The EZ Bridge and Road will be connected to the existing regional road (R301). The improvement of R301 shall be considered during detailed design stage, since R301 is very narrow and damaged in some sections. R301 may not provide required capacity for increased traffic volume by the construction of the EZ Bridge and Road.
- In this Preparatory Survey, the recommendation for EZ Bridge's foundation type in the river is Cast-in-Place Concrete Pile (φ1500, L=54m, n=16). However, it shall be finally determined by confirming the supporting layer at each pier position based on the geotechnical investigations during the detailed design stage.
- 60 bridges are planned to be constructed at 60 river/water crossings in Western Bangladesh. Construction of box culverts shall be considered for some locations, such as pond crossings not having water flow, as a cost reduction measure in the detailed design.
- Safety measures such as providing road marking, road hump, guardrails, etc. shall be considered in the detailed design. Specifically, the countermeasure for ship collisions to piers of the EZ Bridge shall be important.
- Detailed surveys for public utilities such as waterworks, telephone lines, power lines, etc. shall be conducted in the detailed design. The bridge and road design shall be conducted in consideration of that information.
- RHD shall undertake the tasks for the EIA and ARP during the entire project period in order to implement the Project successfully.

PREPARATORY SURVEY ON WESTERN BANGLADESH BRIDGES IMPROVEMENT PROJECT
EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Background

Aiming at becoming a middle income country by 2021, the People's Republic of Bangladesh (hereinafter referred to as Bangladesh) is experiencing robust economic growth while maintaining a GDP growth rate of around 6% for several years. With its continued economic development, cargo transportation volume of the country increased eightfold in 30 years from 1975 to 2005, and in recent years transportation volume of both passengers and cargo is increasing at an annual rate of 6 - 7 %. To meet the increasing demands for domestic transportation, the Government of Bangladesh (hereinafter referred to as GOB) has been actively developing its road network. As a result, in 2005, road transport accounted for around 80% of the domestic transportation, surpassing inland water transport and railway transport. The Road and Highways Department (hereinafter referred to as RHD) is responsible for the construction and the maintenance of the major road and bridge network of Bangladesh.

Most of the approximately 4,500 bridges operated and maintained by RHD have been found to be aging and deteriorated. 1,500 of these bridges are said to be unsafe, since they have significant structural damages.

In addition, another 1,000 bridges are bailey bridges, which are prefabricated steel truss bridges for temporary purpose and not suitable for road bridges due to lack of capability and safety function. Most of these bailey bridges under RHD's control are in unsafe condition; the bridges have already become deteriorated and damaged, and in the some serious cases, bridges have already collapsed.

In the 6th Five-Year Plan of Bangladesh (between F.Y. 2011/12 and 2015/16, hereinafter referred to as 6FYP), it was declared that, in the highway sector, modernized and efficient road transportation systems would take a vital role in accomplishing the 6FYP as well as Vision 2021, the medium-term target of the nation. Rebuilding of the existing bridges, the total length of which reaches around 10,000 km, was listed as one of the major targets in the 6FYP. In National Land Transport Policy in 2004 (hereinafter referred to as NLTP), implementing safety measures to the entire medium and small bridges in the country was featured as one of the major policies. The Road Master Plan in 2009, designed based on

NLTP, states that one of the major goals is rebuilding all bailey bridges as permanent structures.

Assisting RHD in improving its road bridges matches the aid policies of the Government of Japan (hereinafter referred to as GOJ). Also, Japan International Cooperation Agency (hereinafter referred to as JICA) considers the nation-wide development of transport and traffic system to be one of the important issues for the country. In the Country Assistance Policy for Bangladesh, drawn up in June 2012, the GOJ considered the development of infrastructures for traffic and transport to be one of the major goals to enhance efficiency in human and cargo transportation in Bangladesh.

1.2 Objective of the Survey

The Objective of the Survey is to obtain all the data and information required for appraisal of the Project as Japanese ODA loan project, such as defining the project objectives and preparing project summary, project cost, implementation structure, implementation schedule, implementation method (procurement, construction), implementation plan, operation and maintenance plan, environment and social considerations, etc.

2. NECESSITY OF THE PROJECT

The implementation of the Project (i.e. the WBBIP) is important and necessary from the following points of view.

(1) Conformity with Upper Level Plan

Upper plans or programs such as Vision 2021, 6th Five Years Plan, National Land Transport Policy and Road Master Plan state that the development and improvement of the road network and bridges are important and necessary to encourage the economic growth in Bangladesh.

In Western Bangladesh, there are many bridges which are severely damaged and do not have the required carriageway width (at least 7.3m). These bridges should be improved in order to provide smooth traffic flow and ensure road safety.

(2) Not Enough Projects by Other Donors

Some bridges will be improved using funds from other donors such as Chinese government and GOB's own programs, PMP and ADP. A study to improve the road network is ongoing under SASEC financed by ADB.

However, these projects are not enough to develop the efficient road network or to provide safety for the bridges in Western Bangladesh, since approximately 700 bridges are categorized as C (major element damage) or D (major structural damage).

(3) Securing Good Traffic Condition of Asian Highway

As stated in Vision 2021, it is very important to secure the good traffic conditions in the Asian Highway network which connects neighboring countries with Bangladesh, in order to achieve the ultimate goal of becoming a middle-income country.

However, there are many damaged or narrow bridges in the Asian Highway network in Western Bangladesh. These bridges tend to act as bottlenecks in the network, and thus should be improved.

(4) Securing Good Traffic Condition of Important Corridor

There are seven corridors with India in Western Bangladesh, including one railway and six highways. As India is major trading country for Bangladesh, it is very important to secure good traffic conditions in these corridors

There are three EPZs in Western Bangladesh. In addition, GOB has decided to establish thirty economic zones through the Nation, suspending the development of new EPZs, since EPZs have several issues such as full capacity and little impact on domestic industries. In Western Bangladesh, there are two short-listed candidate SEZs.

There are many damaged and/or narrow bridges on corridors with India and EPZs, SEZs in Western Bangladesh. These bridges act as bottlenecks in the network. Improvement of the bridges in the Project shall improve traffic conditions in these corridors, which in turn will contribute to the economic growth of Bangladesh.

(5) Damage Progression of the Bridge

In the past, bridge condition surveys for all bridges managed by RHD were carried out two times; first one was carried out when Bridge Maintenance Management System (BMMS) was established in 2006, second one was carried out in 2014 as a part of Eastern Bangladesh Bridge Improvement Project (EBBIP).

In order to assess the need of repair, rehabilitation and reconstruction of bridges, the existing condition of the classified structures is divided into four categories:

- Category A: Good
- Category B: Minor Element Damage
- Category C: Major Element Damage
- Category D: Major Structural Damage

As result of comparing these data, number of bridges categorized B, C and D has increased, although that of A has decreased from 2004-2006 (the year of the BMMS survey), to 2013 (the year of the EBBIP). This result implies the importance of the necessity of improvement of

the bridges which are seriously damaged.

(6) Increase of Traffic Volume

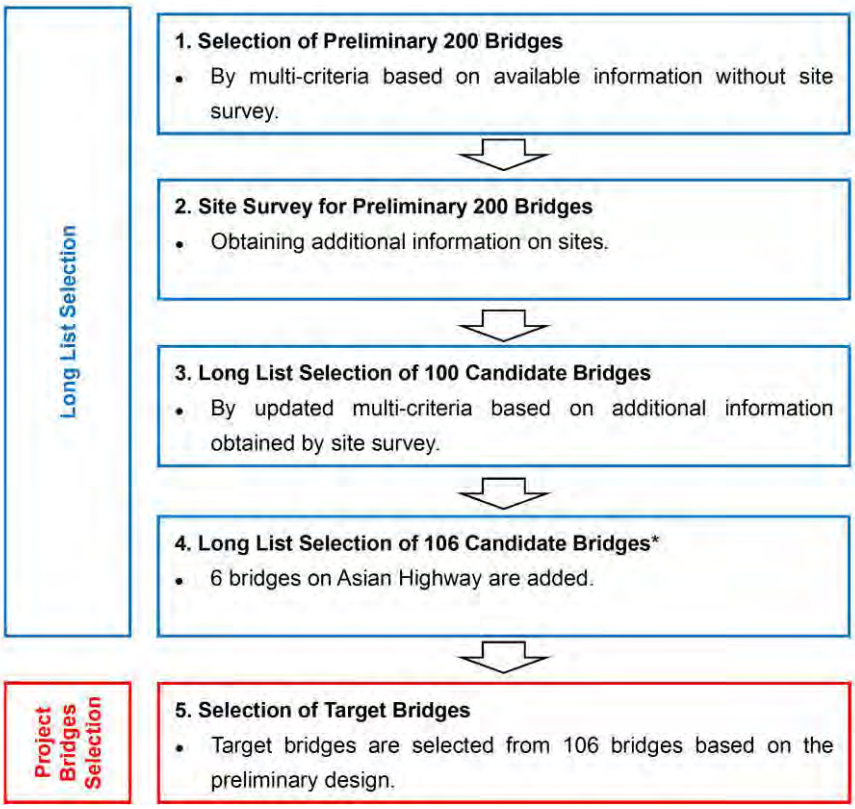
In the 10 years from 2004 to 2014, traffic volume has increased at a rate of 6.25% p.a., 5.62% p.a. and 5.15% p.a. for national roads, regional roads and Zilla roads, respectively.

Road transport is becoming increasingly important among all transport modes. It is very important to provide good traffic conditions in the road network, especially of National Road.

3. SELECTION OF PROJECT BRIDGES

3.1 Selection Approach

Project bridges are selected from approximately 1,700 bridges operated and maintained by RHD in Western Bangladesh. Selection procedure is divided into 2 steps, namely “Long List Selection of Candidate Bridges” and “Selection of Project Bridges”, as shown in following figure.



* 6 bridges were added to “Long List of 100 Candidate Bridges” based on the discussion with MORTB as well as RHD.

Source: JICA Survey Team

Figure S 3.1 Procedure for Project Bridges Selection

3.2 Selection of Preliminary 200 Bridges

(1) Removal from Candidate List

From approximately 1,700 candidate bridges in Western Bangladesh, bridges fitting the following criteria were dropped from the candidate list.

- Bridges whose length is less than 20m
- Box culverts (not bridge)
- Bridges to be constructed under funding from other external donors such as ADB, WB, etc., or under funding from GOB itself
- Bridges located in national parks, wildlife sanctuaries and world heritage sites

As a result, the candidate list was narrowed down to approximately 1,000 bridges.

(2) Multi-criteria

In order to select 200 bridges, remaining 1,000 are evaluated by multi-criteria. Multi-criteria are shown in following table.

Table S 3.1 Multi-criteria for Selecting Preliminary 200 Bridges

Item		Weight	Point	Criteria	
1. Recommendation by RHD		30	4	Recommended bridges by RHD	
			0	Other bridges	
2. Bridge on the important route	2.1 Traffic volume on the route	50	4	on National road	
			2	on Regional road	
			0	on Zilla road	
	2.2 Corridor to India	20	4	Burimari	N5,N,405,N506,N509
				Banglaband ha	N5,N405
				Hili	N5,N405,R550,R585,Z5503,Z5507,Z5509,Z5854,Z5855,Z5856
				Sonamasjid	N6,N507,R680,Z6801,N405
				Benapole	N7,N8(To Madaripur), N702,N706,N804
				Bhomra	N7,N8,N702,N804,R755,R760, Z7062
			0	Other roads	
3. Impact on business activity	3.1 Corridor to planed SEZs	5	4	Sirajgonj	N405,R450,R451
				Mongla	N7,N8,N702,N709
			0	Other roads	
	3.2 Corridor to existing EPZs	5	4	Uttra	N5,N6,N7,N405,N502,N704,R570
				Ishwardi	N6,N405,N507,R680,N704,N705,Z6801
				Mongla	N7,N8,N702,N709,R850,R856
			0	Other road	
	3.3 Other foreign business activities	10	4	Rangpur	N5(To Rangpur),N405
				Ishwardi	N6(To Baraigram), N405,N507N704,N705
			0	Other Roads	
4. Necessity of community	4.1 Population	10	4	≥2,000,000	
			2	2,000,000>Population≥1,000,000	

activity			0	1,000,000
	4.2 GDP	10	4	≥800mil BDT
			2	800mil BDT>GDP≥400mil BDT
			0	400mil BDT
5. Degree of damage and structural deficit	5.1 EBBIP damage level	50	4	Grade-D
			2	Grade-C
			0	Grade-A,B
	5.2 Bridge type	20	4	Bailey bridge (Temporary bridge)
			0	Other bridge type
6. Lack of traffic lane		40	4	N: Carriageway<6.2m
				R: Carriageway<5.5m
				Z: Carriageway<3.7m
			2	N: 6.2m≤Carriageway<7.3m
				R: 5.5m≤Carriageway<7.3m
				Z: 3.7m≤Carriageway<7.3m
			0	Carriageway≥7.3
		Total score =1,000		

Note: Bridges having all of “not recommended by RHD (Item 1)”, “Grade-A, B of EBBIP damage level (Item 5.1)”, “not bailey bridge (Item 5.2)” and “having more than 7.3 m of carriage way (Item 6)” are dropped from the candidate list.

Source: JICA Survey Team

(3) Site Survey for Preliminary 200 Bridges

Site surveys were carried out for the selected 200 bridges in order to obtain additional information. Using this information, EBBIP damage level and width were re-evaluated. In addition that, bridges requiring the resettlement of more than 200 affected persons (APs) would be dropped from the candidate list.

(4) Long List Selection of 106 Candidate Bridges

The JICA Survey Team discussed the 100 bridge candidate bridges with RHD in a meeting held on January 26th, 2014. In the meeting, additional chief engineers (ACEs) from five zones requested that some bridges should be deleted from the list, and that some should be added to the list.

In addition, RHD requested the inclusion of the bridges on Asian Highways with EBBIP damage levels of C or D. It was agreed in further discussion with JICA, RHD and JICA Survey Team that 6 bridges on Asian Highways would be included as candidate project bridges in addition to the previously selected 100 bridges. Therefore, 106 bridges were ultimately selected.

3.3 Selection of Project Bridges

Project bridges are selected through screening of 106 bridges based on the preliminary design, cost estimates and project effect evaluation. Selection of Project bridges will be discussed in “15.1 Selection of Project Bridges”.

4. TRAFFIC DEMAND FORECAST

Traffic demand forecast is conducted by following procedure.

i) Estimating the forecast future traffic demand using growth rate of traffic indicators.

ii) Considering the traffic demand induced by large scale developments in western Bangladesh.

(1) Future Traffic Growth

Past traffic growth rates were applied as traffic indicators in this study. The traffic growth was calculated based on the results attained from preparatory surveys and other surveys conducted by RHD from 2004 to 2011, under the assumption that the traffic growth rate will remain fairly constant until 2031. The annual traffic growth rates in western Bangladesh were found to be 6.25% for national roads, 5.62% for regional roads and 5.15% for zilla roads.

(2) Adjustment in Consideration of Large Scale Development

Two large-scale development projects, the construction of Padma Bridge and the improvement of AH1 (part of Road Master Plan 2009), are expected to influence traffic demand, so these were both considered in calculations of the traffic demand forecast.

(3) Result of Traffic Demand Forecast in 2031

The estimated peak hourly traffic volume was used in the determination of the required number of lanes. The peak rate was calculated to be 8% for national roads and 10% for both regional roads and zilla roads based on RHD road standards. It was predicated that, Asian Highways and national roads connecting to bridges crossing Jamuna river and Padma river will have high peak traffic volume due to the concentration of vehicles on these bridge.

(4) Number of Lane in the Project

In the Project, the bridges including those that require more than 4 lanes based on the traffic demand forecast, will be constructed as 2-lane bridges based on the following considerations:

- As many bridges as possible should be constructed on a limited budget.
- Even if 4-lane/6-lane bridges are constructed, only 2 lanes will be used since the approach roads (adjacent embankment section) only have 2 lanes.
- Even if 4-lane/6-lane bridges are constructed in anticipation of widening of the approach roads, this widening may not occur soon. Deterioration of the bridge will progress even if all lanes are not used, meaning funds will have been wasted.

However, in the meeting between JICA, MORTB, RHD and JICA Survey Team held on April 27, 2014, it was determined that 5 bridges on Asian Highway 1 (AH1) will be constructed with 4 lanes in conformity with a future 4-lane widening plan

5. DETERMINATION OF BRIDGE TYPE

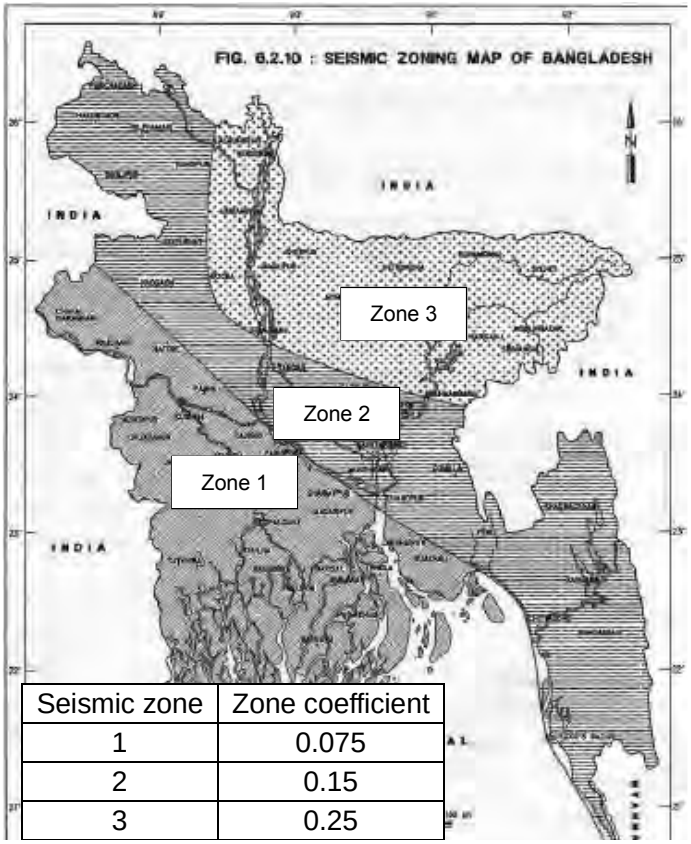
(1) Methodology of Bridge Type Decision

This Project includes the construction of small and mid-sized bridges, but no large bridges.

For small bridges, PC-I girder is widely recognized as the most suitable and economical bridge type in almost all site conditions. For mid-sized bridges, the most appropriate bridge type shall be selected upon comparison of multiple bridge type candidates.

For bridge design, all bridges are classified into 2 groups: Small sized bridge (Group A) and Mid-sized bridge (Group B). Earthquake streng in consideration of bridge length and height as well as seismic coefficient, which is different for each zone.

Group A is defined as follows:



Seismic zone	Zone coefficient
1	0.075
2	0.15
3	0.25

Source:Bangladesh National Building Code (BNBC)

Figure S 5.1 Seismic Zoning Map (BNBC)

- North zone (Z = 0.15 or 0.25): length < 100 m and height < 10 m
- South zone (Z = 0.075): length < 150 m and height < 15 m

Group B is defined as bridges falling outside of the above definition.

(2) Bridge Type for Group A

Group A Bridges are shorter and lower. Accordingly, PC-I girder bridges are to be used for Group A Bridges.

(3) Bridge Type for Group B

Group B bridges (all of which are in the northern zone) are longer and higher. As the result of the comparison among PC-BOX girder, Steel-I girder and Weathering Steel-I girder, Weathering Steel-I girder bridges are recommended as the most appropriate bridge type for Group B bridges from following points.

- Advantage to earthquake resistance
- Short construction period
- Easy maintenance
- No specific environmental impact
- Fair initial and life cycle costs
- Good technical transfer

6. PRELIMINARY DESIGN

6.1 Design Criteria for Roads

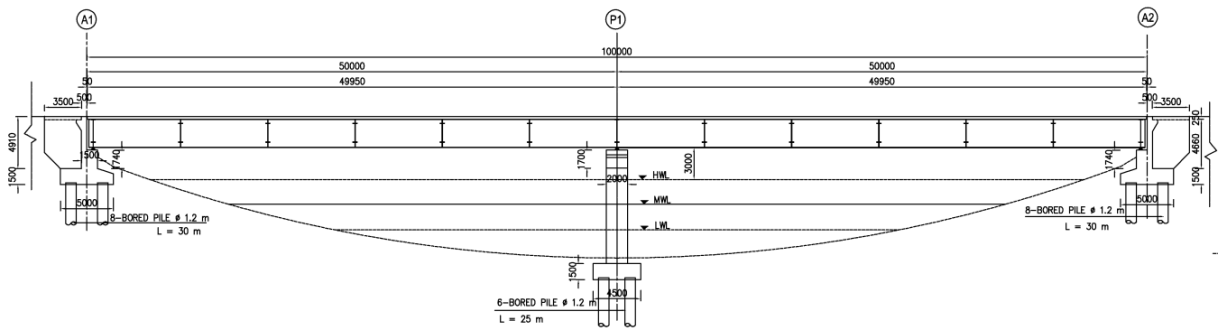
- Design speeds for national road, regional road and zilla road are 80km/h, 65km/h and 50km/h respectively.
- Priority standard used for road design is “Geometric Design Standards for RHD”, Reference standard is AASHTO Standard.
- For national road, new bridge is constructed next to existing bridge in consideration of future widening. For regional road and zilla road, new bridge is constructed at existing bridge location (replacement existing bridge) in consideration of initial coat.

6.2 Design Criteria for Bridges

As mentioned in Chapter-5, the bridge type (super structure) is determined as follows.

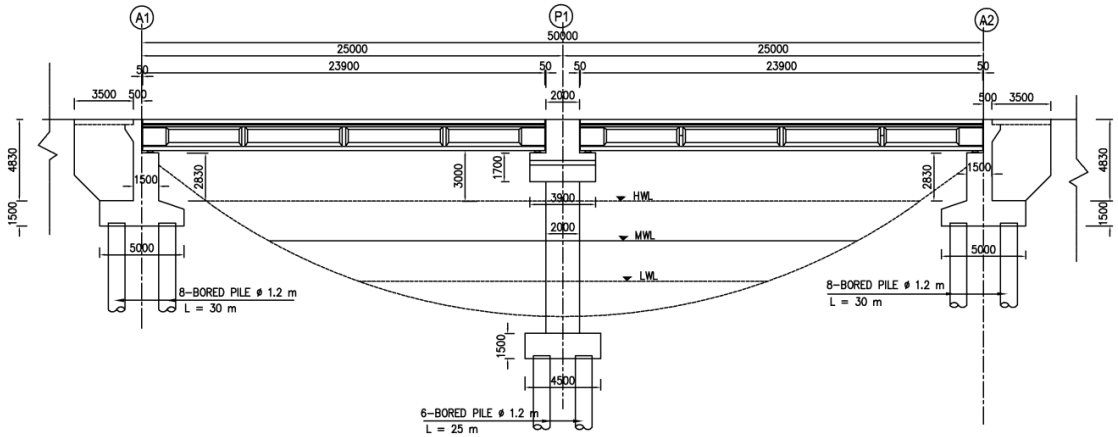
Northern zone (55 bridges):	38 small PC-I girder bridges, and
	17 mid-sized Steel-I (weathering steel) girder bridges
Southern zone (50 bridges):	All small PC-I girder bridges

The bridge span length is standardized with some series of spans to apply easily to all bridge locations. Some examples of side view are shown in following figures.



Source: JICA Survey Team

Figure S 6.1 Steel-I Girder (Continuous Girder)



Source: JICA Survey Team

Figure S 6.2 PC-I Girder (Chaired Single Span Girders)

A summary of preliminary design of superstructure and substructure for project bridges is shown in Table S 10.1.

7. APPLICATION OF MODERN TECHNOLOGIES

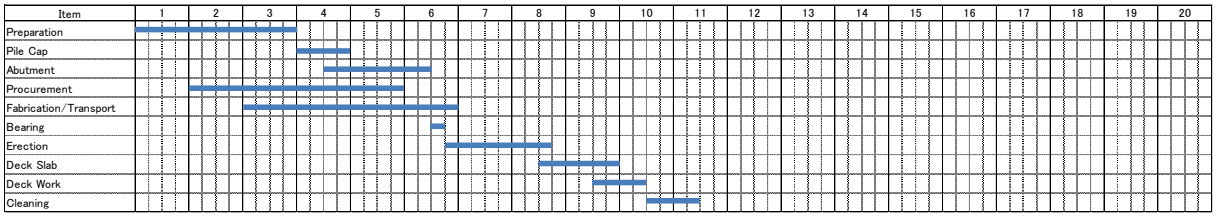
Weathering steel is to be adopted for all mid-sized bridges in this Project. Weathering steel girders have the advantages, which are described in Cap5, over PC box girders, (which are generally adopted for mid-sized bridges). Weathering steel is a high-strength steel that resists corrosion. It resists the corrosive effects of rain, snow, ice, fog, and other meteorological conditions by forming adherent protective rust over the metal. Weathering steel has a low corrosion rate, and bridges fabricated from unpainted weathering steel can achieve long design life with only normal maintenance. In order to confirm whether weathering steel can be applied in Bangladesh, exposure tests and airborne salt tests are carried out in the Survey.

As a result of airborne salt tests as well as exposure tests, it is concluded that weathering steel bridges can be adopted for all mid-sized bridges to be constructed in northern Bangladesh as part of the WBBIP.

8. CONSTRUCTION PLAN

The typical construction schedules for each bridge type are planned. Some examples are shown in following Figure.

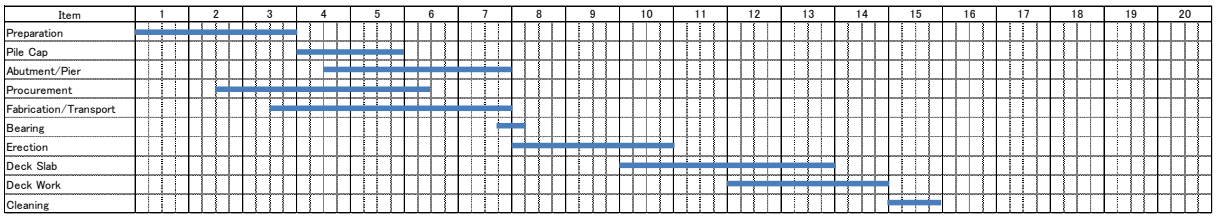
(1) Case-1: Steel-I Girder L=60m



Source: JICA Survey Team

Figure S 8.1 Construction Schedule for Steel-I Girders of Length 60m

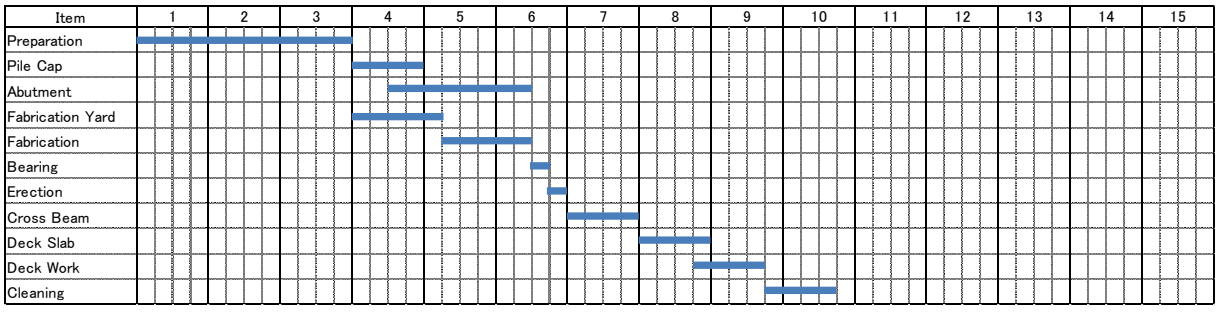
(2) Case-2: Steel-I Girder L=180m (60m x 3)



Source: JICA Survey Team

Figure S 8.2 Construction Schedule for Steel-I Girders of Length 180m (60m x 3)

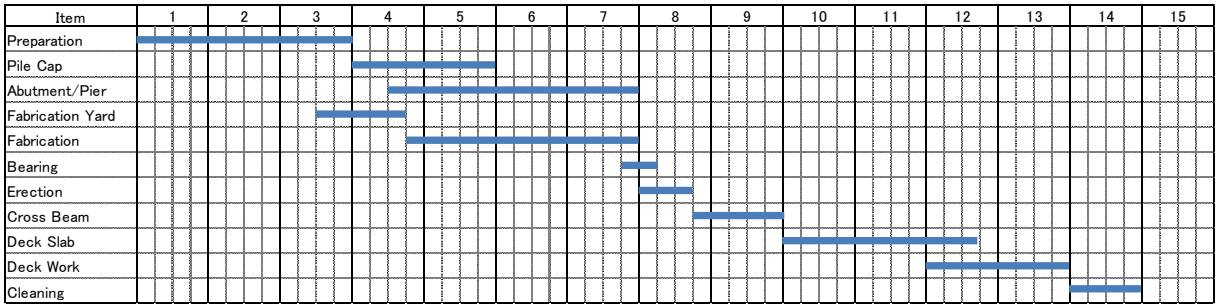
(3) Case-3: PC-I Girder L=40m



Source: JICA Survey Team

Figure S 8.3 Construction Schedule for PC-I Girders of Length 40m

(4) Case-4: PC-I Girder L=120m (40m x 3)



Source: JICA Survey Team

Figure S 8.4 Construction Schedule for PC-I Girders of Length 120m (40m x 3)

9. OPERATION AND MAINTENANCE PLAN

In order to maintain sound conditions to sustain smooth and safe traffic flows, appropriate maintenance should be carried out. The maintenance methodology for weathering steel bridges, which are constructed in Bangladesh for first time, is described in this section.

For weathering steel bridges, it is necessary for weathering steel bridge to take care of chlorides and humidity that can adversely affect the stability of the protective rust and cause excessive corrosion. Surface contamination can be caused by accumulation of dirt, dust and bird droppings that absorb moisture (e.g. due to rain), and hence surfaces should be periodically cleaned. Furthermore, Removal of overhanging vegetation, cleaning/repair for drainage systems should be conducted. In addition to above routine and periodic maintenance, it is desirable to conduct to following:

- Visual Inspection (at least every two years)
- Monitoring by equipment (every six years)

10. COST ESTIMATES

In this chapter, civil costs are estimated for the project candidate bridges. Civil cost for 60 project bridges which are finally selected in “Cap. 14” is summarized in following table.

.

Table S 10.1 Design Summary and Civil Work Cost for 60 bridges in Western Bangladesh

Confidential

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

11. PROJECT EFFECT

(1) Operation and Effect Indicators

Operation and effect indicators are selected based on data availability, validity and reliability in both the current year (taken as the baseline) and 2 years after project completion. Selected operation and effect indicators and example values are shown in following table.

Table S 11.1 Selection of Operation and Effect Indicators

Indicater		SN	ZONE	Bri_ID	Bri_Name	2014	2023
Operation Indicators	Freight Traffic Volume (pcu/day)	8	Khulna	N7_039a	Karimpur Bridge	5,826	8,907
	Passenger Vehicle Traffic Volume (pcu/day)					7,248	11,082
Effect Indicators	Travel Cost from Detour when Bridge Collapsed (1000 taka/year)	4	Rangpur	R545_115c	Mongle bari kuthibari Bridge	114,428	0
	Reduction of Detour Days during Flooding (days)	5	Rangpur	N509_19a	Sharnamoti Bridge	60	0
	Unserviceability rate	13	Khulna	N7_141b	Buri Bhairab Bridge	24%	0

Source: JICA Study team

(2) Economic Evaluation

A substantial portion of the benefits derived from construction of new bridges is the reduction of Vehicle Operation Cost (VOC) and Travel Time Cost (TTC) of passing vehicles, by reducing the probability of bridge collapse. In the case of collapse, vehicles crossing the bridge will be forced to take another bridge located along a detour route that normally requires a longer travel distance with worse surface conditions. The difference between VOC/TTC in regular routes and detour routes will be considered a benefit. The economic life is assumed to be 25 years (2021 - 2045).

In this section, economic evaluations for the 105 project candidate bridges are conducted. Economic evaluations for project bridges which finally selected are summarized in “14.4 Project Effect for 61 Bridges”

12. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

12.1 Environmental and Social Considerations

Various impacts of bridge construction during pre-construction, construction and operation stages are indicted in following table.

Table S 12.1 Comparison of Scoping before/after EIA Study

No.	Items of Impact	Predicted Impact		Assessed Impact	
		Before/ During Construction Stage	Operation Stage	Before/ During Construction Stage	Operation Stage
1	Air pollution	B-	D	B-	D
2	Water pollution	B-	D	B-	D
3	Soil pollution	B-	D	B-	D
4	Waste	B-	D	B-	D
5	Noise and vibration	B-	D	B-	B-
6	Ground subsidence	D	D	D	D
7	Offensive odors	D	D	D	D
8	Global warming/Climate change	D	D	D	D
9	Topography and geology	D	D	D	D
10	Bottom sediment	D	D	D	D
11	Biota and ecosystem	C	C	D	D
12	Hydrology	B-	C	D	D
13	Water use	C	C	D	D
14	Protected area	D	D	D	D
15	Involuntary resettlement	A-	D	B-	D
16	Local economies, such as employment, livelihood, etc.	B-/B+	C	B-	D
17	Land use and utilization of local resources	D	D	D	D
18	Social institutions and local decision-making institutions and social service facilities	C	B+	B-	D
19	Poor	A-	A-	B-	D
20	Indigenous or ethnic minority people	C	C	D	D
21	Misdistribution of benefits and damages	D	D	D	D
22	Local conflicts of interest	D	D	D	D
23	Gender	A-	A-	D	D
24	Children's right	C	C	D	D
25	Cultural heritage	C	C	D	D
26	Infectious diseases such as HIV/AIDS	B-	D	B-	D
27	Landscape	D	D	D	D
28	Working conditions	B-	D	B-	D
29	Social consensus	A-	D	B-	D
30	Accident	B-	D	B-	B-

Note: A: Remarkable negative impact is predicted.
B: Negative impact is expected to some extent.
C: Extent of impact is unknown. (Further examination is needed and the impact could be defined as study progresses)
D: Impact is very small or nil and further survey is not required

Source: JICA Survey Team

12.2 Land Acquisition and Resettlement

For 60 project bridges which are selected in Cap.14, out of the total 1,564 affected units, 1,018 commercial enterprises, 501 residential households and 45 community properties were identified on the Corridor of Impact (CoI). A total of 20.99 ha of land will need to be acquired of which 10.51 ha in Rangpur zone, 6.40 ha in Rajshahi zone, 0.90 ha in Gopalganj zone, 1.67 ha in Khulna zone, 1.50 ha in Barisal zone and 12.89 ha. As a result, 346 households and 1,628 people must be displaced.

Table S 12.2 Distribution of Impacts by Zone

No	Loss type	Zones					Total
		Rangpur	Rajshahi	Gopalganj	Khulna	Barisal	
1	Total number of bridges	19	16	7	9	9	60
2	Total quantity of land (ha) affected	10.51	6.41	0.90	1.67	1.50	20.99
2.a	Total quantity of Residential/Commercial land (ha) affected	1.16	1.82	0.19	0.42	0.84	4.43
2.b	Total quantity of Agriculture/Others land (ha) affected	9.62	4.32	0.72	1.25	0.66	16.56
3	Total of displaced households	64	126	76	62	18	346
4	Total of displaced people	301	561	345	337	84	1,628
5	Total Project Affected Units (PAUs)	426	349	45	285	459	1,564
6	Total Households affected*1	100	167	25	121	88	501
7	Total commerce and business enterprises (CBEs) affected*1	304	176	20	156	362	1,018
8	Total community property (CPR) affected	22	6	0	8	9	45
9	Total number of structures affected	10.7876	6.1337	0.9034	1.6661	1.4999	21
9.a	Total quantity of all structure (sqm) affected	1	2	0	0	1	4
9.b	Total quantity of residential structure (sqm) affected	10	4	1	1	1	17
9.c	Total quantity of commercial structure (sqm) affected	426	349	45	285	459	1,564
9.d	Total quantity of CPR structures (sqm) affected	100	167	25	121	88	501
10	Total no. of toilets affected	304	176	20	156	362	1018
11	Total no. of tube wells affected	22	6	0	8	9	45
12	No. of trees on private land affected	13,171	8,413	2,156	6,935	3,689	34,364
13	No of trees on government land affected	1,970	1,374	1,408	1,153	334	6,239

*1: Households (HHs) are defined as land with residential structures & trees, residential structures, rented residential structures, private trees, and other various items (ponds, fish, gate etc.)

*2: Commerce, Businesses and Enterprises (CBEs) are defined as land with business structures & trees, business structures, or rented business structures

*3The number in the table is not for 105 project candidate bridges but for 60 project bridges selected in Cap.14.

Source: JICA Survey Team

Mitigation of above impacts will be undertaken through implementation of this Abbreviated Resettlement Plan (ARP), addressing the gaps between national legislation and the

requirements of Development Partner (such as JICA)'s Policy on Involuntary Resettlement.

ARP report was prepared and submitted to RHD for obtaining the approval from the GoB side and accordingly Ministry of Highway Transportation and Bridges approved the ARP report on November 28, 2012.

13. THE EZ BRIDGE AND ROAD

13.1 Introduction

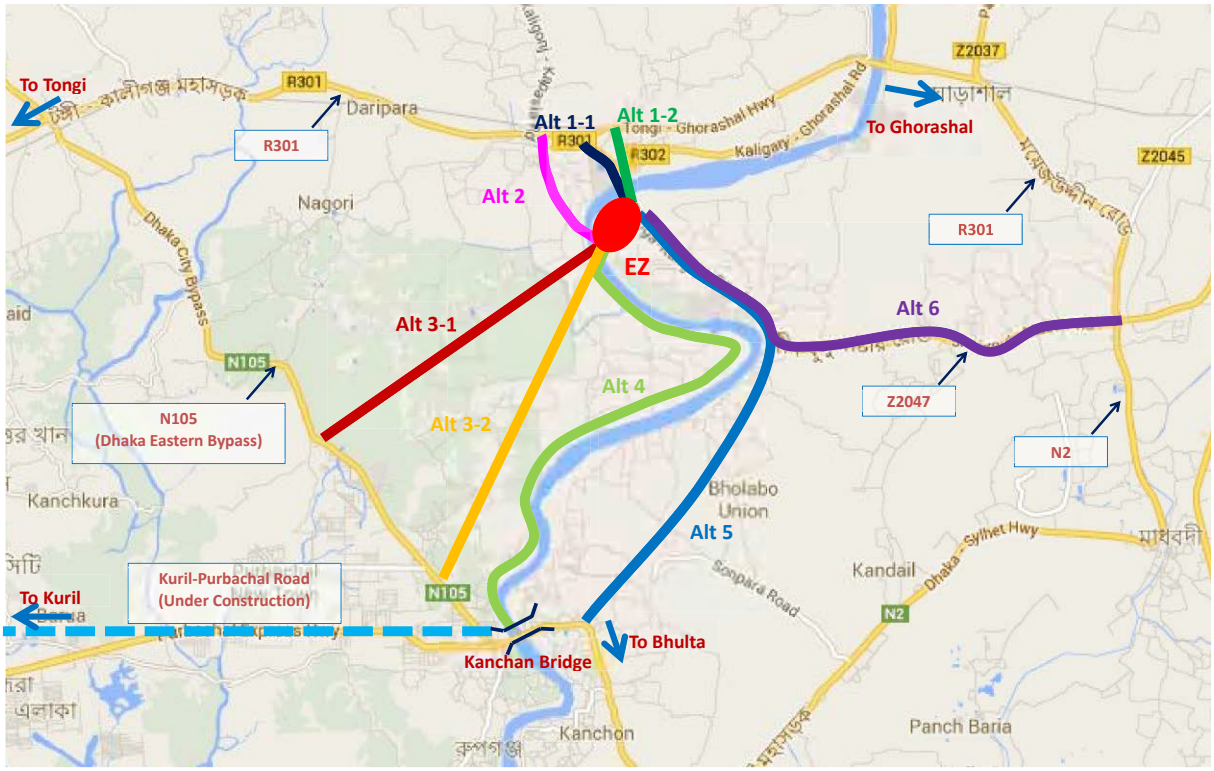
Due to the capacity saturation of existing economic zones (EZ) in Bangladesh, it is an urgent requirement to swiftly launch new economic zones to meet the rising industrial demand, as well as to further enhance foreign direct investment in Bangladesh. For a smooth launch and efficient use of an economic zone, it is essential to develop appropriate road and bridge infrastructures to access the site in a timely manner.

Some EZs have been planned in and around Dhaka, the capital city of Bangladesh. The Survey studied the development of bridge and road access to the EZ planned in Narsingdi (hereinafter referred to as the EZ Bridge and Road) as one of the important EZs in Bangladesh.

13.2 Route Alternatives

The eight route alternatives as shown in following figure for the EZ Bridge and Road were planned. As the result of comparison analysis, Alternative 2 is selected from following points.

- Cheaper construction cost
- Cheaper L/A and resettlement cost
- Small affected house number
- Present accessibility is poor, but it can be improved in the future.



Source: JICA Survey Team

Figure S 13.1 Alternatives of the EZ Bridge and Road

13.3 Traffic Demand Forecast

(1) Traffic Demand Forecast Methodology

The Panchdona-Danga Road (Z2047) of the east access road is only approximately 5 meters wide and identified as an alternative to the one-way road for cars or freight vehicles. The road condition of a certain section (approximately 11.5 km length) of national highway Dhaka-Sylhet (N2) is unsatisfactory. In addition, there is no realistic plan for road development; it is costly due to requiring improvement over a long distance and also acquiring land acquisition. Therefore, it is expected that all trips which relate to the EZ will use the EZ bridge and west access road, and through traffic will not exist after construction of the EZ bridge and west access road. Commuting Trips, Business Trip and Cargo Trip are set as considerable trip in this traffic demand forecast The target years of the traffic demand forecast are set for 3 specific years: 2021 (opening year of EZ bridge), 2023 (evaluation year of operation and effect indicator) and 2031 (10 years after EZ construction).

(2) Result of Traffic Demand Forecast and Number of Lanes

The forecasted peak hour traffic volumes are 1,318 in 2021, 1,694 in 2023 and 3,834 in 2031 as shown in following table. The required number of lanes was 2, thus the number of lanes was determined as 2 lanes (both directions).

Table S 13.1 Future Traffic Volume of Western Access Road of EZ and EZ Bridge

	Daily Traffic Volume (pcu /day)			Peak Ratio (%)	Traffic Volume of Peak Hour (pcu /day)		
	2021	2023	2031		2021	2023	2031
Commuting Trips	853	1,747	7,260	25.0%[1]	213	437	1,815
Business Trip	639	1,260	4,564	12.5%[2]	80	158	571
Cargo Trip	16,398	17,580	23,166	6.3%[3]	1,025	1,099	1,448
Total	17,890	20,587	34,990	-	1,318	1,694	3,834

Source: JICA Study Team

13.4 Preliminary Design

As a result of preliminary design, bridge type and length were summarized as below;

- The Superstructure

- Main Bridge (L=205 m): Steel-Box Girder

- Approach Bridge (L=630 m): PC-I Girder

- The Substructure

- Foundations inside River: Cast-in-Place Concrete Pile (φ1500, L=54m, n=16)

- Foundations on Land: Cast-in-place Concrete Pile (φ1500-4, L=73.0m, n=4)

- The Approach Road (L=4,193 m)

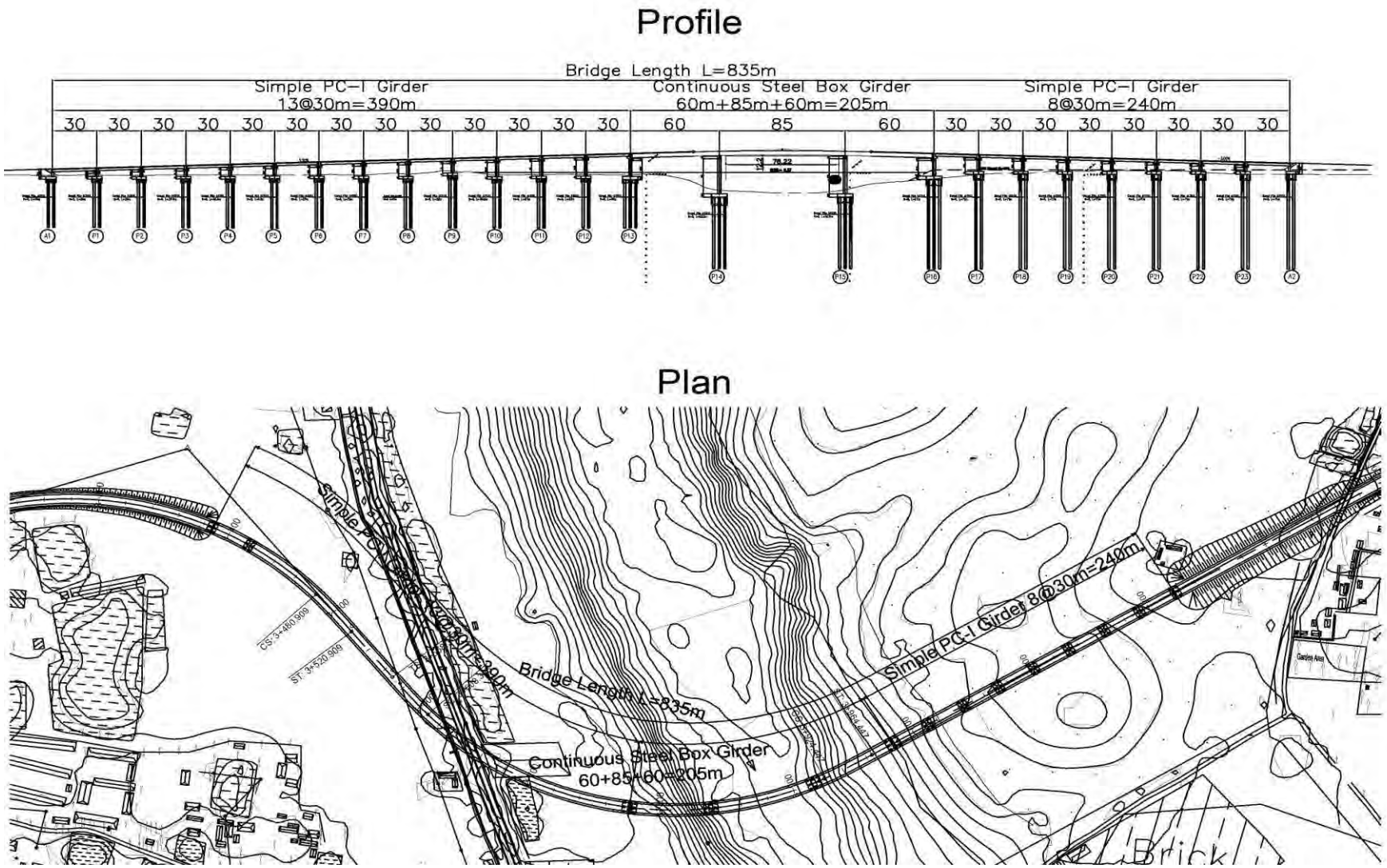
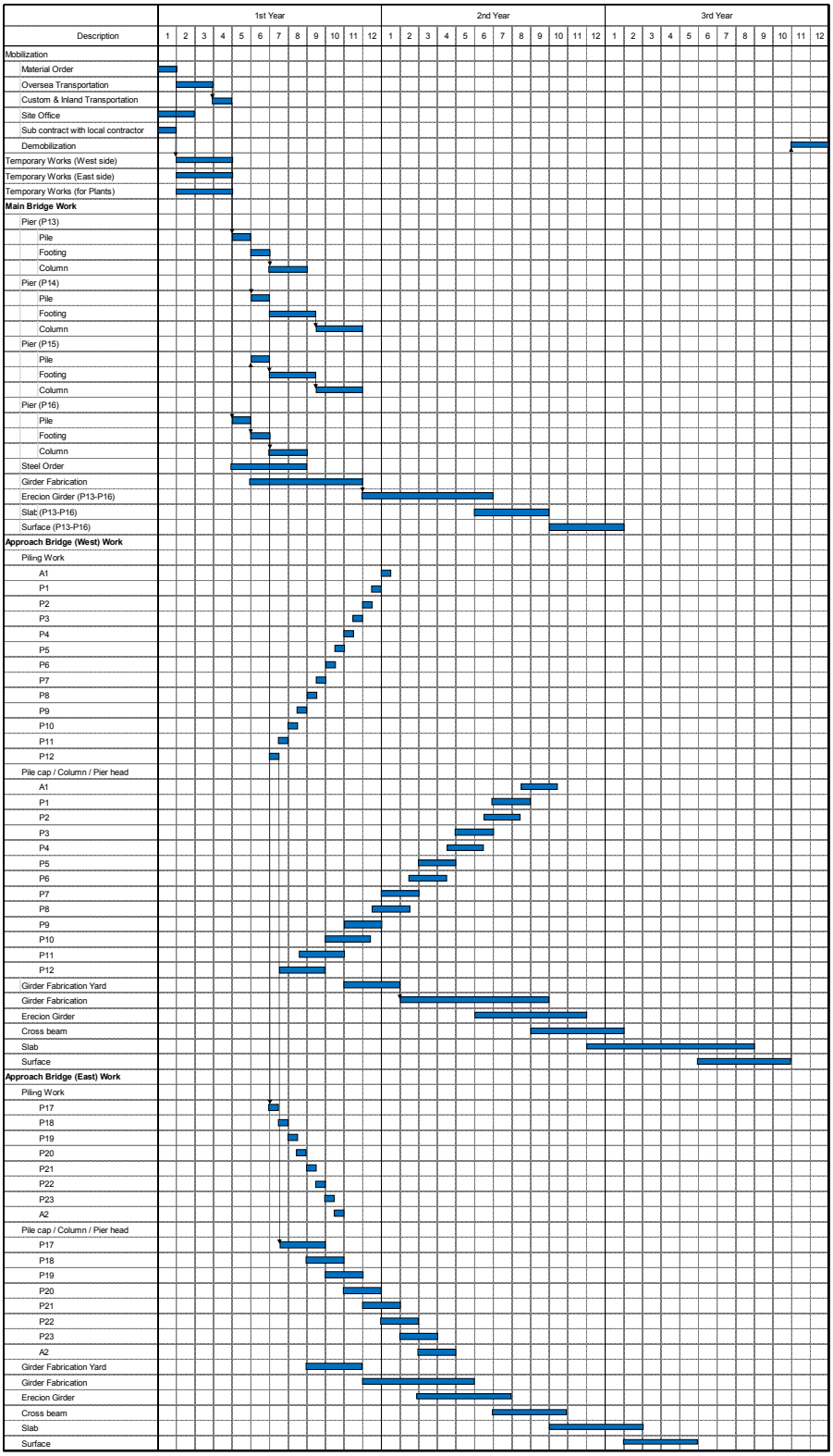


Figure S 13.2 General View of the EZ Bridge

Source: JICA Survey Team

13.5 Construction Plan

The construction period for the EZ is 36 months as shown in following figure.



Source: JICA Survey Team

Figure S 13.3 Construction Schedule

13.6 Cost Estimates

Civil work cost for the EZ Bridge and Road are calculated by unit price and quantities, as shown in following table.

TableS 13.2 Summary of Civil Works Cost by Bridge/Road Component

Confidential

Source: JICA Survey Team

13.7 Project Effect

(1) Operation and Effect Indicator

The freight and passenger traffic volume and reduction of travel cost were selected as an operational indicator and effect indicator respectively. The calculated operation and effect indicators of the baseline and 2 years after the project completion are shown in following table.

Table S13.3 Proposed Operation and Effect Indicators

Indicator		Target	Baseline	2 years after project completion
Operation Indicator	Freight Traffic Volume (pcu/ day)	EZ bridge	NA	17,580
	Passenger Vehicle Traffic volume (pcu/ day)		NA	3,007
Effect Indicator	Reduction of Travel Cost (Million taka/ year)	Total	0	2,810

(2) Economic Analysis

1) General

The economic analysis of the EZ Bridge and approach road construction is carried out by comparing the economic cost of the project with economic benefits, which will be generated by the reduction of (VOC) and (TTC) of passing. Project life is assumed to be 25 years from 2023 -2047 and an opportunity cost of capital is assumed at 12% per annum.

2) Economic Analysis

Economic evaluations for all project bridges which finally selected in Cap.14 are summarized in “14.4 Project Effect for 61 Bridges”

13.8 Environmental and Social Considerations

13.8.1 Environmental and Social Considerations

Methodology of environmental and social considerations is same as of 106 project candidate bridges in Western Bangladesh. Refer to 13.1.

13.8.2 Land Acquisition and Resettlement

(1) Necessity of Land Acquisition and Resettlement

The project is to provide a new bridge, which will connect the existing R301 and the EZ, including an access road. It is observed that only a small number of people (less than 200 or maybe even fewer) are to be affected due to the relevant activities. By following OP 4.12 of WB when impacts on the entire displaced population are minor, or if fewer than 200 people are displaced at a site, an Abbreviated Resettlement Plan (ARP) needs to be prepared for the project.

(2) Census and Socio-economic Survey

39 units are affected in other residential households wards identified on the Corridor of Impact (CoI). All the affected households are losing land, structures, and trees. A total of affected household is 3,709 square meters. The impact of this project is shown in following table.

Table S 13.4 Distribution of Impacts of the Project

Sl No	Loss type	No/Total
1	Total quantity of land (hectares) affected	12.49
2	Total number of households (land with structures) affected	39
3	Total number of structures affected	81
4	Total quantity of structures (Sqm) affected	3,709
5	Total no. of toilets affected	36
6	Total no. of tube wells affected	34
7	Total no. of trees on private land affected	12,259

Source: Census & Socioeconomic survey, July 2014

14. IMPLEMENTATION PLAN

14.1 Selection of Project Bridges

(1) Project Bridges Selection Criteria

The Project bridges are selected from the 106 candidate bridges using selection criteria.

Table S14.1 Project Bridges Selection Criteria

Item	Weight	Point	Criteria
1. Damage Level & Construction Year	7	4	Level D, and 30 years old
		2	Level D, but less than 30 years old
		0	Other Levels
2. Middle-size Bridge	7	4	Middle-size bridge
		0	Small-size bridge
3. Road Type	5	4	National highway
		2	Regional highway
		0	Zilla road
4. Expectation by Stakeholders	3	4	Expected by stakeholders in the stakeholder meetings
		0	Not expected by stakeholders in the stakeholder meetings
5. Constructability	3	4	Not requiring special soft soil treatment (cement mix, piled slab, etc.) in approach road
		0	Requiring special soft soil treatment (cement mix, piled slab, etc.) in approach road
6. Economically Not Viable	Drop		EIRR Less than 12 %
7. Inclusion in Other Projects	Drop		Already included or to be included in other projects
8. Difficulties for Construction	Drop		Significant difficulties for Construction
	Total score=100		

Source: JICA Survey Team

(2) Project Bridges Selection

As a result of evaluation by the project bridge selection criteria, the top 60 bridges were initially selected as the project target bridges. However, 2 bridges were dropped from the list and another 2 bridges were added to the list.

Finally, 61 bridges including 60 bridges in Western Bangladesh and the EZ Bridge were selected as the project target bridges.

14.2 Contract Package for 61 Bridges

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14.3 Cost Estimates for 61 Bridges

The project cost for 61 bridges is shown in following Table

Table S14.2 Project Cost

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Unit: (JPY million)

Notes: 1. Exchange Rate: US$ 1= Tk 77.5 = JPY119
2. Price Escalation: 2.0% per annum (Foreign Currency Portion), 4.9% per annum (Local Currency Portion)
3. Physical Contingency: 5% for consulting services, 10% for civil works
4. Base Year for Cost Estimation: January 2015

Source: JICA Survey Team

14.4 Project Effect for 61 Bridges

The result of the economic analysis for 61 bridges is shown in following table.

Table S14.3 Result of Economic Analysis for 61 Bridges

EIRR (%)	25.48
BCR	2.72
NPV (BDT million)	161.03

Source: JICA Survey Team

14.5 Implementation Schedule

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15. CONCLUSION AND RECOMMENDATIONS

15.1 Conclusion

A summary of the Project is shown in following table.

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15.2 Recommendations

Recommendations for further studies and tasks are as follows:

- Asphalt pavement was selected as a general pavement type in the preliminary design. Adoption of other pavement types such as concrete pavement or stone mastic asphalt (SMA) shall be considered, especially for some sections of the EZ approach road in the detailed design, since a number of heavy vehicles will utilize the EZ Bridge and Road.
- The EZ Bridge and Road will be connected to the existing regional road (R301). The improvement of R301 shall be considered during detailed design stage, since R301 is very narrow and damaged in some sections. R301 may not provide required capacity for increased traffic volume by the construction of the EZ Bridge and Road.
- In this Preparatory Survey, the recommendation for EZ Bridge‘s foundation type in the

river is Cast-in-Place Concrete Pile (φ1500, L=54m, n=16). However, it shall be finally determined by confirming the supporting layer at each pier position based on the geotechnical investigations during the detailed design stage.

- 60 bridges are planned to be constructed at 60 river/water crossings in Western Bangladesh. Construction of box culverts shall be considered for some locations, such as pond crossings not having water flow, as a cost reduction measure in the detailed design.
- Safety measures such as providing road marking, road hump, guardrails, etc. shall be considered in the detailed design. Specifically, the countermeasure for ship collisions to piers of the EZ Bridge shall be important.
- Detailed surveys for public utilities such as waterworks, telephone lines, power lines, etc. shall be conducted in the detailed design. The bridge and road design shall be conducted in consideration of that information.
- RHD shall undertake the tasks for the EIA and ARP during the entire project period in order to implement the Project successfully.

People's Republic of Bangladesh

Preparatory Survey on Western Bangladesh Bridges Improvement Project

Final Report Volume 1

Main Report

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Appendix 2.2 ARP Report (For 105 Bridges)

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Appendix 2.5 Form of Monitoring

Appendix 2.6 TOR for IA for ARP Implementation

Appendix 2.7 TOR for External Monitoring Consultant

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List of Abbreviations

AASHTO	: American Association of State Highway and Transportation Officials
ACE	: Additional Chief Engineer
AD	: Assistant Director
ADB	: Asian Development Bank
ADP	: Annual Development Program
AH	: Asian Highway
AID	: Acquired Immunodeficiency Syndrome
ARIPO	: Acquisition and Requisition of Immovable Property Ordinance
ARP	: Abbreviated Resettlement Plan
ASTM	: American Society for Testing Materials
BCS	: Basic Catalog Structure
BDT	: Bangladeshi Taka
BEPZA	: The Bangladesh Export Processing Zones Authority
BEZA	: Bangladesh Economic Zones Authority
BFD	: Bangladesh Forest Department
BIMST	: Bay of Bengal Institute for Multi-sectoral Technical and Economic Cooperation
BMD	: Bangladesh Meteorological Department
BMMS	: Bridge Maintenance Management System
BNBC	: Bangladesh National Building Code
BOD	: Biochemical Oxygen Demand
BOT	: Build-Operate-Transfer

BRP	: Bridge Replacement Program
BWDB	: Bangladesh Water Development Board
CBR	: California Bearing Ratio
CE	: Chief Engineer
CEGIS	: Center for Environmental and Geographic Information Services
CMIP5	: Coupled Model Intercomparison Project Phase 5
CMP	: Current Market Price
CO	: Carbon Monoxide
COI	: Corridor of Impact
CPI	: Consumer Price Index
C/S	: Construction Supervision
DC	: Deputy Commissioner
D/D	: Detail Design
DO	: Dissolved Oxygen
DoE	: Department of Environment
DPP	: Development Project Proposal
EA	: Executing Agency
EBBIP	: Eastern Bangladesh Bridges Improvement Project
EC	: Electrical Conductivity
ECC	: Environmental Clearance Certificate
ECR	: Environment Conservation Rules
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
EPZ	: Export Processing Zone
ESU	: Engineering Service Unit
EZ	: Economic Zones
FML	: Fortnightly Mean Water Level
F/S	: Feasibility Study
FYP	: Five Years Plan
JVS	: Joint Verification Survey
GBM	: The Ganges-Brahmaputra-Meghna
GDP	: Gross Domestic Product
GRDP	: Gross Regional Domestic Product
GOB	: Government of Bangladesh
GOJ	: Government of Japan
GRC	: Grievance Redress Committee
HIV	: Human Immunodeficiency Virus
HWL	: High Water Level
IA	: Implementing Agency
IACCCZB	: Impact Assessment of Climate Changes on the Coastal Zone of Bangladesh

IACCSLRMF	: Impact Assessment of Climate Change and Sea Level Rise on Monsoon Flooding
ICB	: International Competitive Bidding
IMF	: International Monetary Fund
INGO	: Implementing Non-Government Organization
IPCC	: Intergovernmental Panel on Climate Change
IRC	: Indian Road Congress
IRI	: International Roughness Index
ISD	: Intermediate Sight Distance
IUCN	: International Union for Conservation of Nature,
JDCF	: Japan Debt Cancellation Fund
JICA	: Japan International Cooperation Agency
JJA	: June-July-August
JRA	: Japan Road Association
LAO	: Land Acquisition Officer
LCC	: Location Clearance Certificate
LGD	: Local Government Division
LGED	: Local Government Engineering Department
LIRP	: Livelihood and Income Restoration Program
LMS	: Land Market Survey
LRFD	: Load and Resistance Factor Design
M/D	: Minutes of Discussion
MoD	: Ministry of Defence
MORTB	: Ministry of Road Transport and Bridges
MoL	: Ministry of Lands
MoLGRD&C	: Ministry of Local Government Rural Development and Co-operatives
MoWR	: Ministry of Water Resources
NHWL	: Normal High water Level
NRS	: National Resettlement Consultant
NMV	: Non-Motorized Vehicle
NLTP	: National Land Transport Policy
NOx	: Nitrogen oxide
ODA	: Official Development Assistance
OSD	: Overtaking Sight Distance
PD	: Project Director
PIU	: Project Implementation Unit
PMBDP	: Padma Multipurpose Bridge Design Project
PMP	: Periodic Maintenance Program
PAPs	: Project Affected Persons
PPP	: Public Private Partnership

PPR	: Project Progress Report
The Project	: Western Bangladesh Bridges Improvement Project
PSB	: Portable Steel Bridges
PVAT	: Property Value Assessment Team
RCP	: Representative Concentration Pathways
RMP	: Road Master Plan
RHD	: Road and Highways Department
ROW	: Right Of Way
RS	: Response Spectrum
RU	: Resettlement Unit
RUC	: Road User Cost
RV	: Replacement Value
SAARC	: South Asian Association for Regional Cooperation
SASEC	: South Asia Sub-regional Economic Cooperation
The Survey	: Preparatory Survey on Western Bangladesh Bridges Improvement Project
SES	: Socio-Economic Survey
SEZ	: Special Economic Zone
SHM	: Stake Holder Meeting
SHWL	: Standard High water Level
SLR	: Sea Level Rise
SN	: Structural Number
SO2	: Sulfur dioxide
SPSP	: Steel Pipe Sheet Pile
SPM	: Suspended Particulate Matters
SSD	: Stopping Sight Distance
TA	: Technical Assistance
TIN	: Triangulated Irregular Network
ToR	: Terms of Reference
TTC	: Travel Time Cost
TSS	: Total Suspended Solid
VOC	: Vehicle Operation Cost
WARPO	: The Water Resources Planning Organization
WB	: World Bank
WBBIP	: Western Bangladesh Bridges Improvement Project

1. INTRODUCTION

1.1 Background

Aiming at becoming a middle income country by 2021, the People's Republic of Bangladesh (hereinafter referred to as Bangladesh) is experiencing robust economic growth while maintaining a GDP growth rate of around 6% for several years. With its continued economic development, cargo transportation volume of the country increased eight times in 30 years from 1975 to 2005, and in recent years transportation volume of both passengers and cargo is increasing at an annual rate of 6 - 7 %. To meet the increasing demands for domestic transportation, the Government of Bangladesh (hereinafter referred to as GOB) has been actively developing its road network. As a result, in 2005, road transport accounted for around 80% of the domestic transportation, surpassing inland water transport and railway transport. The Road and Highways Department (hereinafter referred to as RHD) is responsible for the construction and the maintenance of the major road and bridge network of Bangladesh.

Most of the approximately 4,500 bridges operated and maintained by RHD have been found to be aging and deteriorated. 1,500 of these bridges are said to be unsafe, since they have significant structural damages.

In addition, another 1,000 bridges are bailey bridges, which are prefabricated steel truss bridges for temporary purpose and not suitable for road bridges due to lack of capability and safety function. Most of these bailey bridges under RHD's control are in unsafe condition; the bridges have already become deteriorated and damaged, and in the some serious cases, bridges have already collapsed.

In the 6th Five-Year Plan of Bangladesh (between F.Y. 2011/12 and 2015/16, hereinafter referred to as 6FYP), it was declared that, in the highway sector, modernized and efficient road transportation systems would take a vital role in accomplishing the 6FYP as well as Vision 2021, the medium-term target of the nation. Rebuilding of the existing bridges, the total length of which reaches around 10,000 km, was listed as one of the major targets in the 6FYP. In National Land Transport Policy in 2004 (hereinafter referred to as NLTP), implementing safety measures to the entire medium and small bridges in the country was featured as one of the major policies. The Road Master Plan in 2009, designed based on NLTP, states that one of the major goals is rebuilding all bailey bridges as permanent

structures.

Assisting RHD in improving its road bridges matches the aid policies of the Government of Japan (hereinafter referred to as GOJ). Also, Japan International Cooperation Agency (hereinafter referred to as JICA) considers the nation-wide development of transport and traffic system to be one of the important issues for the country. In the Country Assistance Policy for Bangladesh, drawn up in June 2012, the GOJ considered the development of infrastructures for traffic and transport to be one of the major goals to enhance efficiency in human and cargo transportation in Bangladesh.

1.2 Contents of the Request

In May 2013, GOB requested JICA to carry out the preparatory survey on bridge improvement project in 5 zones in western Bangladesh: Rangpur, Rajshahi, Gopalganj, Khulna and Barisal, covering 37 districts to the west of Padma River.

1.3 Objective of the Survey

A Preparatory Survey (hereinafter referred to as the Survey) on Western Bangladesh Bridges Improvement Project (hereinafter referred to as WBBIP) is carried out in accordance with GOB's above-stated request.

The Objective of the Survey is to obtain all the data and information required for appraisal of the Project as Japanese ODA loan project, such as defining the project objectives and preparing project summary, project cost, implementation structure, implementation schedule, implementation method (procurement, construction), implementation plan, operation and maintenance plan, environment and social considerations, etc.

1.4 Survey Area

The survey area is comprised of 5 zones in western Bangladesh, Rangpur, Rajshahi, Gopalganj, Khulna and Barisal.

A location map of the survey area is shown in Figure 1.4.1.

Source: JICA Survey Team

Figure 1.4.1 Survey Area

1.5 Staging and Phasing of the Survey

The survey work can be broken down into 5 phases in 3 main stages as shown below.

Stage 1: Affirmation of the Project and Selection of Project Bridges

Phase 1: Understanding of Basic Information, Study on Framework of the Project, and Selection of Candidate Bridges

Stage 2: Study on Main Content of the Project

Phase 2: Site Survey and Determination of Bridge Type

Phase 3: Preliminary Design

Phase 4: Selection of Project Bridges, Preparation for Appraisal of Japanese ODA Loan

Stage 3: Reporting and Support for JICA Appraisal Mission

Phase 5: Reporting and Support for JICA Appraisal Mission

2. NECESSITY OF THE PROJECT

2.1 Review of Relevant Plans and Programs

2.1.1 Vision 2021

Bangladesh achieved independence in 1971 and will celebrate its fifty years of independence in the year 2021, the golden jubilee of the nation. Bangladesh is aiming to become a middle-income country by that time, through the execution of eight identified goals which are referred to as Digital Bangladesh Vision 2021. This vision will meet the hopes and aspirations of the citizens of the country for an economically inclusive and politically accountable society. The eight goals are outlined as

- Goal one: To become a participatory democracy
- Goal two: To have an efficient, accountable, transparent and decentralized system of governance
- Goal three: To become a poverty-free middle-income country
- Goal four: To have a nation of healthy citizens
- Goal five: To develop skilled and creative human resources
- Goal six: To become a globally-integrated regional economic and commercial hub
- Goal seven: To be environmentally sustainable
- Goal eight: To be a more inclusive and equitable society

Of the eight goals, Goal six comprises a building of super highway connecting the mega port with the neighboring countries Nepal, Bhutan, Eastern India with Bangladesh and onward to Myanmar, South Western China and Thailand, though the Asian Highway and Railway networks. Such highway and railway networks would serve the national goal by making the use of the mega port. It is planned that the highway network extends southwards to Cox's Bazaar, so that it can be further connected with Myanmar, Thailand, and China through a southern route.

2.1.2 Sixth Five Year Plan, 6FYP (2011-2015)

In order to achieve an average GDP growth rate of 7 percent per annum, the transport sector growth rate is projected to increase by 7.5 percent per annum. In order to achieve this goal, the 6FYP (2011-2015) was formulated to develop a balanced and integrated transport network through the adoption of several strategies/programs:

(1) Outline of strategies and policies

Some key strategies and policies for the road sector to be undertaken in accordance with the 6FYP are outlined as:

i. Inclusion of a limited number of projects into Annual Development Program (ADP) on a priority basis

ii. Allocation of adequate funds for domestically funded projects

iii. Implementation of RHD Road Master Plan (2009)

iv. Selection of locally funded projects in consideration of socio-economic merits

v. Establishment of Road Maintenance Fund

vi. Involvement of the private sector by taking up projects on BOT/PPP basis

Moreover, GOB has been following the strategy of road network development on the basis of five important corridors:

a) Dhaka-Chittagong (N1)

b) Dhaka-Northwest (N4)

c) Dhaka-Khulna (N7)

d) Dhaka-Sylhet (N2)

e) Khulna-Northwest

(2) Strategy on development of regional and international connectivity

Bangladesh will actively pursue an open-door policy to international traffic by taking advantage of its strategic location in terms of large access to sea and being the gateway between Eastern and Southern parts of Asia. Accordingly, the Government has been making efforts to improve the road connectivity with neighboring countries through various regional cooperation forums such as South Asian Association for Regional Cooperation (SAARC), South Asia Sub-regional Economic Cooperation (SASEC), Bay of Bengal Institute for Multi-sectoral Technical and Economic Cooperation (BIMSTEC) and Bangladesh-China-India Myanmar (BCIM).

Bangladesh has acceded to the Asian Highway Network on 8 November 2009. The physical alignment of Asian Highway Route in Bangladesh is more or less completed so far as the road connectivity is concerned. GOB has planned to upgrade almost the whole part of the AH Network in Bangladesh by phases in order to bring the same in harmony with such network outside Bangladesh.

(3) RHD Goal and Objectives set forth with 6FYP

The contribution of the road sector to the national income is around 8 percent at current market prices. The prime goal of RHD is to make the growth sustainable, which can be achieved by developing a well-maintained, cost effective and safe road network in the country. RHD objectives necessary to achieve the road sector goal are:

- To develop and manage strategic road corridors to underpin the economic development of all regions of the country and contribute to the Government's poverty reduction objectives.
- To link all rural areas with the national road network to provide basic social access and promote "pro-poor growth".

With a view to address the vision of SYFP, RHD is going to take up several new projects under the following programs and subsequently has set up the some physical targets which are summarized in Table 2.1.1.

i. General Road Network Development

ii. Construction of Bridges

iii. Congestion Reduction in Greater Dhaka and other big cities

iv. Development of Asian Highway Network

v. Regional Connectivity

vi. Construction of Padma Bridge Access Roads/Bridges

vii. Construction of Bypass Roads

viii. Technical Assistance (TA) Projects

ix. Construction of Zilla Roads (new project)

Table 2.1.1 RHD Physical Targets for the 6FYP

Physical activities	Target road/bridge length
Construction of new roads	4,672 km
Improvement/ Rehabilitation of roads	8,433 km
Construction of new bridges/culverts /overpass	23,777 meter
Reconstruction of bridges/culverts	10,362 meter
Construction of Tunnel	5,400 meter

Source: SYFP (2011-2015)

2.1.3 National Land Transport Policy, NLTP (2004)

To face the challenges of the twenty-first century, Bangladesh needs to take its place in the world as a developed country. Integrated development and growth of all the sectors are the necessary means to achieve this goal. The Land Transport Policy has been formulated to meet the needs of the twenty first century. Accordingly Government has introduced a long-term network planning as is stated in NLTP. The road sector policies contained in the NLTP are designed to:

- Develop a long-term (20-year) Road Master Plan (2009)
- Clarify government responsibilities for Roads and Highways
- Maintain the road network at a level that protects the value of investment
- Rehabilitate those roads no longer capable of being maintained
- Secure a sustainable means of funding for road expenditure
- Improve management of traffic on the network to make the best use of assets
- Manage road side activities in a way that maximizes use of road assets
- Develop an integrated planning approach
- Involve the private sector more in infrastructure, services and maintenance
- Develop rational bridge policies

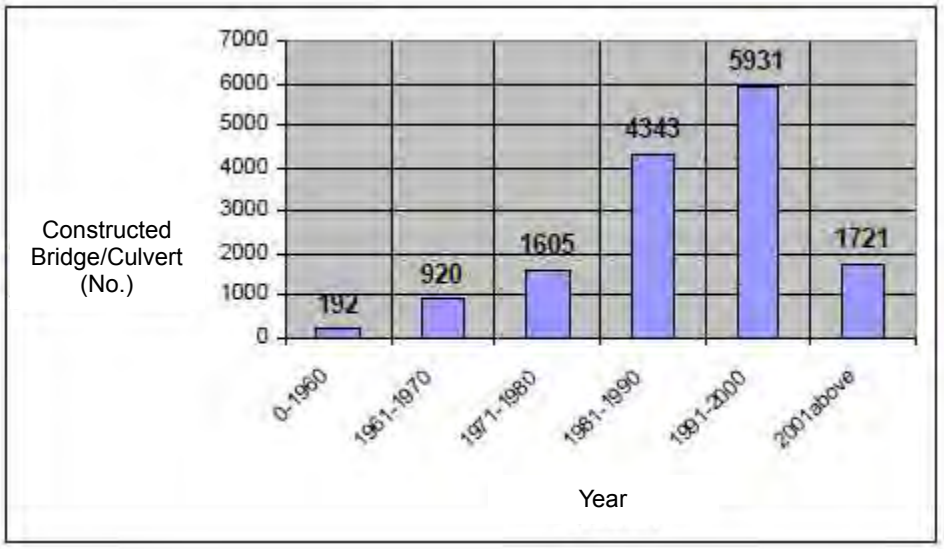
RHD in conjunction with other concerned agencies will be responsible to define the geometric standards for all bridges in the main road network (National, Regional and Feeder Roads). A priority program for widening bridges on National Roads up to the carriageway width will be developed, and where demand exists, incorporating non-motorized vehicle lanes will be considered. This program aims to:

- Improve the quality of the contracting industry
- Foster inter-regional links

Inter-National Links will be encouraged in the greater national interest. Bangladesh will play an active role in the field of international road communications. These actions shall improve management and operations of the Roads and Highways Department

2.1.4 Road Master Plan, RMP (2009)

Several thousand bridges and culverts have been constructed on RHD road network over last four decades, but of these, many were built many years ago and obviously do not meet the current design standards. Moreover, they are undergoing severe damage due to inadequate periodic and routine maintenance.



Source: RMP (2009)

Figure 2.1.1 Bridges/Culverts Constructed in Bangladesh

The GOB prepared a Road Master Plan, RMP (2009) in order to guide the development and maintenance of RHD's road infrastructure over the next 20 years. It provides a physical plan for new road/bridge construction, rehabilitation and maintenance over the next 20 years, and sets out a spending program for the sector. Following subsections briefly demonstrate the overall objectives, issues and policy development, and implementation plan under RMP.

a) Objectives

The overall objectives of RMP have been set out a comprehensive investment program in order to:

- Protect the value of RHD's road and bridge assets
- Improve the connectivity of the road network
- Enhance and develop the strategic road network to meet economic and traffic growth targets

- Improve the Zilla Road network to enhance the connectivity to the growth centers
- Improve road safety and reduce road accidents
- Provide environmental and social protection
- Outline the institutional improvements required for RHD

b) Some key issues

The development of RMP is based on several key issues addressing the existing problems faced by the road and bridge network. Some of the key issues on road network maintenance/development are listed below:

i. The strength of national and regional highway network is largely affected by inadequate maintenance
ii. Vehicle overloading considerably deteriorates the target life span of road/bridge strength
iii. The operation of national highway network is severely affected by poor local traffic management.
iv. Zilla road network is not fulfilling its role in rural connectivity and has also suffered from lack of maintenance.
v. Bridges that have not been properly maintained will shortly need replacement, or major repairs
vi. Traffic is expected to increase by a factor of at least three over the next 20 years, and accordingly, the major strategic corridors require increases in traffic capacity.

In addressing the above issues, RMP has prepared road sector policy and subsequently their implementation plans which are stated hereunder in Table 2.1.2.

Table 2.1.2 Role of RMP to Implementing the Road Sector Policy

Road Sector Policy	Implementation plan
Govt. will create Road Fund and autonomous Board	Government had already decided to promulgate Road Maintenance Fund
RHD road network to be maintained to a set of agreed standards	Target to upgrade network in accordance with "Geometric Design Standards of RHD"
All roads under RHD to be placed under routine maintenance contracts	a) For national highways, - Three-year contracts of total length 150 km, and seven/eight contracts to be let annually - Executive Engineer b) For regional and Zilla roads (3 options) - Annual contract for 40 km road and Sub-divisional Engineer is responsible for supervision - 330 km road under contract and Sub-divisional Engineer from respective division is responsible for supervision - 1,200 km road under contract and Executive Engineer from respective circle is responsible for supervision
RHD to install 18 weighbridges across the country	- Locations are selected on major roads where traffic volume is high, on roads where trucks routinely carry heavy goods - Moreover, police is empowered to stop and weigh vehicles, and equipped with portable weighing pads
The Zilla road network will be rehabilitated over the next ten years to ensure minimum accessibility level	- All growth centers, Upazilla headquarters, land and sea ports should have all weather year round vehicular access - Zilla road is prioritized on the basis of road condition, socio-economic score, and included for implementation under Zilla road program which is reviewed at every five years
Bridges in poor condition will be replaced or undergo major works to ensure safety and access over the next 10 years	- 2,091 Bridges with minor damage ("Category B") are considered as repairable to bring their status up to A condition. - 418 bridges with major damage ("Category C") should be repaired. - 133 bridges with major damage, narrow carriageway ("Category D") should be replaced.
All narrow bridges (less than 7.3m) on National Highways will be replaced over next 20 years by bridges having at least 7.3m carriageway	- 18 bridges on national highways and 108 bridges on regional highways are undertaken into narrow bridge replacement program - A Bridge Replacement Program (BRP) project replacing narrow bridges on mainly Zilla roads began in 2003-04.
All Portable Steel Bridges (PSB) will be replaced by permanent structures over next 20 years	- 262 bridges on highways (D category=62, and C category=200) are undertaken into PSB replacement program
Regular bridge maintenance will be introduced and enhanced	- A comprehensive bridge survey is recommended to update BCS database - A maintenance manual for different types of bridge structures should be prepared - Maintenance should be given high priority and separate provision of budget shall be made

Source: RMP (2009)

2.2 Review of Relevant Projects

2.2.1 Project for Provision of Portable Steel Bridges on Upazila and Union Roads

(1) General Information

This Project was implemented as a Japanese Grant Aid Project. Objective of the Project is to improve the road network in these rural areas. Approximately 80% of the entire population is living in these areas. Steel superstructures of the road bridges were provided in the Project.

The responsible organization of the Project was Local Government Division (hereinafter referred to as LGD), Ministry of Local Government Rural Development and Cooperatives (hereinafter referred to as MoLGRD&C). And the implementing agency was Local Government Engineering Department (hereinafter referred to as LGED).

The Project was implemented in three (3) phases under LGED as stated below. Another similar project for national, regional, and zilla roads was also implemented under RHD, Ministry of Road Transport and Bridges (hereinafter refer to as MORTB).

- Phase 1 : 74 bridges by LGED in 1994-1996
- Phase 2 : 80 bridges by LGED in 2000-2003
- Phase 3 : 92 bridges by LGED in 2010-2012
- Similar : 76 bridges by RHD in 2001-2004

Source: JICA Survey Team

Figure 2.2.1 Project Image

(2) Project Data

Portable steel truss bridges were constructed in the Project. Responsibilities of GOJ and GOB were as follows:

- GOJ: Procurement of superstructures (steel bridge)
- GOB: Construction of substructures and approach roads, and erection of superstructure

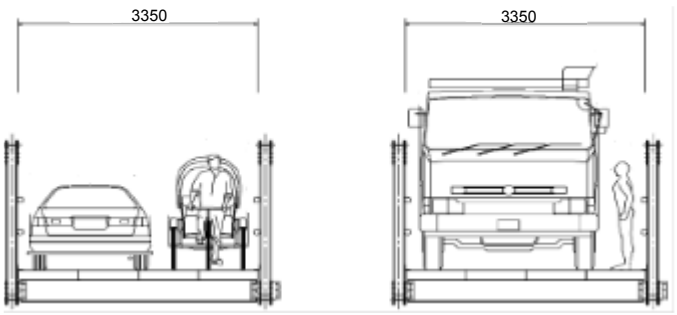
Table 2.2.1 Summary of the Projects

	Implementing Agency	No of Bridges	Total Length	Project Cost (mil. Yen)			Schedule
				GOJ	GOB	Total	
Phase 1	LGED	74 Br	3,445 m	1,503	533	2,036	1994-1997
Phase 2	LGED	80 Br	4,395 m	1,800	590	2,390	2000-2003
Similar	RHD	76 Br		950			2001-2004
Phase 3	LGED	92 Br *(4 Br)	4,885 m	1,971	657	2,628	2010-2012

Note * including replacement of existing bridge

Source: JICA Survey Team

Effective width of the bridges is 3.35m. This narrow width has not been able to manage increased traffic volume in recent years. Such narrow bridges are prone to pedestrian-vehicle accidents.



Source: JICA Survey Team

Figure 2.2.2 Cross Section of the Bridge

2.2.2 Eastern Bangladesh Bridges Improvement Project (EBBIP)

(1) General Information

Objective of this project is to improve reliability of the road network by improving small and medium sized bridges in Eastern Bangladesh, and thereby to contribute to the advancement of the local economy, and to improve economic and social disparity among regions.

This project, financed by a Japanese ODA Loan, saw the improvement 63 bridges in Eastern Bangladesh (Dhaka, Chittagong, Comilla and Sylhet). The executing agency was RHD/MORTB. This project is comprised of following two major components:

- Improvement of 63 bridges in Eastern Bangladesh (Dhaka, Chittagong Comilla and Sylhet)
- Capacity Building of RHD: Improving the institutional capacity of RHD in bridge inspection and maintenance through improvement of the existing BMMS.

Source: JICA Survey Team

Figure 2.2.3 Project Image

(2) Project Data

The EBBIP is a similar project to the WBBIP. The EBBIP is summarized as follows:

- Loan Agreement (L/A): 2008
- Project Cost: Approximately 9.3 billion JPY (GOJ Portion: 7.8 billion JPY, GOB Portion: 1.5 billion JPY)
- Number of Bridges: 63 bridges (Constructed by 4 packages)
- Bridge Type: PCI Girder Bridge
- Contractor: Bangladesh Contractor for 3 packages, Indian Contractor for 1 package
- Project Period: Will be completed in March 2015

2.2.3 Kanchpur, Meghna, and Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation Project

(1) General Information

Since 2008, GOB has been widening National Highway No.1 (NH1) to 4 lanes along its entire length, with the exception of three existing large-scale bridges, namely Kanchpur Bridge, Meghna Bridge and Gumti Bridge. The objective of this project is to construct secondary bridges adjacent to each of these existing bridges, and also to rehabilitate existing three bridges. The project is implemented financed by Japanese ODA Loan (L/A signed Mar 2013). The executing agency is RHD/MORTB.

The existing Kanchpur, Meghna, Gumti bridges were constructed in 1997, 1991 and 1995 respectively, originally with earthquake design standard of seismic coefficients of 0.05, which was increased to 0.15 under the new standards defined by the Bangladesh National Building Code (BNBC) in 2006. This change shall be considered in design of the secondary bridges and rehabilitation of the existing bridges.

Steel bridges were selected for the secondary bridges mainly because of their light weight which is advantageous against earthquakes. A special rehabilitation method for the existing bridges was adopted to increase earthquake resistance. The number of lanes for the secondary bridges was decided based on the traffic demand forecast and assuming a new 4-lane expressway construction between Dhaka and Chittagong.

- Kanchpur Bridge (Length 396.5 m): Existing bridge (4-lane), New bridge (4-lane)
- Meghna Bridge (Length 930.0 m): Existing bridge (2-lane), New bridge (4-lane)
- Gumti Bridge (Length 1,410 m): Existing bridge (2-lane), New bridge (4-lane)

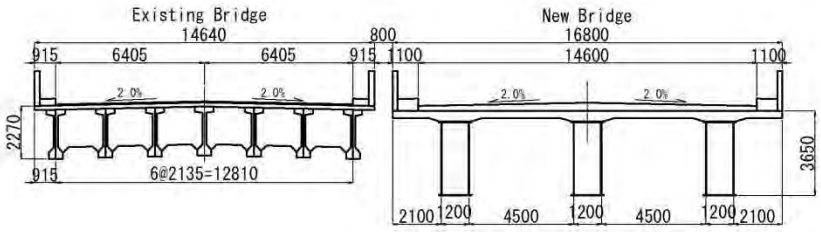
Source: JICA Survey Team

Figure 2.2.4 Project Image

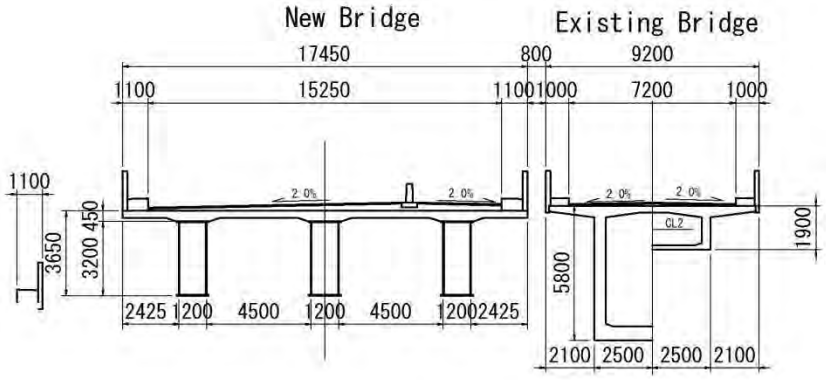
(2) Project Data

This project concerned the new construction of the secondary bridges and rehabilitation of existing bridges. A summary of this project is shown in Table 2.2.2. The total civil works cost including both GOJ and GOB portions is approximately 60,000 million JPY. Experience in the installation of steel narrow box girders and steel sheet piles is required in this project. Therefore construction by sufficiently-experienced foreign contractors is expected through the ICB procurement process.

- Kanchpur Bridge: 42.7 + 85.4 + 97.6 + 73.2 + 54.9 + 42.7 = 396.5 m (6 spans)



- Meghna Bridge: 48.5 + 9*87.0 + 73.5 + 25.0 = 930 m (12 spans)



- Gumti Bridge: (52.5 + 8*87.0 = 748.5) + (7*87.0 + 52.5 = 661.5) = 1,410 m (17 spans)

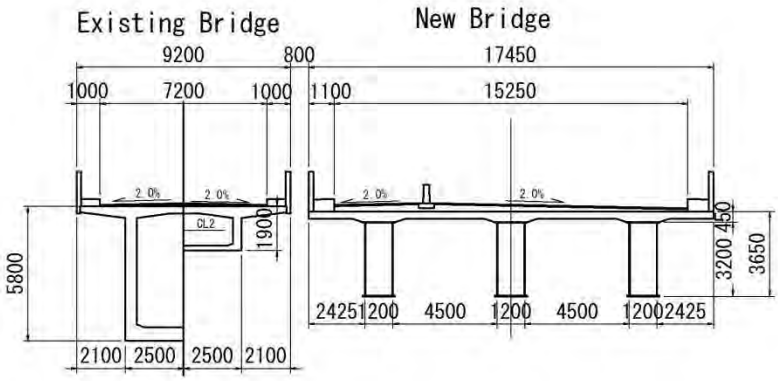


Table 2.2.2 Summary of the Projects

	New bridge			Existing Br.	Total Civil Work Cost		
	Br. Type	Width	Length	rehabilitation	GOJ	GOB	Total
Kanchpur	Steel narrow box girder	16.80 m (4-lane)	396.5 m (6-span)	Repair (cracks/rebar, connecting girders, center hinge)	36,999 Mil. JPY	24,120 Mil. TK	60,299 Mil. JPY
Meghna	Steel narrow box girder	17.45 m (4-lane)	930 m (12-span)				
Gumti	Steel narrow box girder	17.45 m (4-lane)	1,410 m (17-span)	Strengthening (deck, piers, foundation, fall-safe connection)			

Source: JICA Survey Team

2.3 Bridge Rehabilitation/Reconstruction Project by Other Donors

It was confirmed that eleven (11) bridges are under construction/rehabilitation or scheduled to be constructed/rehabilitated using funding from the Chinese government, or GOB itself, under its Periodic Maintenance Program (PMP) and Annual Development Program (ADP), as shown in Table 2.3.1. PMP, which handles reconstruction, rehabilitation and repairing of bridges and culverts, was started in 2005 – 2006, with financing from the Japan Debt Cancellation Fund (JDCF).

These bridges under PMP, ADP or Chinese-funded projects have been removed from consideration as candidate bridges to be improved under WBBIP.

Furthermore, another feasibility study on corridor improvement is ongoing under South Asia Subregional Economic Cooperation (SASEC) project by ADB. The study area of SASEC project is shown in Figure 2.3.1. The SASEC project is still in the feasibility stage, and no specific plans have been set out. Therefore any bridges that overlap with SASEC project are not to be removed from consideration as candidate bridges to be improved under WBBIP.

Table 2.3.1 Bridge Rehabilitation/Reconstruction Projects by GOB and China Fund

Bridge ID	Zone	Division	Description
N8_200c	Barisal	Patuakhali	Under construction by PMP
Z8806_46a	Barisal	Patuakhali	Included in PMP (2013-2014)
N8_096a	Gopalganj	Madaripur	Included in PMP (2013-2014)
R860_21a	Gopalganj	Shariatpur	Overlapped by China fund
Z8404_002a	Gopalganj	Faridpur	Included in PMP (2013-2014)
N8_098a	Gopalganj	Madaripur	Included in PMP (2013-2014)
R860_17a	Gopalganj	Shariatpur	Overlapped by China fund
R860_17d	Gopalganj	Shariatpur	Overlapped by China fund
N708_1a	Khulna	Jessore	Under constrction by ADP
Z5452_27b	Rajshahi	Naogaon	Under ADP
Z6809_7a	Rajshahi	Rajshahi	Included in PMP (2013-2014)

Source: RHD

Source: RHD edited by JICA Survey Team

Figure 2.3.1 Corridor Improvement Project (SASEC) by ADB

2.4 Roads and Bridges in Bangladesh

2.4.1 Introduction

(1) Roads

The road network consists of six road categories: National Highways, Regional Highways, Zilla Roads, Upazila Roads, Union Roads and Village Roads. The Road and Highways Department (RHD), under the Ministry of Road Transport and Bridges (MORTB) of Bangladesh, manages 21,453 km of roads including National Highways, Regional Highways, and Zilla Roads (see Table2.4.1). The total road length managed by RHD makes up 8% of the total road network in Bangladesh. The density of National Roads is 15 km per 100 km^2 of land and 144 km / 1 million people. The Project area (Western Bangladesh) has approximately 7000 km of RHD-managed roads.

Table 2.4.1 Road Network in Bangladesh

Road Class	Definition	Length (km)	Operator
National Highways	Highways connecting National capital with Divisional HQ's or sea ports or land ports or Asian Highway.	3,569.09	RHD
Regional Highways	Highways connecting District HQ's or main river or land ports or with each other not connected by National Highways.	4,222.36	RHD
Zilla Roads	Roads connecting District HQ's with Upazilla HQ's or connecting one Upazilla HQ to another Upazilla HQ by a single main connection with National/Regional Highway, through shortest distance/route.	13,169.48	RHD
	Sub-Total	20,960.93	
Upazila Road	Roads connecting Upazila HQs with growth center with another growth center by a single main connection or connecting growth center to higher road system through shortest distance/route	37,335	LGD
Union road	Roads connecting Union HQs with Upazila HQs, growth centers or local markets or with each other	44,202	LGD
Village Road	a) Roads connecting villages with Union HQs local markets, farms and ghats or with each other. b) Roads within a village	222,842	LGD
	Total	325,968	

Source: RHD website, LGED website As of 2014

(2) Bridge and Other Structures

The number of structures on the RHD road network (National highways, regional highways and Zilla roads) has increased dramatically since 1991. The number of road structures in the

last 20 years is shown in Table 2.4.2. The number of structures managed by RHD in 2013 is 21,482 which is approximately seven times the number in 1991.

Table 2.4.2 The Number of Road Structures on RHD Road Network

	No. of culverts and bridges			No. of Bridges		
	1991	2006	2013	1991	2006	2013
National Highways	1,012	3,617	4,345	-	864	819
Regional Highways	302	3,535	4,118	-	846	741
Zilla Roads	1,843	7,560	13,029	-	2,083	2,292
Total	3,157	14,712	21,492	-	3,793	3,852

Source: Road Master Plan (2009), BMMS database, RHD website, SAPROF Report on EBBIP and EBBIP Bridge condition survey

2.4.2 Important Corridors and Zones

(1) Asian Highways

The Asian Highways (AH) project was initiated in 1959 with the aim of promoting the development of international road transport in the region. Presently, AH network covers 141,000 km of roadways traversing 32 Asian countries, even having linkages to Europe.

Source: United Nation ESCAP Website: http://www.unescap.org/TTDW/index.asp?MenuName=AsianHighway

Figure 2.4.1 Asian Highway Network

GOB has acceded to the Asian Highway Network on 8 November, 2009 to connect the country with 28 countries. The total length of AH Network in Bangladesh is 1,761 km. There are 3 routes in Bangladesh; two routes are considered international trade routes and one route is considered a sub-regional route. The following is a summary of the 3 AH routes in Bangladesh:

International Routes:

(i) Route AH-1:

Benapole–Jessore–Narail–Bhatiapara–Mawa–Dhaka–Katchpur–Sarail–Sylhet–Tamabil (length 495 km)

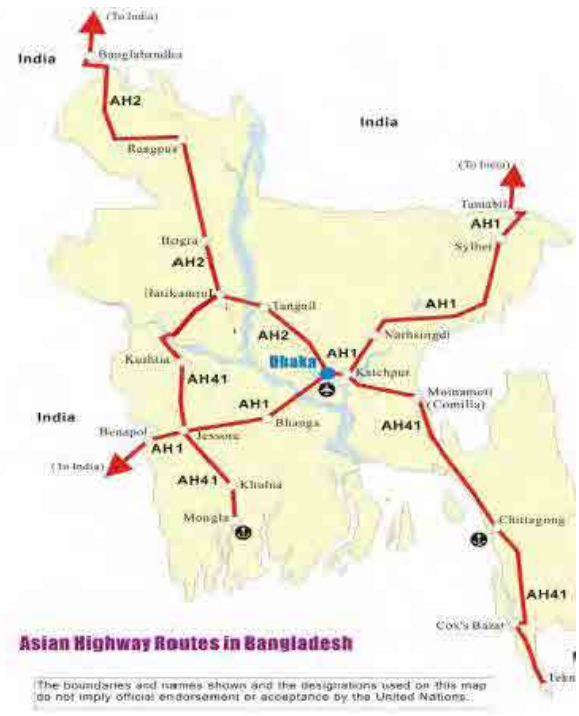
(ii) Route AH-2:

Banglabandh–Panchagarh–Rangpur–Bogra–Hatikamrul–Jamuna Bridge–Tangail–Dhaka–Katchpur–Sarail–Sylhet–Tamabil (length 805 km including 283 km which is overlapped with AH1)

Sub-Regional Routes:

(i) Route AH-41:

Mongla Port–Jessore–Bonpara–Hatikamrul–Katchpur–Comilla–Chittagong–Cox's Bazar–Teknaf Myanmar Border (length 752 km)



Source: STATUS PAPER ON ASIAN HIGHWAY BANGLADESH, MORTB

Figure 2.4.2 Asian Highway Network in Bangladesh

(2) Corridor to India

Bangladesh and India share a land border of 4,094 km and have an intimate relationship. The two countries are undertaking strategic partnerships in developing regional infrastructure, greater trade, environmental protection, energy, and cultural relations.

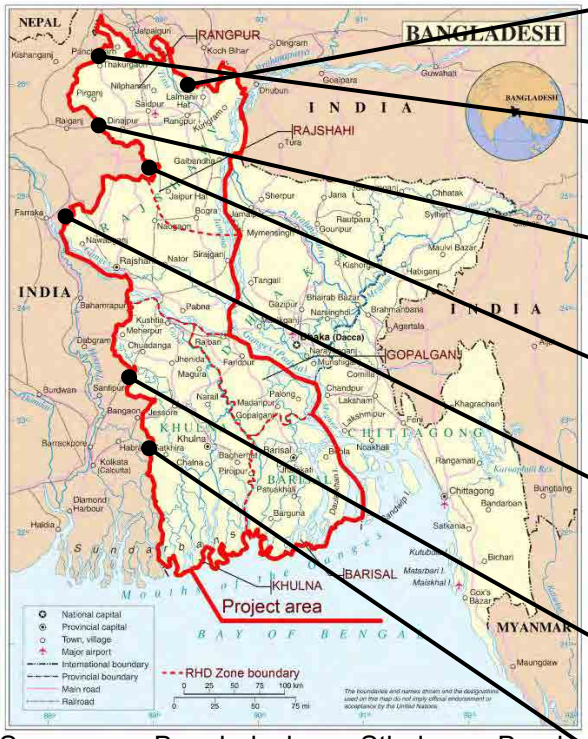
India is major trading country for Bangladesh, ranking second for import and sixth for export. The two-way trade in FY 2011-2012 was US$5.242 billion (with imports from India accounting for US$4.743 billion and exports to India accounting for US$498 million), an increase of 150% since 2005-2006. Table 2.4.3 Trade Performance between Bangladesh and India shows the trade between the two countries in the last six years.

Table 2.4.3 Trade Performance between Bangladesh and India

Financial year (July to June)	05-06	06-07	07-08	08-09	09-10	10-11	11-12
Imports from India	1,864.7	2,268.0	3,364.0	2,841.1	3,202.0	4,586.8	4,743.3
Export to India	242.0	289.4	358.1	276.6	305.0	512.5	498.4
Total trade	2,106.7	2,557.4	3,722.1	3,117.6	3,507.0	5,099.3	5,241.7

Source :Bangladesh Bank Figures in US$ million

The project area has seven corridors to India (comprised of one railway and six highways), all of which are important trunk roads.



Source: Bangladesh Sthala Bandar Kartipaksha, www.bssbk.gov.bd

Burimari Land Port
Location: Patgram, Lalmonirhat
Operator: Appointment private operator (BOT)
Area: 11.15 acres

Banglabandha Land Port
Location: Tetulia, Panchagah
Operator: Banglabandha Land Port. LTD (BOT)
Area: 10 acres

Biral Land Port (Rail way)
Location: Biral, Dinajpur
Operator: Biral Land Port .Ltd(BOT)
Area: 11.15 acres

Hill Land Port
Location: Hakimpur, Dinajpur
Operator: Panama Hill Port Link. Ltd(BOT)
Area: 11.15 acres

Sonamosjid Land Port
Location: Shibganji, Chapai Nawabganj
Operator: Panama Sonamosjid Port Link Ltd(BOT)
Area: 19.13 acres

Benaple Land Port
Location: Sharsha, Jessore
Operator: Bangladesh Land Port Authority
Area: 56.71 acres

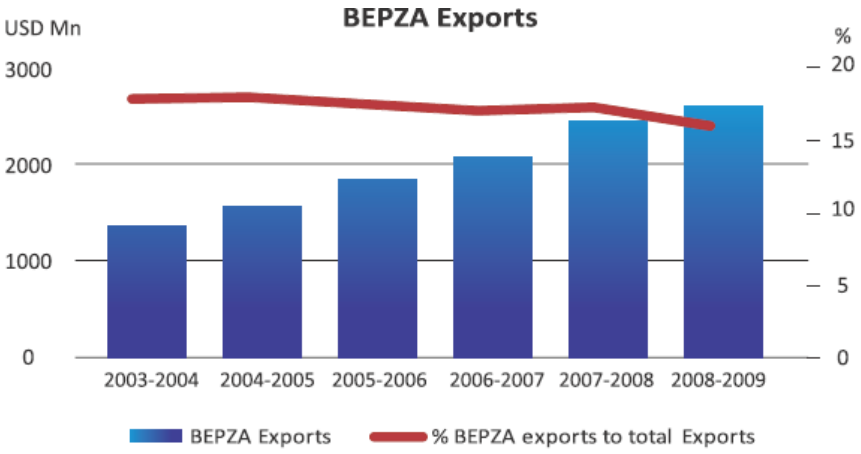
Bhomura Land Port
Location: Sadar, Shatkhira
Operator: Appointment private operator (BOT)
Area: 15.73 acres

Figure 2.4.3 Location of Land Ports in Western Bangladesh

(3) Export Processing Zones (EPZs)

In order to stimulate economic growth of the country, particularly through industrialization, the GOB has adopted an 'Open Door Policy' to attract foreign investment in Bangladesh. The Bangladesh Export Processing Zones Authority (BEPZA) is an official organization of the government to whose task is to promote, attract and facilitate foreign investment in all of the Export Processing Zones (EPZs) of the country. The effect of EPZs on exports is shown in Figure 2.4.4. During past 10 years, BEPZA's export has increased every years, and its annual average contribution to national export stands at 17.23%. EPZs have an impact on national economy. Improvement of the transportation route to EPZs in a timely manner is

very important in Bangladesh.



Source: BEPZA annual repot 2008-09

Figure 2.4.4 The Trend of EPZs Performance

There are eight EPZs (existing or planned) nationwide, three of which are located in the Project area. The location of EPZs in the Project area is shown in Figure 2.4.5.

Source: BEPZA annual report 2008-2009

Uttara EPZ
- Location: Shongalshi, Nilphamari
- Zone area: 230.21 acres
- Number of industrial plots: 202
- Employment: 1,901
- Investment: US$0.31M
- Export: US$0.41M

Ishwardi EPZ
- Location: Pakshi, Pabna
- Zone area: 308.77 acres
- Number of industrial plots: 166
- Employment: 1,537
- Investment: US$7.86M
- Export: US$16.27M

Mongla EPZ
- Location: Port area, Mongla, Bagerhat
- Zone area: 460 acres
- Number of industrial plots: 162
- Employment:269
- Investment: US$4.37M
- Export: US$95.85M

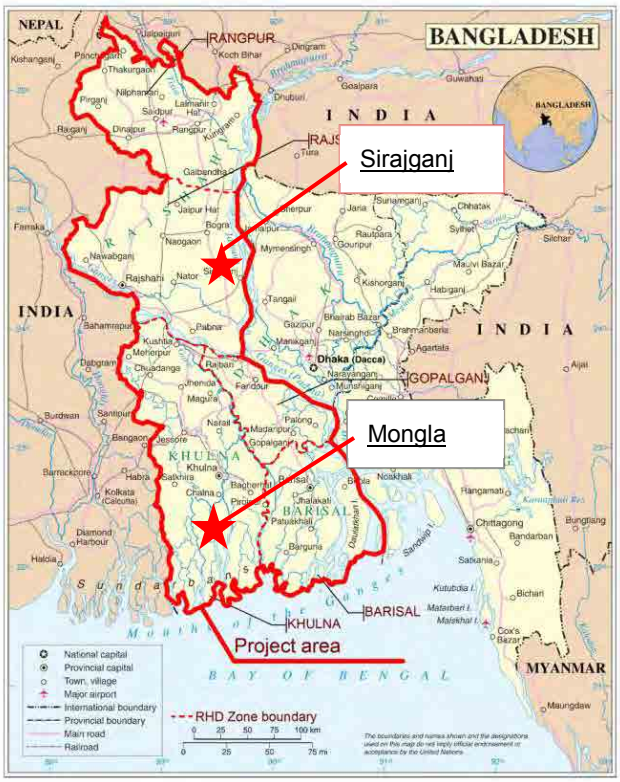
Figure 2.4.5 The Overview of EPZs in Western Bangladesh

(4) Special Economic Zones (SEZs)

GOB has been involved in the development of eight EPZs. However, there are several issues

relating to these EPZs:

- The major EPZs are almost at capacity.
- Due to companies inside EPZs not having relationships with domestic industries outside EPZ, these domestic industries receive little impact in terms of development and skills transfer.
- GOB has no financial leeway to invest in development of new industrial parks.



Source: Data Collection Survey on the Special Economic Zones in the People's Republic of Bangladesh, JICA

Figure 2.4.6 The Location of SEZs Candidate Site in Western Bangladesh

In light of this situation, GOB has decided to suspend the development of new EPZ and to establish thirty Economic Zones throughout the Nation. In 2012, BEZA, which is responsible for the development and operation of Special Economic Zones (SEZs), chose 7 candidate sites out of 30 long-listed candidates, and they plan to conduct a Preliminary Feasibility Study.

In Western Bangladesh, there are 2 short-listed candidate SEZs, namely Sirajganj and Mongla.

2.4.3 Traffic Volume Growth by Road Type

The traffic volume growth rate for each road type, i.e. national roads, regional roads and Zilla roads, was estimated based on the traffic count survey result in 2004 - 2014 by RHD.

The average annual traffic volume growth rate for each road type is shown in Table 2.4.4 Average Annual Traffic Volume Growth Rate.

Table 2.4.4 Average Annual Traffic Volume Growth Rate

Year	Traffic Volume Growth Rate (%/year)		
	National Roads	Regional Roads	Zilla Roads
2004 - 2014	6.25	5.62	5.15

Source: JICA Survey Team

The traffic volume on national roads has the highest growth rate, followed by regional roads,

then Zilla roads. It can be said that national roads are the most important roads, and requires the upgrade or improvement according to the increase of traffic volume.

2.4.4 Local Community Activity

There are 37 districts in Western Bangladesh. Local community activity as well as national economic activity should be considered when planning the infrastructure development.

Nine of these districts (namely Barisal, Bogra, Dinajpur, Jessore, Khulna, Naogaon, Pabna, Rajshahi and Sirajganj) are economically dynamic with GRDP of more than 800 million BDT (see Figure 2.4.7).

Enhancement of the road network will contribute to the local community and economic growth.

Source: JICA Survey Team

Figure 2.4.7 High GRDP District in Western Bangladesh

2.5 Bridge Conditions in Western Bangladesh

2.5.1 Bridge Condition Survey

(1) Bridge Maintenance Management System (BMMS)

Established in 2006, the Bridge Maintenance Management System (BMMS) is an application-based database on the management of information regarding all structures undertaken by RHD. BMMS is an integral part of the RHD Management Information System as it establishes transparency for all bridge projects handled by RHD. The BMMS application has direct links to all major RHD databases, including the Contract Monitoring System database, Road Maintenance Management System database, and the Project Monitoring System Database.

In order to assess the need of repair, rehabilitation and reconstruction of bridges, RHD adopted a simple but effective way of reporting the condition of bridges/structures. This method is set out in their Bridge Condition Survey (BCS) Manual. Accordingly, RHD conducted Bridge Condition Surveys for culverts and bridges on all types of roads to assess their damage condition. The existing condition of the classified structures is divided into four categories:

- Category A: Good
- Category B: Minor Element Damage
- Category C: Major Element Damage
- Category D: Major Structural Damage

From the damage description of damage categories “C” and “D”, it appears that category “C” is used when the repair or replacement are restricted to limited structural components, while for category “D”, repair or replacement is to be carried out for the entire structure.

Most of the data was obtained from 2004 to 2006. The BMMS database lists 4517 bridges, 1730 of which are located in Western Bangladesh. The result of bridge condition survey is shown in Table 2.5.1.

Table 2.5.1 Bridge Condition Category in BMMS

Western Bangladesh

Damage / Zone	A				B				C				D			
	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ
Barisal	28	15	212	255	9	4	28	41	10	6	46	62	4	0	16	20
Gopalganj	35	22	102	159	8	12	27	47	22	2	42	66	6	2	15	23
Khulna	22	61	100	183	9	9	27	45	9	20	49	78	0	2	27	29
Rajshahi	47	20	110	177	10	6	44	60	12	11	45	68	4	12	14	30
Rangpur	37	15	192	244	11	3	40	54	11	7	38	56	4	4	25	33
Total	169	133	716	1,018	47	34	166	247	64	46	220	330	18	20	97	135
															Total	1,730

Eastern Bangladesh

Damage / Zone	A				B				C				D			
	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ
Chittagong	71	53	211	335	52	25	41	118	67	56	119	242	6	11	41	58
Comilla	24	11	197	232	18	24	94	136	15	45	144	204	2	9	65	76
Dhaka	83	47	198	328	56	36	107	199	60	122	143	325	7	34	61	102
Sylhet	71	63	97	231	21	32	28	81	16	45	36	97	2	4	17	23
Total	249	174	703	1,126	147	117	270	534	158	268	442	868	17	58	184	259
															Total	2,787

Source: BMMS database, RHD, www.rhd.gov.bd

(2) Survey in the Eastern Bangladesh Bridge Improvement Project (EBBIP)

GOB/RHD is currently implementing the Eastern Bangladesh Bridge Improvement Project

(EBBIP), financed by a Japanese ODA Loan. One of the EBBIP objectives is to improve the RHD's BMMS and to provide technical assistance for enhancing the RHD's bridge inspection and maintenance capability. As part of the project, the EBBIP team conducted a bridge condition survey to update the existing BMMS inventory. The survey, which was held from February to October, 2013, covered all RHD's bridges on national roads, regional roads and Zilla roads. The survey did not cover box culverts or slab culverts.

The EBBIP bridge condition survey was conducted for 4,480 structures thought to be bridges. However, it was found that many of these structures were other kind of structures such as box culverts that had been misclassified as bridges by the BMMS database, and there were in fact only 3,832 bridges. Of these bridges on the RHD road network, 1,539 are in Western Bangladesh. The result of the bridge condition survey is shown in Table 2.5.2.

Table 2.5.2 Bridge Condition Category in EBBIP Bridge Condition Survey

Western Bangladesh

Damage / Zone	A				B				C				D			
	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ
Barisal	11	11	75	97	10	8	51	69	6	4	120	130	1	0	26	27
Gopalganj	38	12	64	114	15	3	29	47	16	4	44	64	6	4	26	36
Khulna	17	32	32	81	10	24	46	80	11	18	58	87	6	4	26	36
Rajshahi	15	16	56	87	31	9	32	72	21	10	74	105	10	3	29	42
Rangpur	28	17	103	148	20	8	61	89	14	81	5	100	5	3	40	48
Total	109	88	330	527	86	52	219	357	68	117	301	486	28	13	128	169
															Total	1,539

Eastern Bangladesh

Damage / Zone	A				B				C				D			
	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ	N	R	Z	Σ
Chittagong	61	42	111	214	43	28	67	138	39	32	94	165	12	17	84	113
Comilla	21	21	114	156	26	25	119	170	10	19	84	113	3	13	40	56
Dhaka	109	53	134	296	78	61	118	257	13	43	105	161	1	20	65	86
Sylhet	62	42	42	146	39	31	68	138	10	19	41	70	1	4	9	14
Total	253	158	401	812	186	145	372	703	72	113	324	509	17	54	198	269
															Total	2,293

Source: EBBIP bridge condition survey

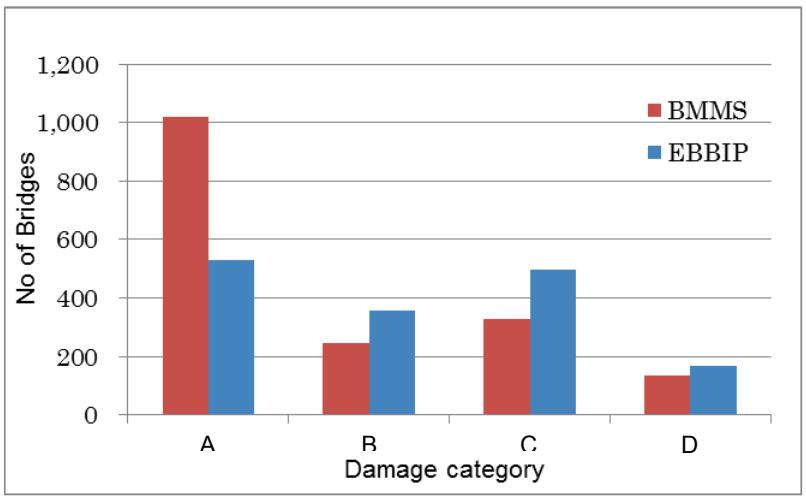
2.5.2 Analysis of Bridge Conditions in Western Bangladesh

(1) Evaluation from Bridge Inventory Data

The condition of bridges in Bangladesh has been worsening due to the limited maintenance budget as well as lack of technology/experience in bridge rehabilitation.

The number of bridges in Western Bangladesh categorized by damage level in both BMMS data base and EBBIP data base is shown in Figure 2.5.1. Number of bridges categorized B, C and D has increased, although that of A has decreased from 2004-2006 (the year of the BMMS survey), to 2013 (the year of the EBBIP).

This result shows that the damage of bridges has been progressing in Western Bangladesh.



Source: BMMS database, RHD, www.rhd.gov.bd, EBBIP bridge condition survey

Figure 2.5.1 Comparison of Damage Level between BMMS and EBBIP

(2) Current Conditions of Existing Bridges

The following summarizes current conditions of existing bridges in Bangladesh:

1) Temporary (Bailey) or Narrow Bridges

Temporary (Bailey) bridges have been constructed with limited truck load capacity of 10-15 tons, and therefore cannot bear the recent increased truck load of 20 tons. Furthermore, these bridges have thin steel deck plates or even timber floors which are easily damaged by repeated truck loading, and they have been left in hazardous conditions without sufficient maintenance.

Many of these Bailey bridges are only one-lane, providing enough space for vehicles to pass each other, which causes traffic bottlenecks. The bridges that are two-lane have narrower widths than their approach roads, which is known to cause high speed vehicles to have traffic accidents on national roads.

2) Old Bridges

There remain many old bridges with weak reinforced concrete structures, most of which were constructed in 1960s. These bridges were designed for a small truck live load of HS-14 and a small earthquake strength of 0.05 (the updated earthquake design code requires 0.075-0.25). Therefore these bridge structures seem top-heavy and very weak to earthquakes and increased truck live loads.

These old bridges have had no rehabilitation works and thus their current conditions are very dangerous for future increasing traffic or medium-sized earthquakes. Their floor beam structures and sub structures have been damaged so severely that it appears they could collapse at any time. These old bridges shall be replaced with great haste.

3) Severe Damage on Deck Slabs

Deck slabs incur visible damage the most quickly of all bridge component s (due to receiving direct vehicle load); therefore damage on deck slabs is a key indicator for bridge diagnosis. Even though the rehabilitation of deck slabs is quite a straightforward process, not much of it has taken place in Bangladesh due to a lack of maintenance budget. In most of these bridges, the damage condition of deck slabs seems to have progressed so much that rehabilitation works will no longer be effective, and now the only solution is replacement.

4) Insufficient Clearance for Rivers

In several cases, water flow of rivers is inducing scouring on bridge substructures due to insufficient bridge length. Additionally, the vertical clearance for water under the bridge may be insufficient, and bridge girders close to the water are subjected to material deterioration on concrete and steel surface.

When designing new bridges on the water, sufficient bridge length and vertical clearance are required to maintain bridges for their design lives. In order to apply weathering steel, sufficient vertical and horizontal distance from the water surface shall be kept so as to develop stabilized rust on the steel surface.

2.6 Necessity of the Project

The implementation of the Project (i.e. the WBBIP) is important and necessary from the following points of view.

2.6.1 Conformity with Upper Level Plan

(1) Vision 2021

In Vision 2021, it is declared that a highway network will be built to connect the SAARC countries, Nepal, Bhutan, and Eastern India with Bangladesh, and that through the Asian Highway network, trade with Myanmar, South Western China and Thailand will be energized.

To achieve this goal of Vision 2021, it is vital to enhance the road network, which includes the improvement of bridges, especially in the Asian Highway network.

(2) Sixth Five-Year Plan (6FYP)

In 6FYP, it is declared that RHD objectives necessary to achieve the road sector vision are:

- To develop and manage strategic road corridors to underpin the economic development of all regions of the country and contribute to the Government's poverty reduction objectives.
- To link all rural areas with the national road network to provide basic social access and promote "pro-poor growth".

In order to achieve the above RHD objectives, it is very important to provide a reliable road network including feeder roads such as Zilla roads as well as national roads and regional roads.

There are many temporary bridges and narrow bridges on Zilla roads. Bridges on these roads should be improved since they tend to act as bottlenecks in the network.

(3) National Land Transport Policy (NLTP)

The bridge policy of NLTP sets the widening of bridges on national roads (incorporating non-motorized vehicle lane where demand exist) as a priority program.

Some bridges on national roads as well as regional roads and Zilla roads in Western Bangladesh do not have the required carriageway width (at least 7.3m). These bridges

should be improved in order to provide smooth traffic flow and ensure road safety.

(4) Road Master Plan, RMP (2009)

RMP formulated its road sector policy in response to the existing problems it is dealing with in regards to its roads and bridges. RMP's major road sector policy is as follows:

- Bridges in poor condition will be replaced or repaired.
- All narrow bridges on National Road will be replaced.
- All portable steel bridges will be replaced by permanent structures.
- Zilla road network will be rehabilitated.

Objectives of the Project, Western Bangladesh Bridges Improvement Project (WBBIP), are consistent with above road sector policy.

The Project should be implemented based on the road sector policy, following the EBBIP.

2.6.2 Not Enough Projects by Other Donors

Some bridges will be improved using funds from other donors such as Chinese government and GOB's own programs, PMP and ADP. A study to improve the road network is ongoing under SASEC financed by ADB.

However, these projects are not enough to develop the efficient road network or to provide safety for the bridges in Western Bangladesh, since approximately 700 bridges are categorized as C (major element damage) or D (major structural damage).

2.6.3 Securing Good Traffic Condition of Asian Highway

As stated in Vision 2021, it is very important to secure the good traffic conditions in the Asian Highway network which connects neighboring countries with Bangladesh, in order to achieve the ultimate goal of becoming a middle-income country.

However, there are many damaged or narrow bridges in the Asian Highway network in Western Bangladesh. These bridges tend to act as bottlenecks in the network, and thus should be improved.

2.6.4 Securing Good Traffic Condition of Important Corridor

(1) Corridor to India

There are seven corridors with India in Western Bangladesh, including one railway and six highways. As India is major trading country for Bangladesh, it is very important to secure good traffic conditions in these corridors

However, there are many damaged and/or narrow bridges on corridors with India in Western Bangladesh. These bridges act as bottlenecks in the network. Improvement of the bridges in the Project shall improve traffic conditions in these corridors, which in turn will contribute to the economic growth of Bangladesh.

(2) Corridor to EPZs and SEZs

There are three EPZs in Western Bangladesh. In addition, GOB has decided to establish thirty economic zones through the Nation, suspending the development of new EPZs, since EPZs have several issues such as full capacity and little impact on domestic industries.

In Western Bangladesh, there are two short-listed candidate SEZs.

As with the corridors with India, there are some bottleneck bridges on the corridors to EPZs and SEZs. In order to promote the economic growth of Bangladesh, it is very important to ensure good traffic conditions in corridors to SEZs and EPZs through the improvement of the bridges in the Project.

2.6.5 Damage Progression of the Bridge

The conditions of bridges were evaluated in 2006 by BMMS and in 2013 by EBBIP. In the 7 years from 2006 to 2013, the number of bridges categorized as B (minor element damage), C (major element damage) and D (major structural damage) has increased, and the number categorized as A (not damaged) has decreased.

This damage progression implies the importance of the adequate maintenance of the existing bridges, and the necessity of improvement of the bridges which are seriously damaged, such as bridges categorized as D. Approximately 200 bridges are categorized as D in Western Bangladesh at present.

2.6.6 Increase of Traffic Volume

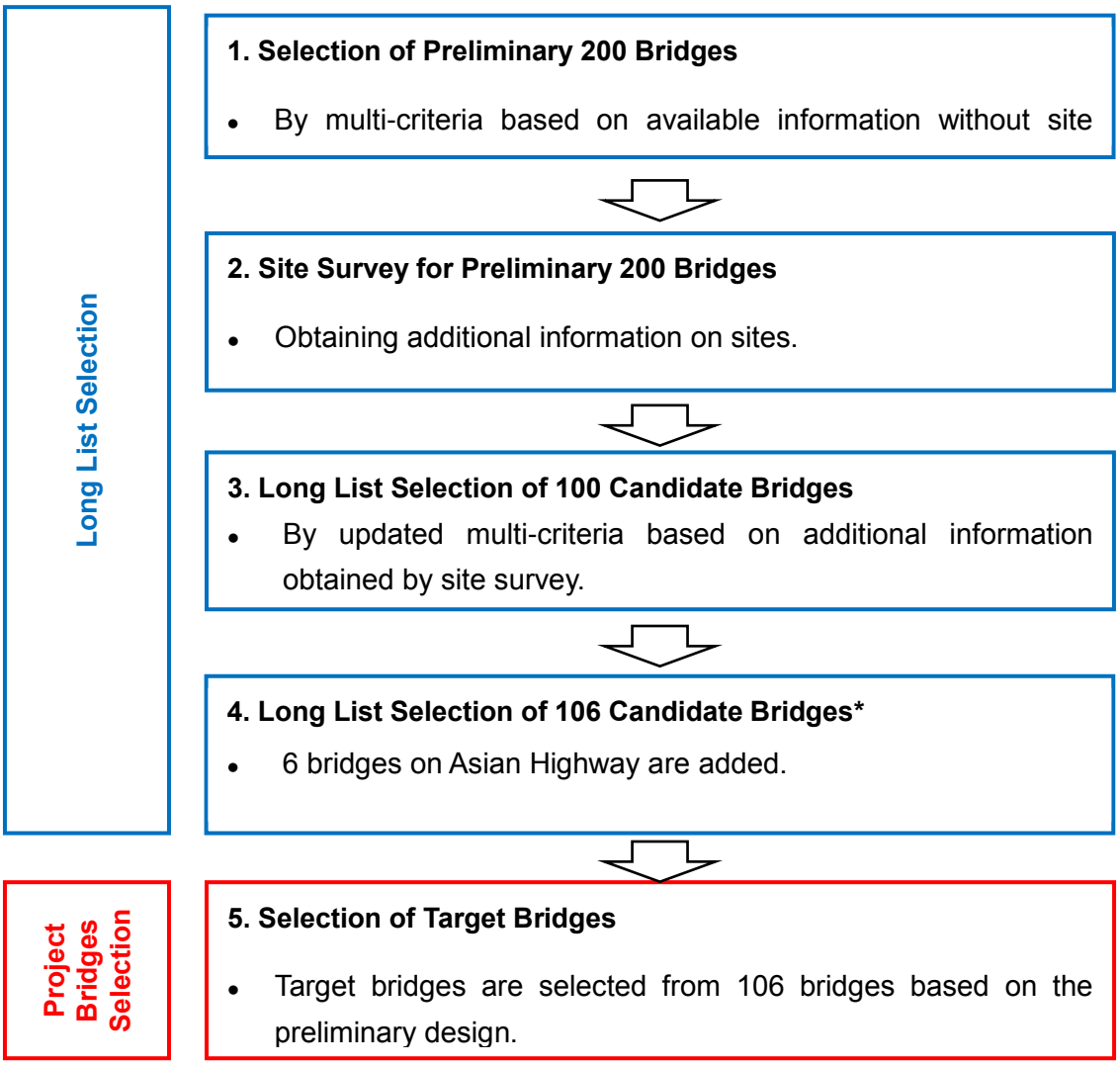
In the 10 years from 2004 to 2014, traffic volume has increased at a rate of 6.25% p.a., 5.62% p.a. and 5.15% p.a. for national roads, regional roads and Zilla roads, respectively.

Road transport is becoming increasingly important among all transport modes. It is very important to provide good traffic conditions in the road network, especially of National Road.

3. SELECTION OF PROJECT BRIDGES

3.1 Selection Approach

Project bridges are selected from approximately 1,700 bridges operated and maintained by RHD in Western Bangladesh. Selection procedure is divided into 2 steps, namely “Long List Selection of Candidate Bridges” and “Selection of Project Bridges”, as shown in Figure 3.1.1.



* 6 bridges were added to “Long List of 100 Candidate Bridges” based on the discussion with MORTB as well as RHD.

Source: JICA Survey Team

Figure 3.1.1 Procedure for Project Bridges Selection

3.2 Selection of Preliminary 200 Bridges

3.2.1 Dropping from Candidate List

From approximately 1,700 candidate bridges in Western Bangladesh, bridges fitting the following criteria were dropped from the candidate list.

- Bridges whose length is less than 20m
- Box culverts (not bridge)
- Bridges to be constructed under funding from other external donors such as ADB, WB, etc., or under funding from GOB itself
- Bridges located in national parks, wildlife sanctuaries and world heritage sites

As a result, the candidate list was narrowed down to approximately 1,000 bridges.

3.2.2 Multi-criteria

200 bridges were selected from the remaining 1,000 using the following multicriteria selection process.

- Each evaluation item is assigned a weight, varying from 5 to 50
- Each bridge is evaluated for each evaluation item, receiving a score of 0, 2, or 4.
- The total score of each bridge is the sum of weight x score for each evaluation item, with a maximum score of 1000.

The weight of evaluation items is classified into 3 levels: high weight, middle weight and low weight. The weight of each evaluation item is shown in Table 3.2.1.

Table 3.2.1 Evaluation Item and Weight

Weight		Item	Note
High weight	50	Traffic volume on the route (Bridge on the important route)	- It is very important to ensure the good traffic conditions for highly-utilized bridges. - National roads have the highest traffic volume.
	50	EBBIP damage level (Degree of damage and structural deficit)	- Highly-damaged bridges should be improved as a priority.
	40	Lack of traffic lane	- It is very important to ensure enough traffic lane width on bridges, since bridges having insufficient width become bottlenecks. - Such bridges should be considered for improvement even if the damaged condition is not bad.
Middle weight	30	Recommendation by RHD	- Recommendation by management agency should be considered.
	20	Corridor to India (Bridge on the important route)	- It is important to ensure the smooth traffic flow in corridors to India, since the export and import trade with India is important to promote economic activity in Bangladesh
	20	Bridge type (Degree of damage and structural deficit)	- Temporary bridges should be considered for improvement even if the damaged condition is not bad.
Low weight	10	Other foreign business activities (Impact on business activity)	- There are some foreign industries in Rangpur and Ishwardi. - It is important to ensure the smooth traffic flow in corridors to such areas to promote foreign industry's as well as economic activities in Bangladesh. - This evaluation item should be considered even though it is assigned low weight.
	10	Population (Necessity of community activity)	- Local community activity as well as national economic activity should be considered. - These evaluation items should be considered even though they are assigned low weight.
	10	GDP (Necessity of community activity)	
	5	Corridor to planed SEZs (Impact on business activity)	- It is important to ensure the smooth traffic flow in corridors to SEZs and EPZs to promote Bangladesh economic activity. - These evaluation items should be considered even though they are assigned low weight.
	5	Corridor to existing EPZs (Impact on business activity)	

Source: JICA Survey Team

Multi-criteria for selecting preliminary 200 bridges are shown in Table 3.2.2.

Table 3.2.2 Multi-criteria for Selecting Preliminary 200 Bridges

Item		Weight	Point	Criteria	
1. Recommendation by RHD		30	4	Recommended bridges by RHD	
			0	Other bridges	
2. Bridge on the important route	2.1 Traffic volume on the route	50	4	on National road	
			2	on Regional road	
			0	on Zilla road	
	2.2 Corridor to India	20	4	Burimari	N5,N,405,N506,N509
				Banglaban dha	N5,N405
				Hili	N5,N405,R550,R585,Z5503 ,Z5507,Z5509,Z5854,Z5855 ,Z5856
				Sonamasjid	N6,N507,R680,Z6801,N405
				Benapole	N7,N8(To Madaripur), N702,N706,N804
				Bhomra	N7,N8,N702,N804,R755,R7 60,Z7062
			0	Other roads	
3. Impact on business activity	3.1 Corridor to planed SEZs	5	4	Sirajganj	N405,R450,R451
				Mongla	N7,N8,N702,N709
			0	Other roads	
	3.2 Corridor to existing EPZs	5	4	Uttara	N5,N6,N7,N405,N502,N704 ,R570
				Ishwardi	N6,N405,N507,R680,N704, N705,Z6801
				Mongla	N7,N8,N702,N709,R850,R8 56
			0	Other road	
	3.3 Other foreign business activities	10	4	Rangpur	N5(To Rangpur),N405
				Ishwardi	N6(To Baraigram), N405,N507N704,N705
			0	Other Roads	
4. Necessity of community activity	4.1 Population	10	4	≥2,000,000	
			2	2,000,000>Population≥1,000,000	
			0	1,000,000	
	4.2 GDP	10	4	≥800mil BDT	
			2	800mil BDT>GDP≥400mil BDT	
			0	400mil BDT	
5. Degree of damage and structural deficit	5.1 EBBIP damage level	50	4	Grade-D	
			2	Grade-C	
			0	Grade-A,B	
	5.2 Bridge type	20	4	Bailey bridge (Temporary bridge)	
			0	Other bridge type	
6. Lack of traffic lane		40	4	N: Carriageway<6.2m	
				R: Carriageway<5.5m	
				Z: Carriageway<3.7m	
			2	N: 6.2m≤Carriageway<7.3m	
				R: 5.5m≤Carriageway<7.3m	
				Z: 3.7m≤Carriageway<7.3m	
			0	Carriageway≥7.3	
		Total score =1,000			

Note: Bridges having all of “not recommended by RHD (Item 1)”, “Grade-A, B of EBBIP damage level (Item 5.1)”, “not bailey bridge (Item 5.2)” and “having more than 7.3 m of carriage way (Item 6)” are dropped from the candidate list.

Source: JICA Survey Team

3.2.3 Selection of Preliminary 200 Bridges

As a result of the evaluation by the multi-criteria, the preliminary 200 bridges were selected as listed in Table 3.2.3.

Table 3.2.3 List of Preliminary 200 Bridges

Ranpur					Rajshahi					Gopalgonj					Barisal					Khulna				
	N	R	Z	Total		N	R	Z	Total		N	R	Z	Total		N	R	Z	Total		N	R	Z	Total
Bogra	2	0	9	11(10)	Natore	1	1	1	3(3)	Faridpur	9	0	3	12(9)	Barguna	0	0	4	4(4)	Bagerhat	4	1	1	6(4)
Dinajpur	3	1	6	10(7)	Naogaon	0	1	1	2(2)	Gopalganj	0	0	1	1(1)	Barisal	7	0	7	14(9)	Chuadanga	0	1	0	1(0)
Gaibanda	2	1	2	5(4)	Nawabganj	0	0	0	0	Madaripur	5	0	0	5(3)	Bhola	0	6	1	7(4)	Jessore	4	0	0	4(1)
Joypurhat	0	2	0	2(2)	Pabna	7	0	0	7(6)	Rajbari	1	0	0	1(0)	Jhalokati	0	0	13	13(13)	Jhenaidah	3	0	0	3(0)
Kurigram	0	0	1	1(0)	Rajshahi	0	2	2	4(3)	Shariatpur	0	8	1	9(5)	Patuakhali	2	0	11	13(11)	Khulna	0	2	0	2(1)
Lalmonirhat	3	0	0	3(1)	Serajganj	11	2	2	15(12)						Pirojpur	0	0	17	17(14)	Kushtia	3	0	1	4(2)
Nilphamari	1	0	6	6(4)																Magura	1	0	0	1(0)
Panchagarh	2	0	0	2(0)																Meherpur	0	0	0	0(0)
Rangpur	5	0	2	7(5)																Narail	0	2	1	3(2)
Thakurgaon	1	0	0	1(0)																Satkhira	1	1	0	2(2)
Zone Total	19	4	26	49(33)	**Zone Total**	19	6	6	31(26)	**Zone Total**	15	8	5	28(18)	**Zone Total**	9	6	53	68(55)	**Zone Total**	16	7	3	26(12)
																				Total	**78**	**31**	**93**	**202(144)**

Note: ( ) : Number of bridges recommended by RHD

Source: JICA Survey Team

3.3 Site Survey for Preliminary 200 Bridges

Site surveys were carried out for the selected 200 bridges in order to obtain additional information. This information was utilized to narrow the list down to the “Long List Selection of 100 Candidate Bridges”.

Information obtained by the site surveys included the following:

1) Bridge and approach road specifications

- Road category
- Bridge width
- Bridge type
- Bridge length
- Bridge span arrangement
- Approach road width

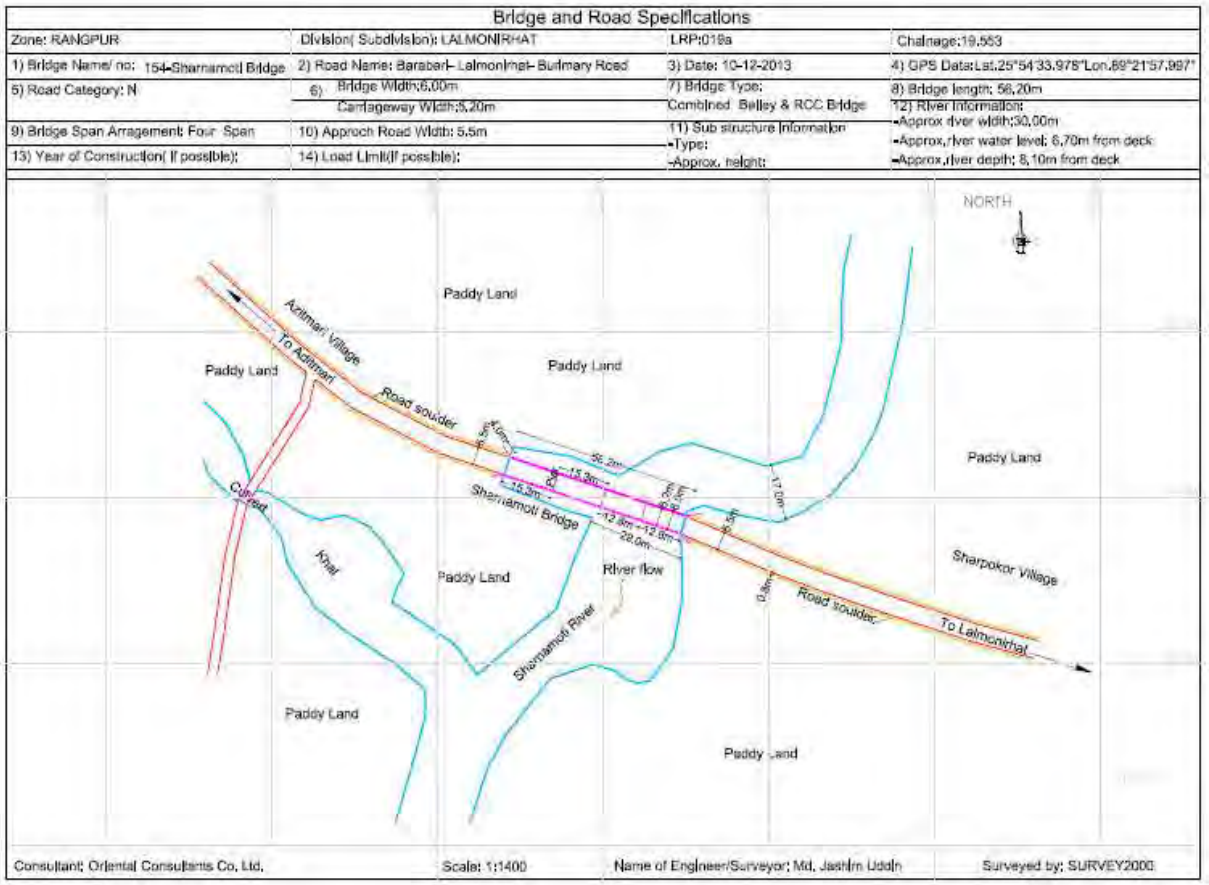
- GPS data
- Year of construction (if possible for each bridge)
- Load limit (if possible for each bridge)

2) Sketches around the bridge site

3) Bridge photos from various angles

4) Photos and information of bridge damage

Sample of survey results are shown in Figure 3.3.1 to Figure 3.3.3.



Source: JICA Survey Team

Figure 3.3.1 Sample of Survey Sheet (Specifications and Sketches)

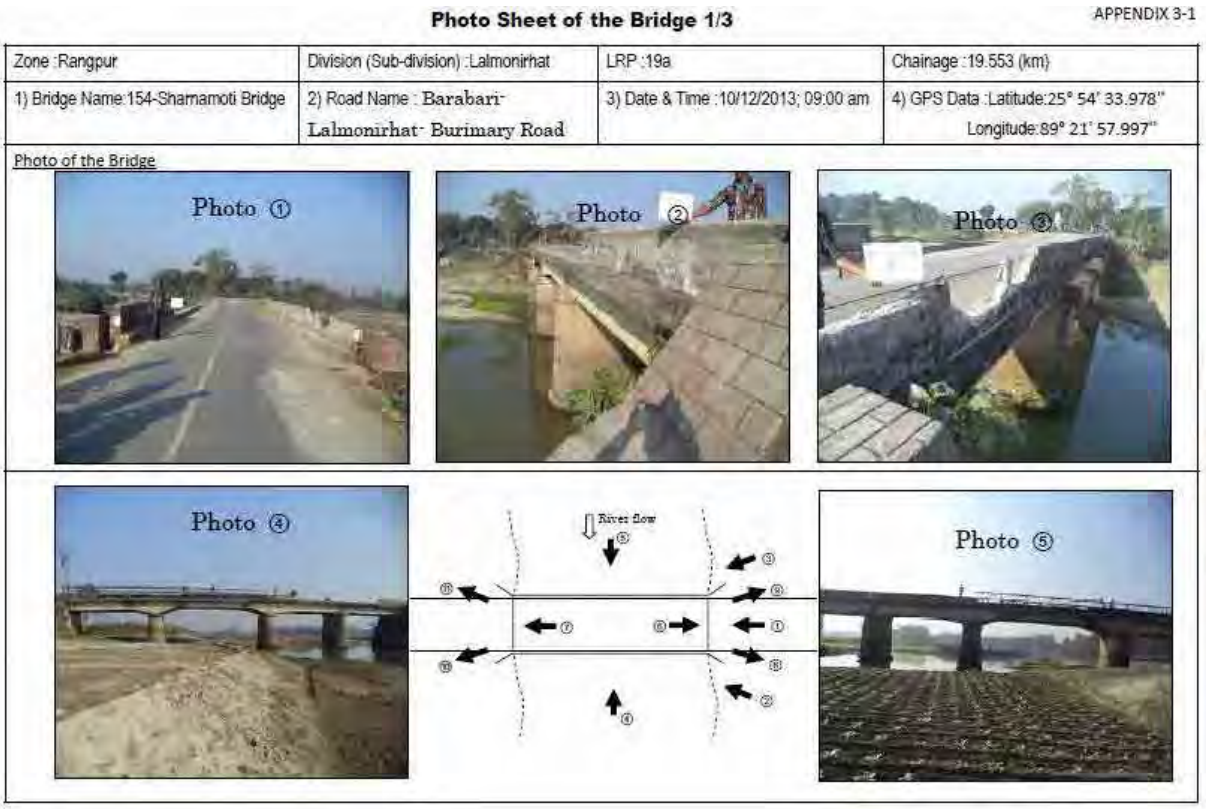


Photo Sheet of the Bridge 1/3

APPENDIX 3-1

Zone :Rangpur	Division (Sub-division) :Lalmonirhat	LRP :19a	Chainage :19.553 (km)
1) Bridge Name:154-Sharnamoti Bridge	2) Road Name : Barabari-Lalmonirhat- Burimary Road	3) Date & Time :10/12/2013; 09:00 am	4) GPS Data :Latitude:25° 54' 33.978" Longitude:89° 21' 57.997"

Photo of the Bridge

Photo Sheet of the Bridge 2/3

APPENDIX 3-2

Zone :Rangpur	Division (Sub-division): Lalmonirhat	LRP :19a	Chainage :19.553 (km)
1) Bridge Name :154-Sharnamoti	2) Road Name : Barabari-Lalmonirhat- Burimary Road	3) Date & Time :10/12/2013; 09:00 am;	4) GPS Data :Latitude:25° 54' 33.978" Longitude:89° 21' 57.997"

Photo of the Bridge

Source: JICA Survey Team

Figure 3.3.2 Sample of Survey Sheet (Bridge Photos)

APPENDIX 3-3
APPENDIX 4

Photo Sheet of the Bridge 3/3

1. **Description of Damages (Present Condition) of the Bridge**

Damage of the Bridge (1/2)

Zone :Rangpur	Division (Sub-division) :Lalmonirhat	LRP :19a	Chainage :19.553 (km)
1) Bridge Name :154-Shamamoti	2) Road Name : Barabari-Lalmonirhat-Burimary Road	3) Date & Time :10/12/2013; 09:00 am;	4) GPS Data :Latitude:25° 54' 33.978" Longitude:89° 21' 57.997"

Damage 1		Damage 2		Damage 3		Damage 4	
Damage Location	/Slab, Girder, Pier, Abutment	Damage Location	/Slab, Girder, Pier, Abutment	Damage Location	/Slab, Girder, Pier, Abutment	Damage Location	/Slab, Girder, Pier, Abutment
Damage Type	For Concrete Structure Crack, Spalling, Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, /Deformed section Others ( )	Damage Type	For Concrete Structure Crack, Spalling, Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, /Deformed section Others ( )	Damage Type	For Concrete Structure Crack, Spalling, Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, /Deformed section Others ( )	Damage Type	For Concrete Structure Crack, Spalling, Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, /Deformed section Others ( )
							
Coments							

Damage of the Bridge (2/2)

Zone :Rangpur	Division (Sub-division) :Lalmonirhat	LRP :19a	Chainage :19.553 (km)
1) Bridge Name :154-Shamamoti Bridge	2) Road Name : Barabari-Lalmonirhat-Burimary Road	3) Date & Time :10/12/2013; 09:00 am;	4) GPS Data :Latitude:25° 54' 33.978" Longitude:89° 21' 57.997"

Damage 9		Damage 10		Damage 11		Damage 12	
Damage Location	Slab, Girder, Pier, Abutment, /Railing	Damage Location	Slab, Girder, Pier, Abutment, /Railing	Damage Location	Slab, /Girder, Pier, Abutment	Damage Location	Slab, Girder, /Pier, Abutment
Damage Type	For Concrete Structure Crack, Spalling, /Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, Deformed section Others ( )	Damage Type	For Concrete Structure Crack, Spalling, Rebar exposure Others (Missing) For Steel Structure Corrosion, Missing bolt, Deformed section Others ( )	Damage Type	For Concrete Structure Crack, Spalling, /Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, Deformed section Others ( )	Damage Type	For Concrete Structure Crack, Spalling, /Rebar exposure Others ( ) For Steel Structure Corrosion, Missing bolt, Deformed section Others ( )
							
Comments							

Source: JICA Survey Team

Figure 3.3.3 Sample of Survey Sheet (Photos and information of bridge damage)

The result of site survey for 200 bridges is shown in Appendix 1.1.

3.4 Long List Selection of 100 Candidate Bridges

100 Candidate Bridges were selected from 200 bridges by updated multi-criteria based on additional information obtained from site survey.

“Resettlement” was added as a new evaluation item in the updated multi-criteria. It was decided that bridges requiring the resettlement of more than 200 affected persons (APs) would be dropped from the candidate list. However, according to the site survey results, none of the 200 bridges require the resettlement of more than 200 APs, so no bridges were dropped as a result of this evaluation item.

Updated multi-criteria for selecting 100 bridge candidates is shown in Table 3.4.1.

Table 3.4.1 Updated Multi-criteria for Selecting 100 Bridge Candidates

Item		Weight	Point	Criteria	
1. Recommendation by RHD		30	4	Recommended bridges by RHD	
			0	Other bridges	
2. Bridge on the important route	2.1 Traffic volume on the route	50	4	on National road	
			2	on Regional road	
			0	on Zilla road	
	2.2 Corridor to India	20	4	Burimari	N5,N,405,N506,N509
				Banglabandha	N5,N405
				Hili	N5,N405,R550,R585,Z5503 ,Z5507,Z5509,Z5854,Z5855 ,Z5856
				Sonamasjid	N6,N507,R680,Z6801,N405
				Benapole	N7,N8(To Madaripur), N702,N706,N804
				Bhomra	N7,N8,N702,N804,R755,R7 60,Z7062
			0	Other roads	
3. Impact on business activity	3.1 Corridor to planed SEZs	5	4	Sirajganj	N405,R450,R451
				Mongla	N7,N8,N702,N709
			0	Other roads	
	3.2 Corridor to existing EPZs	5	4	Uttara	N5,N6,N7,N405,N502,N704 ,R570
				Ishwardi	N6,N405,N507,R680,N704, N705,Z6801
				Mongla	N7,N8,N702,N709,R850,R8 56
			0	Other road	
	3.3 Other foreign business activities	10	4	Rangpur	N5(To Rangpur),N405
				Ishwardi	N6(To Baraigram), N405,N507N704,N705
			0	Other Roads	
4. Necessity of community activity	4.1 Population	10	4	≥2,000,000	
			2	2,000,000>Population≥1,000,000	
			0	1,000,000>	
	4.2 GDP	10	4	≥800mil BDT	
			2	800mil BDT>GDP≥400mil BDT	
			0	400mil BDT>	
5. Degree of damage and structural deficit	5.1 EBBIP damage level	50	4	Grade-D	
			2	Grade-C	
			0	Grade-A,B	
	5.2 Bridge type	20	4	Bailey bridge (Temporary bridge)	
			0	Other bridge type	
6. Lack of traffic lane		40	4	N: Carriageway<6.2m	
				R: Carriageway<5.5m	
				Z: Carriageway<3.7m	
			2	N: 6.2m≤Carriageway<7.3m	
				R: 5.5m≤Carriageway<7.3m	
				Z: 3.7m≤Carriageway<7.3m	
			0	Carriageway≥7.3	
7. Resettlement		Drop from the candidate list		APs≥200	
		Total score =1,000			

Note: Bridges having all of “not recommended by RHD (Item 1)”, “Grade-A, B of EBBIP damage level (Item 5.1)”, “not bailey bridge (Item 5.2)” and “having more than 7.3 m of carriage way (Item 6)” are dropped from the candidate list.

Source: JICA Survey Team

The 200 bridges were re-evaluated and scored by the updated multi-criteria. Examples of the re-evaluation are shown below.

Example 1 (Revision of "5.1 EBBIP damage level" evaluation)

As a result of site survey, it was confirmed that this bridge has more than two major structural defects. Therefore, its score for this evaluation item was updated from 2 points (corresponding to damage level C) to 4 points (corresponding to damage level D).

Crack in Slab

Crack at wing wall

Spalling at girder

EBBIP Damage Level

Damage Level A: No damage
Damage Level B: Minor defects
Damage Level C: One major structural defect
Damage Level D: Two or more major structural defects

Example 2 (Revision of "6. Lack of traffic lane" evaluation)

As a result of the site survey, it was confirmed that the carriageway width of this bridge on a national road is less than 7.3 m, although its width was recorded as more than 7.3 m in the EBBIP survey. Thus its score for this evaluation item was updated from 0 points (corresponding to a carriageway width of more than 7.3 m) to 2 points (a carriageway width between 6.2 m and 7.3 m).

As a result of re-evaluation for 200 bridges by the updated multi-criteria, 100 candidate bridges were selected as listed in Table 3.4.2.

Table 3.4.2 Long List of 100 Candidate Bridges

Ranpur					Rajshahi					Gopalgonj					Barisal					Khulna				
	N	R	Z	Total		N	R	Z	Total		N	R	Z	Total		N	R	Z	Total		N	R	Z	Total
Bogra	2	0	3	5(5)	Natore	1	1	0	2(2)	Faridpur	8	0	0	8(6)	Barguna	0	0	0	0	Bagerhat	2	0	0	2(2)
Dinajpur	3	0	4	7(4)	Naogaon	0	1	1	2(2)	Gopalganj	0	0	0	0	Barisal	4	0	1	5(3)	Chuadanga	0	0	0	0
Gaibanda	2	0	1	3(3)	Nawabganj	0	0	0	0(0)	Madaripur	4	0	0	4(3)	Bhola	0	4	0	4(4)	Jessore	2	0	0	2(1)
Joypurhat	0	2	0	2(2)	Pabna	7	0	0	7(6)	Rajbari	0	0	0	0	Jhalokati	0	0	2	2(2)	Jhenaidah	2	0	0	2(0)
Kurigram	0	0	0	0	Rajshahi	0	1	2	3(3)	Shariatpur	0	5	0	5(3)	Patuakhali	1	0	2	3(2)	Khulna	0	1	0	1(1)
Lalmonirhat	2	0	0	2(1)	Serajganj	10	2	0	12(10)						Pirojpur	0	0	1	1(1)	Kushtia	3	0	0	3(2)
Nilphamari	1	0	3	4(3)																Magura	1	0	0	1(0)
Panchagarh	2	0	0	2(0)																Meherpur	0	0	0	0
Rangpur	4	0	0	4(3)																Narail	0	1	0	1(1)
Thakurgaon	0	0	0	0																Satkhira	0	1	0	1(1)
Zone Total	16	2	11	29(21)	**Zone Total**	18	5	3	26(23)	**Zone Total**	12	5	0	17(12)	**Zone Total**	5	4	6	15(12)	**Zone Total**	10	3	0	13(8)
																				Total	**61**	**19**	**20**	**100(76)**

Note: ( ): Number of bridges recommended by RHD

Source: JICA Survey Team

3.5 Long List Selection of 106 Candidate Bridges

3.5.1 Introduction

The JICA Survey Team discussed the 100 bridge candidate bridges with RHD in a meeting held on January 26th, 2014. In the meeting, additional chief engineers (ACEs) from five zones requested that some bridges should be deleted from the list, and that some should be added to the list. Minutes of the discussion (M/D) are attached in Appendix 1.2.

In a series of subsequent discussions with RHD, it was agreed that 16 bridges would be removed and 16 bridges would be added (leaving the total number of candidate bridges at 100).

3.5.2 Bridges Deleted from 100 Candidate Bridges

It was agreed that the following 16 bridges would be deleted from 100 candidate bridges.

- 8 bridges overlapping with other projects such as ADP (Annual Development Program), PMP (Periodic Maintenance Program) and Chinese-funded projects.
- 7 bridges without major defects in their main structures that seem to be structurally sound.

- 1 bridge that is integrated with an adjacent sluice gate. This bridge, together with the sluice gate, is to be improved in another project.

Damaged Expansion Joint
(Not Damaged in Main Structures)

Bridge Integrated with Sluice Gate

3.5.3 Bridges Added in 100 Bridges

It was agreed that the following 16 bridges would be added in 100 candidate bridges.

- 22 bridges were requested to include in 100 bridges by ACEs of 5 zones.
- 22 bridges were re-evaluated by the multi-criteria, and only 8 bridges were included among them (Another 2 bridges are already included in Top-100 bridges).
- Another 8 bridges were included from out of Top-100 bridges based on the score.

3.5.4 Long List Selection of 106 Candidate Bridges

In the meeting between JICA, RHD, and the JICA Survey Team held on February 6th, 2014, it was agreed that the selected 100 bridges would be the candidate Project bridges.

In addition, RHD requested the inclusion of the bridges on Asian Highways with EBBIP damage levels of C or D. It was agreed in further discussion with JICA, RHD and JICA Survey Team that 6 bridges on Asian Highways would be included as candidate project bridges in addition to the previously selected 100 bridges. Therefore, 106 bridges were ultimately selected.

The 106 selected candidate bridges are listed in Table 3.5.1, Table 3.5.2 and their locations are shown in Figure 3.5.1.

The scores used for evaluation and photos of the 106 candidate bridges can be seen in Appendix 1.3.

Table 3.5.1 List of 106 Candidate Bridges by Divisions (Summary)

Zone	Division	RCC Bridge			PC Bridge			Steel Bridge			Bailey Bridge			Other Type Bridge			Division Total	Zone Total
		N	R	Z	N	R	Z	N	R	Z	N	R	Z	N	R	Z		
Ranpur	Bogra	2	0	1	0	0	0	0	0	0	0	0	3	0	0	0	6	32
	Dinajpur	2	0	1	0	0	0	0	0	1	0	1	3	0	0	0	8	
	Gaibanda	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	
	Joypurhat	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
	Kurigram	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lalmonirhat	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	
	Nilphamari	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	4	
	Panchagarh	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	
	Rangpur	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	
	Thakurgaon	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Rajshahi	Natore	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	23
	Naogaon	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	
	Nawabganj	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Pabna	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	6	
	Rajshahi	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	2	
	Serajganj	8	0	0	0	0	0	1	0	0	0	2	1	0	0	0	12	
Gopalgor	Faridpur	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	15
	Gopalganj	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	
	Madaripur	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
	Rajbari	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Shariatpur	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5	
Barisal	Barguna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
	Barisal	3	0	1	1	0	0	0	0	0	2	0	5	0	0	0	12	
	Bhola	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4	
	Jhalokati	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	
	Patuakhali	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
	Pirojpur	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	
Khulna	Bagerhat	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	16
	Chuadanga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Jessore	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
	Jhenaidah	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
	Khulna	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
	Kushtia	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
	Magura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Meherpur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Narail	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	4	
	Satkhira	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
Bridge Type Total		49	7	6	2	0	0	3	1	1	2	14	20	1	0	0	Total	
		62			2			5			36			1			**106**	

Source: JICA Survey Team

Table 3.5.2 List of 106 Candidate Bridges by Divisions

Barisal Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
1	N8_178a	Barisal	Barisal	Bailey with Steel Deck,	39.7	1990	4	D
12	N8_182a	Barisal	Barisal	Bailey with Steel Deck,	33.6	1990	4	C
56	N8_152c	Barisal	Barisal	PC Girder Bridge,	56.9	1991	7.1	A
57	N8_127b	Barisal	Barisal	RCC Girder Bridge,	33.7	1995	7.2	B
64	N8_123a	Barisal	Barisal	RCC Girder Bridge,	30.8	1992	8.6	D
69	N8_129a	Barisal	Barisal	RCC Girder Bridge,	27.4	1984	7.2	C
82	Z8033_017a	Barisal	Barisal	RCC Girder Bridge,	42.4	1981	4.3	D
92	Z8810_13a	Barisal	Barisal	Bailey with Steel Deck,	50	2000	4.25	C
94	Z8033_008a	Barisal	Barisal	Bailey with Steel Deck,	105.4	1997	5	C
95	Z8033_019a	Barisal	Barisal	Bailey with Steel Deck,	31.3	1996	3.9	C
96	Z8034_011a	Barisal	Barisal	Bailey with Steel Deck,	33.7	1996	4.5	C
97	Z8044_004a	Barisal	Barisal	Bailey with Steel Deck,	30.7	1988	4.1	C

Bhola Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
42	R890_45a	Barisal	Bhola	Bailey with Steel Deck,	62.3	1990	5.03	C
70	R890_16a	Barisal	Bhola	Bailey with Steel Deck,	37.7	1989	4.1	A
71	R890_21a	Barisal	Bhola	Bailey with Steel Deck,	24.55	1987	4.15	B
72	R890_28a	Barisal	Bhola	Bailey with Steel Deck,	30.85	1995	4.22	B

Jhalokati Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
78	Z8708_1c	Barisal	Jhalokati	Bailey with Steel Deck,	26	1990	4	D
81	Z8708_12b	Barisal	Jhalokati	Bailey with Steel Deck,	51	1996	3.8	D

Patuakhali Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
58	Z8052_009d	Barisal	Patuakhali	Bailey with Steel Deck,	22.8	1986	3.9	D

Pirojpur Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
65	Z8701_3d	Barisal	Pirojpur	Bailey with Steel Deck,	22	1985	4.01	D

Shariatpur Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
77	R860_31a	Gopalganj	Shariatpur	Bailey with Steel Deck,	28.89	1991	4.8	A
83	R860_34a	Gopalganj	Shariatpur	Bailey with Steel Deck,	33.5	1990	4.8	A
84	R860_44c	Gopalganj	Shariatpur	Bailey with Steel Deck,	111.2	2001	5	B
85	R860_53d	Gopalganj	Shariatpur	Bailey with Steel Deck,	93	1989	4	A
99	R860_35a	Gopalganj	Shariatpur	Bailey with Steel Deck,	30.6	1989	5.1	C

Madaripur Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
26	N8_095a	Gopalganj	Madaripur	RCC Girder Bridge,	37	1972	7	D
86	N8_69a	Gopalganj	Madaripur	RCC Girder Bridge,	110	1990	8.9	C

Faridpur Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
13	N7_025a	Gopalganj	Faridpur	RCC Girder Bridge,	27.4	1990	7.2	D
14	N7_039a	Gopalganj	Faridpur	RCC Girder Bridge,	51.65	1978	7	D
15	N7_049a	Gopalganj	Faridpur	RCC Girder Bridge,	24.7	1980	7	D
23	N7_054a	Gopalganj	Faridpur	RCC Girder Bridge,	82.6	1982	7.8	D
29	N7_036c	Gopalganj	Faridpur	RCC Girder Bridge,	27.5	1982	7.1	C
30	N7_048a	Gopalganj	Faridpur	RCC Girder Bridge,	24.9	1982	7	C
32	N7_047a	Gopalganj	Faridpur	RCC Girder Bridge,	50	1985	7	D

Gopalganj Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
IV	N805_24a	Gopalganj	Bhatiapara	PC Girder Bridge,	105.05	2004	10	C

Bagerhat Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
22	N7_248c	Khulna	Bagerhat	RCC Box girder bridge,	25.7	1983	9.4	D
25	N7_246a	Khulna	Bagerhat	RCC Girder Bridge,	56	X	9.54	D

Jessore Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
39	N7_141b	Khulna	Jessore	RCC Girder Bridge,	30.9	1976	8.7	D
I	N706_14b	Khulna	Jessore	RCC Girder Bridge,	118.67	1968	7.3	C

Jhenaidah Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
41	N703_Sd	Khulna	Jhenaidah	RCC Girder Bridge,	134.5	1978	6.1	D
43	N704_14a	Khulna	Jhenaidah	RCC Girder Bridge,	97.9	1978	7.2	D
III	N704_12c	Khulna	Jhenaidah	RCC Girder Bridge,	24.2	1992	7.5	C

Khulna Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
98	R760_003a	Khulna	Khulna	RCC Girder Bridge,	57.6	1960	8.4	D

Kushtia Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
21	N704_43a	Khulna	Kushtia	RCC Girder Bridge,	31.5	1987	7.15	D
44	N704_33b	Khulna	Kushtia	RCC Girder Bridge,	26	1978	7.2	D
67	N704_27b	Khulna	Kushtia	RCC Girder Bridge,	33.5	1978	7.3	C

Narail Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
40	R720_44a	Khulna	Narail	RCC Girder Bridge,	33	1993	4.8	D
68	R750_22c	Khulna	Narail	RCC Girder Bridge,	31.2	1968	4.3	C
V	R750_25a	Khulna	Narail	RCC Girder Bridge,	91.5	1964	8.23	D
VI	Z7503_5a	Khulna	Narail	RCC Girder Bridge,	26.1	1976	7.9	C

Satkhira Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
63	R760_049c	Khulna	Satkhira	RCC Girder Bridge,	36.1	1968	7.1	C

Naogaon Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
28	R548_28b	Rajshahi	Naogaon	Truss with Steel Deck,	140.08	1994	4	D

Natore Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
17	N6_97a	Rajshahi	Natore	RCC Girder Bridge,	30	1968	6.9	D
73	R548_40a	Rajshahi	Natore	Bailey with Steel Deck,	33	2006	4.1	B

Pabna Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
3	N5_119a	Rajshahi	Pabna	RCC Girder Bridge,	43.3	1963	7.1	D
4	N5_127a	Rajshahi	Pabna	RCC Girder Bridge,	43.2	1968	6.9	D
7	N5_120a	Rajshahi	Pabna	RCC Girder Bridge,	41.4	1963	7.1	D
20	N5_118a	Rajshahi	Pabna	RCC Girder Bridge,	82	1963	7	C
27	N505_2a	Rajshahi	Pabna	Truss with Steel Deck,	135.2	2011	4.3	C
37	N5_126a	Rajshahi	Pabna	RCC Girder Bridge,	59.1	1965	7.1	B

Rajshahi Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
18	R681_10a	Rajshahi	Rajshahi	Bailey with Steel Deck,	39.3	X	3.4	D
87	Z6010_12b	Rajshahi	Rajshahi	RCC Girder Bridge,	21.7	1985	4.7	D

Serajganj Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
5	N5_176a	Rajshahi	Serajganj	RCC Girder Bridge,	72.8	1975	7.2	D
8	N5_128a	Rajshahi	Serajganj	RCC Girder Bridge,	43.7	1968	7	D
9	N5_158a	Rajshahi	Serajganj	RCC Girder Bridge,	70	1965	7	D
16	N5_134a	Rajshahi	Serajganj	RCC Girder Bridge,	44.8	1964	7.3	D
19	N5_140a	Rajshahi	Serajganj	RCC Girder Bridge,	53	1975	8.6	D
33	N5_156a	Rajshahi	Serajganj	RCC Girder Bridge,	43	1964	7.5	C
34	N5_172a	Rajshahi	Serajganj	RCC Girder Bridge,	43.3	1972	7.6	C
35	N5_179a	Rajshahi	Serajganj	RCC Girder Bridge,	54.1	1975	7.5	C
54	N5xx_Sa	Rajshahi	Serajganj	Steel Beam & RCC Slab,	39.1	1961	5.6	C
74	R451_1a	Rajshahi	Serajganj	Bailey with Steel Deck,	50	1980	8.2	C
75	R451_7a	Rajshahi	Serajganj	Bailey with Steel Deck,	50.2	1985	8.3	C
100	Z5041_2a	Rajshahi	Serajganj	Bailey with Steel Deck,	60	1985	4.2	C

Bogra Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
6	N5_235a	Rangpur	Bogra	RCC Girder Bridge,	77.3	1957	7.2	D
36	N5_188a	Rangpur	Bogra	RCC Girder Bridge,	52	1988	7	B
50	Z5401_45a	Rangpur	Bogra	Bailey with Steel Deck,	61.8	1991	4.3	D
51	Z5072_14a	Rangpur	Bogra	Bailey with Steel Deck,	57.8	1998	5	D
53	Z5472_6a	Rangpur	Bogra	Bailey with Steel Deck,	60.9	2006	4.9	D
91	Z5040_4a	Rangpur	Bogra	RCC Girder Bridge,	26.9	1968	4.8	D

Dinajpur Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
31	N5_378a	Rangpur	Dinajpur	RCC Girder Bridge,	53.9	1978	7.2	D
46	N5_382a	Rangpur	Dinajpur	RCC Girder Bridge,	55	1983	7.8	D
48	Z5025_55a	Rangpur	Dinajpur	Bailey with Steel Deck,	153.9	1992	4.3	D
49	Z5025_64a	Rangpur	Dinajpur	Bailey with Steel Deck,	73.6	1989	4.2	D
52	Z5025_60a	Rangpur	Dinajpur	Bailey with Steel Deck,	87	1990	4.2	D
88	Z5008_1a	Rangpur	Dinajpur	Steel Beam & RCC Slab,	42.2	1956	4.05	D
90	Z5025_46a	Rangpur	Dinajpur	RCC Girder Bridge,	45.7	1969	3.7	D
93	R585_80a	Rangpur	Dinajpur	Bailey with Steel Deck,	24.9	1988	8.4	B

Gaibanda Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
10	N5_265a	Rangpur	Gaibanda	RCC Girder Bridge,	42.2	1960	7.1	D
55	Z5552_10a	Rangpur	Gaibanda	Bailey with Steel Deck,	52.5	2010	4	D
66	N5_260b	Rangpur	Gaibanda	RCC Girder Bridge,	158.6	1972	7.3	B

Joypurhat Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
62	R545_115c	Rangpur	Joypurhat	RCC Girder Bridge,	78.8	1960	7.1	D
76	R550_28b	Rangpur	Joypurhat	RCC Girder Bridge,	65.4	1982	6.9	C

Lalmonirhat

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
2	N509_19a	Rangpur	Lalmonirhat	RCC Girder Bridge, Bailey with Steel Deck	56.2	1960	6	D

Nilphamari Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
38	N518_4a	Rangpur	Nilphamari	RCC Girder Bridge,	49.5	1985	5.2	D
59	Z5015_22a	Rangpur	Nilphamari	Bailey with Steel Deck,	189	1990	5.3	D
60	Z5701_1a	Rangpur	Nilphamari	Bailey with Steel Deck,	24.39	1991	4.04	D
61	Z5701_9a	Rangpur	Nilphamari	Bailey with Steel Deck,	37.37	1990	4.52	D

Panchagarh

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
79	N5_458a	Rangpur	Panchagarh	Steel Beam & RCC Slab,	28.5	1967	7.1	C
80	N5_488a	Rangpur	Panchagarh	RCC Girder Bridge,	49.3	1994	7.1	C

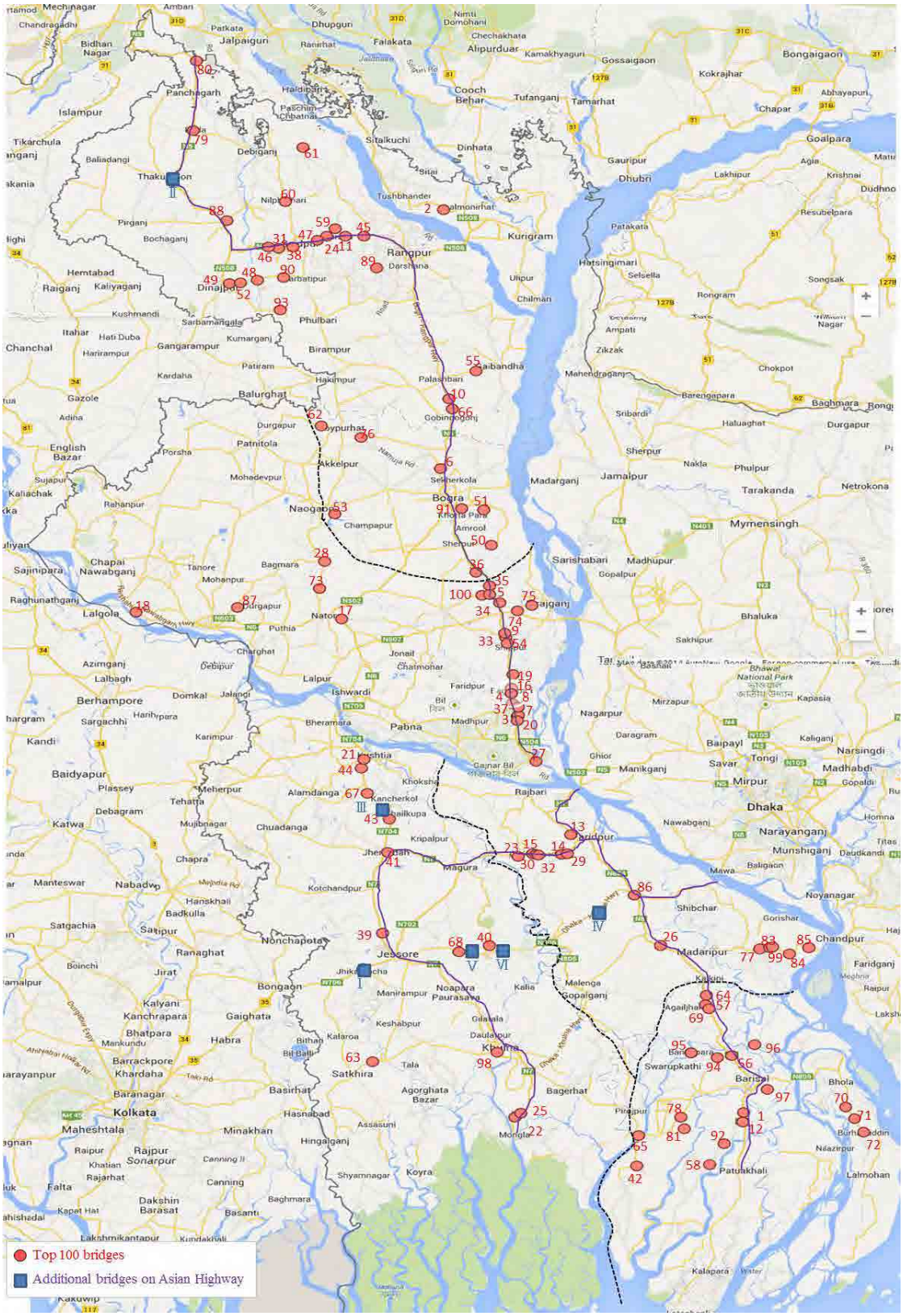
Rangpur Division

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
11	N5_350b	Rangpur	Rangpur	RCC Girder Bridge,	135.4	1991	7.2	D
24	N5_356a	Rangpur	Rangpur	RCC Girder Bridge,	20.7	1992	7.2	C
45	N5_344c	Rangpur	Rangpur	RCC Girder Bridge,	26.2	1991	7.1	B
47	N5_360a	Rangpur	Rangpur	RCC Girder Bridge,	49.2	1991	7.1	C
89	Z5024_5c	Rangpur	Rangpur	RCC Girder Bridge,	22.3	1978	4	D

Thakurgaon

Rank	Bridge Data							
	Bridge ID	Zone	Division	Bridge Type	Total Length (m)	Year of Construction	Width (m)	Damage level
II	N5_435a	Rangpur	Thakurgaon	RCC Girder Bridge,	38.3	1985	7.8	C

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.5.1 Map of Long Listed 106 Candidate Bridges

3.6 Selection of Project Bridges

Project bridges are selected through screening of 106 bridges based on the preliminary design, cost estimates and project effect evaluation in Phase 3, following site surveys such as topographic surveys, geological surveys and determination of bridge type in Phase 2.

Selection of Project bridges will be discussed in “15.2.2 Project Bridges Selection”.

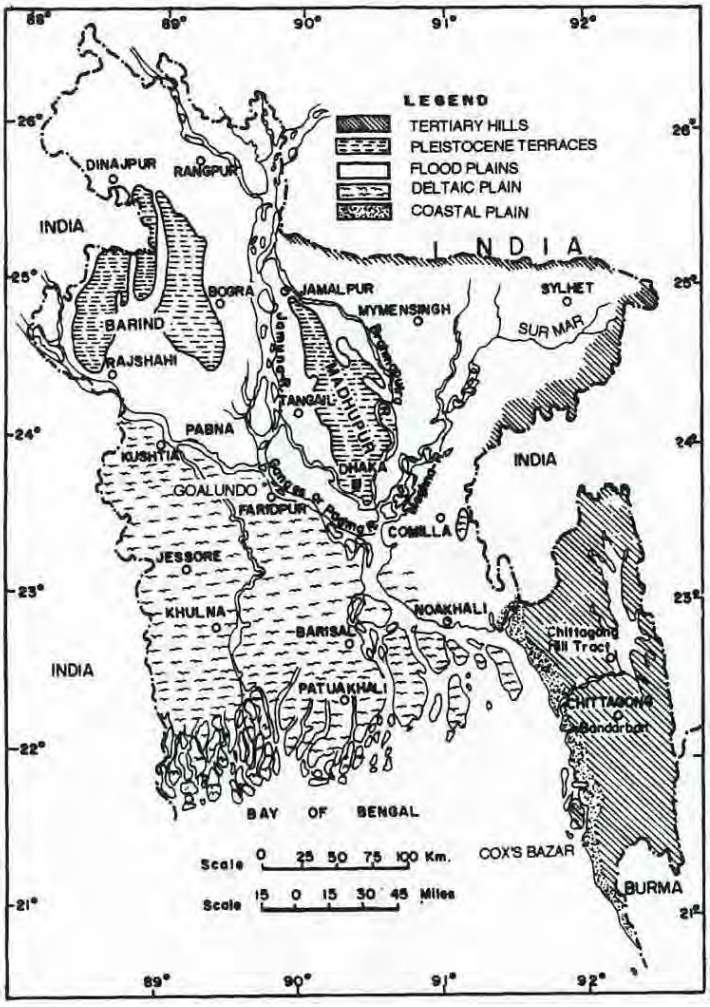
4. NATURAL CONDITIONS

4.1 Physiography

The physiography of Bangladesh is characterized by two distinctive features: a broad deltaic plain subject to frequent flooding, and a small hilly region crossed by swiftly-flowing rivers.

Roughly 80 percent of the landmass of Bangladesh is made up of fertile alluvial lowland called the Bangladesh Plain. The plain is part of the larger Plain of Bengal, which is sometimes called the Lower Gangetic Plain. Although altitudes up to 105 meters above sea level occur in the northern part of the plain, most elevations are less than 10 meters above sea level; elevations decrease in the coastal south, where the terrain is generally at sea level. With such low elevations and numerous rivers, water--and concomitant flooding--is a predominant physical feature. About 10,000 square kilometers of the total area of Bangladesh is covered with water, and larger areas are routinely flooded during the monsoon season.

The only exceptions to Bangladesh's low elevations are the Chittagong Hills in the southeast, the Low Hills of Sylhet in the northeast, and highlands in the north and northwest. The Chittagong Hills constitute the only significant hill system in the country and, in effect, are the western fringe of the north-south mountain ranges of Burma and eastern India. At 1,046 meters, the highest elevation in Bangladesh is found at Keokradong, in the southeastern part of the hills. Fertile valleys lie between the hill lines, which generally run north-south.



Source: Encyclopedia of European and Asian Regional Geology

Figure 4.1.1 Physiographic Division of Bangladesh

Figure 4.1.1 explains physiographic divisions of Bangladesh. Geomorphologically, Bangladesh has five basic landscape categories:

- Tertiary hills, which include the hills of Chittagong and the Chittagong Hill Tracts and hills in Sylhet, all marked by deeply weathered lateritic red soils.
- Pleistocene terraces which include the Barind Tract (North Bengal), the Madhupur Tract (Tangail and Dhaka), the Lalmi Tract (Comilla) and some higher ground in Sylhet; these areas are also lateritic.
- The Flood Plain, which is the broad area mainly north and east of the Padma River, which includes the Sylhet Basin, the Faridpur Trough and the piedmont alluvial plain of north Bengal. The soils are little-weathered gray silts and clays; locally there are near-surface peats.
- The Deltaic Plain which covers the area between the Ganges and the Bay of Bengal, passing southwards into the Sundarbans – the low tidal area of Khulna and Patuakhali.

- The South Coastal Plain, the low coastal area extending from Noakhali to south of Cox's Bazar.

Figure 4.1.2 shows main rivers of Bangladesh. As most parts of Bangladesh are composed of alluvial lowland, major rivers in the country play vital roles in forming, deforming, and eroding alluvial soil layers covering the lowland. Bangladesh has 4 major rivers flowing down through its territory; the Ganges, Brahmaputra, Suma and Karnaphuli.

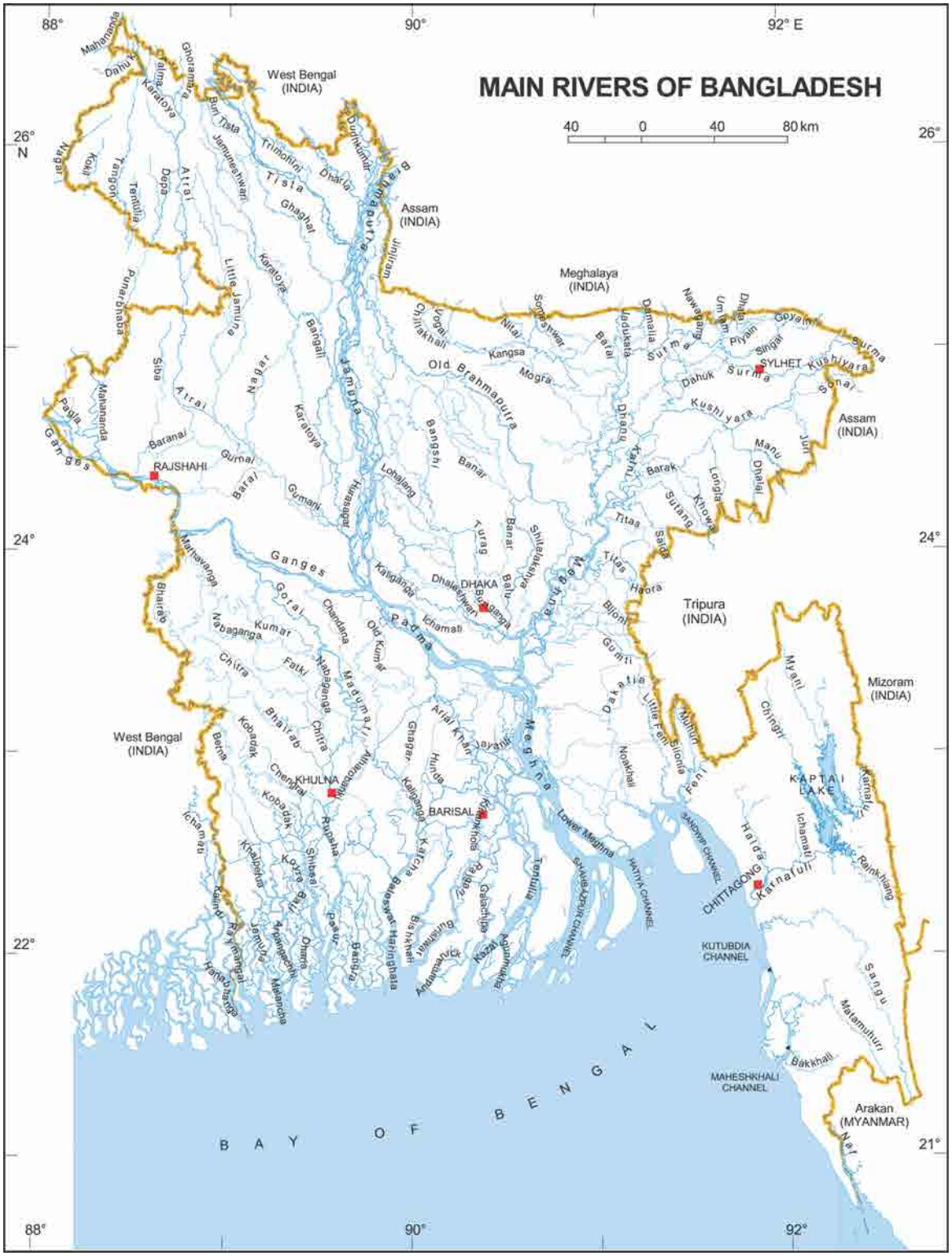
The main channel of the lower Ganges (the Ganges or Padma River) with increasing sluggishness debouches into the shallow northeast corner of the Bay of Bengal between Barisal and Noakhali. It has been migrating progressively eastward, and many of its former distributaries are partly abandoned or even dried up.

The Brahmaputra River rises in Tibet and flows first to the east and then southwest, in a manner of cutting through the Himalayas as an antecedent stream. After flowing through Assam, it enters northwest Bangladesh, where it is joined by the Tista and another river from the Himalayas. In Bangladesh, The Brahmaputra has a N-S course known as the Jamuna, which now joins the Ganges near Goalundo, but formerly the Brahmaputra flowed to the east of the Madhupur Jungle. Through history, it has been gradually shifting its braided system westward, and it made its present junction near Goalundo only in the 19th century.

The northeast part of Bangladesh is drained by the Surma River, which rises from the mountains near Manipur (India). At Bhairab Bazar (about 60 km NW of Dhaka), it joins with the old course of the Brahmaputra (presently an abandoned channel that takes the name Meghna).

In the south-east area of Bangladesh, in the Chittagong Hill Tracts and Chittagong, the Karnaphuli is the main river. It rises from the Lushai Hills (India) and flows to the Bay of Bengal near Chittagong city.

These for rivers play the major roles in the drainage pattern of Bangladesh, which is generally dendritic, except in the south-east part where trellis pattern is dominant.



Source: Geology of Bangladesh, University Press Limited, Dhaka, 1991

Figure 4.1.2 Main Rivers of Bangladesh

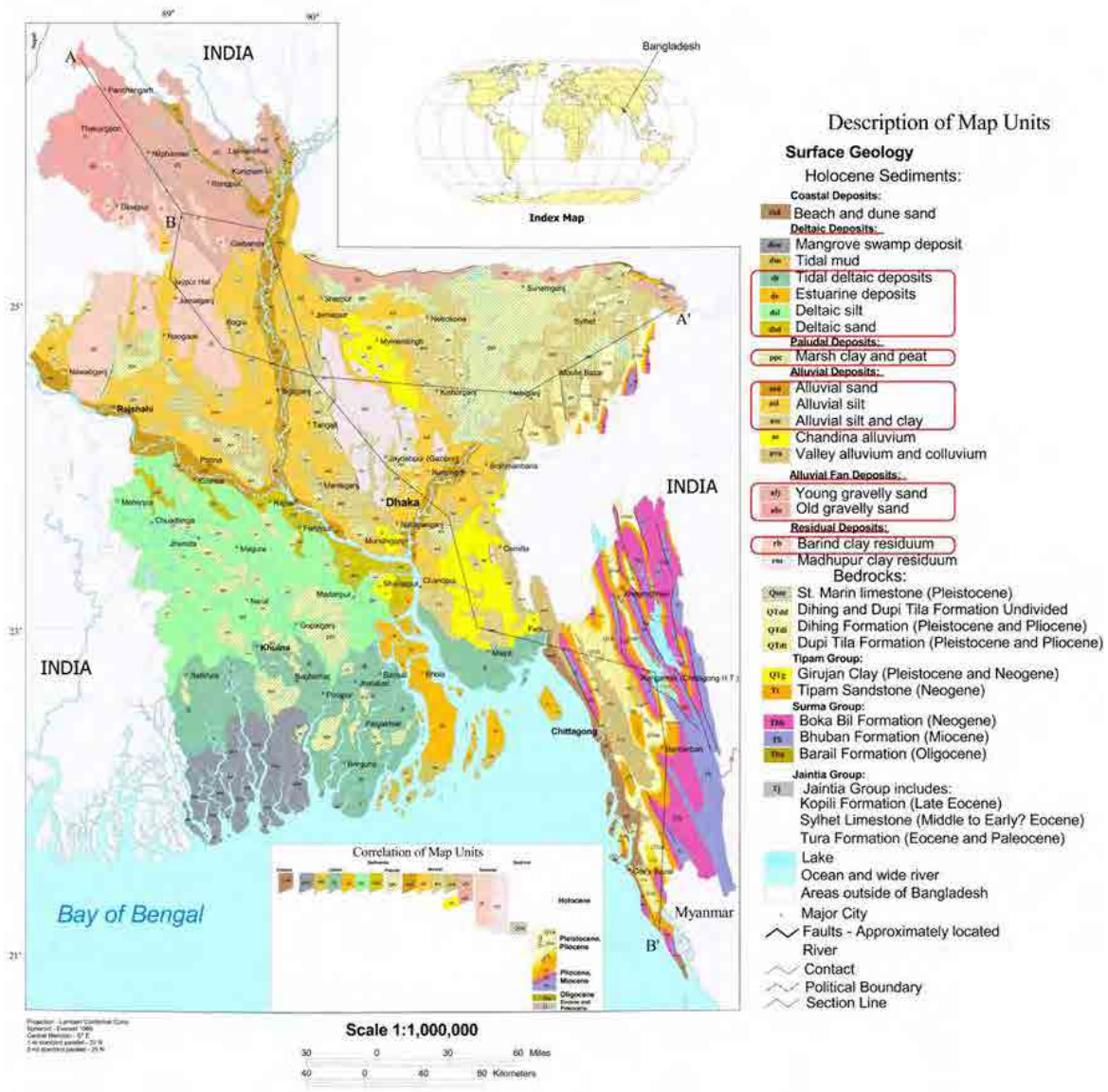
4.2 Geology

4.2.1 Overview of Geological Condition

Figure 4.2.1 summarizes geological condition in Bangladesh. Candidate sites of the Project scatter in the western Bangladesh where various types of Holocene sediments cover the lowland. According to Figure 4.2.1, clear difference can be understood between both sides of the Ganges-Padma River; the northern part of the survey area, Rangpur and Rajshahi, is composed of alluvial deposits, alluvial fan deposits and residual deposits, whereas the southern part of the study area, Khulna, Gopalganj, and Barisal, is made up of deltaic deposits. Marsh clay and peat of paludal deposits are distributed in both sides of the Ganges-Padma except Rangpur, but mainly occur in the southern part and are scattered in the areas of deltaic silt and tidal deltaic deposits.

In the survey area, the deltaic deposits mainly consist of deltaic silt and tidal deltaic deposits. Deltaic sand is distributed along the Ganges-Padma. Estuarine deposits form barrier islands at the estuaries of the Padma. According to the construction record of Rupsa Bridge in Khulna where the tidal deltaic deposits are distributed, thick strata of soft silt are deposited down to 60 meters below sea level and underlain by thick strata of silty fine sand. The silty fine sand contains plenty of mica and, in particular condition, decreases its shear strength even under an increased confined pressure.

The alluvial deposits consist of sand and silt. The alluvial fan deposits are composed of gravelly sand and distributed in Rangpur, the northwest boundary of the country. The residual deposits occur on the Pleistocene terrace of Barind and supposed to be rather hard compared with clay of Holocene sediments.



Source: Geological Survey of Bangladesh

Figure 4.2.1 Geological Framework of Bangladesh

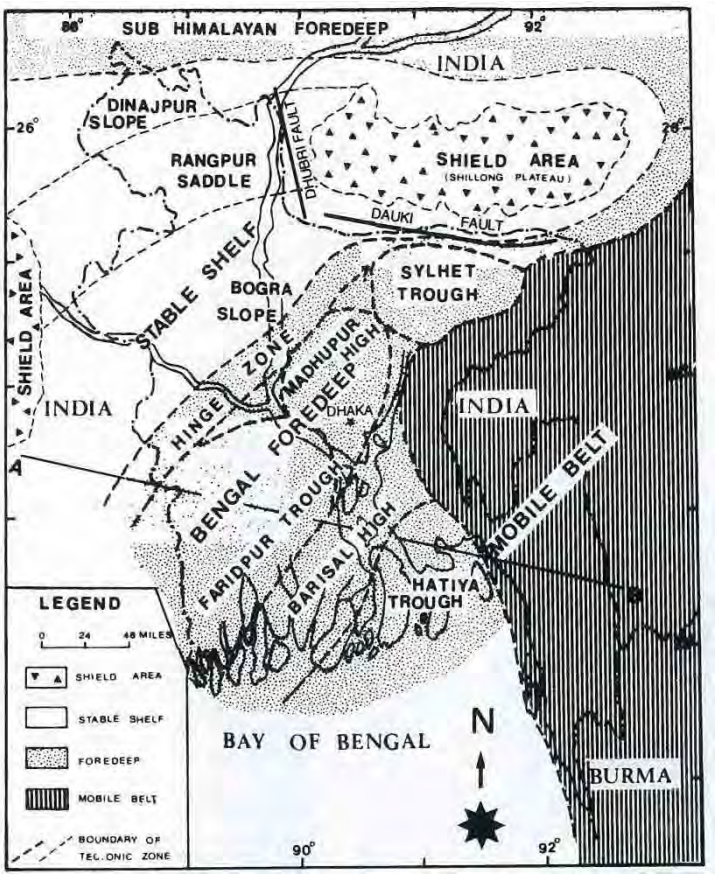
Figure 4.2.2 summarizes tectonic setting and profile of the Bengal Basin. The modern Bengal delta and offshore fan complex associated with the Ganges, Brahmaputra and Meghna rivers form one of the world's largest depositional systems.

The Bengal Basin has long history of subsidence and deposition. Sedimentation in the Bengal Basin started about 290 Ma ago in the Permian Period. Since then, through a series of transgression and regression which left a numbers of unconformity in local stratigraphic succession and dissection of unconsolidated sediments, deposition has developed in the basin and formed the succession of thick sedimentary strata.

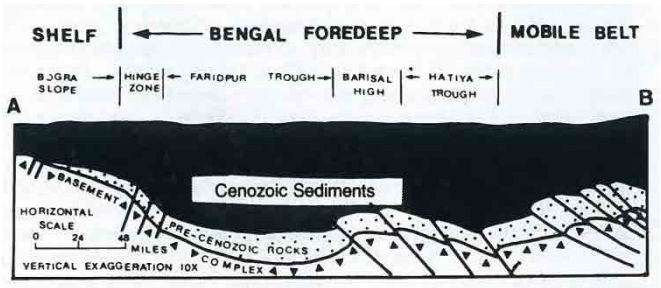
Major uplift in Himalayas began during Miocene and has continued through Neogene and Quaternary. Uplift in Himalayas has provided rainfall (and hence stream flow intensity) and clastic material to be transported to the Bengal Basin by the major river system, and

quickened development of sedimentary strata in the basin.

Along with subsidence of the Bengal Basin, a massive amount of clastic material provided with abundant flow of the major rivers from the Himalayas has made the Quaternary strata much thicker than in usual depositional basins. In the central part of the basin, the Quaternary layer is probably over 500 meters thick.



(Tectonic Setting)



(E-W Profile)

Source: Encyclopedia of European and Asian Regional Geology

Figure 4.2.2 Tectonic Setting of Bengal Basin

4.2.2 Boring Investigation and Lab Test

Boring investigation was carried out at the 106 bridge sites. For each bridge, 1 borehole was drilled.

Along with drilling, standard Penetration Test (hereinafter referred to as SPT) conformig to ASTM D1586 was carried out at each 1.0 meter interval. Until confirming STP N-value of 50 or more for at least 5 meters deep, drillings were executed. To counteract erratic situation of the ground, much deeper drilling was done at some sites.

With the disturbed samples obtained through SPT, the following lab tests were carried out to determine soil classification of the strata:

- Specific Gravity (ASTM D 854)
- Natural Moisture Content (ASTM D 2216)
- Atterberg Limits (ASTM D 4318)
- Sieve Analysis (ASTM D 422)

Classification of soil conforms to ASTM D 2487 or ASTM D 2488.

The results of boring, SPT, and lab tests were organized into borehole logs and attached to Appendix 1.4.

4.2.3 Bearing Layer

Based on the results of drilling, SPT, and lab tests, possible bearing layers for each bridge sites are proposed in Table 4.2.1.

At two bridge sites in Barisal Zone, R890_16a and R890_28a, due to lower SPT-N Values confirmed through the drilling, no appropriate bearing layer was found.

At one bridge site in Khulna Zone, N7_248c, and one in Rajshahi Zone, N5_176a, due to micaceous sand, no appropriate bearing layer was found. Micaceous sand contains much mica particles and shows a lesser value of specific gravity than ordinary sand. The highest specific gravity of micaceous sand recorded in the Study was 2.57 g/cm3; most of the results of micaceous sand show specific gravity of around 2.4~2.5 g/cm3. Mica is a luster mineral with flat fragile structure and slippery surface and usually found in the sediments underlying Bangladesh flatland. With its fragile and slippery property, mica richly contained in micaceous sand provides much lower bearing capacity and/or skin friction than expected from SPT-N value of a layer and has caused a number of problems in construction of pile foundations in Bangladesh. Based on the experience in Bangladesh, bearing capacity and/or skin friction cannot be expected in micaceous sand.

Table 4.2.1 List of Bearing Layer (Barisal Zone)

SN	Bridge Data				Bearing Layer			
	Bridge ID	Zone	Division	Sub-Division	Depth (GL-m)	Soil Type	SPT N Value	Remarks
1	N8_178a	Barisal	Barisal	Barisal	46	Silty Sand w Gravel, SM	50<	
2	N509_19a	Rangpur	Lalmonirhat	Lalmonirhat	23	Poorly Graded Sand w Gravel, SP	50 <	
3	N5_119a	Rajshahi	Pabna	Pabna-1	29	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
4	N5_127a	Rajshahi	Pabna	Ullahpara	28	Silty Sand w Gravel, SM	50 <	
5	N5_176a	Rajshahi	Sirajganj	Serajganj-2	***No***	***Micaceous Silty Sand w Gravel, SP-SM***	***50 < (28m~)***	***Micaceous sand shall not be used as a bearing layer.***
6	N5_235a	Rangpur	Bogra	Bogra	25	Silty Sand w Gravel, SM	50 <	
7	N5_120a	Rajshahi	Pabna	Pabna-1	27	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
8	N5_128a	Rajshahi	Sirajganj	Ullahpara	31	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
9	N5_158a	Rajshahi	Sirajganj	Ullahpara	24	Silty Sand w Gravel, SM	50 <	
10	N5_265a	Rangpur	Gaibandha	Palashbari	22	Poorly Graded Sand w Gravel, SP	50 <	
11	N5_350b	Rangpur	Rangpur	Rangpur	22	Silty Sand w Gravel, SM	50 <	
12	N8_182a	Barisal	Barisal	Barisal	40	Silty Sand w Gravel, SM	***30<***	
13	N7_025a	Gopalganj	Faridpur	Faridpur-2	38	Silty Sand w Gravel, SM	50<	
14	N7_039a	Gopalganj	Faridpur	Faridpur-1	45	Silty Sand w Gravel, SM	50<	
15	N7_049a	Gopalganj	Faridpur	Faridpur-1	33	Poorly Graded Sand w Gravel, SP	50<	
16	N5_134a	Rajshahi	Sirajganj	Ullahpara	29	Poorly Graded Sand w Gravel, SP	50 <	
17	N6_97a	Rajshahi	Natore	Natore-2	***27***	***Poorly Graded Sand w Gravel, SP***	***50 <***	***Thickness shall be confirmed during D/D.***
18	R681_10a	Rajshahi	Rajshahi	Rajshahi-1	***29***	***Silty Sand w Gravel, SM***	***50 <***	***Thickness shall be confirmed during D/D.***
19	N5_140a	Rajshahi	Sirajganj	Ullahpara	23	Poorly Graded Sand w Gravel, SP	50 <	
20	N5_118a	Rajshahi	Pabna	Pabna-1	25	Silty Sand w Gravel, SM	50<	

SN	Bridge Data				Bearing Layer			
	Bridge ID	Zone	Division	Sub-Division	Depth (GL-m)	Soil Type	SPT N Value	Remarks
21	N704_43a	Khulna	Kushtia	Kushtia	30	Silty Sand w Gravel, SM	50<	
22	N7_248c	Khulna	Bagerhat	Bagerhat-2	***No***	***Micaceous Silty Sand w Gravel, SP-SM***	***50 < (51m~)***	***Micaceous sand shall not be used as a bearing layer.***
23	N7_054a	Gopalganj	Faridpur	Faridpur-1	52	Silty Sand w Gravel, SM	50<	
24	N5_356a	Rangpur	Rangpur	Rangpur	24	Silty Sand w Gravel, SM	50 <	
25	N7_246a	Khulna	Bagerhat	Bagerhat-2	54	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
26	N8_095a	Gopalganj	Madaripur	Madaripur	36	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
27	N505_2a	Rajshahi	Pabna	Pabna-1	29	Silty Sand w Gravel, SM	50 <	
28	R548_28b	Rajshahi	Naogaon	Naogaon	***28***	***Silty Sand w Gravel, SM***	***50 <***	***Thickness shall be confirmed during D/D.***
29	N7_036c	Gopalganj	Faridpur	Faridpur-1	33	Silty Sand w Gravel, SM	50<	
30	N7_048a	Gopalganj	Faridpur	Faridpur-1	34	Poorly Graded Sand w Gravel, SP	50<	
31	N5_378a	Rangpur	Dinajpur	Dinajpur	25	Silty Sand w Gravel, SM	50 <	
32	N7_047a	Gopalganj	Faridpur	Faridpur-1	36	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
33	N5_156a	Rajshahi	Sirajganj	Ullahpara	28	Silty Sand w Gravel, SP-SM	50 <	
34	N5_172a	Rajshahi	Sirajganj	Sirajganj-2	32	Silty Sand w Gravel, SM	50 <	
35	N5_179a	Rajshahi	Sirajganj	Sirajganj-2	25	Silty Sand w Gravel, SM	50 <	
36	N5_188a	Rangpur	Bogra	Sherpur	21	Silty Sand w Gravel, SM	50 <	
37	N5_126a	Rajshahi	Pabna	Pabna-1	24	Poorly Graded Sand w Gravel, SP	50 <	
38	N518_4a	Rangpur	Nilphamari	Nilphamari	31	Fine Sand, SM	50 <	
39	N7_141b	Khulna	Jessore	Jessore-1	38	Silty Sand w Gravel, SM	50<	
40	R720_44a	Khulna	Narail	Narail	48	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
41	N703_Sd	Khulna	Jhenaidah	Jhenaidah	30	Poorly Graded Silty Sand w Gravel, SP-SM	50<	

SN	Bridge Data				Bearing Layer			
	Bridge ID	Zone	Division	Sub-Division	Depth (GL-m)	Soil Type	SPT N Value	Remarks
42	R890_45a	Barisal	Bhola	Bhola	45	Silty Sand w Gravel, SM	50<	
43	N704_14a	Khulna	Jhenaidah	Jhenaidah	31	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
44	N704_33b	Khulna	Kushtia	Kushtia	27	Silty Sand w Gravel, SM	50<	
45	N5_344c	Rangpur	Rangpur	Rangpur	26	Silty Sand w Gravel, SM	50 <	
46	N5_382a	Rangpur	Dinajpur	Dinajpur	38	Silty Sand w Gravel, SM	50 <	
47	N5_360a	Rangpur	Rangpur	Rangpur	28	Silty Sand w Gravel, SM	50 <	
48	Z5025_55a	Rangpur	Dinajpur	Dinajpur	23	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
49	Z5025_64a	Rangpur	Dinajpur	Dinajpur	22	Silty Sand w Gravel, SM	50 <	
50	Z5401_45a	Rangpur	Bogra	Sherpur	24	Silty Sand w Gravel, SM	50 <	
51	Z5072_14a	Rangpur	Bogra	Sherpur	23	Silty Sand w Gravel, SM, Shale	50 <	
52	Z5025_60a	Rangpur	Dinajpur	Dinajpur	***50***	***Clay w Sand, CL or CH***	***20<***	
53	Z5472_6a	Rangpur	Bogra	Bogra	19	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
54	N5xx_Sa	Rajshahi	Sirajganj	Ullahpara	18	Silty Sand w Gravel, SP-SM	50 <	
55	Z5552_10a	Rangpur	Gaibandha	Gaibandha	21	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
56	N8_152c	Barisal	Barisal	Barisal1	39	Silty Sand w Gravel, SM	50<	
57	N8_127b	Barisal	Barisal	Barisal1	59	Silt w Sand, ML	50<	
58	Z8052_009d	Barisal	Patuakhali	Patuakhali	53	Silty Sand w Gravel, SM	50<	
59	Z5015_22a	Rangpur	Nilphamari	Nilphamari	23	Poorly Graded Sand w Gravel, SP	50 <	
60	Z5701_1a	Rangpur	Nilphamari	Nilphamari	26	Silty Sand w Gravel, SM	50 <	
61	Z5701_9a	Rangpur	Nilphamari	Nilphamari	18	Poorly Graded Sand w Gravel, SP	50<	
62	R545_115c	Rangpur	Joypurhat	Joypurhat	21	Poorly Graded Sand w Gravel, SP	50 <	
63	R760_049c	Khulna	Satkhira	Satkhira-1	66	Fine Sand, SM	50<	

SN	Bridge Data				Bearing Layer			
	Bridge ID	Zone	Division	Sub-Division	Depth (GL-m)	Soil Type	SPT N Value	Remarks
64	N8_123a	Barisal	Barisal	Barisal1	44	Silty Sand w Gravel, SM	50<	
65	Z8701_3d	Barisal	Pirojpur	Kawkhali	37	Silty Sand w Gravel, SM	50<	
66	N5_260b	Rangpur	Gaibandha	Palashbari	28	Silty Sand w Gravel, SM	50 <	
67	N704_27b	Khulna	Kushtia	Kushtia	24	Silty Sand w Gravel, SM	50<	
68	R750_22c	Khulna	Narail	Narail	45	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
69	N8_129a	Barisal	Barisal	Barisal1	44	Low Plasticity Clay w Sand, CL	***30<***	
70	R890_16a	Barisal	Bhola	Bhola	***No***			***No appropriate bearing layer was found.***
71	R890_21a	Barisal	Bhola	Bhola	50	Silty Sand w Gravel, SM	50<	
72	R890_28a	Barisal	Bhola	Bhola	***No***			***No appropriate bearing layer was found.***
73	R548_40a	Rajshahi	Natore	Natore-1	24	Silty Sand w Gravel, SM	50 <	
74	R451_1a	Rajshahi	Sirajganj	Sirajganj-2	33	Silty Sand w Gravel, SM	50 <	
75	R451_7a	Rajshahi	Sirajganj	Sirajganj-2	43	Sand w Gravel, SP	50 <	
76	R550_28b	Rangpur	Joypurhat	Joypurhat	12	Silty Sand w Gravel, SM	50 <	
77	R860_31a	Gopalganj	Shariatpur	Shariatpur	41	Silty Sand w Gravel, SM	50<	
78	Z8708_1c	Barisal	Jhalokati	Jhalokati	37	Silty Sand w Gravel, SM	50<	
79	N5_458a	Rangpur	Panchagarh	Panchagarh	17	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
80	N5_488a	Rangpur	Panchagarh	Panchagarh	14	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
81	Z8708_12b	Barisal	Jhalokati	Jhalokati	36	Fine Sand, SM	50<	
82	Z8033_017a	Barisal	Barisal	Barisal1	49	Silty Sand w Gravel, SM	50<	
83	R860_34a	Gopalganj	Shariatpur	Shariatpur	31	Silty Sand w Gravel, SM	50<	
84	R860_44c	Gopalganj	Shariatpur	Shariatpur	48	Silty Sand w Gravel, SM	50<	
85	R860_53d	Gopalganj	Shariatpur	Shariatpur	38	Poorly Graded Sand w Gravel, SP	50<	

SN	Bridge Data				Bearing Layer			
	Bridge ID	Zone	Division	Sub-Division	Depth (GL-m)	Soil Type	SPT N Value	Remarks
86	N8_69a	Gopalganj	Madaripur	Bhanga	41	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
87	Z6010_12b	Rajshahi	Rajshahi	Rajshahi-2	***26***	***Silty Sand w Gravel, SM***	***50 <***	***Thickness shall be confirmed during D/D.***
88	Z5008_1a	Rangpur	Dinajpur	Dinajpur	18	Silty Sand w Gravel, SM	50 <	
89	Z5024_5c	Rangpur	Rangpur	Rangpur-1	25	Silty Sand w Gravel, SP-SM	50 <	
90	Z5025_46a	Rangpur	Dinajpur	Dinajpur	34	Fine Sand, SM	50 <	
91	Z5040_4a	Rangpur	Bogra	Sherpur	25	Sand w Gravel, SP	50 <	
92	Z8810_13a	Barisal	Barisal	Barisal1	57	Silty Sand w Gravel, SM	***30<***	
93	R585_80a	Rangpur	Dinajpur	Phulbari	24	Silty Sand w Gravel, SM	50 <	
94	Z8033_008a	Barisal	Barisal	Barisal1	51	Silty Sand w Gravel, SM	50<	
95	Z8033_019a	Barisal	Barisal	Barisal1	45	Low Plasticity Clay w Sand, CL	***20<***	
96	Z8034_011a	Barisal	Barisal	Barisal1	38	Silty Sand w Gravel, SM	50<	
97	Z8044_004a	Barisal	Barisal	Barisal2	39	Silty Sand w Gravel, SM	50<	
98	R760_003a	Khulna	Khulna	Khulna-2	50	Silty Sand w Gravel, SM	50<	
99	R860_35a	Gopalganj	Shariatpur	Shariatpur	34	Poorly Graded Silty Sand w Gravel, SP-SM	50<	
100	Z5041_2a	Rajshahi	Sirajganj	Sirajganj-2	30	Silty Sand w Gravel, SM	50 <	
Ⅰ	N706_14b	Khulna	Jessore	Jessore-1	39	Silty Sand w Gravel, SM	50<	
Ⅱ	N5_435a	Rangpur	Thakurgaon	Thakurgaon	18	Poorly Graded Silty Sand w Gravel, SP-SM	50 <	
Ⅲ	N704_12c	Khulna	Jhenaidah	Jhenaidah	37	Silty Sand w Gravel, SM	50<	
Ⅳ	N805_24a	Gopalganj	Gopalganj	Bhatiapara	34	Silty Sand w Gravel, SM	50<	
Ⅴ	R750_25a	Khulna	Narail	Narail	37	Silty Sand w Gravel, SM	50<	
Ⅵ	Z7503_5a	Khulna	Narail	Narail	44	Silty Sand w Gravel, SM	50<	

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: JICA Survey Team

4.3 Meteorological and Hydrological Conditions

4.3.1 General

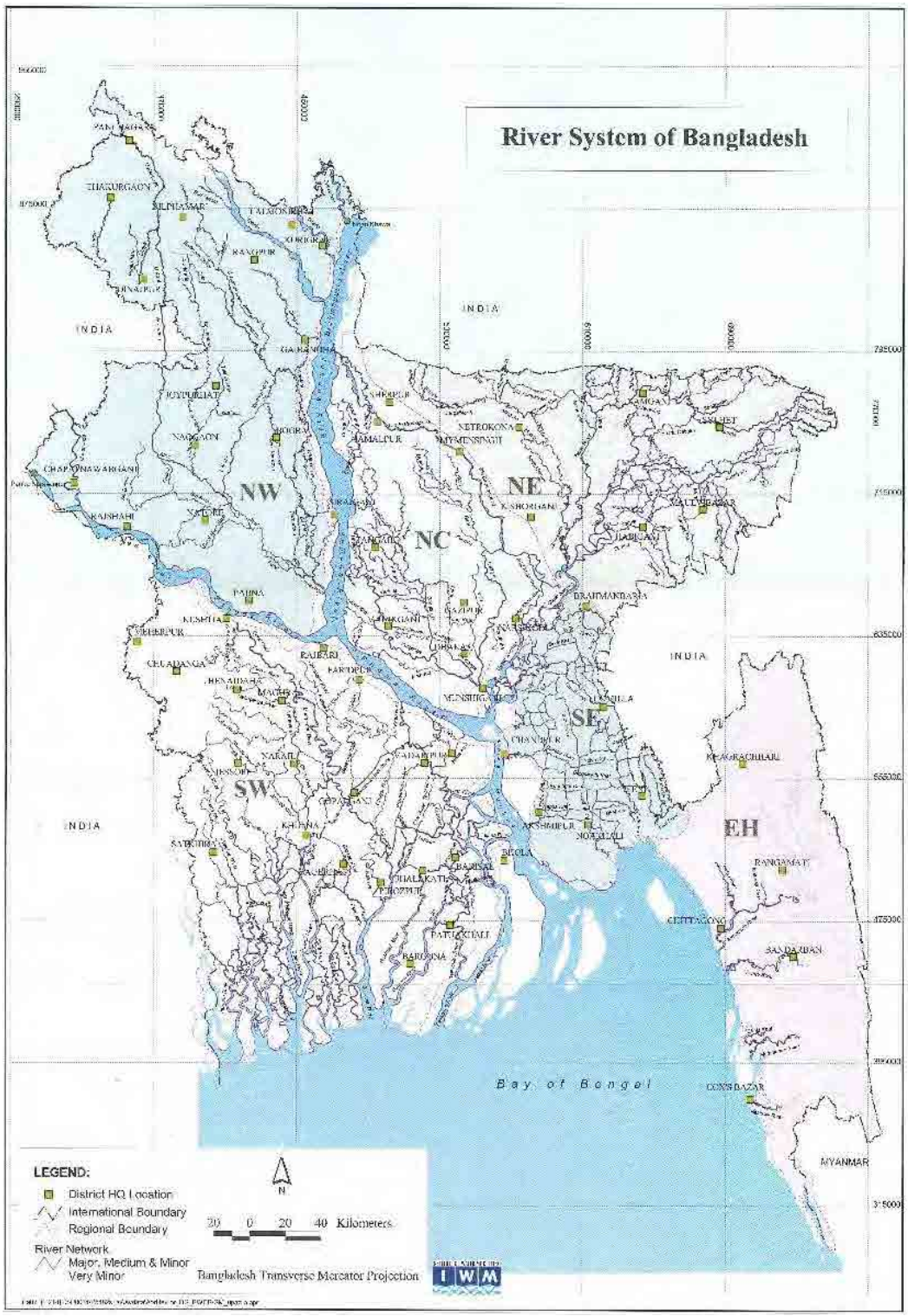
Bangladesh is located in the tropical monsoon region, and the climate of Project area is characterized by high temperatures, heavy rainfall, extreme humidity, and considerable seasonal variation. The most notable feature of its climate is the alternation of the wind circulation between summer and winter, which is an integral part of the circulation system of the South Asian subcontinent. With regards to the climate, three distinct seasons can be recognized in Bangladesh: the cool dry season from November through February, the pre-monsoon hot season from March through May, and the rainy monsoon season from June through October.

Bangladesh has to drain water from lands with a combined area of 12 times of its own size. The amount of water that annually reaches Bangladesh from outside the country would form a lake of the size of the country of 10.3m depth. A flat, low-lying topography is the most characteristic geomorphological feature: 60 percent of the country lies less than 6m above sea-level. Therefore, floods occur in Bangladesh frequently, and on-average, 20 percent of Bangladesh is flooded annually. Bangladesh has riverine systems with a total of about 700 rivers including tributaries, which have a total length of about 24,140km, as shown in Figure 4.3.1. In these riverine systems, Bangladesh predominantly has three major river systems - (1) the Brahmaputra-Jamuna, (2) the Ganges-Padma, and (3) the Surma-Meghna river system. These 3 rivers are international and trans-boundary river systems. 8% of the total catchment area is located within Bangladesh, with 62% in India, 18% in China, 8% in Nepal and 4% in Bhutan.

In Bangladesh, the collection of meteorological data is managed by BMD (Bangladesh Meteorological Department) under MoD (Ministry of Defence), while the collection of hydrological data such as water level, discharge and sediment-flow is managed by BWDB (Bangladesh Water Development Board) under MoWR (Ministry of Water Resources).

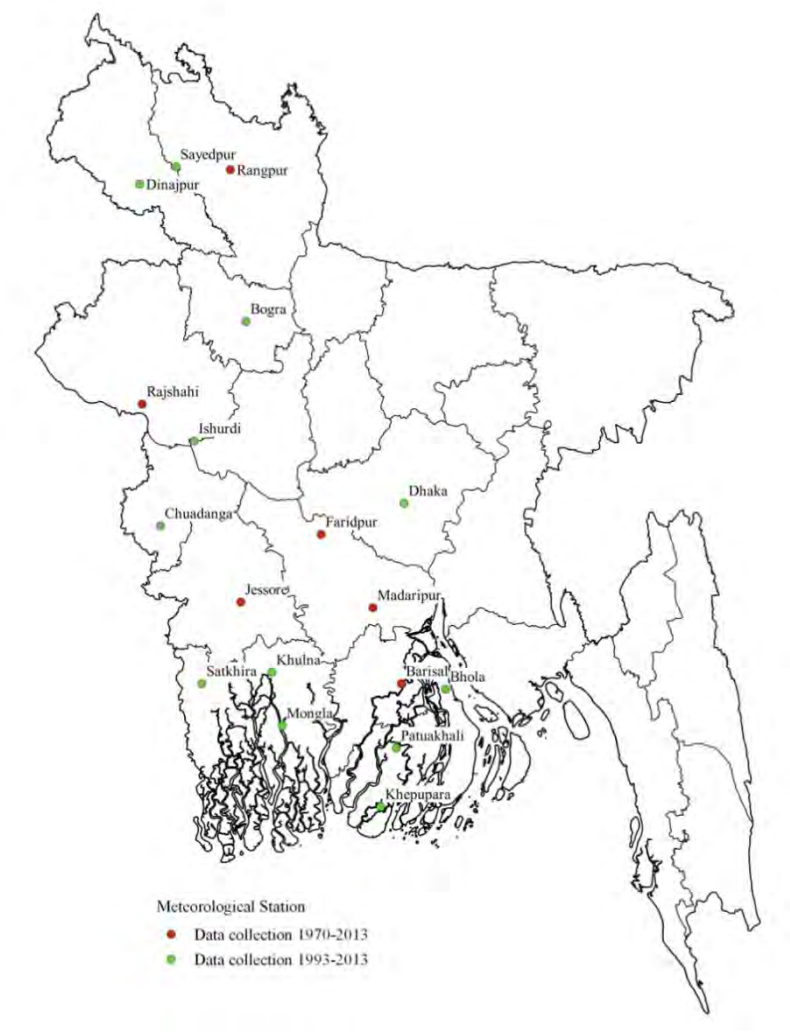
There are 35 synoptic observation stations for climatic data under BMD. Of these stations, climatic data of 18 stations (as shown in Figure 4.3.2 and listed in Table 4.3.1) was collected.

Of approximately 500 hydrological stations under BWDB, water level data of 86 stations (as shown in Figure 4.3.3) was collected. (Also, discharge data at 5 stations was collected.)



Source: BWDB, Institute of Water Modeling (IWM)

Figure 4.3.1 River System of Bangladesh



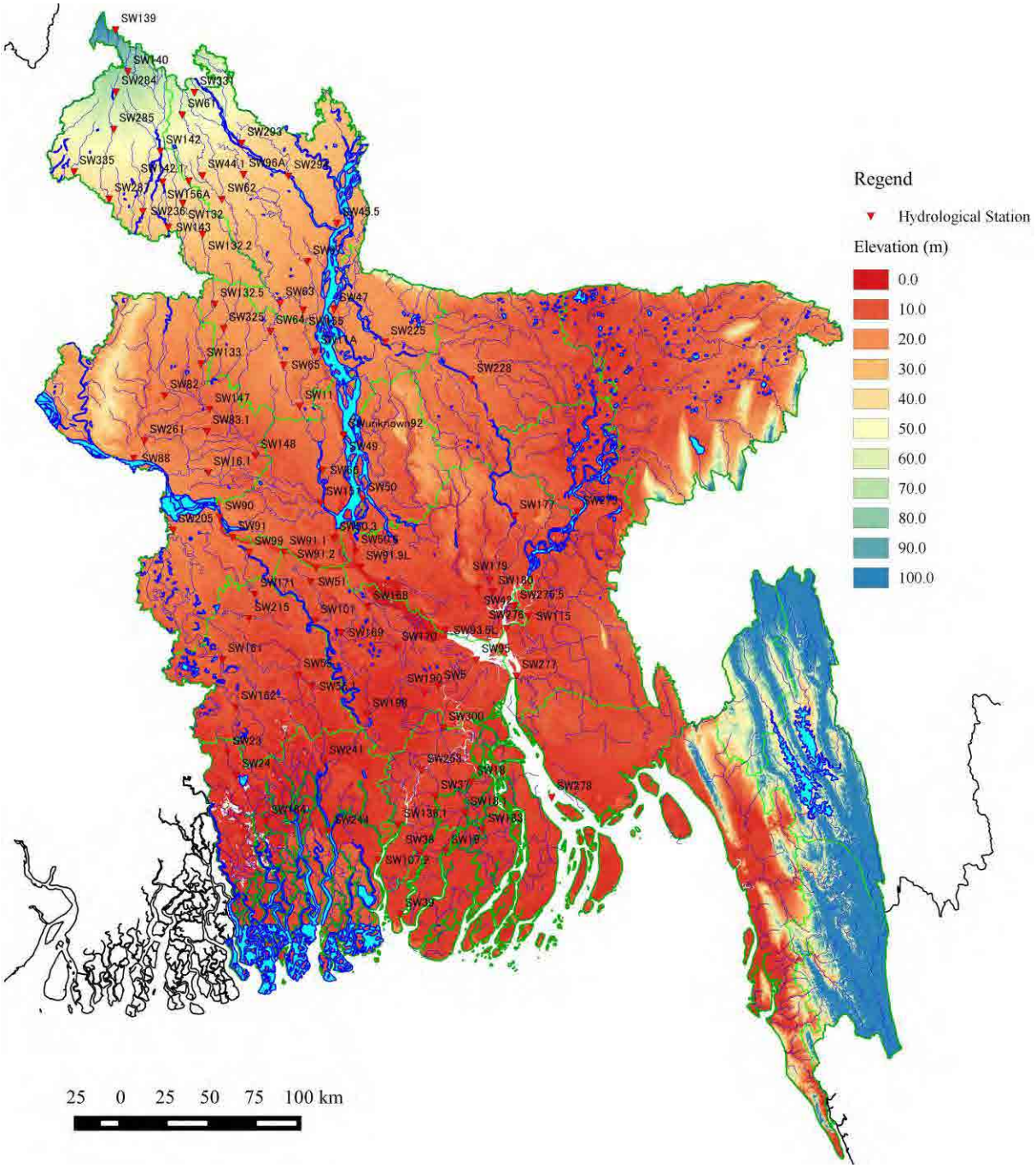
Source: JICA Survey Team, BMD

Figure 4.3.2 Location of Meteorological Stations for Data Collection

Table 4.3.1 Inventory of Meteorological Stations for Data Collection

No.	Name	Station ID (WMO)	Year of Establishment	Elevation (m)	Latitude	Longitude	Period of Record					Remarks
							Temperature	Humidity	Wind	Sunshine Hrs.	Rainfall	
1	Barisal	41950	1883	2.10	22.71667	90.36667	1970-2013	1969-2012	2003-2013	1970-2013	1970-2013	
2	Faridpur	41929	1883	8.10	23.60000	89.85000	1970-2013	1969-2012	2003-2013	1985-2013	1970-2013	
3	Jessore	41936	1867	6.10	23.20000	89.33333	1970-2013	1969-2012	2003-2013	1970-2013	1970-2013	
4	Madaripur	41939	1976	7.00	23.16667	90.18333	1977-2013	1977-2013	2003-2013	1985-2013	1977-2013	
5	Rajshahi	41895	1883	19.50	24.36667	88.70000	1971-2013	1969-2013	2003-2013	1979-2013	1971-2013	
6	Rangpur	41859	1883	32.61	25.73333	89.26667	1970-2013	1969-2013	2003-2013	1979-2013	1970-2013	
7	Dhaka	41923	1949	8.45	23.78333	90.38333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
8	Ishwardi(Ishrdi)	41907	1963	12.90	24.15000	89.03333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
9	Bogra	41883	1884	17.90	24.85000	89.36667	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
10	Dinajpur	41863	1883	37.58	25.65000	88.68333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
11	Sayedpur(Sydpur)	41858	1980	39.60	25.75000	88.91667	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
12	Khulna	41947	1921	2.10	22.78333	89.53333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
13	Mongla	41958	1988	1.80	22.46667	89.60000	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
14	Satkhira	41946	1877	3.96	22.71667	89.08333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
15	Chuadanga	41926	1986	11.58	23.65000	88.81667	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
16	Patuakhali	41906	1973	1.50	22.33333	90.33333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
17	Khepupara	41984	1973	1.83	21.98333	90.23333	2003-2013	2003-2013	2003-2013	2003-2013	1993-2013	
18	Bhola	41951	1965	4.30	22.68333	90.65000	2003-2013	2006-2010	2003-2013	2003-2013	1993-2013	

Source: JICA Survey Team, BMD



Source: JICA Survey Team, BWDB

Figure 4.3.3 Location of Hydrological Stations for Data Collection

4.3.2 Meteorological Condition

(1) General Weather Conditions

1) Temperature

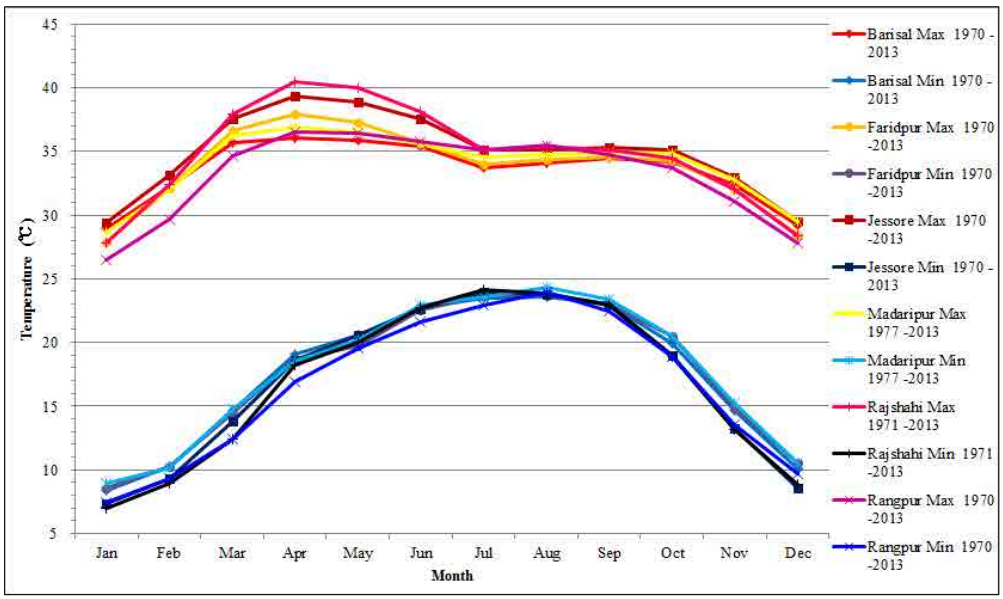
The monthly mean temperature at 18 stations is shown in Figure 4.3.5, and the mean monthly maximum and minimum temperature at 6 of these stations is shown in Figure 4.3.4. (The corresponding data is shown in Table 4.3.2.).

Table 4.3.2 Monthly Maximum, Mean and Minimum Temperature

Station	Item	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Remarks
Barisal	Maximum	1970 -2013	28.9	32.2	35.7	36.0	35.8	35.4	33.8	34.1	34.5	34.2	32.4	29.2	33.5	
	Average	1970 -2013	18.4	21.6	26.1	28.5	28.9	28.7	28.2	28.3	28.3	27.5	24.0	19.7	25.7	
	Minimum	1970 -2013	8.4	10.3	14.6	19.1	20.6	22.7	23.5	23.6	23.0	19.9	14.6	10.0	17.5	
Faridpur	Maximum	1970 -2013	27.9	32.1	36.6	38.0	37.3	35.7	34.0	34.4	34.6	34.2	32.0	28.5	33.8	
	Average	1970 -2013	18.0	21.2	26.0	28.6	28.8	28.9	28.6	28.8	28.7	27.6	23.9	19.5	25.7	
	Minimum	1970 -2013	8.5	10.3	14.4	18.7	19.8	22.6	23.7	23.6	23.0	20.5	14.8	10.5	17.5	
Jessore	Maximum	1970 -2013	29.4	33.2	37.5	39.3	38.9	37.5	35.1	35.1	35.3	35.1	33.0	29.5	34.9	
	Average	1970 -2013	18.1	21.4	26.4	29.6	30.0	29.6	29.0	29.0	28.9	27.6	23.7	19.2	26.1	gap 1978
	Minimum	1970 -2013	7.4	9.3	13.8	18.6	20.5	22.6	24.0	23.7	23.1	19.0	13.3	8.6	17.0	gap 1978
Madaripur	Maximum	1977 -2013	28.6	32.0	36.2	36.9	36.5	35.6	34.6	34.8	34.9	34.8	32.8	29.5	33.9	gap 1979
	Average	1977 -2013	18.7	21.5	26.1	28.5	28.9	29.1	28.8	29.0	29.0	27.9	24.6	20.3	26.0	gap 1979
	Minimum	1977 -2013	8.9	10.2	14.8	18.5	20.2	22.9	23.6	24.3	23.4	20.5	15.2	10.6	17.8	gap 1979
Rajshahi	Maximum	1971 -2013	27.8	32.4	38.0	40.4	40.0	38.2	35.1	35.4	35.1	34.5	32.0	28.4	34.8	
	Average	1971 -2013	17.2	20.4	25.4	29.5	29.6	29.7	29.0	29.2	28.8	27.2	23.2	18.9	25.7	gap 1977_1981-1982
	Minimum	1971 -2013	6.9	8.9	12.4	18.2	20.0	22.7	24.2	23.8	22.9	18.9	13.2	8.9	16.8	gap 1977_1981-1982
Rangpur	Maximum	1970 -2013	26.5	29.7	34.6	36.5	36.5	35.8	35.1	35.5	34.7	33.7	31.1	27.8	33.1	gap 1973-1977
	Average	1970 -2013	16.7	19.5	23.6	26.4	27.5	28.5	28.7	29.1	28.3	26.5	22.8	18.8	24.7	gap 1973-1977
	Minimum	1970 -2013	7.5	9.4	12.5	16.9	19.5	21.6	22.9	23.9	22.5	18.9	13.5	9.7	16.6	gap 1973-1977
Dhaka	Maximum	2003 -2013	28.3	32.3	36.0	36.9	36.8	36.0	34.8	35.0	35.1	34.9	32.3	29.2	34.0	
	Average	2003 -2013	18.2	22.5	26.7	28.8	29.3	29.2	29.0	29.0	28.7	27.6	24.0	20.1	26.1	
	Minimum	2003 -2013	9.8	12.6	16.5	19.5	20.7	22.6	24.1	24.2	24.1	20.9	15.6	11.7	18.5	
Ishwardi (Ishrdi)	Maximum	2003 -2013	27.5	32.7	37.7	39.7	39.5	38.2	35.6	36.0	35.6	34.8	32.1	28.9	34.9	
	Average	2003 -2013	15.7	20.1	25.3	28.8	29.3	29.4	28.9	29.0	28.5	26.5	22.2	17.9	25.1	
	Minimum	2003 -2013	6.3	9.4	12.7	18.7	20.6	22.8	24.5	24.9	23.9	19.0	12.6	8.1	17.0	
Bogra	Maximum	2003 -2013	27.8	31.7	35.5	37.2	38.4	37.1	35.5	36.0	36.1	35.1	32.6	29.8	34.4	
	Average	2003 -2013	16.4	20.8	25.3	27.8	28.8	29.1	29.2	29.3	28.8	27.1	23.2	18.9	25.4	
	Minimum	2003 -2013	7.4	10.6	14.6	19.4	20.7	22.8	24.7	24.6	24.0	19.9	13.9	9.9	17.7	
Dinajpur	Maximum	2003 -2013	26.9	30.7	35.4	37.2	38.1	37.4	35.4	35.8	35.4	33.9	31.5	28.1	33.8	
	Average	2003 -2013	15.3	19.8	24.2	26.7	28.2	28.9	29.1	29.3	28.7	26.4	22.1	17.8	24.7	
	Minimum	2003 -2013	6.8	9.3	13.5	18.0	20.1	22.0	24.3	24.8	23.6	18.5	12.5	8.8	16.9	
Sayedpur (Sydpur)	Maximum	2003 -2013	27.0	30.9	35.2	36.5	37.7	37.0	35.6	36.3	35.7	34.4	31.4	28.5	33.9	
	Average	2003 -2013	15.8	20.2	24.3	26.6	28.0	28.9	29.1	29.4	28.7	26.5	22.3	18.3	24.8	
	Minimum	2003 -2013	6.8	10.0	13.7	17.8	19.7	21.4	23.9	24.4	23.3	18.6	12.8	9.0	16.8	
Khulna	Maximum	2003 -2013	28.9	33.1	36.6	38.2	38.0	37.3	35.1	35.2	35.3	35.1	32.3	29.2	34.5	
	Average	2003 -2013	18.1	22.3	26.8	29.6	30.1	29.9	29.0	29.1	28.9	27.6	24.0	19.6	26.2	
	Minimum	2003 -2013	9.4	12.0	15.7	20.1	21.4	23.1	24.6	24.5	24.3	20.4	15.3	10.9	18.5	
Mongla	Maximum	2003 -2013	29.3	33.6	37.0	38.2	38.5	37.0	34.8	35.0	35.3	35.1	32.5	29.4	34.6	
	Average	2003 -2013	18.6	22.6	27.0	29.5	30.0	29.6	28.7	28.7	28.6	27.6	24.2	20.1	26.3	
	Minimum	2003 -2013	9.9	12.8	16.9	20.6	21.5	23.5	24.5	24.6	24.5	21.3	16.0	11.8	19.0	
Satkhira	Maximum	2003 -2013	28.7	33.0	36.5	38.0	38.2	37.4	34.8	35.0	34.9	34.5	32.0	28.8	34.3	
	Average	2003 -2013	17.7	21.9	26.5	29.4	30.2	30.0	29.0	29.0	28.7	27.2	23.3	19.0	26.0	
	Minimum	2003 -2013	8.5	11.3	15.0	19.9	21.3	23.2	24.4	24.6	24.2	20.0	14.1	9.3	18.0	
Chuadanga	Maximum	2003 -2013	28.2	33.5	38.1	40.1	39.8	38.9	35.7	36.0	35.7	35.1	32.3	28.8	35.2	
	Average	2003 -2013	15.9	20.4	25.5	28.9	29.7	29.4	28.5	28.6	28.2	26.4	22.2	17.7	25.1	
	Minimum	2003 -2013	6.6	9.6	12.8	19.4	20.8	22.8	24.6	24.7	23.8	18.9	12.7	7.9	17.0	
Patuakhali	Maximum	2003 -2013	29.5	33.3	36.3	37.0	37.0	35.9	34.0	34.9	35.0	35.2	32.6	30.2	34.2	
	Average	2003 -2013	18.3	22.2	26.5	28.8	29.5	29.2	28.5	28.6	28.4	27.5	23.9	19.8	25.9	
	Minimum	2003 -2013	9.7	11.9	15.9	20.2	21.5	23.3	24.5	24.5	24.1	20.9	15.3	10.9	18.6	
Khepupara	Maximum	2003 -2013	29.6	32.8	35.5	36.2	35.8	35.3	33.7	33.9	34.4	34.7	32.3	30.0	33.7	
	Average	2003 -2013	18.6	22.4	26.6	29.0	29.8	29.4	28.6	28.6	28.5	27.5	24.0	19.9	26.1	
	Minimum	2003 -2013	9.7	11.8	15.9	20.4	21.7	23.6	24.0	24.4	24.0	20.8	15.1	10.6	18.5	
Bhola	Maximum	2003 -2013	29.0	32.2	35.4	35.6	35.9	35.4	33.7	34.2	34.3	34.5	32.2	29.4	33.5	
	Average	2003 -2013	17.7	21.7	26.0	28.4	29.1	28.9	28.3	28.5	28.2	27.4	23.7	19.4	25.6	
	Minimum	2003 -2013	9.1	11.5	15.5	20.0	21.6	23.4	24.5	24.4	24.2	21.1	15.1	10.8	18.4	

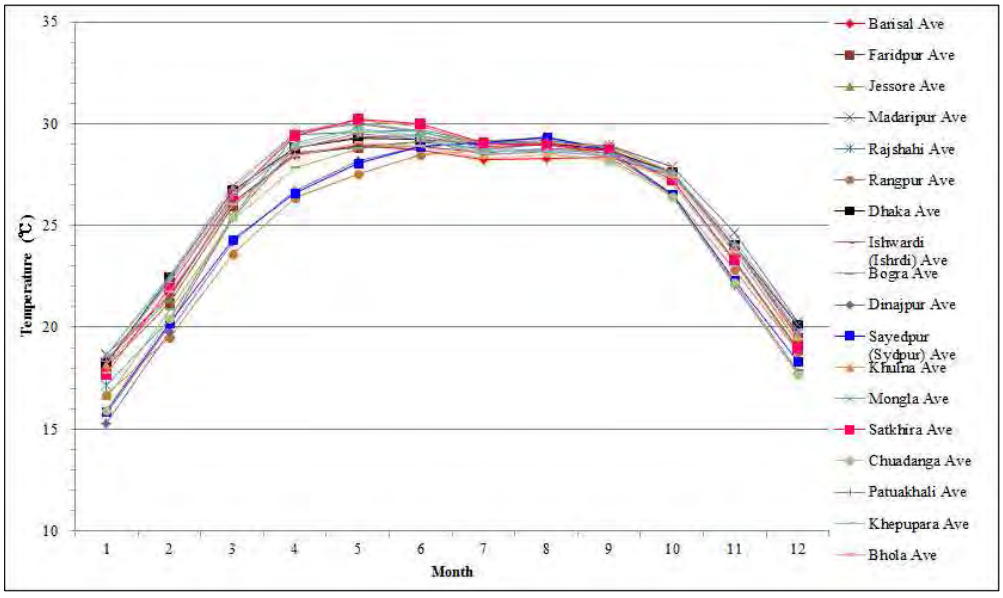
Source: JICA Survey Team, BMD

The temperature data of all 18 stations shows similar trends. January is the coldest month in the Project area. However, there is variation in the warmest month: the highest monthly maximum temperature is in April, while the highest monthly minimum temperature is in July-August. The highest monthly mean temperature is in August in the 4 northwestern cities (Rangpur, Dinajpur, Syedpur, Bogra) and is in June or May at other areas. The mean temperature in Western Bangladesh varies approximately from 17°C to 29°C.



Source: JICA Survey Team, BMD

Figure 4.3.4 Monthly Maximum and Minimum Temperature at 6 stations



Source: JICA Survey Team, BMD

Figure 4.3.5 Monthly Mean Temperature at 18 Stations

2) Relative Humidity

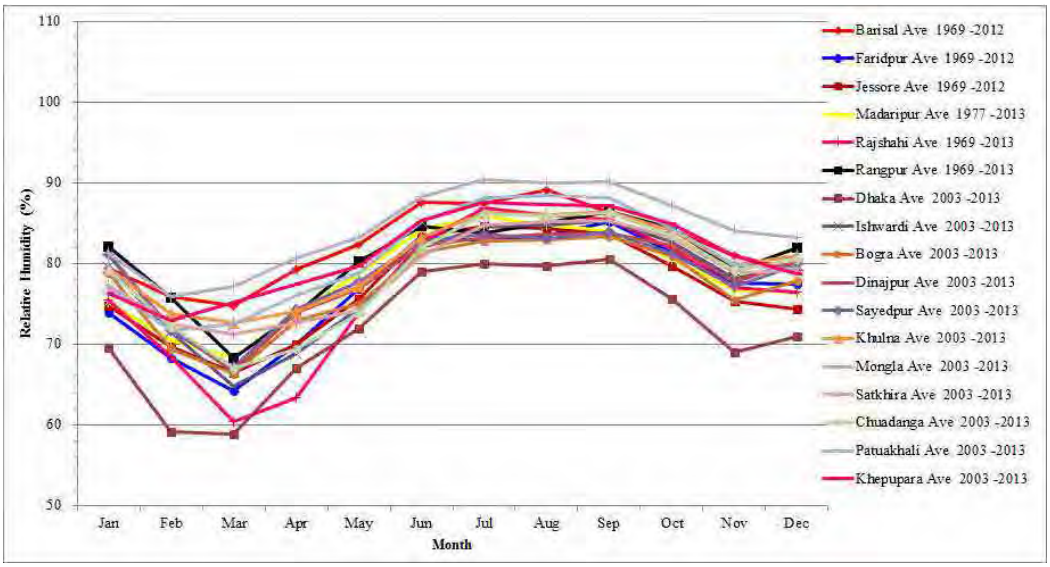
The monthly mean relative humidity (RH) at 17 stations is shown in Figure 4.3.6 (with corresponding data in Table 4.3.3).

The lowest average monthly RH is occurs in February-March and the highest average RH occurs throughout the rainy season. However, the RH is high throughout the entire year, and often reaches extreme levels.

Table 4.3.3 Monthly Mean Relative Humidity at 17 Stations

Station	Item	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Remarks
Barisal	Average	1969 -2012	79.5	75.9	74.8	79.3	82.3	87.6	87.4	89.1	86.3	84.2	81.0	79.2	82.2	Gap 2002
Faridpur	Average	1969 -2012	74.0	68.4	64.2	70.0	76.8	83.4	82.8	83.5	85.2	81.4	77.6	77.5	77.1	Gap 2002
Jessore	Average	1969 -2012	74.8	69.7	66.5	70.0	75.6	83.4	84.6	84.3	83.6	79.7	75.3	74.3	76.8	Gap 1978_2002
Madaripur	Average	1977 -2013	75.1	70.6	68.2	74.0	78.7	84.2	85.8	84.7	84.1	80.6	76.7	76.5	78.3	Gap 1979_2002
Rajshahi	Average	1969 -2013	75.4	68.4	60.4	63.4	73.9	82.7	86.8	86.0	85.4	81.8	77.0	76.4	76.5	Gap 2002
Rangpur	Average	1969 -2013	82.1	75.7	68.3	73.7	80.2	84.6	83.8	85.0	86.4	84.4	79.1	81.9	80.4	Gap 2002
Dhaka	Average	2003 -2013	69.5	59.2	58.8	67.0	71.9	79.0	80.0	79.6	80.5	75.6	69.0	71.0	71.8	
Ishwardi	Average	2003 -2013	79.5	71.5	64.8	68.8	74.5	81.9	84.6	84.7	85.3	82.7	78.1	79.8	78.0	
Bogra	Average	2003 -2013	78.8	69.4	66.4	72.9	75.0	81.4	82.7	83.0	83.3	81.0	75.5	77.9	77.3	
Dinajpur	Average	2003 -2013	81.3	71.9	66.5	73.9	76.9	82.3	83.2	83.6	83.7	82.3	77.7	80.2	78.6	
Sayedpur	Average	2003 -2013	81.1	71.7	67.2	74.4	77.7	82.7	83.6	83.1	83.9	81.3	77.1	79.8	78.6	
Khulna	Average	2003 -2013	79.4	73.7	72.6	74.0	77.1	83.3	86.3	86.0	86.5	84.0	79.9	80.9	80.3	
Mongla	Average	2003 -2013	77.0	71.7	72.5	76.1	78.8	85.2	88.1	88.4	88.2	84.3	79.9	79.3	80.8	
Satkhira	Average	2003 -2013	77.3	72.5	71.3	72.7	74.3	80.9	84.7	85.2	85.3	83.2	78.9	79.1	78.8	
Chuadanga	Average	2003 -2013	79.1	72.2	67.0	69.5	73.8	81.9	86.2	85.9	86.3	83.5	79.1	80.6	78.8	
Patuakhali	Average	2003 -2013	81.3	75.9	77.1	80.6	83.3	88.3	90.5	89.9	90.1	87.1	84.1	83.2	84.3	
Khepupara	Average	2003 -2013	76.3	72.9	75.2	77.4	79.7	85.3	87.6	87.3	87.1	84.9	80.9	78.7	81.1	
Bhola	Average	2006 -2010	86.0	99.0	93.5	83.5	101.5	90.0	89.0	103.0	90.5	89.0	98.0	94.5	93.1	
Bangaldesh	Average		78.2	72.8	69.7	73.4	78.5	83.8	85.4	86.2	85.7	82.8	79.2	79.5	79.6	

Source: JICA Survey Team, BMD



Source: JICA Survey Team, BMD

Figure 4.3.6 Monthly Mean Relative Humidity at 17 Stations

3) Wind Speed and Direction

The monthly maximum wind speed at 17 stations and the monthly mean wind speed at 18 stations are shown in Figure 4.3.7 (data in Table 4.3.4) and Figure 4.3.8 (data in Table 4.3.5) respectively.

The wind-direction in Bangladesh is characterized by seasonal alternation between summer and winter. During the winter season, a high-pressure center lies over northwestern India. A stream of cold air flows eastward from this high pressure and enters the country through its northeast corner by changing its course clockwise, almost at a right-angle. This wind is the part of the winter monsoon circulation of the South Asian subcontinent. During this season, the wind inside the country generally has a northerly component. On the other hand, during the summer season, a low-pressure center develops over the west-central part of India because of intense surface heat. As a result, a stream of warm and moist air from the Bay of Bengal flows toward the above-mentioned low pressure through Bangladesh. This wind is the part of the summer monsoon circulation of the sub-continent. Therefore, the prevailing wind direction in Bangladesh during the summer season generally has a southerly component.

The mean wind speed is in the range of about 1-3m/s, except in Jessore where it can reach about 4m/s. The data given for the maximum wind speed has been affected by a cyclone in Southern Bangladesh in 2007 (which explains why monthly maximum wind speeds in Barisal were recorded at 40m/s).

Table 4.3.4 Monthly Maximum Wind Speed at 17 Stations (in m/s)

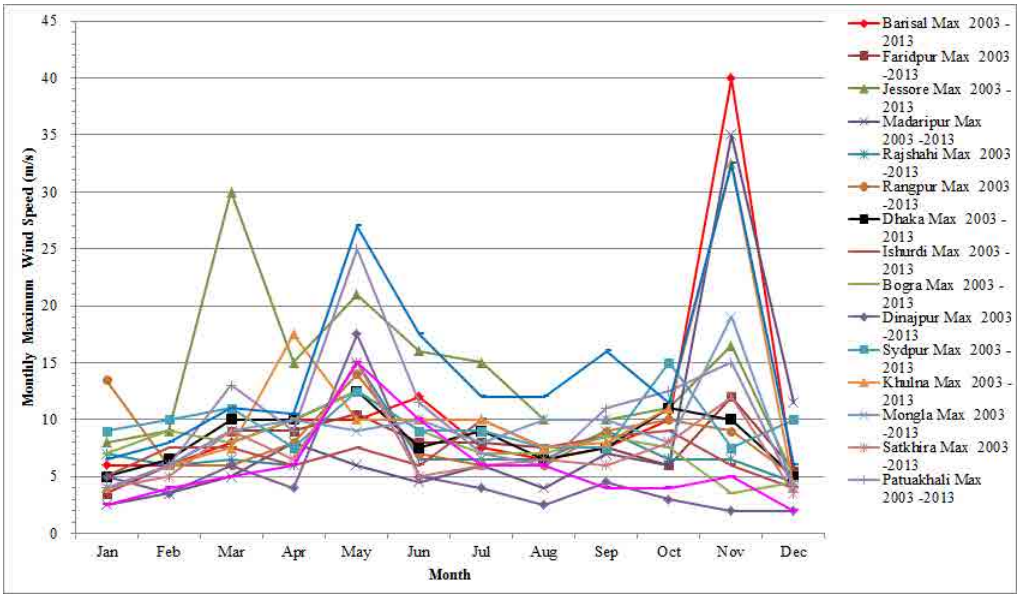
Station	Item	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max	Remarks
Dhaka	Maximum	2003 -2013	5.0	6.5	10.0	10.0	12.5	7.5	9.0	6.5	7.5	11.0	10.0	5.0	12.5	
Faridpur	Maximum	2003 -2013	3.5	6.0	9.0	9.0	10.5	8.0	8.0	7.5	7.5	6.0	12.0	5.5	12.0	
Madaripur	Maximum	2003 -2013	2.5	3.5	5.0	8.0	6.0	4.5	6.0	4.0	7.0	6.0	35.0	11.5	35.0	
Rajshahi	Maximum	2003 -2013	7.0	6.0	6.5	6.0	15.0	6.5	6.5	6.5	9.0	6.5	6.5	4.5	15.0	
Ishurdi	Maximum	2003 -2013	5.0	7.5	7.5	6.0	7.5	6.0	10.0	7.5	8.5	9.0	6.0	4.0	10.0	
Bogra	Maximum	2003 -2013	7.0	9.0	8.0	10.0	12.5	9.0	7.0	7.0	8.5	7.5	3.5	4.5	12.5	
Rangpur	Maximum	2003 -2013	13.5	6.0	6.0	8.0	14.0	7.0	6.0	6.0	9.0	10.0	9.0	5.0	14.0	
Dinajpur	Maximum	2003 -2013	5.0	3.5	6.0	4.0	17.5	5.0	4.0	2.5	4.5	3.0	2.0	2.0	17.5	
Sydpur	Maximum	2003 -2013	9.0	10.0	11.0	7.5	12.5	9.0	9.0	7.5	7.5	15.0	7.5	10.0	15.0	
Khulna	Maximum	2003 -2013	4.0	6.0	7.5	17.5	10.0	10.0	10.0	7.5	8.0	11.0	32.5	4.0	32.5	
Mongla	Maximum	2003 -2013	4.0	6.0	9.0	10.0	9.0	10.0	8.0	10.0	10.0	8.0	19.0	4.0	19.0	
Satkhira	Maximum	2003 -2013	4.0	5.0	9.0	6.5	15.0	5.0	6.0	6.5	6.0	8.0	12.0	3.5	15.0	
Jessore	Maximum	2003 -2013	8.0	9.0	30.0	15.0	21.0	16.0	15.0	10.0	10.0	11.0	16.5	5.0	30.0	
Barisal	Maximum	2003 -2013	6.0	6.0	8.0	10.0	10.0	12.0	7.5	6.5	7.5	10.0	40.0	5.0	40.0	
Patuakhali	Maximum	2003 -2013	4.0	6.0	13.0	9.0	25.0	11.5	7.0	6.0	11.0	12.5	15.0	4.0	25.0	
Khepupara	Maximum	2003 -2013	6.5	8.0	11.0	10.5	27.0	17.5	12.0	12.0	16.0	11.5	32.5	6.0	32.5	
Bhola	Maximum	2003 -2013	2.5	4.0	5.0	6.0	15.0	10.0	6.0	6.0	4.0	4.0	5.0	2.0	15.0	
Bangladesh	Maximum	2003 -2013	13.5	10.0	30.0	17.5	27.0	17.5	15.0	12.0	16.0	15.0	40.0	11.5	40.0	

Source: BMD

Table 4.3.5 Monthly Mean Wind Speed at 18 Stations (in m/s)

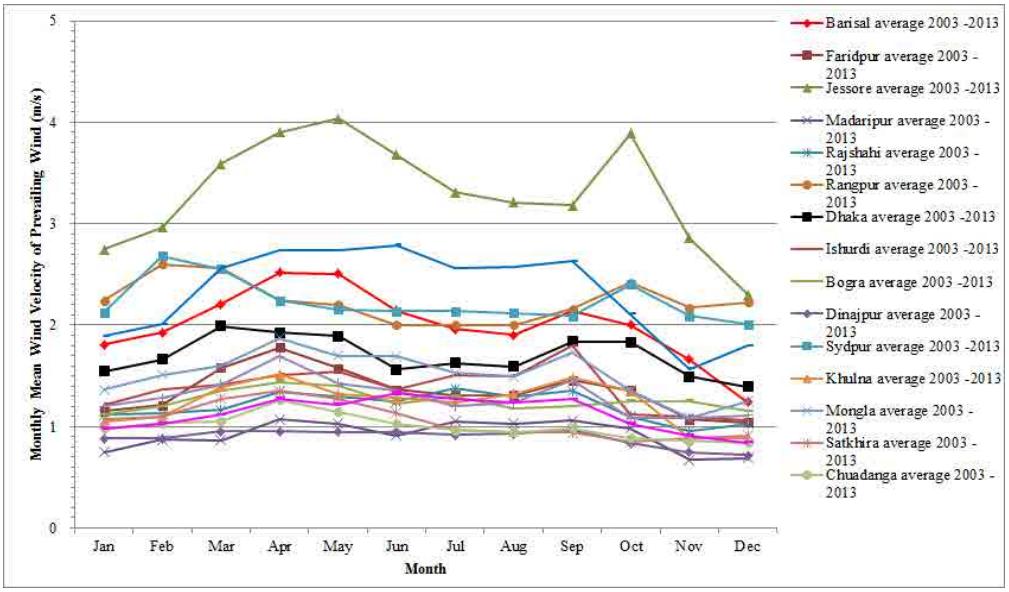
Station	Item	Period of Record		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Remarks
Dhaka	Average	2003	-2013	1.55	1.66	1.99	1.93	1.89	1.56	1.63	1.59	1.84	1.83	1.49	1.39	2.0	
Faridpur	Average	2003	-2013	1.15	1.21	1.58	1.78	1.57	1.36	1.31	1.31	1.46	1.36	1.07	1.04	1.8	
Madaripur	Average	2003	-2013	0.75	0.87	0.86	1.07	1.03	0.91	1.05	1.03	1.06	0.98	0.67	0.69	1.1	
Rajshahi	Average	2003	-2013	1.12	1.13	1.16	1.35	1.29	1.25	1.37	1.29	1.35	1.10	0.95	1.03	1.4	
Ishurdi	Average	2003	-2013	1.22	1.36	1.42	1.51	1.54	1.36	1.51	1.50	1.80	1.12	1.10	1.06	1.8	
Bogra	Average	2003	-2013	1.12	1.20	1.36	1.44	1.40	1.22	1.30	1.18	1.20	1.25	1.25	1.15	1.4	
Rangpur	Average	2003	-2013	2.24	2.60	2.56	2.24	2.20	2.00	2.00	2.00	2.16	2.42	2.18	2.23	2.6	
Dinajpur	Average	2003	-2013	0.88	0.88	0.95	0.95	0.95	0.95	0.92	0.93	0.97	0.84	0.75	0.72	1.0	
Sydpur	Average	2003	-2013	2.13	2.68	2.55	2.25	2.15	2.14	2.14	2.12	2.09	2.40	2.09	2.01	2.7	
Khulna	Average	2003	-2013	1.05	1.10	1.39	1.52	1.32	1.28	1.24	1.32	1.48	1.35	0.89	0.88	1.5	
Mongla	Average	2003	-2013	1.36	1.51	1.60	1.87	1.70	1.69	1.53	1.49	1.73	1.36	1.09	1.25	1.9	
Satkhira	Average	2003	-2013	1.07	1.09	1.27	1.35	1.27	1.14	0.97	0.95	0.94	0.85	0.88	0.91	1.4	
Jessore	Average	2003	-2013	2.75	2.96	3.59	3.90	4.04	3.68	3.31	3.21	3.18	3.89	2.86	2.30	4.0	
Chuadanga	Average	2003	-2013	0.98	1.04	1.05	1.26	1.15	1.03	0.96	0.95	0.98	0.89	0.86	0.84	1.3	
Barisal	Average	2003	-2013	1.81	1.93	2.21	2.52	2.51	2.15	1.96	1.90	2.14	2.00	1.66	1.24	2.5	
Patuakhali	Average	2003	-2013	1.20	1.28	1.42	1.69	1.43	1.35	1.20	1.24	1.46	1.08	1.09	1.11	1.7	
Khepupara	Average	2003	-2013	1.89	2.01	2.56	2.74	2.74	2.79	2.56	2.57	2.63	2.11	1.57	1.80	2.8	
Bhola	Average	2003	-2013	0.98	1.03	1.12	1.27	1.22	1.34	1.27	1.24	1.27	1.03	0.91	0.84	1.3	
Bangladesh	Average	2003	-2013	1.40	1.53	1.70	1.81	1.74	1.62	1.57	1.54	1.65	1.55	1.30	1.25	1.8	

Source: BMD



Source: BMD

Figure 4.3.7 Monthly Maximum Wind Speed at 17 Stations



Source: BMD

Figure 4.3.8 Monthly Mean Wind Speed at 18 Stations

4) Sunshine Hours

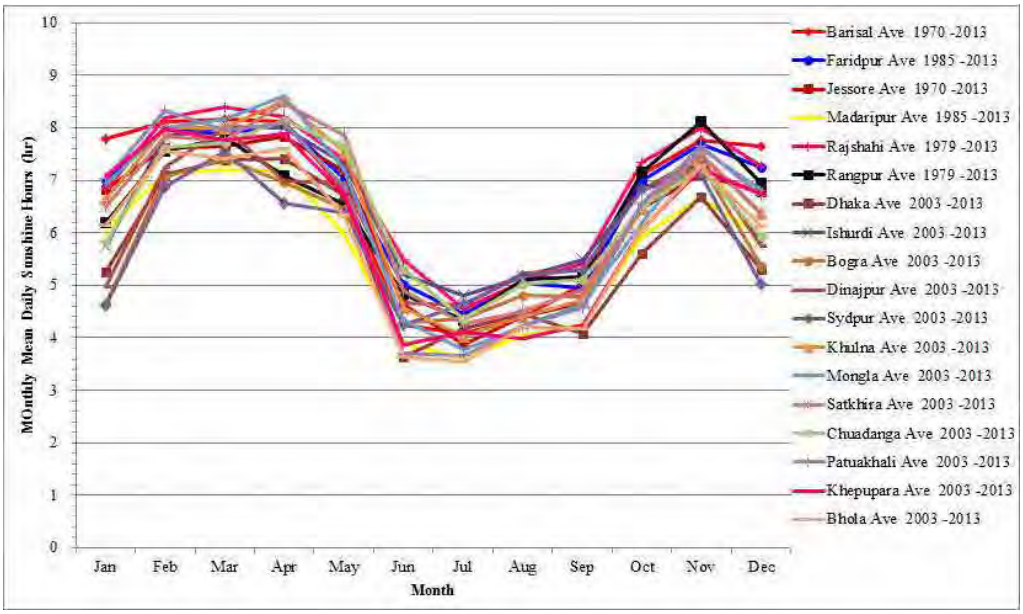
The monthly mean sunshine hours at 18 stations is shown in Figure 4.3.9 and Table 4.3.6.

The sunshine-hours have two opposing seasonal patterns, coinciding with the winter monsoon and the summer monsoon. With the progression of the rainy season, the cloud-cover increases, and the sunshine hours decrease.

Table 4.3.6 Monthly Mean Sunshine Hours at 18 Stations

Station	Item	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average	Remarks
Barisal	Average	1970 -2013	7.8	8.1	8.2	8.1	6.8	4.2	4.1	4.4	5.0	7.1	7.8	7.7	6.6	Gap 1978
Faridpur	Average	1985 -2013	7.0	8.0	7.9	8.1	7.0	5.0	4.5	5.0	5.0	7.0	7.7	7.2	6.6	
Jessore	Average	1970 -2013	6.8	7.6	7.6	7.8	7.2	4.7	3.9	4.4	4.7	6.5	7.1	6.8	6.3	Gap 1971
Madaripur	Average	1985 -2013	6.1	7.1	7.2	7.2	6.0	3.9	3.6	4.0	4.3	5.9	6.7	5.9	5.7	Gap 1985-1986_1989
Rajshahi	Average	1979 -2013	6.8	8.2	8.4	8.2	7.4	5.5	4.6	5.1	5.4	7.3	8.0	7.3	6.8	Gap 1980_2007
Rangpur	Average	1979 -2013	6.2	7.5	7.8	7.1	6.5	4.8	4.3	5.1	5.2	7.2	8.1	6.9	6.4	
Dhaka	Average	2003 -2013	5.3	7.1	7.4	7.4	6.7	3.6	4.2	4.5	4.1	5.6	6.7	5.3	5.7	
Ishurdi	Average	2003 -2013	5.7	7.8	8.0	8.0	7.3	5.2	4.8	5.2	5.5	6.8	7.3	5.8	6.5	
Bogra	Average	2003 -2013	4.6	7.1	7.4	7.0	6.5	4.3	4.4	4.8	4.8	6.5	7.3	5.4	5.8	
Dinajpur	Average	2003 -2013	5.0	7.2	8.0	7.0	6.9	4.7	4.6	5.2	5.3	6.8	7.4	5.8	6.2	
Sydpur	Average	2003 -2013	4.6	6.9	7.6	6.6	6.4	4.3	4.7	5.2	5.3	6.8	7.1	5.0	5.9	
Khulna	Average	2003 -2013	6.6	8.0	8.0	8.5	7.5	4.6	4.0	4.4	4.7	6.5	7.5	6.4	6.4	
Mongla	Average	2003 -2013	6.9	8.0	8.2	8.6	7.2	4.3	3.8	4.2	4.6	6.2	7.6	6.8	6.4	
Satkhira	Average	2003 -2013	6.5	7.8	7.8	8.5	7.8	4.9	4.3	4.5	4.9	6.5	7.5	6.4	6.4	
Chuadanga	Average	2003 -2013	5.8	7.6	7.7	8.1	7.6	5.3	4.4	5.0	5.1	6.5	7.2	5.9	6.4	
Patuakhali	Average	2003 -2013	7.0	8.3	8.0	8.1	6.9	3.7	3.7	4.2	4.6	6.6	7.6	6.7	6.3	
Khepupara	Average	2003 -2013	7.1	8.0	7.8	7.9	6.7	3.9	4.1	4.0	4.2	6.1	7.2	6.7	6.1	
Bhola	Average	2003 -2013	6.1	7.6	7.4	7.6	6.3	3.6	3.6	4.2	4.2	6.1	7.3	6.1	5.8	
Bangaldesh	Average		6.2	7.7	7.8	7.8	6.9	4.5	4.2	4.6	4.8	6.6	7.4	6.3	6.2	

Source: JICA Survey Team, BMD



Source: JICA Survey Team, BMD

Figure 4.3.9 Monthly Mean Sunshine Hours at 18 Stations

(2) Rainfall

1) Monthly and Annual Mean Rainfall

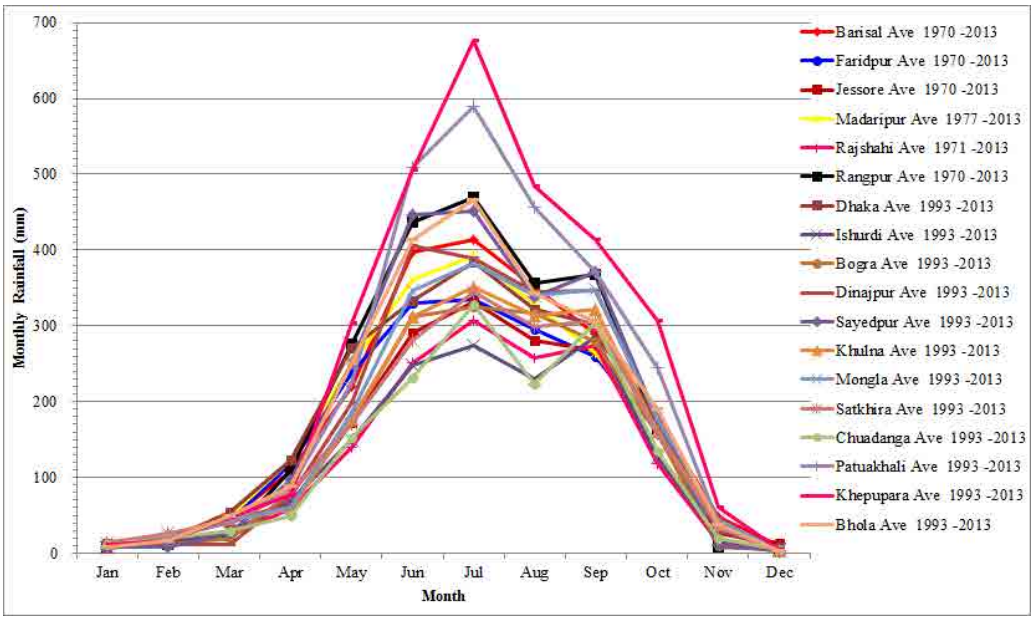
The monthly mean rainfall at 18 stations is shown in Figure 4.3.10 Figure 4.3.11 and Table 4.3.7.

Bangladesh is in the tropical monsoon region, the amount of rainfall is very high. And, there is a distinct seasonal pattern in the annual cycle of rainfall, which is much more pronounced than the annual cycle of temperature. The winter season accounts for only 2%-4% of the total annual rainfall. Rainfall during the rainy season is caused by the tropical depressions that enter the country from the Bay of Bengal. For example, the amount of rainfall in July 2013 covers a wide range, varying from 101mm in mid-western Rajshahi to over 1000mm in southeastern Cox's Bazar, as shown in Figure 4.3.11. Geographic distribution of annual mean rainfall in Western Bangladesh shows a variation from 1456mm in mid-western Ishwardi to 2910mm in southern Khepupara.

Table 4.3.7 Monthly Mean Rainfall at 18 Stations

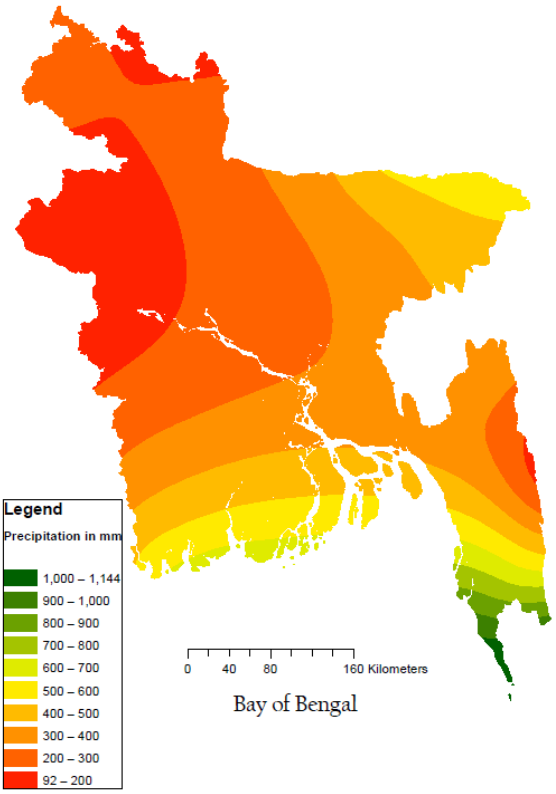
Station	Item	Period of Record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	Remarks
Barisal	Average	1970 -2013	8	22	45	108	220	398	415	351	289	178	48	11	2085	
Faridpur	Average	1970 -2013	7	25	43	117	237	329	335	296	260	161	33	11	1854	
Jessore	Average	1970 -2013	13	22	42	66	173	291	332	281	267	132	27	13	1654	
Madaripur	Average	1977 -2013	8	22	49	124	249	361	392	328	264	161	34	4	1981	
Rajshahi	Average	1971 -2013	9	14	23	58	139	251	308	258	274	119	15	9	1473	
Rangpur	Average	1970 -2013	8	11	23	110	275	437	470	356	367	164	8	7	2237	
Dhaka	Average	1993 -2013	7	19	54	122	271	333	384	322	301	175	28	8	2024	
Ishurdi	Average	1993 -2013	7	15	28	69	150	247	274	230	286	126	18	5	1456	
Bogra	Average	1993 -2013	9	12	20	79	175	313	325	317	279	158	10	3	1700	
Dinajpur	Average	1993 -2013	9	11	12	76	198	405	388	345	346	178	9	4	1980	
Sayedpur	Average	1993 -2013	9	8	26	97	252	447	451	338	371	176	11	4	2189	
Khulna	Average	1993 -2013	15	24	46	57	177	312	352	314	321	161	38	3	1821	
Mongla	Average	1993 -2013	10	20	43	60	186	346	382	341	349	177	44	3	1960	
Satkhira	Average	1993 -2013	14	26	40	80	170	281	344	299	306	158	35	4	1757	
Chuadanga	Average	1993 -2013	12	19	29	49	152	232	328	223	304	134	20	5	1507	
Patuakhali	Average	1993 -2013	8	20	43	87	224	509	589	457	371	244	39	1	2593	
Khepupara	Average	1993 -2013	11	16	47	77	303	506	677	485	414	307	62	5	2910	
Bhola	Average	1993 -2013	8	16	49	88	251	414	466	343	306	191	38	4	2173	
Bangaldesh	Average		9	18	37	85	211	356	401	327	315	172	29	6	1964	

Source: JICA Survey Team, BMD



Source: JICA Survey Team, BMD

Figure 4.3.10 Monthly Mean Rainfall at 18 Stations



Source: BMD

Figure 4.3.11 Monthly Rainfall Contour Map at July, 2013

2) Long-term Fluctuation of Annual Rainfall

The long-term fluctuation of annual rainfall at 6 stations is shown in Figure 4.3.12 (with corresponding data in Table 4.3.8).

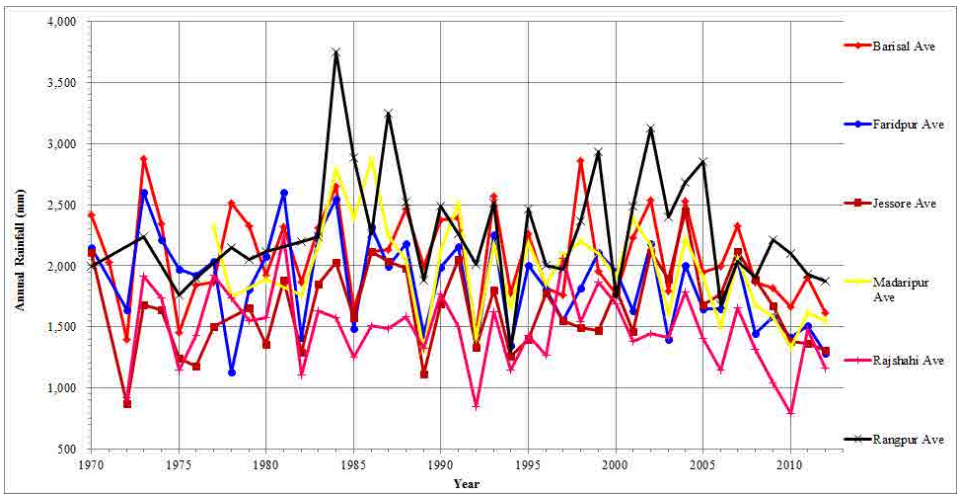
Each station has undergone significant rainfall fluctuation, with fluctuations ranging from 1500mm to 2400mm. However, as an example, Figure 4.3.13 Annual Rainfall and 5 Year Running Mean Rainfall at Jessore and Rangpur (1970-2013) shows the long-term fluctuation of annual rainfall using a 5-year "running mean" (moving average) at Jessore and Rangpur. Although the cycle of wet and droughty periods is not clear, periods of high rainfall and drought can be recognized with this figure. (However, in this figure, the rising trend of annual rainfall in recent years cannot be observed.)

Table 4.3.8 Long-term Fluctuation of Annual Rainfall at 6 Stations

Station	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Barisal	2413	2025	1396	2877	2346	1450	1845	1862	2516	2325	1919	2322	1868	2312	2649	1645	2119	2129	2464	1994	2378	2392	1439	2566	1777
Faridpur	2152	****	1642	2599	2211	1969	1924	2039	1130	1809	2072	2599	1410	2251	2544	1482	2319	1993	2183	1438	1985	2156	1336	2256	1344
Jessore	2108	****	870	1678	1640	1243	1179	1500	****	1651	1358	1879	1295	1848	2031	1576	2118	2039	1976	1117	1686	2052	1333	1802	1260
Madaripur	-	-	-	-	-	-	-	2321	1748	****	1892	****	1758	2164	2790	2390	2865	2246	2041	1304	2127	2511	1407	2184	1663
Rajshahi	-	****	921	1914	1736	1144	1427	1918	1734	1548	1576	2241	1103	1629	1575	1252	1510	1487	1584	1325	1767	1498	843	1623	1142
Rangpur	1997	****	****	2237	****	1763	1895	****	2145	2048	2120	****	2201	2238	3748	2882	2264	3247	2524	1878	2487	2263	2007	2510	1301

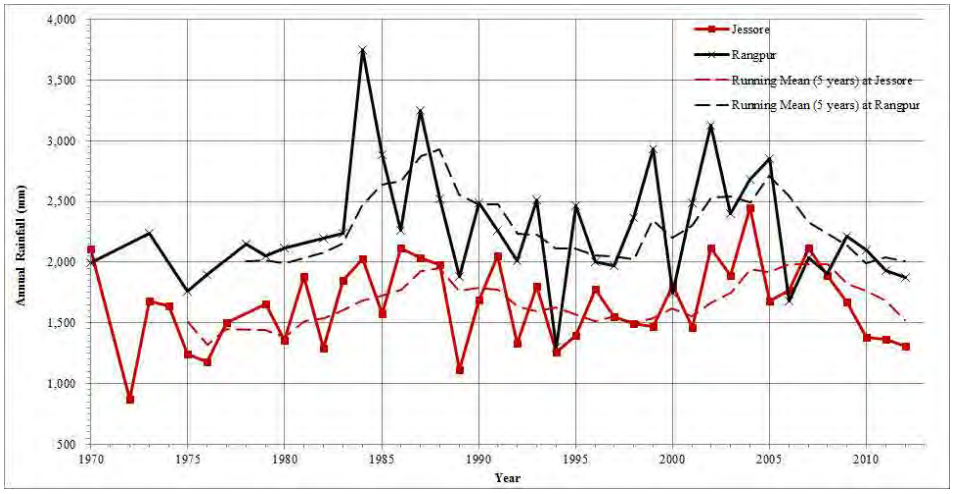
Station	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Remarks
Barisal	2258	1819	1758	2858	1955	1770	2228	2537	1795	2529	1943	1998	2328	1864	1820	1662	1909	1617	****	Gap 2013
Faridpur	2006	1810	1548	1818	2105	1952	1634	2179	1400	2001	1650	1649	2040	1443	1584	1409	1509	1279	****	Gap 1971_2013
Jessore	1397	1775	1553	1490	1467	1811	1457	2120	1892	2444	1678	1769	2119	1888	1668	1380	1361	1305	****	Gap 1971_1978_2013
Madaripur	2189	1847	2087	2200	2099	1917	2379	2165	1608	2221	1905	1503	2061	1679	1580	1330	1613	1546	****	Gap 1979_1981_2013
Rajshahi	1432	1269	2062	1540	1862	1690	1382	1445	1412	1786	1405	1145	1658	1315	1043	792	1475	1164	****	Gap 1971_2013
Rangpur	2461	2004	1971	2365	2931	1745	2492	3127	2402	2680	2853	1682	2037	1907	2217	2102	1932	1877	****	Gap 1971-1972_1974_1977_1981_2013

Source: JICA Survey Team, BMD



Source: JICA Survey Team, BMD

Figure 4.3.12 Long-term Fluctuation of Annual Rainfall at 6 Stations



Source: JICA Survey Team

Figure 4.3.13 Annual Rainfall and 5 Year Running Mean Rainfall at Jessore and Rangpur (1970-2013)

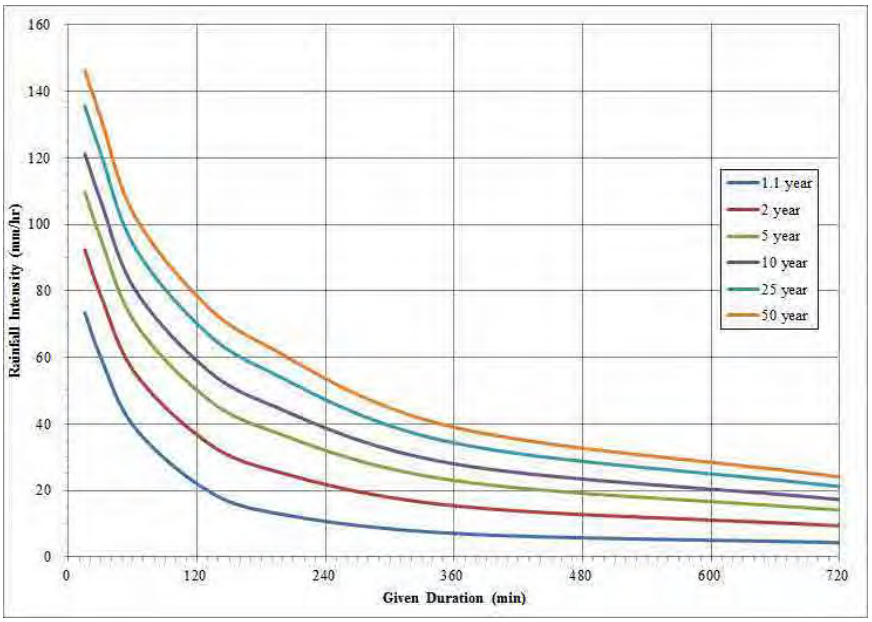
3) Exceedance Probability and Intensity Curve of Rainfall

The exceedance probability and the intensity curve for rainfall in Dhaka are indicated in the "Urban Drainage Manual" published by the Local Government Engineering Department in 1998, as shown in Figure 4.3.14 (with corresponding data in Table 4.3.9) and. The design rainfall intensity can be calculated by multiplying Dhaka's value by conversion factors each district, as shown in Table 4.3.10.

Table 4.3.9 Rainfall-Intensity each Return Period at Dhaka

Return Period (years)	Rainfall Intensity (mm/hr) in given duration							Remarks
	15minutes	30minutes	60minutes	120minutes	180minutes	360minutes	720minutes	
	0.25 hours	0.50 hours	1 hours	2 hours	3 hours	6 hours	12 hours	
1.1	73.5	59.9	39.6	22.0	14.0	7.1	4.3	
2	92.4	78.6	56.2	36.7	27.0	15.4	9.4	
5	109.7	95.7	71.4	50.1	39.0	23.0	14.1	
10	121.3	107.0	81.4	58.9	46.9	28.0	17.3	
25	135.6	121.3	94.1	70.1	56.9	34.3	21.2	
50	146.3	132.0	103.5	78.4	64.3	39.0	24.1	

Source: Urban Drainage Manual (1998), Local Government Engineering Department



Source: Urban Drainage Manual (1998), Local Government Engineering Department

Figure 4.3.14 Rainfall Intensity Curve at Dhaka

Table 4.3.10 Rainfall Intensity Formula in Dhaka

Return Period (years)	a	b	c
1.1	72	1.29	0.81
2	110.6	1.02	0.95
5	153.8	0.95	1.12
10	186.8	0.93	1.25

$$i = \frac{a}{T^b + c} * m$$

i: Rainfall Intensity (mm/hr)
T: Given Duration (hr)
a, b, c: Constants
m: Conversion Factor each District (0.84~1.79)

Source: Urban Drainage Manual (1998), Local Government Engineering Department

4.3.3 Hydrological Condition

(1) Data Collection

The Bangladesh Water Development Board (BWDB) manages gauge station records for large rivers in Bangladesh.

For studying hydrological conditions in the Project area, the observed data of 86 stations for annual highest/lowest water level and 6 stations for annual maximum/minimum discharge was collected.

(2) Estimation of Probable Water Levels

1) Design High Flood Level (HFL)

There are two different methods for the estimation of Design High Water Level (High Flood Level, HFL) generally. They are (a) Log-Pearson's Type-3, and (b) Gumbel's Extreme Value Type-1 distribution method. The calculations for this DHWL will be done using method (b) which is most commonly practiced in Bangladesh.

The following outlines Gumbel's distribution method.

Computation for Probable Flood Level (Gumebel's Extreme Value Type-1 distribution method)

$$K_T = \frac{\sqrt{6}}{\pi}\left[0.5772 + ln\left\{ln\left(\frac{T}{T-1}\right)\right\}\right]$$

And the Extreme Value within that distribution is given by:

$$X_T = \bar{X} + K_T \times \sigma_{n-1}$$

where $X_T = Extreme\,Value$

$T = return\ period\ in\ years.$

$\bar{X} = Mean = \frac{\sum x_i}{n}$

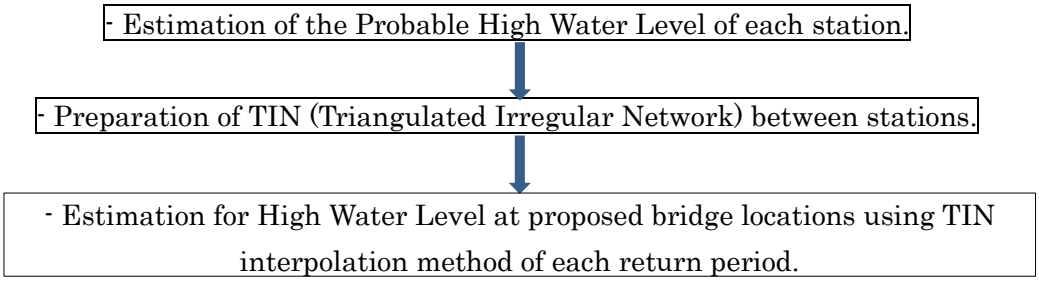
x_i=annual high flood level (HFL)

n=numbers pf years of records available

$\sigma_{n-1} = Standard\ Deviation$

The calculated probable high water levels at 86 gauge stations are shown in Table 4.3.11 and Table 4.3.12. Return periods by Gumbel's distribution are for 1.1, 5, 10, 20, 25, 50 and 100 years. Also, 13 station's results for HFL are added from National Water Management Plan in 1999 .

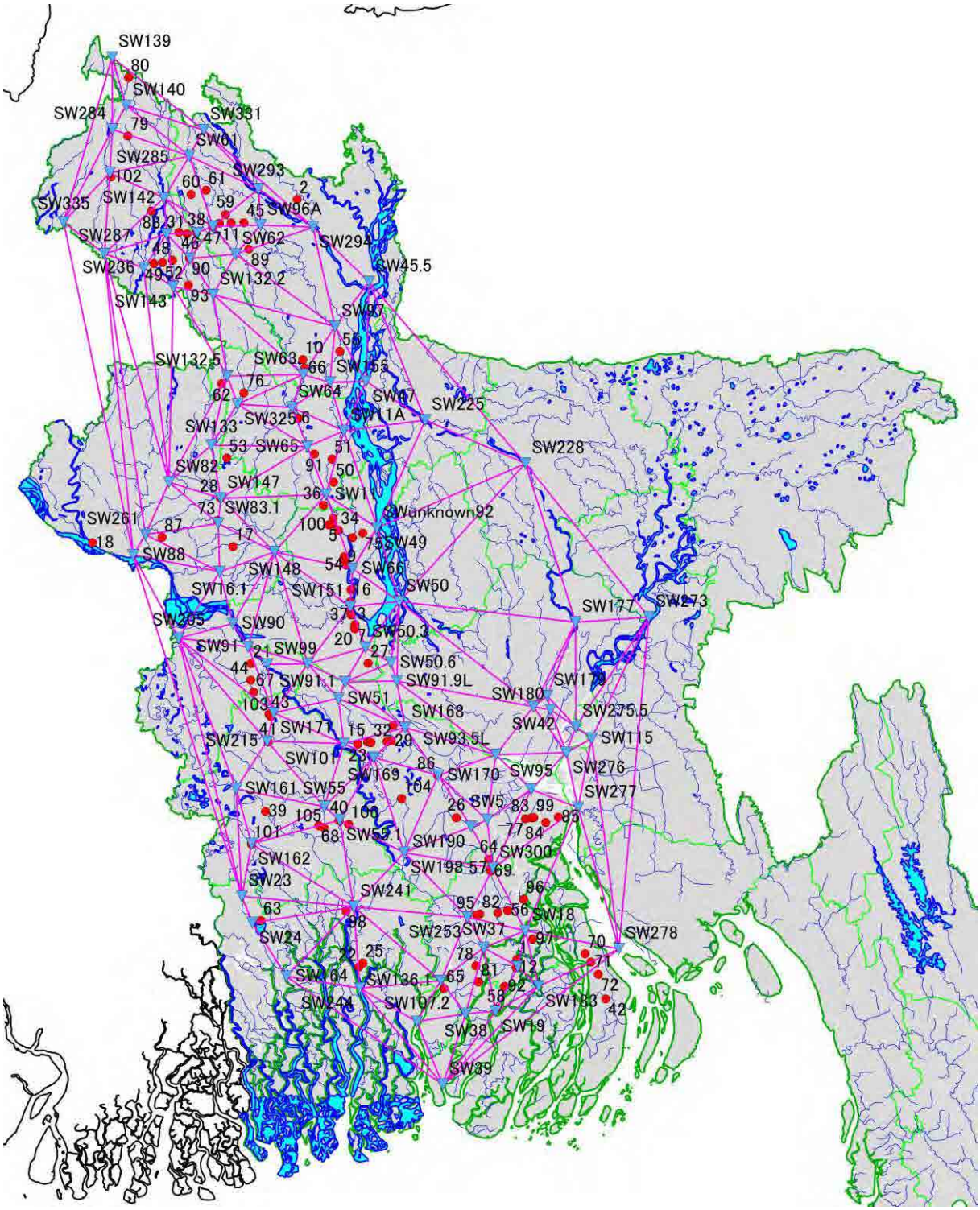
The design high water level at proposed bridge sites is calculated using the following procedure:



After calculation based on above procedure, the calculated probable high water levels of each bridge will be re-examined by checking the historical water level (acquired through interviews), the topographical conditions and the river condition, etc.

The criterion for calculation of the HFL depends on the classification of proposed bridges: a 20-year flood is used for Zilla roads, and a 50-year flood is used for national roads and regional roads (in reference to the RHD standards). The freeboard of each bridge (taken as the clearance with girder) is set to 30cm or more. For steel-girder bridges, a clearance of 3.0m for a 1.1-year flood is taken. Also, special designated clearances against SHWL are ensured if the bridge crosses an official navigable waterway. (Refer to 4.3.4.)

Design high water levels (HFL) are shown for each bridge in Table 4.3.13 and Table 4.3.14.



Source: JICA Survey Team

Figure 4.3.15 Interpolation of HWL by TIN method

Table 4.3.11 Estimation of HWL at each gauging station (1)

River / Station Name, Station No.			Longitude (X)	Latitude (Y)	Row No.	Catchment Area (km²)	Data item	No. in sample	Mean	Std. Deviation σ_{n-1}
<Water Level>										
Arial Khan	Madaripur	SW5	90.213	23.187	289	1,428	Water Level	30	4.491	0.506
Bangali	Khanpur	SW11	89.478	24.620	252	1,100	Water Level	30	13.472	1.292
~~Baral~~	~~Nandangachi~~	~~SW16~~	~~88.883~~	~~24.293~~	~~342~~	~~772~~	~~Water Level~~	~~2~~	~~12.777~~	~~1.288~~
Barisal-Buriswar	Bakerganj	SW18.1	90.342	22.544	29	5577	Water Level	29	2.416	0.335
Barisal-Buriswar	Barisal	SW18	90.380	22.700	39	5577	Water Level	30	2.463	0.204
Barisal-Buriswar	Mirzaganj	SW19	90.233	22.352	311	5577	Water Level	21	2.392	0.356
Betna-Kholpetua	Kalaroa	SW23	89.050	22.872	234	9847	Water Level	29	3.768	0.786
Betna-Kholpetua	Benarpota	SW24	89.098	22.757	48	9847	Water Level	30	3.428	0.422
Bishkhali	Jhalokati	SW37	90.183	22.630	212	26997	Water Level	29	2.298	0.235
Bishkhali	Bamna	SW38	90.093	22.244	31	26997	Water Level	30	2.924	0.294
Bishkhali	Patharghata	SW39	89.978	22.027	384	5577	Water Level	29	3.201	0.423
Buriganga	Dhaka_Mill Barrack	SW42	90.444	23.676	121	253	Water Level	30	5.619	0.713
Burikhora Chilu	Nitbari Road Crossing	SW44.1	88.958	25.798	389	120	Water Level	26	36.709	0.340
Brahmaputra-Jamuna	Sirajganj	SW49	89.721	24.471	445	3,000	Water Level	30	14.031	0.570
Brahmaputra-Jamuna	Mathura	SW50.3	89.654	23.950	303	2,590	Water Level	34	-	-
Brahmaputra-Jamuna	Aricha	SW50.6	89.773	23.831	11	3,000	Water Level	30	9.613	0.650
Chitra	Khatur Magura	SW55	89.445	23.259	264	505	Water Level	30	3.300	0.662
Deonai_Charalkata_Jamuneswari_Karatoa	Boragari	SW61	88.849	26.108	68	750	Water Level	30	51.989	0.645
Deonai_Charalkata_Jamuneswari_Karatoa	Badarganj	SW62	89.065	25.675	21	750	Water Level	29	31.835	0.907
Deonai_Charalkata_Jamuneswari_Karatoa	Chak-Rahimpur	SW63	89.381	25.146	79	1,250	Water Level	30	20.498	0.716
Deonai_Charalkata_Jamuneswari_Karatoa	Bogra	SW65	89.394	24.831	67	750	Water Level	30	15.312	0.885
Deonai_Charalkata_Jamuneswari_Karatoa	[illegible]_Rly_Crossing	SW66	89.599	24.294	466	1,250	Water Level	30	11.774	0.953
Fakirni Bamal	Naldanga_Rly Crossing)	SW83.1	88.983	24.501	338	250	Water Level	27	12.944	0.914
Ganges-Padma	Rajshahi	SW88	88.565	24.368	405	2,279	Water Level	30	18.267	0.756
Ganges-Padma	Talbaria	SW91	89.096	23.961	464	2,279	Water Level	29	12.957	0.638
Ghagot	Gaibandha	SW97	89.537	25.352	147	720	Water Level	30	21.976	1.134
Gorai-Madhumati-Haringhata-Baleswar	Gorai Railway Bridge	SW99	89.186	23.884	172	4,568	Water Level	30	12.439	0.586
Gorai-Madhumati-Haringhata-Baleswar	KamarkhaliTransit	SW101	89.543	23.532	245	4,568	Water Level	26	8.384	0.506
Gorai-Madhumati-Haringhata-Baleswar	Rayenda	SW107.2	89.862	22.313	411	486	Water Level	30	3.348	0.357
Little Jamuna	Phulbari	SW132.2	88.954	25.500	389	270	Water Level	16	29.298	0.946
Little Jamuna	Joypurhat	SW132.5	89.016	25.144	221	3,000	Water Level	29	20.005	1.088
Little Jamuna	Mannathpur	SW132	88.848	25.669	301	3,000	Water Level	29	36.110	0.958
Little Jamuna	Naogaon	SW133	88.935	24.844	346	160	Water Level	30	15.249	0.519
Kocha	Umedpur	SW136.1	89.978	22.490	487	100	Water Level	22	2.589	0.123
Karatoa-Atrai-Gur-Gumani-Hurasagar	Bardeswari	SW139	88.481	26.542	36	1,267	Water Level	29	85.990	1.025
Karatoa-Atrai-Gur-Gumani-Hurasagar	Panchagarh	SW140	88.547	26.330	374	1,267	Water Level	30	70.525	0.610
Karatoa-Atrai-Gur-Gumani-Hurasagar	Bhushirbandar	SW142.1	88.735	25.767	60	654	Water Level	30	39.893	0.578
Karatoa-Atrai-Gur-Gumani-Hurasagar	Khansama	SW142	88.724	25.925	262	1,267	Water Level	29	46.239	1.437
Karatoa-Atrai-Gur-Gumani-Hurasagar	Shambhaghat	SW143	88.763	25.537	435	1,267	Water Level	30	31.314	0.789
Karatoa-Atrai-Gur-Gumani-Hurasagar	Atrai Rly. Bridge	SW147	88.977	24.611	17	2,770	Water Level	30	13.603	0.517
Karatoa-Atrai-Gur-Gumani-Hurasagar	Chanchkair	SW148	89.229	24.373	81	1,250	Water Level	30	11.731	0.674
Karatoa-Atrai-Gur-Gumani-Hurasagar	Baghabari	SW151	89.586	24.129	25	2,770	Water Level	30	11.036	0.787
Katakhal	Mohimaganj Railway Crossi	SW155	89.508	25.109	321	3,200	Water Level	30	18.409	0.821
Kharkhuria	Kundal	SW156A	88.581	25.771	273	265	Water Level	28	39.161	0.726
Kobadak	Tahirpur	SW161	89.030	23.342	458	800	Water Level	28	5.188	1.013
Kobadak	Jhikargacha	SW162	89.099	23.101	214	800	Water Level	29	4.066	0.843
~~Kumar_Faridpur~~	~~Ibrahimdi~~	~~SW167~~	~~89.794~~	~~23.562~~	~~196~~	~~620~~	~~Water Level~~	~~2~~	~~7.888~~	~~0.180~~
Kumar_Faridpur	Faridpur	SW168	89.534	23.597	139	620	Water Level	30	5.619	1.278
Kumar_Faridpur	Mazardia	SW169	89.683	23.469	308	620	Water Level	28	4.351	1.289
Kumar_Faridpur	Bhanga	SW170	89.986	23.396	54	620	Water Level	29	4.538	0.914
Kumar (Jessore)	Garagan	SW171	89.214	23.671	151	950	Water Level	30	6.499	1.220
Madaripur Beel Route	Haridaspur	SW198	89.818	23.062	169		Water Level	27	3.493	0.696
Nabaganga	Jhenaidaha	SW215	89.180	23.548	213	4,000	Water Level	28	6.413	0.829
Rupsa-Pasur	Khulna	SW241	89.576	22.820	267	2,935	Water Level	30	3.222	0.198
Rupsa-Pasur	Mongla	SW244	89.598	22.464	324	425	Water Level	24	2.948	0.396

Station No.	Water Level each Return Period (year) (m, PWD) 1.1	5	10	20	25	50	100	Water Level each Return Period (year) (m, MSL) 1.1	5	10	20	25	50	100
K_T	-1.132	0.719	1.305	1.866	2.044	2.592	3.137	-1.132	0.719	1.305	1.866	2.044	2.592	3.137
SW5	3.919	4.856	5.151	5.435	5.525	5.802	6.077	3.459	4.395	4.691	4.975	5.065	5.342	5.617
SW11	12.009	14.402	15.158	15.883	16.113	16.822	17.526	11.549	13.942	14.698	15.423	15.653	16.362	17.066
~~SW16~~	~~11.317~~	~~13.704~~	~~14.458~~	~~15.182~~	~~15.411~~	~~16.116~~	~~16.820~~	~~10.857~~	~~13.244~~	~~13.998~~	~~14.722~~	~~14.951~~	~~15.656~~	~~16.360~~
SW18.1	2.037	2.657	2.853	3.040	3.100	3.283	3.466	1.577	2.197	2.393	2.580	2.640	2.823	3.006
SW18	2.231	2.610	2.729	2.844	2.880	2.993	3.104	1.771	2.150	2.269	2.384	2.420	2.533	2.644
SW19	2.490	3.149	3.356	3.556	3.619	3.814	4.008	2.030	2.688	2.896	3.096	3.159	3.354	3.548
SW23	2.900	4.353	4.812	5.252	5.392	5.822	6.250	2.440	3.893	4.352	4.792	4.932	5.362	5.790
SW24	2.939	3.731	3.981	4.221	4.297	4.532	4.764	2.479	3.271	3.521	3.761	3.837	4.072	4.304
SW37	2.032	2.467	2.604	2.736	2.778	2.906	3.034	1.572	2.007	2.144	2.276	2.318	2.446	2.574
SW38	2.591	3.135	3.307	3.471	3.524	3.685	3.845	2.131	2.675	2.847	3.011	3.064	3.225	3.385
SW39	2.722	3.506	3.754	3.992	4.067	4.299	4.530	2.262	3.046	3.294	3.532	3.607	3.839	4.070
SW42	4.812	6.132	6.549	6.948	7.076	7.467	7.856	4.352	5.672	6.089	6.489	6.616	7.007	7.395
SW44.1	35.819	37.374	37.865	38.338	38.486	38.946	39.403	35.359	36.914	37.405	37.878	38.026	38.486	38.943
SW49	13.386	14.441	14.774	15.094	15.195	15.508	15.818	12.926	13.981	14.314	14.634	14.735	15.048	15.358
SW50.3	-	10.614	10.932	-	11.330	11.623	11.911	-	10.154	10.472	-	10.870	11.163	11.451
SW50.6	8.990	10.008	10.330	10.639	10.737	11.039	11.339	8.530	9.548	9.870	10.179	10.277	10.579	10.879
SW55	2.551	3.775	4.162	4.534	4.652	5.014	5.374	2.091	3.315	3.702	4.074	4.192	4.554	4.914
SW61	51.259	52.453	52.830	53.192	53.307	53.660	54.011	50.799	51.993	52.370	52.732	52.847	53.200	53.551
SW62	30.809	32.488	33.018	33.527	33.689	34.186	34.680	30.349	32.028	32.558	33.067	33.229	33.726	34.220
SW63	19.689	21.012	21.430	21.832	21.959	22.351	22.740	19.229	20.552	20.970	21.372	21.499	21.891	22.280
SW65	14.310	15.949	16.467	16.964	17.122	17.607	18.089	13.850	15.489	16.007	16.504	16.662	17.147	17.629
SW66	10.695	12.460	13.019	13.553	13.723	14.246	14.766	10.235	12.000	12.559	13.093	13.264	13.786	14.305
SW83.1	11.910	13.602	14.137	14.650	14.812	15.314	15.811	11.450	13.142	13.677	14.190	14.352	14.854	15.351
SW88	17.412	18.811	19.253	19.677	19.812	20.227	20.638	16.952	18.351	18.793	19.217	19.352	19.767	20.178
SW91	12.236	13.416	13.789	14.147	14.261	14.610	14.958	11.776	12.956	13.329	13.687	13.801	14.150	14.498
SW97	20.691	22.791	23.454	24.091	24.292	24.914	25.532	20.231	22.331	22.994	23.631	23.832	24.454	25.072
SW99	11.775	12.861	13.204	13.533	13.637	13.959	14.278	11.315	12.401	12.744	13.073	13.177	13.499	13.818
SW101	7.812	8.748	9.044	9.327	9.417	9.695	9.970	7.352	8.288	8.584	8.867	8.957	9.235	9.510
SW107.2	2.939	3.600	3.809	4.010	4.073	4.269	4.463	2.479	3.140	3.349	3.550	3.613	3.809	4.003
SW132.2	28.222	29.973	30.526	31.057	31.225	31.744	32.259	27.762	29.513	30.066	30.597	30.765	31.284	31.799
SW132.5	18.777	20.791	21.427	22.038	22.232	22.828	23.420	18.317	20.331	20.967	21.578	21.772	22.368	22.960
SW132	35.025	36.799	37.368	37.898	38.068	38.594	39.116	34.565	36.339	36.908	37.438	37.608	38.134	38.656
SW133	14.663	15.622	15.925	16.215	16.308	16.592	16.873	14.203	15.162	15.465	15.755	15.848	16.132	16.413
SW136.1	2.450	2.678	2.750	2.819	2.841	2.908	2.975	1.990	2.218	2.290	2.359	2.381	2.448	2.515
SW139	84.830	86.727	87.326	87.902	88.084	88.646	89.204	84.370	86.267	86.866	87.442	87.624	88.186	88.744
SW140	69.835	70.964	71.321	71.663	71.771	72.106	72.438	69.375	70.504	70.861	71.203	71.311	71.646	71.978
SW142.1	39.238	40.309	40.647	40.972	41.075	41.392	41.707	38.778	39.849	40.187	40.512	40.615	40.932	41.247
SW142	44.612	46.273	47.113	47.920	48.176	48.964	49.746	44.152	45.813	46.653	47.460	47.716	48.504	49.286
SW143	30.421	31.882	32.343	32.786	32.927	33.359	33.789	29.961	31.422	31.883	32.326	32.467	32.899	33.329
SW147	13.016	13.975	14.277	14.567	14.659	14.942	15.224	12.556	13.515	13.817	14.107	14.199	14.482	14.764
SW148	10.968	12.216	12.611	12.989	13.109	13.479	13.846	10.508	11.756	12.151	12.529	12.649	13.019	13.386
SW151	10.146	11.604	12.065	12.507	12.647	13.079	13.507	9.686	11.144	11.605	12.047	12.187	12.619	13.047
SW155	17.706	18.856	19.220	19.569	19.679	20.020	20.359	17.246	18.396	18.760	19.109	19.219	19.560	19.899
SW156A	38.340	39.693	40.108	40.515	40.644	41.042	41.437	37.880	39.223	39.648	40.055	40.184	40.582	40.977
SW161	4.042	5.917	6.509	7.078	7.258	7.814	8.365	3.582	5.457	6.049	6.618	6.798	7.354	7.905
SW162	3.111	4.673	5.166	5.640	5.790	6.252	6.712	2.651	4.213	4.706	5.180	5.330	5.792	6.252
~~SW167~~	~~7.683~~	~~8.017~~	~~8.123~~	~~8.224~~	~~8.256~~	~~8.355~~	~~8.453~~	~~7.223~~	~~7.557~~	~~7.663~~	~~7.764~~	~~7.796~~	~~7.896~~	~~7.993~~
SW168	4.175	6.537	7.283	7.999	8.226	8.926	9.620	3.715	6.077	6.823	7.539	7.766	8.466	9.160
SW169	2.892	5.279	6.033	6.756	6.986	7.693	8.394	2.432	4.819	5.573	6.296	6.526	7.233	7.934
SW170	3.717	5.224	5.700	6.157	6.302	6.749	7.192	3.257	4.764	5.240	5.697	5.842	6.289	6.732
SW171	5.116	7.376	8.090	8.774	8.991	9.660	10.324	4.656	6.916	7.630	8.314	8.531	9.200	9.864
SW198	2.706	3.994	4.401	4.792	4.916	5.298	5.677	2.246	3.534	3.941	4.332	4.456	4.838	5.217
SW215	5.475	7.009	7.494	7.959	8.107	8.562	9.013	5.015	6.549	7.034	7.499	7.647	8.102	8.553
SW241	3.001	3.362	3.477	3.588	3.621	3.728	3.835	2.541	2.902	3.017	3.126	3.161	3.268	3.375
SW244	2.499	3.233	3.465	3.688	3.758	3.976	4.191	2.039	2.773	3.005	3.228	3.298	3.516	3.731

Station No.	Records of Annual High Flood Level 1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Remarks
SW5			4.15	4.41	4.28	4.04	5.17	5.60	4.20	4.50	4.68	3.75	4.57	4.25	4.83	4.95	4.50	5.80	5.04	4.35	4.14	4.45	4.68	5.03	4.20	3.90	4.23	4.80	4.00	4.45	4.39	3.60	
SW11			15.39	15.14	13.57	14.35	14.87	15.94	13.26	14.35	14.67	12.72	13.62	11.10	15.00	14.30	12.35	14.29	14.67	12.71	12.68	14.17	13.80	13.88	14.97	11.20	10.80	12.65	12.94	11.96	12.65	12.57	
~~SW16~~			~~11.87~~	~~13.69~~																													Deselection
SW18.1			2.10	2.45	2.36	2.99	2.33	2.82	2.72	2.37	2.22	2.29	2.22	2.58	2.56	2.58	2.52	2.80	2.52	2.40	2.55	3.40	2.87	2.33	1.44			2.32	2.27	2.61	1.80	2.31	
SW18			2.51	2.55	2.64	2.65	2.62	2.66	2.57	2.07	2.45	2.50	2.64	2.45	2.66	2.59	2.30	2.62	2.23	2.19	2.42	2.00	2.30	2.52	2.51	2.15	1.99	2.81	2.80	2.31	2.50	2.47	
SW19										3.05	2.43	2.49	2.78	2.80	3.23	3.22	2.75	2.65	2.64	2.78	2.85	2.85	2.79	2.92	2.83	4.06	2.82	2.90	3.37	2.56			
SW23			3.04	3.69	2.01	4.23	3.61	3.43	2.93	3.23	3.15	4.99	3.42	3.00	3.65	4.49	4.06	4.39	4.22	2.38	3.88	4.29	4.83	5.64	4.97		4.30	4.07	3.86	3.08	3.87	2.45	
SW24			3.05	3.10	2.92	2.93	3.08	3.12	3.07	3.12	2.67	3.76	3.26	3.21	3.20	3.05	3.43	3.38	3.53	3.38	3.34	3.33	3.15	3.72	4.97	3.87	3.27	3.42	3.97	3.42	4.00	4.03	
SW37			2.06	2.32	2.30	2.18	2.14	2.19	2.28	2.59	2.14	2.34	2.13	2.01	1.68	2.43	2.16	2.62	2.40	2.33	2.56	2.37	2.38	2.44	1.96		2.46	2.70	2.31	2.62	2.42	2.34	
SW38			2.85	3.04	3.32	3.15	3.10	3.15	2.75	2.80	2.64	2.95	3.02	2.68	2.80	2.37	2.31	2.75	2.60	2.85	2.95	2.83	2.78	2.98	2.83	2.99	3.16	3.25	3.40	3.65	3.15	2.55	
SW39			2.43	3.50	3.00	2.70	2.56	2.55	3.00	3.10	2.75	3.10	2.88	2.78	3.45	3.19	3.06	3.09	3.03	3.23	3.30	3.16	3.40	3.43	3.73		3.65	3.27	4.15	3.85	3.68	3.06	
SW42			5.77	6.04	5.41	5.00	5.84	7.58	5.10	5.38	5.64	4.39	5.82	5.03	6.10	5.10	5.39	7.24	5.81	5.75	5.10	5.82	5.87	6.58	5.36	4.65	5.01	5.73	5.10	5.16	5.16	4.95	
SW44.1			36.54	37.26	37.36	36.48	37.41	37.85	36.67	35.98	37.63	36.04	35.44	34.18	37.59	37.08	36.94	37.60	37.20	36.61	37.30	37.10	36.43	36.74	37.05	35.40	36.50	36.10	37.30	36.97			
SW49			14.19	14.52	14.14	13.66	14.57	15.11	13.66	13.97	14.37	13.25	13.76	13.05	14.69	14.01	13.58	14.76	14.10	14.04	13.44	14.38	14.34	14.81	13.31	12.94	14.95	14.33	13.68	13.83	13.42	13.98	
SW50.3		(from National Water Mangement Plan 1999)																															
SW50.6			9.62	9.48	8.97	9.03	10.13	10.57	8.72	9.27	9.65	8.50	9.18	9.11	9.71	9.78	9.20	10.76	9.82	9.75	9.57	10.20	10.08	10.31	9.72	9.20	10.67	9.82	9.26	9.60	9.60	9.22	
SW55			3.04	3.77	3.13	4.36	4.72	3.74	3.31	3.44	3.15	3.03	3.51	3.23	1.83	2.41	3.65	3.52	3.73	3.70	3.34	2.00	3.30	4.32	4.22	2.67	2.36	3.33	2.89	2.95	2.89	2.49	
SW61			51.48	52.25	51.85	52.10	52.47	52.24	51.78	51.92	53.00	51.96	51.67	50.99	52.51	52.53	51.97	52.84	52.47	52.37	51.96	51.75	50.65	50.95	53.13	51.98	52.32	51.82	51.70	52.52	52.16	50.38	
SW62			31.71	32.01	32.41	31.29	32.75	32.86	31.26	30.87	32.61	31.01	30.93	29.32	32.75	31.94	32.33	33.12	32.27	30.93	32.33		31.64	31.84	33.29	30.51	31.51	31.33		31.81	31.83	32.65	
SW63			20.99	21.19	20.74	20.23	20.83	20.82	20.28	20.48	21.16	20.47	20.23	17.97	21.38	20.42	20.76	20.88	21.39	19.72	20.68	21.34	20.88	20.33	21.11	19.01	20.73	20.33	20.54	19.67	20.07	20.33	
SW65			15.49	15.76	15.32	16.19	17.98	17.02	14.27	15.16	16.29	14.91	15.05	13.66	16.49	14.83	14.27	15.57	15.53	14.78	14.59	15.56	14.71	15.85	15.82	16.48	15.70	14.95	15.10	13.99	15.20	13.68	
SW66			10.87	12.12	10.56	10.96	12.18	13.17	10.71	11.88	11.91	9.87	11.13	10.24	12.02	11.42	10.80	12.42	11.39	11.12	10.76	11.79	12.48	13.07	12.41	11.19	13.66	12.56	12.06	12.51	12.65	13.20	
SW83.1			14.08	13.56	13.80	13.84	13.90	13.73	13.20	13.11	13.80	12.17	12.64	11.25	13.92	13.07	13.32	13.68			13.12	12.63		13.23	13.64	10.26	11.51	12.54	12.77	12.11	13.12	12.02	
SW88			19.22	19.14	18.61	18.48	19.46	19.00	17.20	18.02	19.16	17.53	17.97	18.66	18.55	18.86	17.59	19.58	19.18	18.60	18.01	17.49	18.85	17.48	18.06	17.10	17.80	17.95	16.85	17.20	18.19	17.89	
SW91			13.88	13.84	13.16	13.15	13.72	14.09	12.36	12.89		12.45	12.50	13.39	12.58	13.77	12.42	14.53	13.37	12.67	12.66	12.61	13.46	12.95	12.41	12.56	12.52	12.67	11.97	11.95	12.75	12.66	
SW97			21.29	21.79	21.46	21.95	22.08	22.16	21.34	21.37	21.45	20.95	21.51	20.38	22.38	22.20	22.04	22.30	22.19	22.60	21.58	22.02	21.49	22.81	21.59	27.27	22.66	21.95	21.66	21.56	21.81	22.35	
SW99			13.51	13.28	12.72	12.71	13.49	13.65	11.86	12.45	13.06	11.91	12.05	12.44	12.08	12.69	11.98	13.45	12.77	12.49	12.23	11.96	11.94	12.33	12.05	11.57	12.45	12.24	11.51	11.84	12.42	12.09	
SW101			8.98	8.81	8.57	8.82	9.25				8.84	7.84	8.12			8.74	8.26	9.27	8.73	9.43	8.38	8.43	8.51	8.16	8.38	7.46	8.02	8.19	7.84	7.84	8.44	7.46	
SW107.2			3.31	3.95	3.60	3.21	3.19	3.51	3.63	3.46	3.23	3.27	3.28	3.24	3.47	3.45	2.30	3.55	2.67	3.38	3.48	3.19	3.37	3.39	3.29	3.16	3.04	3.05	3.80	4.20	3.75	2.99	
SW132.2																27.16		30.17	30.35	28.28	30.47	29.83	30.04	29.73	30.26	29.81	28.87	29.06	29.53	28.71	29.44	28.01	
SW132.5			20.61	21.33	20.42	20.32	21.69	21.33	18.89	19.89	20.65	20.40	20.40	18.60	21.31	20.59	19.77	21.29	22.00	19.39	19.78	19.71	19.88	19.47	20.74		18.50	18.06	19.50	18.45	19.17	18.06	
SW132			36.30	36.41	36.40	36.34	36.88	36.87	36.07	36.10	36.53	36.45	36.22	35.78	37.10	36.52	36.69	36.88	36.48	36.02	36.22	36.29	36.13	36.68	37.63		36.19	36.39	34.89	32.78	34.76	33.81	
SW133			15.49	15.42	15.46	15.40	15.51	15.63	14.93	14.99	15.65	14.75	15.59	13.80	15.72	15.11	15.48	15.48	15.61	14.51	15.29	14.94	15.41	16.21	16.32	14.52	15.38	15.05	15.20	14.28	15.13	14.45	
SW136.1										2.70	2.54	2.48	2.51	2.51	2.69	2.60	2.63	2.63	2.49	2.67	2.64	2.60		2.85	2.75	2.46	2.29	2.60	2.79	2.78	2.45	2.60	
SW139			86.26	86.05	86.35	85.89	86.68	86.32	86.35	86.58	86.97	86.35	87.67	86.10	86.31	88.13	86.00	87.00	88.00		86.25	84.02	86.45	85.42	85.89	84.41	85.18	85.88	85.78	84.06	85.69	84.70	
SW140			70.79	70.96	70.63	70.03	71.42	70.86	70.81	70.40	71.81	69.93	71.00	69.78	70.82	71.77	69.75	71.08	71.12	70.78	70.58	70.55	71.00	70.10	69.42	69.78	70.27	70.28	69.88	70.10	69.90	70.20	
SW142.1			39.81	40.56	39.96	38.96	40.44	40.34	40.22	40.10	40.81	39.91	40.02	38.89	40.40	40.69	39.52	40.80	40.10	39.80	39.84	39.50	40.26	38.98	39.57	38.79	39.45	39.60	39.07	40.44	40.06	38.86	
SW142			44.92	40.48	46.62	46.25	46.62	46.51	46.03	45.89	46.61	45.91	46.23	45.33	46.67	46.85	45.59	46.65	46.22	46.15	42.92		45.00	45.52	45.84	43.52	44.07	44.24	44.40	44.38	44.15	43.45	
SW143			31.00	31.88	31.44	30.35	32.38	32.81	31.24	31.26	32.43	31.19	31.32	30.20	32.75	31.99	30.99	32.21	31.66	31.14	31.46	31.17	31.80	31.53	31.13	29.45	29.64	30.87	30.95	30.98	31.79	30.83	
SW147			13.62	13.36	13.79	14.09	14.18	14.31	13.58	13.39	14.10	12.98	13.69	12.29	13.79	13.94	13.48	13.87	14.39	13.22	13.85	13.77	14.02	13.69	14.04	12.37	12.60	12.80	13.66	13.48	14.01	13.57	
SW148			11.28	12.02	11.35	11.81	12.69	13.24	11.54	12.06	12.00	10.67	11.48	10.86	12.44	11.50	11.26	12.12	12.29	11.34	11.36	12.36	12.57	12.82	11.86	10.68	11.57	11.73	11.15	10.97	11.36	11.56	
SW151			10.58	10.93	10.18	8.95	11.50	12.32	10.11	10.80	10.94	9.66	10.44	9.95	11.34	11.45	11.35	12.11	11.61	11.32	10.81	11.45	12.20	11.87	10.35	9.68	11.58	11.37	10.73	10.92	11.48	12.56	
SW155			18.36	18.48	16.63	18.28	19.35	19.74	18.28	19.47	18.73	18.30	18.28	16.33	19.14	18.44	18.42	18.87	18.78	17.66	18.47	16.58	18.58	18.66	18.81	17.14	17.68	18.19	18.45	18.20	18.54	18.36	
SW156A			39.56	39.13	39.30	38.98	39.62	39.60	39.40	38.64	38.22	39.28	38.86	38.27	39.80	39.43	39.18	39.55			39.33	38.91	39.66	38.93	40.00	39.51	39.55	38.52	39.64	40.00	38.40	39.64	
SW161			4.99	6.75	4.42	6.64	6.98	6.06	5.31	5.70	5.40	4.77	5.18	4.02	3.28	4.96		5.21	5.00		4.32	3.50	5.55	6.81	4.85	5.36	6.38	6.43	4.77	3.86	5.24	3.72	
SW162			3.04	4.38	2.42	4.98	4.72	3.70	2.97	3.19	3.08	2.92	3.43	2.80		3.74	4.04	4.40	4.09	5.45	3.88	4.39	4.77	6.27	4.65	4.59	4.74	5.28	4.81	3.80	4.59	3.55	
~~SW167~~			~~8.02~~	~~7.76~~																													Deselection
SW168			7.94	7.94	6.24	6.66	8.26	8.75	4.24	4.85	5.33	4.18	5.34	4.89	5.34	5.18	4.65	6.53	6.11	5.33	4.66	5.34	4.70	6.20	4.74	5.03	7.25	4.89	4.57	4.93	5.45	4.23	
SW169			6.55	6.17	5.09	6.09	6.78	7.43	3.88	4.13	4.74	3.35	4.55	3.85	4.45	3.82	3.24			2.28	3.58	4.21	3.52	5.17	2.65	4.60	4.52	3.71	2.82	2.50	4.20	3.02	
SW170			5.15	5.34	4.48	4.81	6.01	6.87	3.86	4.86	5.06	3.76	4.73	4.27	4.90	4.73	4.22	6.44	4.88	4.81	4.11		4.06	5.40	4.05	3.97	3.25	4.46	3.77	4.48	4.42	3.77	
SW171			7.37	7.85	5.97	8.33	9.25	7.11	5.65	6.42	6.42	6.06	5.13	6.00	3.13	6.75	6.32	6.97	5.64	7.60	6.34	6.67	6.55	6.46	7.48	6.42	7.75	6.56	4.77	4.19	5.48	4.38	
SW198			3.87	4.25	3.34	3.57	4.50	4.85	2.80	3.34		2.90	3.40	3.17	4.12	3.87	2.25	5.05	3.64	3.36	2.98	3.55	2.90	2.08			4.00	3.65	3.13	3.37	3.62	2.86	
SW215			7.18	8.96	6.85	7.88	7.65	7.20	6.73	6.06	6.91	6.76	6.67	6.36	5.35	6.48			6.42	7.66	5.69	6.46	5.64	7.48	5.37	6.06	4.81	7.09	5.97	5.07	5.66	5.00	
SW241			2.92	3.28	3.06	2.94	3.12	3.41	2.96	3.15	3.15	3.10	3.25	3.22	3.16	3.25	3.21	3.48	3.44	3.28	3.24	3.27	3.28	3.34	3.85	3.19	2.83	3.22	3.20	3.26	3.41	3.30	
SW244			2.39	2.68	2.88	2.77	2.61	2.58	2.86	2.89	2.68	2.66	2.90	3.10	3.03		2.92	3.91	2.93	2.95					3.99	2.86		3.06	2.84	3.00	3.43	3.45	

Source: JICA Survey team

Table 4.3.12 Estimation of HWL at each gauging station (2)

River / Station Name, Station No.			Longitude (X)	Latitude (Y)	Row No.	Catchment Area (km^2)	Data item	No. in sample	Mean	Std. Deviation σ_{n-1}	Water Level each Return Period (year) (m, PWD)							Water Level each Return Period (year) (m, MSL)							Records of Annual High Flood Level																																Remarks
											1.1	5	10	20	25	50	100	1.1	5	10	20	25	50	100	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
											K_T							K_T																																							
											-1.132	0.719	1.305	1.866	2.044	2.592	3.137	-1.132	0.719	1.305	1.866	2.044	2.592	3.137																																	
< Water Level >																																																									
Swarupkati	Swarupkati	SW253	90.111	22.765	426		Water Level	27	2.362	0.225	2.108	2.524	2.655	2.781	2.821	2.945	3.067	1.648	2.064	2.195	2.321	2.361	2.485	2.607			2.10	2.44	2.45	2.27	2.12	2.27	2.36	2.28	2.18	2.21	2.21	2.16	2.38	2.66	2.45	2.55	2.10	2.41	2.04		2.33	2.10	2.40			3.01	2.55	2.64	2.41	2.70	
Siva-Barnai-Gurnai	Nawhata	SW261	88.615	24.457	352	250	Water Level	30	14.687	0.725	13.866	15.208	15.632	16.039	16.168	16.566	16.960	13.406	14.748	15.172	15.579	15.708	16.106	16.500			14.53	14.51	14.49	15.53	15.34	15.14	14.64	14.70	15.15	13.76	14.11	13.13	16.02	15.17	14.79	15.47	15.62	15.63	14.87	14.50	14.38	15.48	15.12	13.89	15.04	13.99	14.10	13.67	14.56	13.28	
Surma-Meghna	Chandpur	SW277	90.642	23.231	84	1,595	Water Level	29	4.752	0.328	4.380	4.988	5.180	5.364	5.423	5.603	5.782	3.920	4.528	4.720	4.904	4.963	5.143	5.322			4.68	4.96	4.72	4.41	4.77	5.16		4.96	4.81	4.40	4.75	4.33	5.00	4.94	4.95	5.62	4.95	4.79	4.57	4.87	4.93	5.42	4.88	4.25	4.48	4.53	4.27	4.38	4.55	4.47	
Surma-Meghna	Daulatkhan	SW278	90.818	22.611	116	1,595	Water Level	28	3.988	0.407	3.527	4.281	4.519	4.748	4.820	5.043	5.265	3.067	3.821	4.059	4.288	4.360	4.583	4.805			3.70	4.12	3.90	4.17	3.93	4.10	4.23	4.18	4.10	3.80	4.15	4.23	4.33	4.44	4.31	4.40	4.08	4.18	4.03	3.62	3.44	3.10	2.73			3.48	4.38	4.38	4.25	3.90	
Tangon	Thakurgaon	SW285	88.464	26.038	477	600	Water Level	30	50.063	0.492	49.506	50.416	50.704	50.980	51.068	51.337	51.605	49.046	49.956	50.244	50.520	50.608	50.877	51.145			50.01	50.36	50.33	49.70	51.26	50.75	50.08	49.84	51.11	49.79	49.71	49.07	50.19	50.05	50.07	50.58	50.02	49.92	50.10	49.81	50.32	49.95	50.10	48.72	49.93	49.80	50.10	50.12	50.33	49.77	
Teesta	Kaliganj	SW293	89.181	25.958	238	1,719	Water Level	29	40.556	0.473	40.021	40.896	41.172	41.438	41.522	41.781	42.038	39.561	40.436	40.712	40.978	41.062	41.321	41.578			40.75	40.80	40.45	40.29	41.08	40.43	40.97	40.65	40.68	40.77	40.06	40.43	40.56	40.58	38.78	40.27	40.23	39.70	40.99	40.90	40.76	40.45	40.41		40.78	40.93	41.24	40.97	40.60	40.64	
Teesta	Kaunia	SW294	89.440	25.787	253	1,719	Water Level	30	29.711	0.465	29.184	30.046	30.318	30.579	30.662	30.917	31.171	28.724	29.586	29.858	30.119	30.202	30.457	30.711			30.12	30.05	30.02	29.87	30.46	30.41	30.10	30.06	30.49	29.71	30.18	29.48	29.87	30.12	29.55	29.91	29.83	29.69	29.51	29.81	29.39	29.30	28.80	28.58	29.66	29.11	29.34	29.44	29.20	29.31	
Torki	Gournadi	SW300	90.235	22.976	174		Water Level	13	3.005	0.730	2.178	3.530	3.957	4.367	4.497	4.897	5.295	1.718	3.070	3.497	3.907	4.037	4.437	4.835																3.12	3.23	4.65	3.71	3.56	2.88	3.07	2.25					1.92	2.21	3.28	2.56	2.62	
Tulshiganga	Sonaimukhi	SW325	89.063	25.021	447	360	Water Level	29	16.813	0.789	15.920	17.380	17.842	18.284	18.425	18.857	19.287	15.460	16.920	17.382	17.824	17.965	18.397	18.827			17.18	17.03	17.15	17.25	18.36	17.10	16.37	16.89	17.30	15.74	17.30	14.84	17.98	16.76	15.90	17.50	17.52	16.78	16.87	16.48	16.82	17.74		15.50	17.35	16.57	16.80	16.43	16.79	15.27	
Buri Teesta	Uttar Gomanati	SW331	88.920	26.220	490	70	Water Level	25	58.691	0.273	58.382	58.888	59.047	59.201	59.249	59.399	59.548	57.922	58.428	58.587	58.741	58.789	58.939	59.088								58.42	58.30	58.44	59.31	59.10	58.46	58.18	58.52	59.12	58.66	58.90	58.66	58.75	58.50	58.80	58.70	58.80	58.98	58.68	58.56	58.77	58.85	58.92	58.55	58.35	
Kulik	Bhutdangi	SW335	88.238	25.824	62	150	Water Level	25	38.752	0.979	37.644	39.457	40.029	40.579	40.753	41.290	41.823	37.184	38.997	39.569	40.119	40.293	40.830	41.363								40.40	39.34	38.82	40.53	38.02	38.22	36.72	39.17	38.79	38.47	39.03	39.76	38.66	40.03	39.86	38.82	37.04	39.03	37.65	39.11	39.32	38.31	37.73	38.50	37.47	
Meghna	Meghna Ferryghat	SW275.5	90.642	23.584	309	2,103	Water Level	36	5.479	0.641	4.754	5.941	6.316	6.675	6.789	7.141	7.490	4.294	5.481	5.856	6.215	6.329	6.681	7.030	5.40	5.19	5.56	5.73	5.44	5.03	5.99	6.55	5.22	5.29	5.51	4.44	5.45	5.06	5.90	5.72	5.53	6.76	5.93	5.68	5.33	5.90	5.74	6.60	5.48	3.85	3.50	5.65	5.12	5.06			
Gumti	Daudkandi	SW115	90.716	23.531	115	41	Water Level	36	5.564	0.600	4.885	5.996	6.347	6.684	6.791	7.120	7.447	4.425	5.536	5.887	6.224	6.331	6.660	6.987	5.55	5.20	5.53	5.52	4.95	5.40	6.06	6.34	5.08	5.10	5.23	4.60	5.47	4.82	5.77	5.85	5.50	6.68	5.96	5.22	5.26	6.45	5.65	6.49	5.75	5.21	5.96	6.77	5.17	6.67			
Lahkya	Demra	SW179	90.510	23.722	118		Water Level	38	5.820	0.492	5.264	6.174	6.462	6.738	6.825	7.095	7.363	4.804	5.714	6.002	6.278	6.365	6.635	6.903	5.65	5.35	5.81	6.04	5.57	5.14	6.38	6.92	5.34	5.28	5.82	5.36	5.80	5.07	6.13	5.88	5.71	7.11	6.03	5.85	5.55	5.93	6.11	6.86	6.00	5.12	6.20	5.94	5.42	5.30			
Chandana Arkandikhal	Ramdia	SW51	89.521	23.730	403	425	Water Level	19	8.858	0.918	7.819	9.519	10.057	10.572	10.736	11.239	11.739	7.359	9.059	9.597	10.112	10.276	10.779	11.279	9.31	9.37	10.53	9.76	9.14	9.44	9.76	10.42	8.18	8.05	8.60	7.88	8.62	9.60	8.25	7.85	7.45	8.15	7.95														
Chitra	Ratandanga	SW55.1	89.517	23.199	410	505	Water Level	29	3.708	0.743	2.867	4.242	4.676	5.093	5.225	5.632	6.037	2.407	3.782	4.216	4.633	4.765	5.172	5.577			4.39	4.76	3.63	4.66	5.01	5.02	3.53	3.63	4.10	3.30	3.75	3.55	1.85	3.61	3.40	4.17	4.03	3.92	2.10		3.37	4.64	3.54	3.29	3.18	3.80	3.32	3.60	3.67	2.70	
DCJ Karatoa	Shibganj	SW64	89.324	25.003	439	1,250	Water Level	32	17.754	0.720	16.939	18.272	18.694	19.098	19.226	19.621	20.013	16.479	17.812	18.234	18.638	18.766	19.161	19.553	17.50	17.81	17.57	16.96	18.28	18.46	19.10	18.58	17.28	17.73	19.02	17.76	17.77	16.68	19.00	17.32	17.56	18.05	17.96	17.10	17.61	18.01	18.43	18.60	18.55	16.50	17.69	16.52	17.23	16.63	17.60	17.30	
Fakirni Barnai	Jote Bazar (Off take	SW82	88.730	24.684	219		Water Level	31	16.434	0.531	15.833	16.816	17.127	17.425	17.520	17.811	18.100	15.373	16.356	16.667	16.965	17.060	17.351	17.640	16.45	16.23	16.58	16.74	16.87	16.72	16.84	16.18	15.84	15.83	16.47	16.52	16.47	14.92	16.67	16.68	16.78	16.86	16.61	16.34	16.73	16.76		16.91	16.88	14.71	16.67	16.05	16.47	16.37	17.13	16.20	
Ganges	Sureswar	SW95	90.424	23.316	454	1,163	Water Level	30	4.850	0.597	4.174	5.280	5.630	5.965	6.071	6.399	6.724	3.714	4.820	5.170	5.505	5.611	5.939	6.264			3.01	5.03	4.49	4.55	5.50	6.03	4.98	5.00	4.82	4.41	4.84	4.63	5.05	4.92	4.57	5.82	5.03	4.93	4.17	5.05	3.72	5.78	5.15	4.31	5.35	5.20	4.55	4.92	4.88	4.82	
Kobadak	Chandkhali	SW164	89.254	22.521	83	200	Water Level	21	3.331	0.810	2.414	3.914	4.387	4.842	4.986	5.430	5.871	1.954	3.454	3.927	4.382	4.526	4.970	5.411	3.15	3.00	3.05	3.05	3.11	3.03	3.70	3.00	3.64	3.24	3.16	3.18	3.20	3.24	2.93	6.74	3.40	3.09	2.87	3.27	2.90												
Lohalia	Kaitpara	SW183	90.437	22.456	231	468	Water Level	9	2.684	0.101	2.570	2.757	2.816	2.873	2.891	2.946	3.001	2.110	2.297	2.356	2.413	2.431	2.486	2.541																2.73	2.70	2.83	2.64	2.80	2.52	2.68	2.70									2.56	
Lower Kumar	Mostafapur	SW190	90.137	23.159	328		Water Level	30	4.015	0.557	3.384	4.416	4.742	5.055	5.154	5.460	5.763	2.924	3.956	4.282	4.595	4.694	5.000	5.303			3.80	4.17	3.67	3.62	4.80	5.50	3.70	4.00	4.22	3.40	3.84	3.80	4.24	4.35	3.94	5.94	3.97	3.84	3.66	3.99	4.24	3.84	3.91	3.68	3.40	3.50	3.85	4.06	4.08	3.44	
Punarbhaba	Pulhat	SW236	88.622	25.620	399	200	Water Level	17	33.211	0.587	32.547	33.633	33.977	34.306	34.411	34.733	35.052	32.087	33.173	33.517	33.846	33.951	34.273	34.592																33.89	33.35	34.09	33.72	33.08	33.53	32.91	33.53	33.25	33.57	31.56	32.56	32.88	32.99	33.28	33.55	32.85	
Tangon	Raniganj	SW284	88.479	26.227	408	600	Water Level	39	61.284	3.049	57.833	63.478	65.262	66.973	67.516	69.188	70.848	57.373	63.018	64.802	66.513	67.056	68.728	70.388	60.75	58.49	60.31	61.15	60.53	59.94	60.99	60.54	60.27	59.97	60.72	60.02	59.99	59.40	60.47	60.54	61.09	61.52	61.55	60.97	60.40	57.97		70.52	70.54	69.94	68.54	60.03	60.46	59.43	59.10	59.60	
Bangali	Sharia Kandi	SW11A	89.570	24.896	436	1,100	Water Level	32	16.384	0.595	15.710	16.812	17.160	17.494	17.600	17.927	18.251	15.250	16.352	16.700	17.034	17.140	17.467	17.791	16.03	15.71	16.31	17.22	16.51	16.25	17.12	17.35	16.33	16.64	17.30	16.03	16.22	14.50	16.99	16.58	15.90	16.63	17.08	15.53	16.19	16.82	16.37	16.67	16.67	15.61	16.58	16.14	16.42	15.73	16.17	16.70	
Baral	Malanchi	SW16.1	88.967	24.291	297	772	Water Level	32	13.196	1.129	11.918	14.008	14.668	15.302	15.503	16.122	16.736	11.458	13.548	14.208	14.842	15.043	15.662	16.276	14.62	10.01	10.83	12.85	12.36	12.44	12.89	13.19	12.62	12.61	12.71	12.55	12.63	12.72	12.71	11.77	13.62	15.33	13.52	13.88	13.79	14.75	13.71	14.89	13.71	13.67	12.44	13.58	13.57	14.92	13.51	13.87	
Ghagot	Jafarganj Rd.Crossin	SW96A	89.188	25.800	202	720	Water Level	32	34.021	0.786	33.131	34.586	35.047	35.488	35.628	36.059	36.487	32.671	34.126	34.587	35.028	35.168	35.599	36.027	33.67	33.61	34.09	34.62	35.43	33.63	34.63	34.57	33.51	33.99	35.05	33.61	33.44	32.74	34.87	34.24	34.35	34.45	34.24	33.30	33.81	34.73	34.87	34.13	35.32	33.78	33.52	32.21	34.64	33.66	33.83	32.14	
Lahkya	Narayanganj	SW180	90.524	23.660	348		Water Level	19	5.749	0.548	5.129	6.143	6.464	6.771	6.868	7.169	7.467	4.669	5.683	6.004	6.311	6.408	6.709	7.007	5.19	5.20														5.75	5.59	6.93	5.99	5.92	5.41	5.81	6.42	6.75	5.71	4.68	6.05	5.99	5.52	5.28	5.38	5.66	
Tangon	Kodalkatigaon	SW287	88.434	25.684	270	600	Water Level	32	34.376	1.289	32.916	35.303	36.058	36.782	37.011	37.718	38.420	32.456	34.843	35.598	36.322	36.551	37.258	37.960	31.79	34.15	34.75	35.06	34.99	34.19	35.73	35.09	34.81	34.39	35.79	33.61	33.62	32.17	35.14	34.43	34.43	35.50	34.82	33.83	35.02	34.62	36.51	35.63	36.78	32.60	31.06	35.05	34.33	33.80	33.73	32.62	
Surma-Meghna	Satnal	SW276	90.594	23.472	428	2,103	Water Level	32	5.136	0.577	4.483	5.551	5.888	6.212	6.315	6.631	6.945	4.023	5.091	5.428	5.752	5.855	6.171	6.485	5.24	4.82	5.26	5.62	4.99	4.71	5.61	6.04	4.91	4.98	5.11	4.35	5.03	4.75	5.53	5.47	5.10	6.40	3.97	5.35	4.97	5.80	5.29	6.62	4.87	5.42	4.13	5.12	4.85	4.70	4.76	4.58	
Lahkya	Lakhpur	SW177	90.653	24.040	277		Water Level	34	6.523	0.636	5.803	6.981	7.353	7.710	7.824	8.173	8.519	5.343	6.521	6.893	7.250	7.364	7.713	8.059			6.63	7.07	6.62	6.26	7.33	7.84	6.17	6.31	6.78	5.41	6.71	5.25		6.53	6.38	7.87	6.82	6.77	6.42	6.10	6.10	6.13	6.01	5.27				6.49	6.38	5.60	
Brahmaputra-Jamuna	Chilmari	SW45.5	89.704	25.544	99		Water Level	34	-	-	-	24.371	24.583	-	24.805	24.942	25.080	-	23.911	24.123	-	24.345	24.482	24.620		(from National Water Management Plan 1999)																															
Brahmaputra-Jamuna	Bahadurabad	SW47	89.680	25.111	27		Water Level	34	-	-	-	20.135	20.281	-	20.413	20.484	20.538	-	19.675	19.821	-	19.953	20.024	20.078		(from National Water Management Plan 1999)																															
Mathabhanga	Kazipur	SW205	88.767	24.003	257		Water Level	34	-	-	-	16.023	16.258	-	16.517	16.685	16.834	-	15.563	15.798	-	16.057	16.225	16.374		(from National Water Management Plan 1999)																															
Jamuna	Serajganj	SWunknown92	89.718	24.471	432		Water Level	34	-	-	-	14.249	14.742	-	15.134	15.424	15.710	-	13.789	14.282	-	14.674	14.964	15.250		(from National Water Management Plan 1999)																															
Brahmaputra-Jamuna	Porabari	SW50	89.818	24.147	394		Water Level	34	-	-	-	12.648	12.867	-	13.082	13.206	13.305	-	12.188	12.407	-	12.622	12.746	12.845		(from National Water Management Plan 1999)																															
Ganges	Hardinge Bridge	SW90	89.026	24.064	187		Water Level	34	-	-	-	14.668	14.858	-	15.037	15.135	15.211	-	14.208	14.398	-	14.577	14.675	14.751		(from National Water Management Plan 1999)																															
Ganges	Sengram	SW91.1	89.378	23.883	431		Water Level	34	-	-	-	12.155	12.425	-	12.716	12.902	13.063	-	11.695	11.965	-	12.256	12.442	12.603		(from National Water Management Plan 1999)																															
Ganges	Mahendrapur	SW91.2	89.554	23.801	320		Water Level	34	-	-	-	11.102	11.383	-	11.699	11.909	12.098	-	10.642	10.923	-	11.239	11.449	11.638		(from National Water Management Plan 1999)																															
Ganges	Baruria	SW91.9L	89.799	23.800	40		Water Level	34	-	-	-	8.565	8.842	-	9.215	9.509	9.817	-	8.105	8.382	-	8.755	9.049	9.357		(from National Water Management Plan 1999)																															
Ganges	Mawa	SW93.5L	90.261	23.470	306		Water Level	34	-	-	-	6.291	6.548	-	6.913	7.215	7.545	-	5.831	6.088	-	6.453	6.755	7.085		(from National Water Management Plan 1999)																															
Surma-Meghna	Bhairab Bazar	SW273	91.002	24.053	51		Water Level	34	-	-	-	6.982	7.218	-	7.462	7.612	7.739	-	6.522	6.758	-	7.002	7.152	7.279		(from National Water Management Plan 1999)																															
Old Brahmaputra	Jamalpur	SW225	89.961	24.936	209		Water Level	34	-	-	-	17.408	17.519	-	17.590	17.617	17.633	-	16.948	17.059	-	17.130	17.157	17.173		(from National Water Management Plan 1999)																															
Old Brahmaputra	Mymensingh	SW228	90.434	24.737	333		Water Level	34	-	-	-	12.843	13.078	-	13.267	13.356	13.417	-	12.383	12.618	-	12.807	12.896	12.957		(from National Water Management Plan 1999)																															

Source: JICA Survey team

Table 4.3.13 Design HWL for each proposed bridge (1)

SN	Bridge ID	Zone	Division	Latitude	Longitude	Bridge Name	Water Level (m, MSL)												Vertical Clearance (m, MSL)				
							1.1 yr (NHWL)	10 yr	20 yr (Design HWL)	50 yr (Design HWL)	100 yr	Applied Calculation High Water Level		Historical WL (by Interview)		**Applied Design High Water Level**		Bottom of Existing Bot. Girder		Necessary Freeboar	Design Bottom Level	Free board
1	N8_178a	Barisal	Barisal	22.57523	90.33665	Boalia Bazar Bridge	1.61	2.36	2.54	2.76	2.93	2.76	50yr	2.78	2007	2.78	Interview	4.767	1	3.08	4.77	1.99
2	N509_19a	Rangpur	Lalmonirhat	25.90944	89.36611	Shamamoti Bridge	33.52	34.66	34.92	35.26	35.52	35.26	50yr	32.91	1988	35.26	50yr	34.352	3	35.56	35.56	0.30
3	N5_119a	Rajshahi	Pabna	24.04596	89.60433	Chanda Bridge	10.92	11.25	11.64	12.14	12.51	12.14	50yr	10.21	1988	12.14	50yr	12.547	3	12.44	12.55	0.40
4	N5_127a	Rajshahi	Pabna	24.10685	89.58131	Palgari Bridge	9.59	11.52	11.95	12.51	12.92	12.51	50yr	10.70	1988	12.51	50yr	11.918	3	12.81	12.81	0.30
5	N5_176a	Rajshahi	Serajganj	24.49098	89.50970	Bhuyagati Bridge	11.03	13.80	14.44	15.26	15.88	15.26	50yr	12.43	1988	15.26	50yr	16.592	3	15.56	16.59	1.33
6	N5_235a	Rangpur	Bogra	24.95429	89.35218	Mohosthan Bridge	15.77	17.64	18.06	18.58	19.00	18.58	50yr	18.13	1988	18.58	50yr	19.504	4	18.88	19.50	0.92
7	N5_120a	Rajshahi	Pabna	24.05006	89.60539	Chanda Bridge	9.56	11.30	11.59	12.14	12.51	12.14	50yr	10.29	1988	12.14	50yr	12.803	3	12.44	12.80	0.66
8	N5_128a	Rajshahi	Serajganj	24.10884	89.58032	Golhar Bridge	9.59	11.52	11.95	12.51	12.92	12.51	50yr	10.51	1988	12.51	50yr	12.424	3	12.81	12.81	0.30
9	N5_158a	Rajshahi	Serajganj	24.34696	89.56022	Purbodalua Bridge	10.43	12.80	13.35	14.09	14.63	14.09	50yr	11.93	1988	14.09	50yr	14.192	3	14.39	14.39	0.30
10	N5_265a	Rangpur	Gaibanda	25.20998	89.37933	Bupinath Bridge	20.02	21.87	22.36	22.90	23.58	22.90	50yr	20.00	1988	22.90	50yr	22.030	3	23.20	23.20	0.30
11	N5_350b	Rangpur	Rangpur	25.81133	89.04645	Barati Bridge	34.71	36.82	37.37	37.59	38.03	37.59	50yr	37.61	1988	37.61	Interview	38.652	1	37.91	38.65	1.04
12	N8_182a	Barisal	Barisal	22.54080	90.33331	Bakerganj Steel Bridge	1.60	2.41	2.59	2.84	3.02	2.84	50yr	2.57	2007	2.84	50yr	4.249	2	3.14	4.25	1.41
13	N7_025a	Gopalgan	Faridpur	23.60797	89.77770	Jhuldibazar Bridge	4.45	7.29	7.89	8.75	9.39	8.75	50yr	7.62	1988	8.75	50yr	8.956	2	9.05	9.05	0.30
14	N7_039a	Gopalgan	Faridpur	23.53718	89.74696	Karimpur Bridge	3.39	6.25	6.96	7.97	8.64	7.97	50yr	6.34	1988	7.97	50yr	10.140	3	8.27	10.14	2.17
15	N7_049a	Gopalgan	Faridpur	23.53743	89.65488	Porkilpur Bridge	5.27	7.26	7.84	8.45	9.16	8.45	50yr	7.81	1988	8.45	50yr	7.878	2	8.75	8.75	0.30
16	N5_134a	Rajshahi	Serajganj	24.15113	89.58649	Nukali Bridge	9.74	11.70	12.15	12.73	13.17	12.73	50yr	10.86	1988	12.73	50yr	12.314	4	13.03	13.03	0.30
17	N6_97a	Rajshahi	Natore	24.39912	89.03121	Dattapara Bridge	11.21	13.44	13.96	14.65	15.15	14.65	50yr	14.29	1988	14.65	50yr	15.380	2	14.95	15.38	0.73
18	R681_10a	Rajshahi	Rajshahi	24.42377	88.36178	Horisonkorpur Bridge	16.95	18.79	19.22	19.77	20.18	19.77	50yr	21.61	1998	21.61	Interview	21.072	1	21.91	21.91	0.30
19	N5_140a	Rajshahi	Serajganj	24.20225	89.58975	Jugnidaha Bridge	9.91	12.05	12.53	13.09	13.57	13.09	50yr	11.45	1988	13.09	50yr	13.330	3	13.39	13.39	0.30
20	N5_118a	Rajshahi	Pabna	24.03262	89.60422	Punduria Bridge	9.59	11.21	11.58	12.06	12.47	12.06	50yr	10.36	1988	12.06	50yr	12.028	4	12.59	12.59	0.53
21	N704_43a	Khulna	Kushtia	23.88814	89.10800	G.K. Bridge	10.57	12.24	12.62	13.05	13.45	13.05	50yr	14.11	1988	14.11	Interview	13.615	1	14.41	14.41	0.30
22	N7_248c	Khulna	Bagerhat	22.55598	89.59497	Gora bridge	2.17	3.01	3.20	3.44	3.64	3.44	50yr	5.36	1988	5.36	Interview	4.547	1	5.66	5.66	0.30
23	N7_054a	Gopalgan	Faridpur	23.52929	89.60843	Barashia Bridge	5.86	7.80	8.22	8.72	9.14	8.72	50yr	8.77	1988	8.77	Interview	9.886	1	9.07	9.89	1.12
24	N5_356a	Rangpur	Rangpur	25.81108	88.98938	-	35.34	37.58	38.03	38.37	38.82	38.37	50yr	38.19	1988	38.37	50yr	39.267	2	38.67	39.27	0.89
25	N7_246a	Khulna	Bagerhat	22.57306	89.61417	Balai bridge	2.19	2.97	3.16	3.36	3.54	3.36	50yr	4.75	1988	4.75	Interview	7.342	1	5.05	7.34	2.59
26	N8_095a	Gopalgan	Madaripur	23.19906	90.06697	Amgram bridge	2.93	4.47	4.82	5.29	5.63	5.29	50yr	7.05	1988	7.05	Interview	7.465	1	7.35	7.47	0.42
27	N505_2a	Rajshahi	Pabna	23.88051	89.66450	Kazir Hat Bridge	8.65	10.18	10.54	11.03	11.38	11.03	50yr	11.72	1988	11.72	Interview	11.778	1	12.02	12.02	0.30
28	R548_28b	Rajshahi	Naogaon	24.61256	88.97474	Atrai Bridge	12.58	13.85	14.14	14.52	14.81	14.52	50yr	14.00	1988	14.52	50yr	17.890	4	**18.84**	18.84	4.32
29	N7_036c	Gopalgan	Faridpur	23.53911	89.76787	Kanaipur Bridge	3.11	6.18	7.11	7.88	8.57	7.88	50yr	6.81	1988	7.88	50yr	8.761	2	8.18	8.76	0.89
30	N7_048a	Gopalgan	Faridpur	23.53526	89.66585	Brahmonkanda Bridge	5.12	7.22	7.75	8.44	8.99	8.44	50yr	7.69	1988	8.44	50yr	8.017	2	8.74	8.74	0.30
31	N5_378a	Rangpur	Dinajpur	25.76659	88.83297	Gaudangi Bridge	37.95	39.77	40.16	40.54	40.92	40.54	50yr	39.85	1988	40.54	50yr	40.393	3	40.84	40.84	0.30
32	N7_047a	Gopalgan	Faridpur	23.53437	89.67187	Bimankanda bridge	4.94	7.12	7.67	8.48	8.99	8.48	50yr	7.68	1988	8.48	50yr	10.092	3	8.78	10.09	1.61
33	N5_156a	Rajshahi	Serajganj	24.33330	89.56192	Chowkidhoh Bridge	10.36	12.69	13.23	14.01	14.45	14.01	50yr	11.01	1988	14.01	50yr	13.822	3	14.31	14.31	0.30
34	N5_172a	Rajshahi	Serajganj	24.46282	89.53583	Noturi Dhoh Bridge	10.89	13.67	14.28	15.12	15.74	15.12	50yr	13.38	1988	15.12	50yr	15.577	3	15.42	15.58	0.45
35	N5_179a	Rajshahi	Serajganj	24.51525	89.51174	Dhatia Bridge	11.13	13.93	14.61	15.43	16.22	15.43	50yr	13.51	1988	15.43	50yr	14.367	3	15.73	15.73	0.30
36	N5_188a	Rangpur	Bogra	24.57326	89.46623	Ghoga Bridge	11.34	14.26	14.93	15.82	16.47	15.82	50yr	13.08	1988	15.82	50yr	15.625	3	16.12	16.12	0.30
37	N5_126a	Rajshahi	Pabna	24.09295	89.58880	Vitapara Bridge	9.64	11.43	11.89	12.38	12.83	12.38	50yr	10.68	1988	12.38	50yr	12.784	4	12.68	12.78	0.40
38	N518_4a	Rangpur	Nilphamari	25.77357	88.87754	Khorkhori bridge	37.99	39.50	40.02	40.45	41.25	40.45	50yr	39.83	1988	40.45	50yr	39.771	3	40.75	40.75	0.30
39	N7_141b	Khulna	Jessore	23.24180	89.16655	Bun Bhairab Bridge	2.89	5.00	5.49	6.11	6.58	6.11	50yr	5.43	1988	6.11	50yr	6.595	2	6.41	6.60	0.48
40	R720_44a	Khulna	Narail	23.19756	89.51320	Gurakhali Bridge	2.41	4.21	4.63	5.14	5.54	5.14	50yr	6.16	1971	6.16	Interview	5.106	1	6.46	6.46	0.30
41	N703_Sd	Khulna	Jhenaidah	23.54434	89.18502	Dhopa Ghata Bridge	5.03	7.04	7.50	8.04	8.53	8.04	50yr	4.28	1972	8.04	50yr	7.721	3	8.34	8.34	0.30
42	R890_45a	Barisal	Bhola	22.39444	90.75028	Dawrey Bridge	2.74	3.50	3.68	3.87	4.04	3.87	50yr	3.39	2007	3.87	50yr	4.334	3	4.17	4.33	0.46
43	N704_14a	Khulna	Jhenaidah	23.66693	89.19069	Barda Bridge	5.61	8.11	8.68	9.42	9.98	9.42	50yr	6.93	2004	9.42	50yr	9.344	3	9.72	9.72	0.30
44	N704_33b	Khulna	Kushtia	23.81508	89.10669	Balipara Bridge	9.59	10.59	11.67	11.76	12.43	11.76	50yr	11.13	1988	11.76	50yr	11.019	2	12.06	12.06	0.30
45	N5_344c	Rangpur	Rangpur	25.81161	89.10748	-	33.87	36.06	36.49	36.81	37.24	36.81	50yr	37.55	1988	37.55	Interview	38.710	1	37.85	38.71	1.16
46	N5_382a	Rangpur	Dinajpur	25.77362	88.79370	Ichamoti Bridge	38.51	39.96	40.32	40.95	41.31	40.95	50yr	41.61	1988	41.61	Interview	42.006	1	41.91	42.01	0.40
47	N5_360a	Rangpur	Rangpur	25.79629	88.96549	Chikli Bridge	35.48	37.31	37.84	38.40	39.24	38.40	50yr	37.89	1988	38.40	50yr	37.143	3	38.70	38.70	0.30
48	Z5025_55a	Rangpur	Dinajpur	25.65236	88.76100	Kakra Bridge	34.35	35.95	36.35	36.88	37.26	36.35	20yr	35.72	1988	36.35	20yr	36.024	4	37.35	37.35	0.99
49	Z5025_84a	Rangpur	Dinajpur	25.63913	88.67052	Gabura Bridge	33.05	34.52	34.88	35.38	35.72	34.88	20yr	35.16	1988	35.16	Interview	35.912	1	35.46	35.91	0.75
50	Z5401_45a	Rangpur	Bogra	24.67306	89.51615	Mathpara Bridge	12.47	15.12	15.73	16.51	17.11	15.73	20yr	14.61	1988	15.73	20yr	15.416	4	16.03	16.03	0.30
51	Z5072_14a	Rangpur	Bogra	24.77375	89.51114	Bombgara Bridge	13.54	15.73	16.27	16.94	17.49	16.27	20yr	15.71	1988	16.27	20yr	15.478	3	16.57	16.57	0.30
52	Z5025_60a	Rangpur	Dinajpur	25.64322	88.71289	Madarganj Bridge	33.75	35.54	35.91	36.13	36.56	35.91	20yr	35.05	1988	35.91	20yr	35.614	3	36.21	36.21	0.30
53	Z5472_6a	Rangpur	Bogra	24.78607	89.00834	Raktodaho Bridge	13.65	14.91	15.20	15.58	15.86	15.20	20yr	13.32	1995	15.20	20yr	14.047	3	15.50	15.50	0.30

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: JICA Survey Team

Table 4.3.14 Design HWL for each proposed bridge (2)

SN	Bridge ID	Zone	Division	Latitude	Longitude	Bridge Name	Water Level (m. MSL)										Vertical Clearance (m. MSL)			
							1.1 yr (NHWL)	10 yr	20 yr (Design HWL)	50 yr (Design HWL)	100 yr	Applied Calculation High Water Level		Historical WL (by Interview)		Applied Design High Water Level	Bottom of Existing Brd. Girder		Necessary Freeboard	Design Bottom Level	Free board
54	N5xx_Sa	Rajshahi	Serajganj	24.31051	89.56874	Pura Mukto Mancli Bridge	10.29	12.60	13.13	13.80	14.32	13.80	50yr	13.08	1988	13.80	50yr	14.133	2	14.10	14.13	0.33
55	Z5552_10a	Rangpur	Gaibandha	25.24301	89.55842	Barodia Khal Bridge	19.03	21.57	22.14	22.82	23.38	22.14	20yr	19.00	1988	22.14	20yr	21.566	4	22.44	22.44	0.30
56	N8_152c	Barisal	Barisal	22.78977	90.29966	Rahamatpur bridge	1.74	2.64	2.84	3.11	3.26	3.11	50yr	3.42	2007	3.42	Interview	6.004	1	3.72	6.00	2.58
57	N8_127b	Barisal	Barisal	22.97476	90.22227	gouriagata bridge	1.73	3.49	3.89	4.41	4.83	4.41	50yr	3.47	2007	4.41	50yr	5.775	2	4.71	5.78	1.36
58	Z8058_008c	Barisal	Patuakhali	22.36149	90.23581	Gabtala Steel Bridge	2.02	2.68	3.07	3.33	3.52	3.07	20yr	2.93	2007	3.07	20yr	2.534	2	3.37	3.37	0.30
59	Z5015_22a	Rangpur	Nilphamari	25.84820	89.01941	Baitagali Bridge	36.90	38.42	38.84	39.63	40.03	38.84	20yr	39.64	1988	39.64	Interview	39.493	1	39.94	39.94	0.30
60	Z5701_1a	Rangpur	Nilphamari	25.93820	88.85464	Anandababur Pool	42.68	45.00	45.54	46.23	47.75	45.54	20yr	46.67	1988	46.67	Interview	47.561	1	46.97	47.56	0.89
61	Z5701_9a	Rangpur	Nilphamari	25.95899	88.92791	Duhuli Bridge	43.13	44.85	45.25	45.75	46.15	45.25	20yr	44.90	1988	45.25	20yr	45.089	2	45.55	45.55	0.30
62	R545_115c	Rangpur	Joypurhat	25.11106	88.98848	Monigle bari kuthibari Bridge	18.17	20.70	21.29	22.04	22.61	22.04	50yr	21.82	1995	22.04	50yr	22.542	4	22.34	22.54	0.50
63	R760_049c	Khulna	Satkhira	22.76601	89.13783	Shakdaha bridge	2.48	3.48	3.71	4.00	4.22	4.00	50yr	2.18	2004	4.00	50yr	4.748	2	4.30	4.30	0.30
64	N8_123a	Barisal	Barisal	23.01499	90.21673	Soudenkhal bridge	1.95	3.68	4.07	4.57	4.94	4.57	50yr	4.11	1988	4.57	50yr	4.554	2	4.87	4.87	0.30
65	Z8701_3d	Barisal	Pirojpur	22.45557	89.99217	Bottala Bridge	2.05	2.47	2.58	2.67	2.77	2.58	20yr	3.02	2007	3.02	Interview	2.378	1	3.32	3.32	0.30
66	N5_260b	Rangpur	Gaibandha	25.17302	89.38917	Katakhali Bridge	19.47	21.27	21.69	22.29	22.70	22.29	50yr	21.85	1988	22.29	50yr	22.587	4	22.59	22.59	0.30
67	N704_27b	Khulna	Kushtia	23.76316	89.11935	Bittipara Bridge	8.72	9.60	10.87	10.90	11.62	10.90	50yr	9.12	2007	10.90	50yr	9.522	2	11.20	11.20	0.30
68	R750_22c	Khulna	Narail	23.17611	89.41748	Bhangura Bridge	2.17	3.58	3.90	4.32	4.63	4.32	50yr	3.16	1988	4.32	50yr	4.144	2	4.62	4.62	0.30
69	N8_129a	Barisal	Barisal	22.96278	90.22483	Asoked bridge	1.72	3.40	3.79	4.29	4.67	4.29	50yr	3.51	1988	4.29	50yr	4.676	2	4.59	4.68	0.39
70	R890_16a	Barisal	Bhola	22.59354	90.65823	Banglabazar Bridge	2.64	3.38	3.55	3.77	3.93	3.77	50yr	3.56	1988	3.77	50yr	4.294	2	4.07	4.29	0.53
71	R890_21a	Barisal	Bhola	22.55647	90.68513	Box culvert Bridge	2.74	3.50	3.68	3.87	4.04	3.87	50yr	1.98	1988	3.87	50yr	3.789	2	4.17	4.17	0.30
72	R890_26a	Barisal	Bhola	22.50263	90.71806	Borhanuddin Bridge	2.74	3.50	3.68	3.87	4.04	3.87	50yr	3.09	1988	3.87	50yr	3.780	2	4.17	4.17	0.30
73	R548_40a	Rajshahi	Natore	24.51393	88.95990	Mohis Mari Bridge	11.67	13.68	14.27	14.85	15.41	14.85	50yr	12.94	1988	14.85	50yr	13.417	2	15.15	15.15	0.30
74	R451_1a	Rajshahi	Serajganj	24.42991	89.60143	Naion Bridge	11.34	13.50	13.92	14.46	14.87	14.46	50yr	12.81	1988	14.46	50yr	13.155	3	14.76	14.76	0.30
75	R451_7a	Rajshahi	Serajganj	24.44847	89.65045	Chondi Das Bridge	12.81	13.84	14.32	14.81	15.32	14.81	50yr	13.91	1988	14.81	50yr	14.041	4	15.11	15.11	0.30
76	R550_28b	Rangpur	Joypurhat	25.06914	89.09408	Bottoli Bridge	16.65	18.59	19.06	19.81	20.28	19.81	50yr	19.31	1988	19.81	50yr	20.041	4	20.11	20.11	0.30
77	R860_31a	Gopalganj	Shariatpur	23.18750	90.39278	Paprail Bailey Bridge	3.65	4.52	4.86	5.29	5.61	5.29	50yr	4.81	1988	5.29	50yr	5.479	2	5.59	5.59	0.30
78	Z8708_1c	Barisal	Jhalokati	22.55173	90.14478	Alalbarir Khal Bridge	1.75	2.31	2.44	2.64	2.77	2.44	20yr	2.96	2007	2.96	Interview	3.028	1	3.26	3.26	0.30
79	N5_458a	Rangpur	Panchagarh	26.19750	88.55333		55.81	61.30	62.84	64.37	66.93	64.37	50yr	63.41	1988	64.37	50yr	63.910	2	64.67	64.67	0.30
80	N5_480a	Rangpur	Panchagarh	26.45259	88.56027	Chawai Bridge	77.43	79.45	79.91	80.52	80.97	80.52	50yr	80.86	1988	80.86	Interview	81.710	1	81.16	81.71	0.85
81	Z8708_12b	Barisal	Jhalokati	22.48093	90.15608	Boda Bridge	1.85	2.53	2.68	2.89	3.04	2.68	20yr	2.70	2007	2.70	Interview	3.846	1	3.00	3.85	1.15
82	Z8032_017a	Barisal	Barisal	22.77733	90.16790	Rayer hat bridge	1.68	2.36	2.52	2.67	2.88	2.52	20yr	2.81	1988	2.81	Interview	4.179	1	3.11	4.18	1.37
83	R860_34a	Gopalganj	Shariatpur	23.19173	90.42214	Nathar Bridge	3.16	4.52	4.84	5.28	5.60	5.28	50yr	4.24	1988	5.28	50yr	5.187	2	5.58	5.58	0.30
84	R860_44a	Gopalganj	Shariatpur	23.16974	90.48852	Gazipur Bridge	3.22	4.43	4.71	5.05	5.31	5.05	50yr	4.88	1988	5.05	50yr	11.061	3	5.35	11.06	6.02
85	R860_53d	Gopalganj	Shariatpur	23.19181	90.54877	Nalar Bazar Bridge	3.50	4.50	4.74	5.09	5.32	5.09	50yr	5.51	1988	5.51	Interview	6.604	1	5.81	6.60	1.10
86	N8_69a	Gopalganj	Madaripur	23.38619	89.98333	Kumar Bridge	3.25	5.22	5.68	6.28	6.72	6.28	50yr	6.39	1988	6.39	Interview	12.157	1	6.69	12.16	5.77
87	Z8010_12b	Rajshahi	Rajshahi	24.44441	88.69412	Faisarbil Bridge	12.94	14.87	15.31	15.92	16.37	15.31	20yr	13.84	1998	15.31	20yr	15.080	2	15.61	15.61	0.30
88	Z5006_1a	Rangpur	Dinajpur	25.86823	88.66274	Choto Dhepa bridge	40.50	43.50	44.20	45.09	45.75	44.20	20yr	42.99	1988	44.20	20yr	43.685	3	44.50	44.50	0.30
89	Z5024_6c	Rangpur	Rangpur	25.69610	89.12868	Shampur Bridge	30.10	32.09	32.56	33.20	33.65	32.56	20yr	33.09	1988	33.09	Interview	33.577	1	33.39	33.58	0.49
90	Z5025_46a	Rangpur	Dinajpur	25.66035	88.84279	Bombarer pool Bridge	34.60	37.00	37.53	38.06	38.68	37.53	20yr	36.56	1988	37.53	20yr	36.837	3	37.83	37.83	0.30
91	Z5040_4a	Rangpur	Bogra	24.79717	89.42718	Khottapara Bridge	13.49	15.79	16.32	17.01	17.52	16.32	20yr	15.73	1988	16.32	20yr	16.555	2	16.62	16.62	0.30
92	Z8510_13a	Barisal	Barisal	22.45972	90.27722	Banogram Bridge	1.79	2.60	2.79	3.04	3.23	2.79	20yr	3.25	2007	3.25	Interview	5.787	1	3.55	5.79	2.53
93	R565_80a	Rangpur	Dinajpur	25.54303	88.83569	Bhela Bridge	29.80	32.03	32.52	32.96	33.48	32.96	50yr	32.36	1988	32.96	50yr	32.310	2	33.26	33.26	0.30
94	Z8033_028a	Barisal	Barisal	22.78109	90.25389	Kalara bridge	1.72	2.49	2.67	2.90	3.08	2.67	20yr	4.44	2007	4.44	Interview	6.409	1	4.74	6.41	1.67
95	Z8033_019a	Barisal	Barisal	22.77402	90.15490	Masrong bridge	1.67	2.33	2.49	2.69	2.76	2.49	20yr	2.80	2007	2.80	Interview	2.687	1	3.10	3.10	0.30
96	Z8034_021a	Barisal	Barisal	22.83763	90.37638	Padamat bridge	2.03	2.90	3.10	3.36	3.56	3.10	20yr	3.30	1988	3.30	Interview	3.803	1	3.60	3.80	0.59
97	Z5044_004a	Barisal	Barisal	22.66268	90.41371	Talukdarhat Bailey Bridge	1.88	2.37	2.52	2.67	2.73	2.52	20yr	2.19	1988	2.52	20yr	3.602	2	2.82	3.60	1.06
99	R860_35a	Gopalganj	Shariatpur	23.19230	90.43252	Shajanpur Bailey Bridge	3.20	4.51	4.82	5.26	5.57	5.26	50yr	4.77	1988	5.26	50yr	6.327	2	5.56	6.33	1.06
100	Z5041_2a	Rajshahi	Serajganj	24.48767	89.48966	Debokbazar Bridge	10.99	13.76	14.39	15.11	15.71	14.39	20yr	14.63	1988	14.63	Interview	14.269	1	14.93	14.93	0.30
101	N706_14b	Khulna	Jessore	23.10002	89.09856	Jhikorgacha Bridge	2.65	4.68	5.16	5.77	6.23	5.77	50yr	3.77	2000	5.77	50yr	4.790	3	6.07	6.07	0.30
102	N5_435a	Rangpur	Thakurgaon	26.01972	88.46917		48.28	49.59	49.90	50.07	50.58	50.07	50yr	52.76	1988	52.76	Interview	52.497	1	53.06	53.06	0.30
103	N704_12c	Khulna	Jhenaidah	23.65560	89.19864	Chandi Pur Bridge	5.19	7.76	8.36	9.21	9.80	9.21	50yr	6.93	?	9.21	50yr	9.834	2	9.51	9.83	0.62
104	N805_24a	Gopalganj	Gopalganj	23.28778	89.81083	Garakola Bridge	2.55	4.87	5.40	6.07	6.59	6.07	50yr	5.73	1988	6.07	50yr	8.691	3	6.37	8.69	2.62
105	R750_25a	Khulna	Narail	23.16694	89.44167	Tularampur Bridge	2.18	3.57	3.89	4.30	4.61	4.30	50yr	3.39	1971	4.30	50yr	5.704	3	4.60	5.70	1.40
106	Z7503_5a	Khulna	Narail	23.18000	89.55861	Nawai khal Bridge	2.39	4.20	4.62	5.10	5.60	5.10	50yr	6.03	1971	6.03	Interview	5.761	1	6.33	6.33	0.30

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: JICA Survey Team

2) Standard High Water Level (SHWL)

Standard High Water Level (SHWL) is known as the overhead clearance datum which will rarely be exceeded. SHWL at stations near proposed bridges, have been determined by BIWTA (Inland Waterways of Bangladesh, 1991). SHWL at the stations and one of the proposed bridges are shown in the following Tables.

Table 4.3.15 Standard High Water Level at proposed Bridges (in meters)

No.	Bridge Name	River Name	Downstream Station Name	Distance from Downstream Station(km)	Upstream Station Name	Distance to Upstream Station(km)	SHWL	
							(m,PWD)	(m,MSL)
28	Atrai rly	Atrai	Atrai rly Bridge	0.0	-	-	14.30	13.84

Source: JICA Survey Team

Table 4.3.16 Standard High and Low Water Level at Stations (in meters above PWD)

SL No.	Station Name	River Name	Longitude (X)	Latitude (Y)	Station Number	SLWL (m)	SHWL (m)	Observed Years	Remarks
8	Atrai rly. Bridge	Atrai	88.9770	24.6110	147	7.83	14.30	4	
45	Demra	Lakhya	90.5101	23.7217	179	0.73	6.65	9	
52	Ghorashal	Lakhya	90.6199	23.9384	3240	0.76	6.88	10	
93	Lakhpur	Lakhya	90.6534	24.0397	177	0.81	8.50	7	

Note: Standard High Water Level (SHWL) is Fortnightly Mean Water Level (FML) with 5% exceedance, and Standard Low Water Level (SLWL) is FML with 95% exceedance. The difference between MSL (Mean Sea Level) and PWD (Public Works Datum) is 46cm.

Source: JICA Survey Team

(3) Estimation of Probable Maximum Discharge

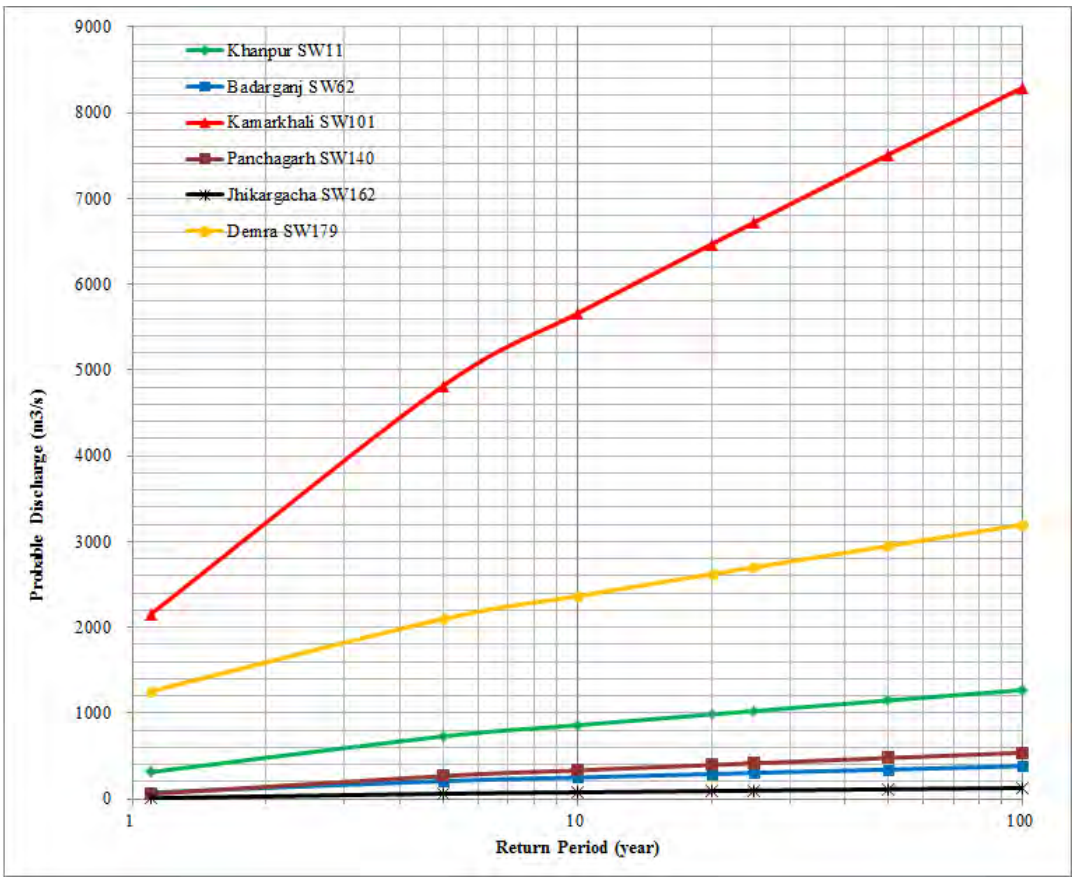
Probable maximum discharge is estimated using the same method used to calculate the HFL, based on annual maximum records at stations. The extreme value (annual maximum discharge) is collected for 6 gauging stations. The calculated probable discharges at each station are shown in Table 4.3.17, and the correlation between the return period of flood and the maximum discharge is shown in Figure 4.3.16. From the correlation seen in this figure, we can see that there is a large difference between the "specific discharges" (a ratio of the flow rate to the catchment area) of each gauging station, regardless of the low-lying rivers.

In this study, the maximum discharge estimated here is only used as reference. The reason for this is that, due to the many tributary and distributary systems in Bangladesh's rivers, the true boundaries of the catchment area and the system itself are difficult to define. Further detailed study is needed for accurate estimation of the discharge. Hence, the estimation of maximum discharge at proposed bridges will require much time and effort.

Table 4.3.17 Estimation of Probable Maximum Discharge each Gauging Station

River / Station Name, Station No.			Longitude (X)	Latitude (Y)	Catchment Area (km^2)	No. in sample	Collected year	Mean	Std. Deviation σ_{n-1}	Discharge each Return Period (year) (m^3/s)							Remarks
										1.1	5	10	20	25	50	100	
										K_T							
										-1.132	0.719	1.305	1.866	2.044	2.592	3.137	
< Discharge >																	
Bangali	Khanpur	SW11	89.4781	24.6197	1,100	26	1985-2011	567.676	224.040	314.1	728.9	860.0	985.7	1025.6	1148.5	1270.4	
DCJ Karatoa	Badarganj	SW62	89.0653	25.6749	750	14	1998-2012	156.011	72.155	74.3	207.9	250.1	290.6	303.5	343.1	382.3	
Gorai-Madhumoti	Kamarkhali	SW101	89.5427	23.5315	4,568	25	1983-2012	3782.338	1438.417	2154.1	4817.2	5658.8	6466.2	6722.2	7511.1	8294.2	
Karatoa-Atrai-GGH	Panchagarh	SW140	88.547	26.3295	1,267	31	1982-2012	186.219	112.302	59.1	267.0	332.7	395.8	415.7	477.3	538.5	
Kobadak	Jhikargacha	SW162	89.0994	23.1011	800	19	1982-2011	40.704	27.706	9.3	60.6	76.8	92.4	97.3	112.5	127.6	
Lakhya	Demra	SW179	90.5101	23.7217	1,500	33	1973-2011	1771.851	454.634	1257.2	2098.9	2364.9	2620.1	2701.1	2950.4	3197.9	
										1257.2	(2197.0)	(2350.0)	(2456.0)	(2484.0)	(2553.0)	(2605.0)	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 4.3.16 Correlation between the Flood Return Period and the Maximum Discharge each Gauging Station

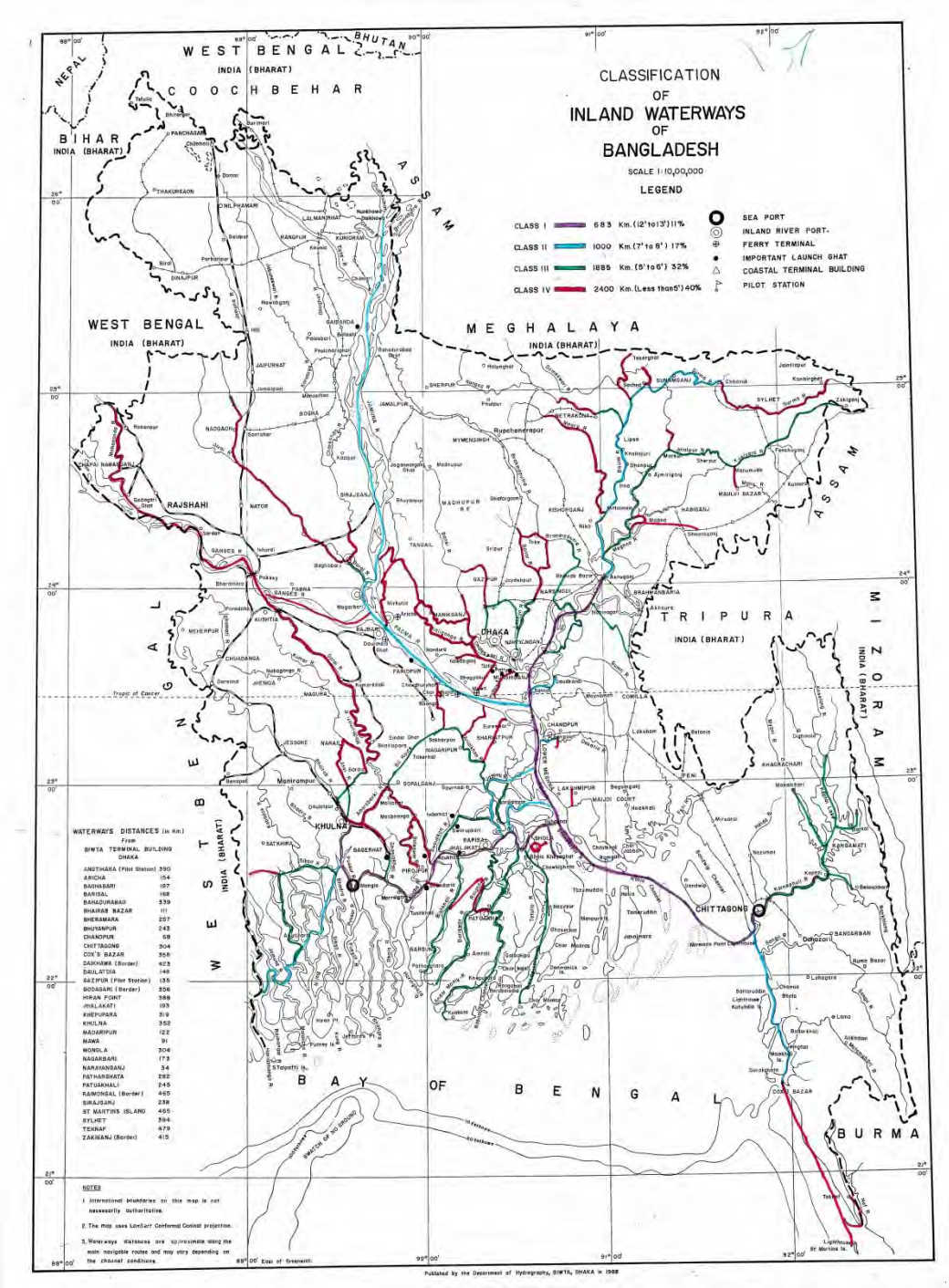
4.3.4 Navigation Clearance

BIWTA has specified the minimum vertical and horizontal clearance for free navigation, in consideration of the type of navigational routes (classified as Class I through Class IV as given in Table 4.3.18 Fairway Limitation in Bangladesh). According to Classification of BIWTA, the river passing under Atrai Bridge (R548_28b) is classified as Class IV.

Table 4.3.18 Fairway Limitation in Bangladesh

Classification of Waterways	Minimum Vertical Clearance	Minimum Horizontal Clearance	Remarks
Class-I	18.30m	76.22m	
Class-II	12.20m	76.22m	
Class-III	7.62m	30.48m	
Class-IV Including seasonal rivers	5.00m	20.00m	Atrai River (Atrai bridge)

Source: BIWTA, 1991



Source: BIWTA

Figure 4.3.17 (Official) Navigation Channel in Bangladesh

4.4 Climate Change

4.4.1 Introduction

Bangladesh is a low-lying deltaic country in South Asia formed by the Ganges (Padma), the Brahmaputra (Jamuna) and the Meghna rivers and their respective tributaries (GBM basin). The country has been suffering from various types of major natural disasters like floods, cyclones, storm-surges, tidal bores, river bank erosion, salinity intrusion and drought etc. Due to its geophysical setting, the country is extremely vulnerable to climate change. With the increase of precipitation and rising sea levels, the devastation caused by monsoon flooding is expected to escalate. (Impact Assessment of Climate Change and Sea Level Rise on Monsoon Flooding, November 2008, Climate Change Cell, Bangladesh).

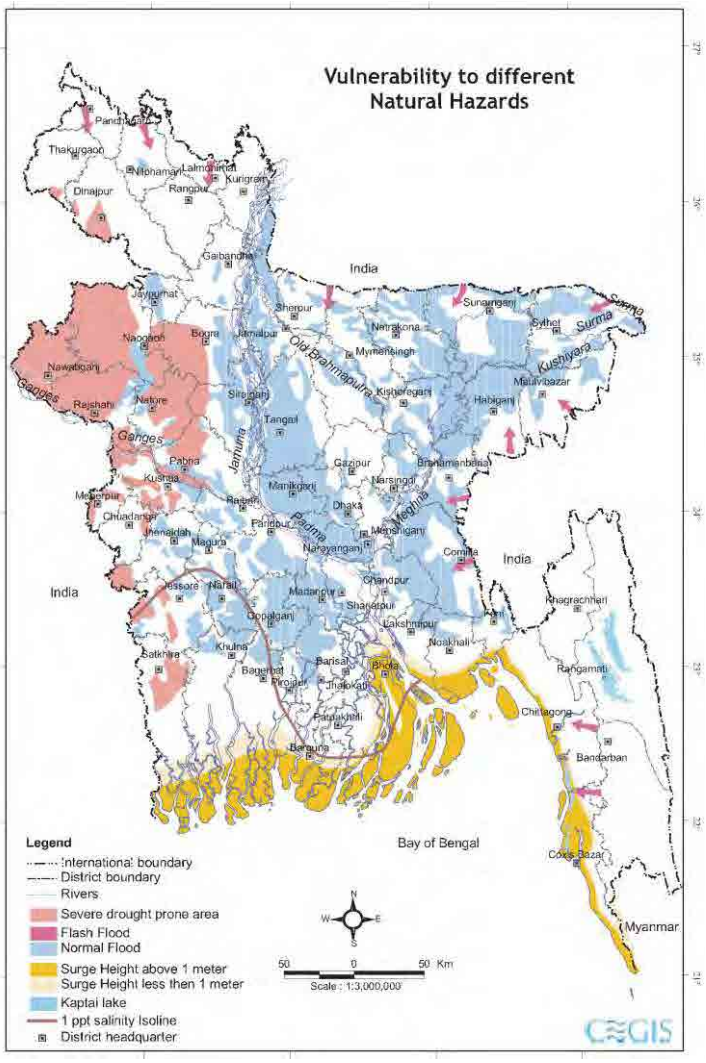


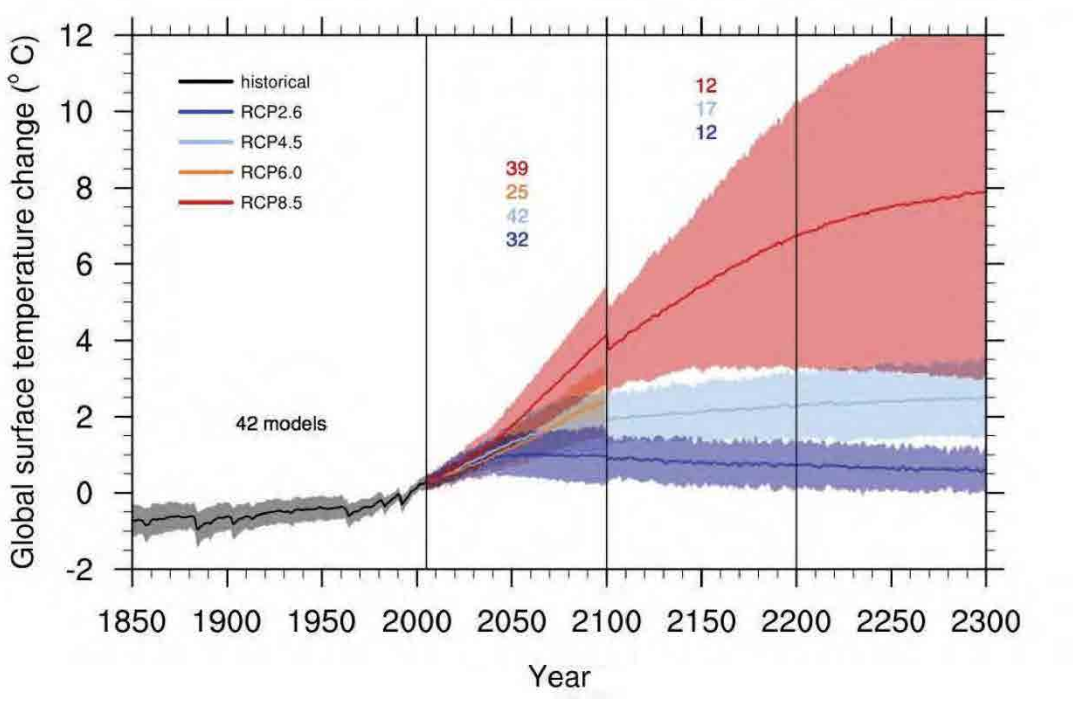
Figure 4.4.1 Areas Affected by Different Types of Climate-related Disaster,

Figure 4.4.1 shows the areas affected by different types of climate-related disasters. The northwestern areas including Rangpur and Rajshahi are so-far relatively unscathed from the effects of flooding, but southwestern areas have already begun to feels the effects of salinity

(source: CEGIS Dhaka, Bangladesh Climate Change Strategy and Action Plan, 2009).

4.4.2 Temperature Change

The final draft Report, dated 7 June 2013, of the Working Group I contribution to the IPCC (Intergovernmental Panel on Climate Change) 5th Assessment Report "Climate Change 2013" explained that global mean temperature will continue to rise over the 21st century if greenhouse gas emissions continue unabated. Figure 4.4.2 shows the projections of global surface temperature change (°C) for varying RCP (Representative Concentration Pathways), with the projected temperature change by 2100 ranging from 0.3°C to 5.0°C.

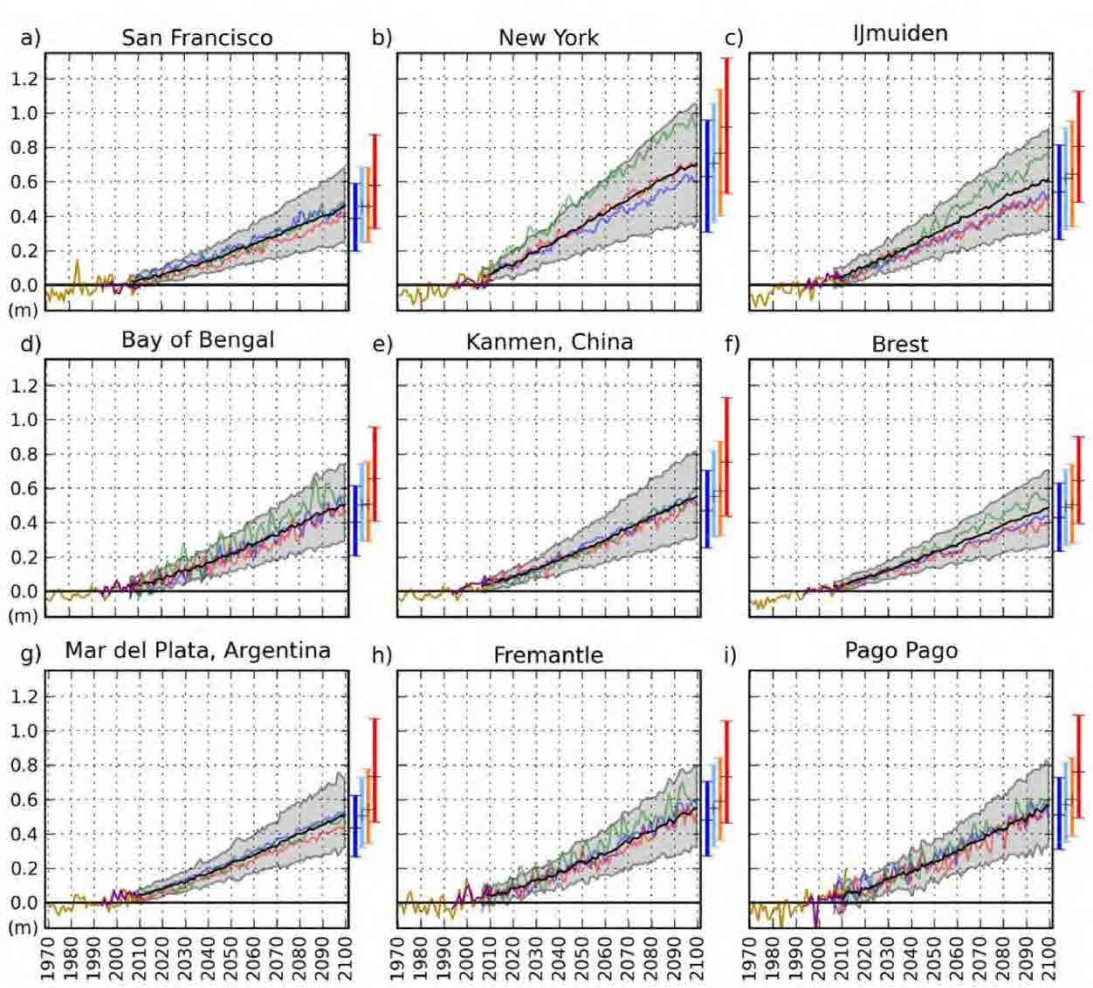


Source: IPCC WGI 5th Assessment Report)

Figure 4.4.2 Global Surface Temperature Change

4.4.3 Sea Level Change

Figure 4.4.3 (also in accordance with the final draft report of IPCC WGI 5th Assessment Report) shows observed and projected relative net sea level change near nine representative coastal locations for which tide-gauge measurements and satellite records are available. Vertical bars on the right side of each panel represent ensemble spread of sea level change by the year 2100 inferred from the four RCPs 2.6 (dark blue), 4.5 (light blue), 6.0 (yellow), and 8.5 (red). In Bay of Bengal sea level rise is projected range of 0.2m to 0.98m.



Source: IPCC WGI 5th Assessment Report

Figure 4.4.3 Observed and Projected Relative Net Sea Level Change

4.4.4 Impact of Sea Level Change

(1) Water Level and Inundation

The studies of river water level and inundation due to sea level rise were carried out in "Impact Assessment of Climate Changes on the Coastal Zone of Bangladesh (IACCCZB)" by WARPO in 2005 and in Padma Multipurpose Bridge Design Project (PMBDP) in 2010. The result of IACCCZB shows water level along the Shahbazpur channel (Figure 4.4.4) in the case of a 0.88m-sea level rise.

Table 4.4.1 shows the predicted water levels for differing scenarios of sea level rise (0.26m, 0.60m, 0.88m and 1.00m). In the case of a sea level rise of 0.98m, a rise of water level of around 0.2m is projected at the confluence of Padma and Jamuna river, and water is not predicted to rise near Jamuna Bridge (at Bahadurabad).

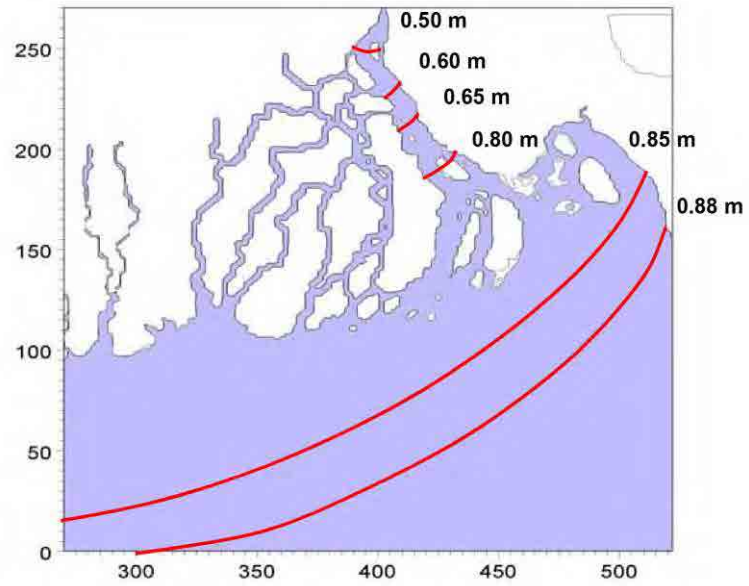


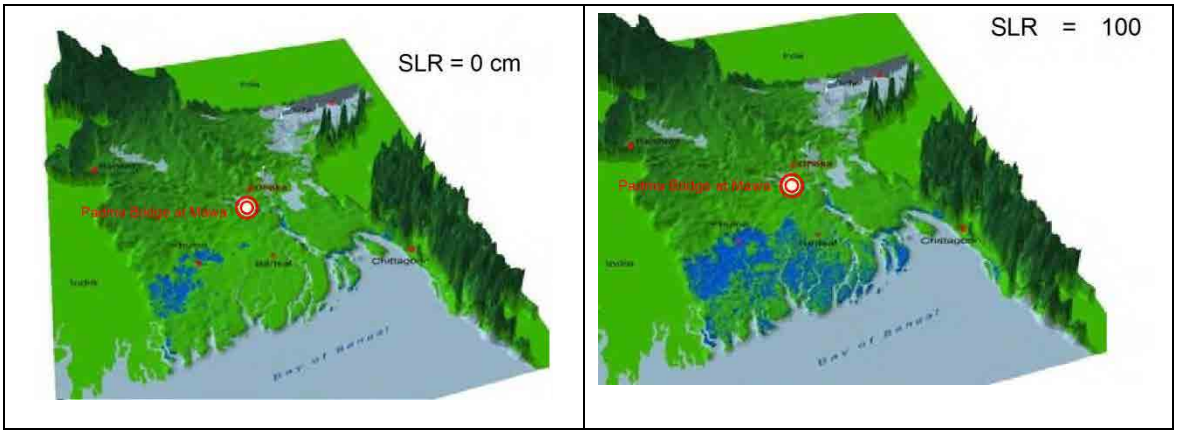
Figure 4.4.4 Increase in Water Level in Meghna Estuary due to 88 cm Sea Level Rise

Table 4.4.1 Propagation of Sea Level into the River and Estuary Region Including the Change in Water Level at Various Locations

Distance from the outer most boundary of SLR in estuary (Km)[8]	Sea Level Rise (SLR in m)			
	0.88	1.00	0.60	0.26
	Rise in water level due to SLR (m, PWD)			
26 (Doulat khan)	0.85	0.96	0.55	0.19
105	0.80	0.90	0.52	0.18
131	0.65	0.73	0.42	0.15
149	0.60	0.68	0.39	0.14
168 (Chandpur)	0.50	0.56	0.33	0.11
240 (Padma Bridge)	**0.42**	**0.47**	**0.27**	**0.09**

Source: PMBDP

Figure 4.4.5 shows the simulation of water level rise and its propagation into inland areas due to a sea level rise of 1.00m, and in this case the coastal area is affected widely.

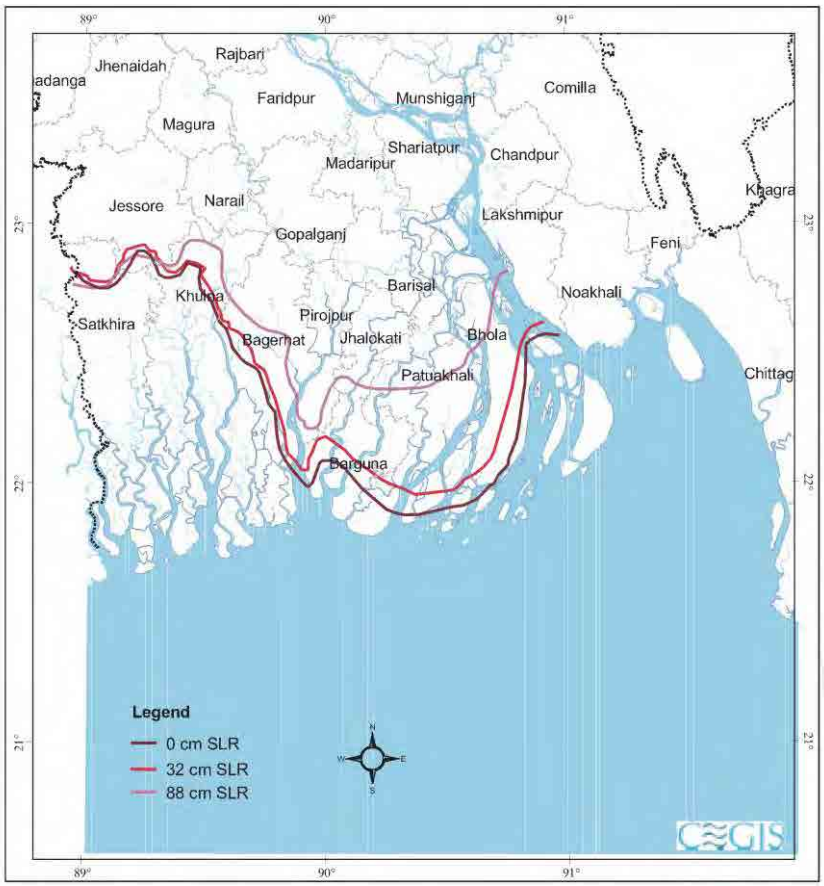


Source: PMBDP

Figure 4.4.5 Simulation of Sea Level Rise

(2) Intrusion of Saline Water

Sea level rise leads saline water intrusion up coastal rivers. Figure 4.4.6 shows salinity ingress in southern coastal areas due to differing sea level rise projections by CEGIS.



Source: BCCSAP, Original source: CEGIS

Figure 4.4.6 Likely Salinity Ingress in Southern Coastal Areas due to Different Sea Level Rise

4.4.5 Impact of Precipitation Projection

In the IACCSLRMF report (2008), inflow in the major rivers was generated using calibrated GBM basin model by increasing the precipitation by 13% (under A1F1 scenario; very high emission) in accordance with the 4th IPCC prediction to establish flood level during monsoon in 2040. Increase of peak flood level was calculated as about 37cm in a moderate flood event (2004 flood event) and 27cm in a normal flood event (2005 flood event) at Bahadurabad in the Jamuna river.

Table 4.4.2 shows the temperature and precipitation projections by the CMIP5 global models (scenario RCP4.5). The peak flood levels are predicted based on hypothesis of proportion of precipitation increasing percentile between 4th IPCC predictions and CMIP5 ones. In case of precipitation increasing percentile 33% in max in JJA of 2065 and 37% in 2100 the peak flood level at Bahadurabad in the Jamuna River are calculated as 94cm and 105cm respectively.

Table 4.4.2 Temperature and Precipitation Projections by the CMIP5 Global Models

RCP4.5			Temperature (°C)					Precipitaion (%)				
REGION	MONTH[a]	Year	min	25%	50%	75%	max	min	25%	50%	75%	max
South Asia	DJF	2035	0.1	0.7	1.0	1.1	1.4	–18	–6	–1	4	8
		2065	0.6	1.6	1.8	2.3	2.6	–17	–3	4	7	13
		2100	1.4	2.0	2.3	3.0	3.7	–14	0	8	14	28
	JJA	2035	0.3	0.6	0.7	0.9	1.3	–3	2	3	6	9
		2065	0.9	1.1	1.3	1.7	2.6	–3	5	7	11	33
		2100	0.7	1.4	1.7	2.2	3.3	–7	8	10	13	37
	Annual	2035	0.2	0.7	0.8	1.0	1.3	–2	1	3	4	7
		2065	0.8	1.4	1.6	1.9	2.5	–2	3	7	9	26
		2100	1.3	1.7	2.1	2.7	3.5	–3	6	10	12	27

5. TRAFFIC DEMAND FORECAST

5.1 Introduction

This chapter outlines the forecast of future traffic volume on the 105 Project bridges[1] (whose selection is detailed in "Chapter 3 Selection of Project Bridges"). National OD and network data prepared for the National Road Master Plan in 2009 was considered for use in the forecast, as data had not updated since the report's completion, but this data was difficult to apply to the Project. Therefore, the growth rate of traffic indicators was used to forecast future traffic demand, and traffic demand induced by large scale developments in western Bangladesh were considered. This chapter summarizes the traffic indicators used for traffic demand forecast, large scale development plans, and the results of the traffic demand forecast. (The target year of traffic demand forecast is 2031, 10 years of construction, in accordance with RHD standards.)

5.2 Traffic Demand Forecast Methodology

5.2.1 Current Traffic Volume

(1) Current Traffic Volume on Selected Bridges

24-hour traffic count surveys were conducted from February 2014 to March 2014 to understand the current traffic volume. Current Traffic Volume on selected bridges is shown in Table 5.2.1 and Table 5.2.2.

[1] Although 106 candidate bridges were selected (as shown in Chapter 3), 1 bridge was found to be under construction in another project, so the number of bridges for preliminary design was reduced to 105.

Table 5.2.1 24 Hour Traffic Volume (vehicle/day) (1)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Truck	Bus	Minibus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total
2		N509_19a	Sharnamoti Bridge		231	92	110	169	61	1,027	1,485	3,175
6		N5_235a	Mohosthan Bridge		4,800	3,039	1,473	1,288	907	3,912	1,996	17,415
10		N5_265a	Bupinath Bridge		2,628	1,863	727	555	568	1,541	1,705	9,587
11		N5_350b	Barati Bridge		891	680	359	468	297	373	1,563	4,631
24		N5_356a	Nangtichara (Taraganj) Bridge		891	680	359	468	297	373	1,563	4,631
31		N5_378a	Gaudangi Bridge		827	449	398	422	307	1	1,601	4,005
36		N5_188a	Ghogar Bridge		6,183	4,250	1,820	1,322	1,586	1,738	1,649	18,548
38		N518_4a	Khorkhori bridge	National Road	827	449	398	422	307	1	1,601	4,005
45		N5_344c	Kharobaj Bridge		891	680	359	468	297	373	1,563	4,631
46		N5_382a	Ichamoti Bridge		827	449	398	422	307	1	1,601	4,005
47		N5_360a	Chikli Bridge		891	680	359	468	297	373	1,563	4,631
66		N5_260b	Katakhali Bridge		2,628	1,863	727	555	568	1,541	1,705	9,587
79		N5_458a	Pathoraj Bridge		623	223	377	276	130	535	4,453	6,617
80		N5_488a	Chawai Bridge		1,450	132	704	855	454	530	1,779	5,904
102		N5_435a	Sattapir Bridge		1,073	396	470	418	188	306	4,270	7,121
62	Rangpur	R545_115c	Mongle bari kuthibari Bridge		750	260	554	657	480	2,263	2,769	7,733
76		R550_28b	Bottoli Bridge	Regional Road	977	256	622	298	224	718	2,281	5,376
93		R585_80a	Bhela Bridge		1,372	293	685	311	251	169	2,582	5,663
48		Z5025_55a	Kakra Bridge		439	126	277	271	132	33	2,458	3,736
49		Z5025_64a	Gabura Bridge.		439	126	277	271	132	33	2,458	3,736
50		Z5401_45a	Matpara Bridge		881	458	328	319	264	2,720	2,208	7,178
51		Z5072_14a	Bombgara Bridge		373	2	20	15	70	917	1,321	2,718
52		Z5025_60a	Madarganj Bridge		439	126	277	271	132	33	2,458	3,736
53		Z5472_6a	Rakhta Dha Bridge		-	-	7	4	12	67	129	219
55		Z5552_10a	Barodia Khali Bridge		224	52	172	292	99	1,351	2,028	4,218
59		Z5015_22a	Bahagili Bridge	Zilla Road	77	20	42	63	21	82	1,146	1,451
60		Z5701_1a	Anandababur Pool		187	34	100	167	28	563	2,850	3,929
61		Z5701_9a	Duhuli Bridge		96	24	101	236	39	662	1,441	2,599
88		Z5008_1a	Choto Dhepa bridge.		214	65	256	163	140	84	3,312	4,234
89		Z5024_5c	Shampur Bridge.		224	1	73	67	61	-	790	1,216
90		Z5025_46a	Bondorer pool Bridge		458	17	236	253	176	477	2,014	3,631
91		Z5040_4a	Khottapara Bridge		446	2	11	29	18	2,339	569	3,414
3		N5_119a	Chanda Bridge		1,332	942	743	540	518	1,388	835	6,298
4		N5_127a	Palgari Bridge		1,332	942	743	540	518	1,388	835	6,298
5		N5_176a	Bhuyagati Bridge		5,029	2,751	1,410	1,320	1,021	1,980	1,146	14,657
7		N5_120a	Chanda Bridge		1,332	942	743	540	518	1,388	835	6,298
8		N5_128a	Goilhar Bridge		1,458	512	322	326	482	1,845	1,999	6,944
9		N5_158a	Purbodalua Bridge		2,078	947	820	935	474	2,238	1,171	8,663
16		N5_134a	Nukali Bridge		1,458	512	322	326	482	1,845	1,999	6,944
17		N6_97a	Dattapara Bridge		3,407	1,138	677	642	383	1,512	2,790	10,549
19		N5_140a	Jugnidaha Bridge	National Road	1,458	512	322	326	482	1,845	1,999	6,944
20		N5_118a	Punduria Bridge		1,332	942	743	540	518	1,388	835	6,298
27	Rajshahi	N505_2a	Kazir Hat Bridge		81	3	43	26	16	286	537	992
33		N5_156a	Chowkidhoh Bridge		2,078	947	820	935	474	2,238	1,171	8,663
34		N5_172a	Notun Dhoh Bridge		5,029	2,751	1,410	1,320	1,021	1,980	1,146	14,657
35		N5_179a	Dhatia Bridge		6,183	4,250	1,820	1,322	1,586	1,738	1,649	18,548
37		N5_126a	Vitapara Bridge		1,332	942	743	540	518	1,388	835	6,298
54		N5xx_Sa	Pura Mukto Monch Bridge		2,078	947	820	935	474	2,238	1,171	8,663
18		R681_10a	Horisonkorpur Bridge		167	12	35	46	12	310	695	1,277
28		R548_28b	Atrai Bridge		219	-	104	274	104	370	1,928	2,999
73		R548_40a	Mohis Mari Bridge	Regional Road	190	134	198	294	39	662	1,212	2,729
74		R451_1a	Naiori Bridge		1,510	761	1,241	1,269	882	3,565	1,640	10,868
75		R451_7a	Chondi Das Bridge		1,510	761	1,241	1,269	882	3,565	1,640	10,868

*:SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: Traffic Count Survey Result 2014, JICA Survey Team

Table 5.2.2 24 Hour Traffic Volume (vehicle/day) (2)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Truck	Bus	Minibus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total
87	Rajshahi	Z6010_12b	Faliarbil Bridge	Zilla Road	185	-	18	63	11	392	754	1,423
100		Z5041_2a	Debokbazar Bridge		362	31	205	208	68	893	863	2,630
1	Barisal	N8_178a	Boalia Bazar Bridge	National Road	1,556	1,076	1,504	1,859	1,150	1,510	3,473	12,128
12		N8_182a	Bakerganj Steel Bridge		1,556	1,076	1,504	1,859	1,150	1,510	3,473	12,128
26		N8_095a	Amgram bridge		965	904	596	590	305	795	1,232	5,387
56		N8_152c	Rahamatpur bridge		1,034	1,167	520	557	253	1,548	2,967	8,046
57		N8_127b	gounagata bridge		796	939	459	295	199	1,369	2,452	6,509
64		N8_123a	Souderkhal bridge		796	939	459	295	199	1,369	2,452	6,509
69		N8_129a	Asokoti bridge		796	939	459	295	199	1,369	2,452	6,509
86		N8_69a	Kumar Bridge		1,683	1,165	1,250	1,273	409	3,037	2,692	11,509
104		N805_24a	Garakola Bridge		2,335	1,427	1,549	1,116	936	725	1,429	9,517
42		R890_45a	Dowry Bridge	Regional Road	1,596	975	1,166	1,590	771	1,460	2,514	10,072
70		R890_16a	Bangla Bazar Bridge		495	235	255	286	220	354	1,467	3,312
71		R890_21a	Boksheali Bridge		495	235	255	286	220	354	1,467	3,312
72		R890_28a	Sheyali Bailey Bridge		495	235	255	286	220	354	1,467	3,312
77		R860_31a	Paprail Bailey Bridge		498	96	286	306	161	773	754	2,874
83		R860_34a	Jajihar Bridge		498	96	286	306	161	773	754	2,874
84		R860_44c	Gazipur Bridge		498	96	286	306	161	773	754	2,874
85		R860_53d	Balar Bazar Bridge		498	96	286	306	161	773	754	2,874
99		R860_35a	Shajonpur Bailey Bridge		498	96	286	306	161	773	754	2,874
58		Z8052_009d	Gabtala Steel Bridge	Zilla Road	155	50	294	239	177	465	2,147	3,527
65		Z8701_3d	Bottala Bridge		230	175	149	228	159	669	1,346	2,956
78		Z8708_1c	Algy Bridge		3	2	26	20	13	389	963	1,416
81		Z8708_12b	Satani Bridge		235	-	135	216	236	333	1,653	2,808
82		Z8033_017a	Raiyer hat bridge		169	641	108	253	127	1,934	1,500	4,732
92		Z8810_13a	Madhabkhali bridge		155	50	294	239	177	465	2,147	3,527
94		Z8033_008a	Kalijira bridge		112	134	178	255	86	1,460	1,046	3,271
95		Z8033_019a	Masrong bridge		351	759	589	508	260	827	1,341	4,635
96		Z8034_011a	Padarhat bridge		45	106	27	110	48	10	2,900	3,246
97		Z8044_004a	Talukdarhat Bailey Bridge		317	8	456	232	146	234	2,973	4,366
13	Khulna	N7_025a	Jhuldibazar Bridge	National Road	2,799	1,352	307	483	561	664	1,472	7,638
14		N7_039a	Karimpur Bridge		1,942	1,214	400	650	296	552	1,394	6,448
15		N7_049a	Porkitpur Bridge		1,984	1,202	394	728	330	669	1,067	6,374
21		N704_43a	Khulna-Kushtia-Churash Bridge		6,577	2,124	1,717	1,269	939	4,796	5,358	22,780
22		N7_248c	Gora bridge		1,322	205	374	324	224	258	1,229	3,936
23		N7_054a	Barashia Bridge		1,984	1,202	394	728	330	669	1,067	6,374
25		N7_246a	Balai bridge.		1,322	205	374	324	224	258	1,229	3,936
29		N7_036c	Kanaipur Bridge		1,942	1,214	400	650	296	552	1,394	6,448
30		N7_048a	Brahmonkanda Bridge		1,984	1,202	394	728	330	669	1,067	6,374
32		N7_047a	Bimankanda bridge		1,984	1,202	394	728	330	669	1,067	6,374
39		N7_141b	Buri Bhairab Bridge		2,797	569	364	612	305	803	1,552	7,002
41		N703_Sd	Dhopa Ghata Bridge		1,373	922	815	758	675	5,794	5,353	15,688
43		N704_14a	Barda Bridge		4,343	1,535	1,385	1,098	828	1,126	1,713	12,028
44		N704_33b	Balipara Bridge		3,761	1,046	709	1,003	544	986	1,417	9,466
67		N704_27b	Bittipara Bridge		3,761	1,046	709	1,003	544	986	1,417	9,466
101		N706_14b	Jhikorgacha Bridge		4,320	1,723	1,302	1,060	1,160	1,647	5,058	16,270
103		N704_12c	Chandi Pur Bridge		4,343	1,535	1,385	1,098	828	1,126	1,713	12,028
40		R720_44a	Gurakhali Bridge	Regional Road	144	65	29	52	35	403	1,157	1,885
63		R760_049c	Shakdaha bridge		1,146	443	160	341	291	649	2,812	5,842
68		R750_22c	Bhangura Bridge		660	587	337	438	267	243	1,196	3,728
105		R750_25a	Tularampur Bridge		660	587	337	438	267	243	1,196	3,728
106		Z7503_5a	Hawai khali Bridge	Zilla Road	1,034	565	701	1,037	473	1,020	2,002	6,832

*1:: Bridge No.98 was excluded from 106 candidate bridges, but it was included to calculate the traffic growth rate

*2:SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: Traffic Count Survey Result 2014, JICA Survey Team

(2) Traffic Volume by Road Class

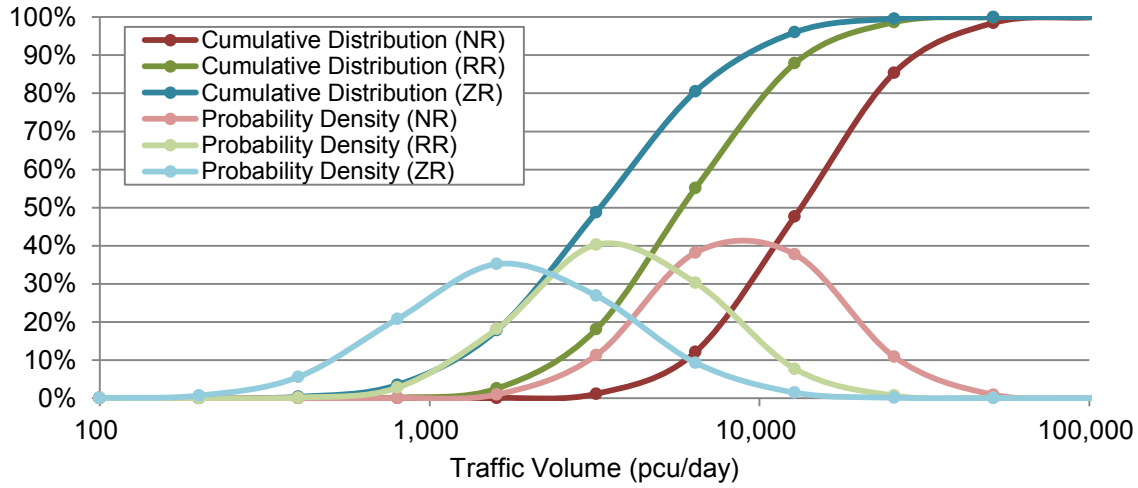
Based on the results of the 2014 traffic count survey and the PCU (Passenger Car Unit) factors shown in Table 5.2.3, the traffic volume characteristics were identified by road class.

Table 5.2.3 PCU Factor

Vehicle Type	PCU Factor
Truck	3.0
Bus	3.0
Minibus	3.0
Utility	1.0
Car	1.0
Auto-Rickshaw	0.75
Motorcycle	0.75

Source: Geometric Design of RHD Roads Ver.4

As a result, trends of cumulative distribution and probability density were identified by road class as shown in Figure 5.2.1.



Source: JICA Study Team made this data based on Traffic Count Survey Result 2014

Figure 5.2.1 Cumulative Distribution and Probability Density by Road Class

Table 5.2.4 lists each the average traffic volume (pcu/day), median (pcu/day), standard deviation, kurtosis[2] and skewness for each road class. The standard deviation was 9,378 for national roads, 4,793 for regional roads, and 2,311 for zilla roads. The kurtosis was negative at -0.06 for regional roads, but positive at 1.60 for national roads, and 2.21 for zilla roads. The skewness was positive for all roads: 1.38 for national roads, 1.05 for regional roads, and 1.19 for zilla roads.

[2] The kurtosis indicates degree of peakedness of cumulative probability distribution and the skewness indicates a measure of the asymmetry of the probability distribution. Both measures are zero for a normal distribution.

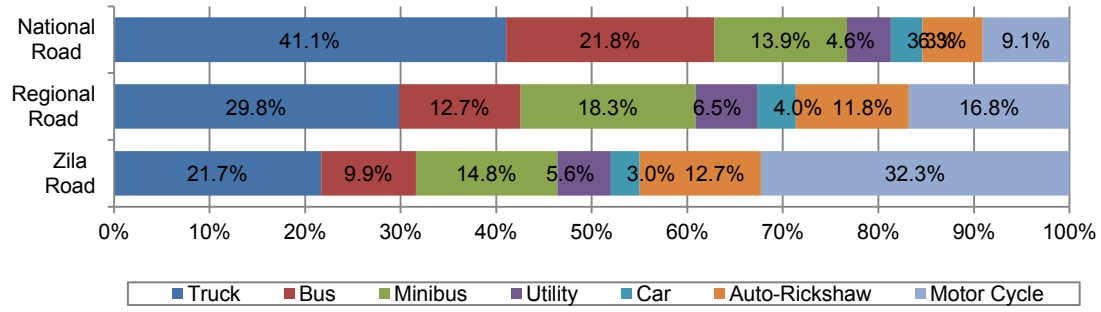
Table 5.2.4 Standard Deviation, Kurtosis and Skewness by Road Class

Items	National Roads	Regional Roads	Zilla Roads
Average Traffic Volume (pcu/day)	15,722	7,214	4,023
Median (pcu/day)	13,074	4,827	3,718
Standard Deviation	9,378	4,793	2,311
Kurtosis	1.60	-0.06	2.21
Skewness	1.38	1.05	1.19

Source: Analysis by JICA Study Team based on Traffic Count Survey Result 2014

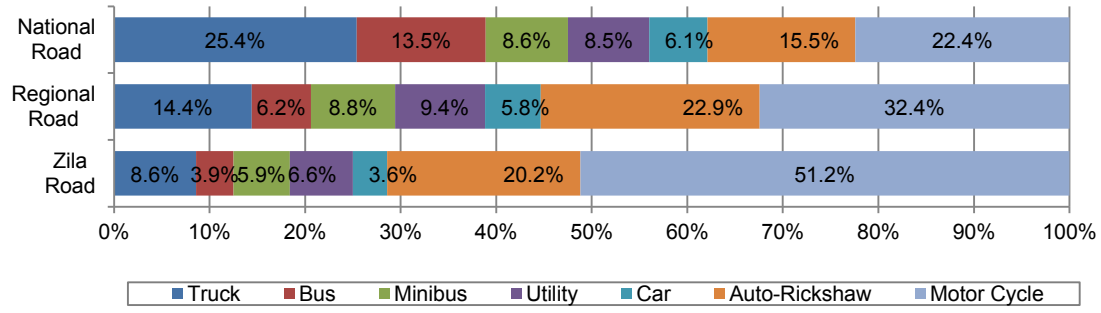
(3) Vehicle Share by Road Class

Using PCU factors specified by RHD (Table 5.2.3) and the results of the above-mentioned traffic count survey, the vehicle share in western Bangladesh was calculated by road class. The results indicate that the road classes have different vehicle-share characteristics. The share of large vehicles (trucks, buses, etc.) increases with increasing road class (ZR, RR, NR), while the share of small vehicles (motorcycles, auto-rickshaws, etc.) decreases. The vehicle share by road class is shown in Figure 5.2.2 and Figure 5.2.3.



Source: JICA Survey Team

Figure 5.2.2 Vehicle Share by Road Class (PCU)



Source: JICA Survey Team

Figure 5.2.3 Vehicle Share by Road Class (Vehicles)

5.2.2 Future Traffic Growth

Past traffic growth rates were applied as traffic indicators in this study. The traffic growth was calculated based on the results attained from preparatory surveys and other surveys conducted by RHD from 2004 to 2011, under the assumption that the traffic growth rate will remain fairly constant until 2031. The annual traffic growth rates in western Bangladesh were found to be 6.25% for national roads, 5.62% for regional roads and 5.15% for zilla roads. It is observed that high-class roads have higher growth rate than low-class roads. The annual number of registered vehicles was also considered for use as a traffic indicator, but it was not selected due to the possibility of a large discrepancy between the number of registered vehicles and the actual number of vehicles on the road.

Table 5.2.5 Recent Traffic Growth

SN	Bridge ID	Name of Bridge	Traffic Volume of Motorized Vehicles (PCU/Day)					Annual Growth Rate	Average Annual Growth Rate
			2007	2008	2009	2011	2014		
14	N7_039a	Karimpur Bridge	–	–	–	4,827	6,448	10.1%	
16	N5_134a	Nukali Bridge	–	–	–	5,624	6,944	7.3%	
17	N6_97a	Dattapara Bridge	–	–	6,845	–	10,549	9.0%	
21	N704_43a	Khulna-Kushtia-Churash Bridge	12,380	–	–	–	22,780	9.1%	
22	N7_248c	Gora bridge	–	–	–	3,510	3,936	3.9%	
26	N8_095a	Amgram bridge	–	–	4,335	–	5,387	4.4%	
34	N5_172a	Notun Dhoh Bridge	–	–	13,873	–	14,657	1.1%	6.25%
46	N5_382a	Ichamoti Bridge	–	–	–	3,253	4,005	7.2%	
56	N8_152c	Rahamatpur bridge	–	–	–	6,338	8,046	8.3%	
57	N8_127b	gounagata bridge	–	–	4,335	–	6,509	8.5%	
66	N5_260b	Katakhali Bridge	–	–	7,471	–	9,587	5.1%	
80	N5_488a	Chawai Bridge	5,091	–	–	–	5,904	2.1%	
101	N706_14b	Jhikorgacha Bridge	11,475	–	–	–	16,270	5.1%	
28	R548_28b	Atrai Bridge	2,752	–	–	–	2,999	1.2%	
40	R720_44a	Gurakhali Bridge	1,404	–	–	–	1,885	4.3%	
62	R545_115c	Mongle bari kuthibari Bridge	6,664	–	–	–	7,733	2.1%	
63	R760_049c	Shakdaha bridge	–	3,349	–	–	5,842	9.7%	
71	R890_21a	Boksheali Bridge	2,840	–	–	–	3,312	2.2%	5.62%
75	R451_7a	Chondi Das Bridge	6,761	–	–	–	10,868	7.0%	
93	R585_80a	Bhela Bridge	–	2,454	–	–	5,663	15.0%	
98	R760_003a	Gollamari bridge	9,828	–	–	–	12,385	3.4%	
50	Z5401_45a	Matpara Bridge	4,849	–	–	–	7,178	5.8%	
55	Z5552_10a	Barodia Khali Bridge	3,555	–	–	–	4,218	2.5%	
58	Z8052_009d	Gabtala Steel Bridge	–	2,640	–	–	3,527	4.9%	
59	Z5015_22a	Bahagili Bridge	–	1,056	–	–	1,451	5.4%	5.15%
87	Z6010_12b	Faliarbil Bridge	–	1,010	–	–	1,423	5.9%	
90	Z5025_46a	Bondorer pool Bridge	3,263	–	–	–	3,631	1.5%	
96	Z8034_011a	Padarhat bridge	1,666	–	–	–	3,246	10.0%	

*1: The traffic growth rate was calculated after the converted by PCU factor due to the difference of vehicle classification in the survey years. The regional growth rate was not adapted to achieve the accuracy

*2:SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges

Source: JICA Survey Team

5.2.3 Adjustment in Consideration of Large Scale Development

Two large-scale development projects, the construction of Padma Bridge and the improvement of AH1 (part of Road Master Plan 2009), are expected to influence traffic demand, so these were both considered in calculations of the traffic demand forecast.

(1) Location of Padma Bridge and Route of AH1

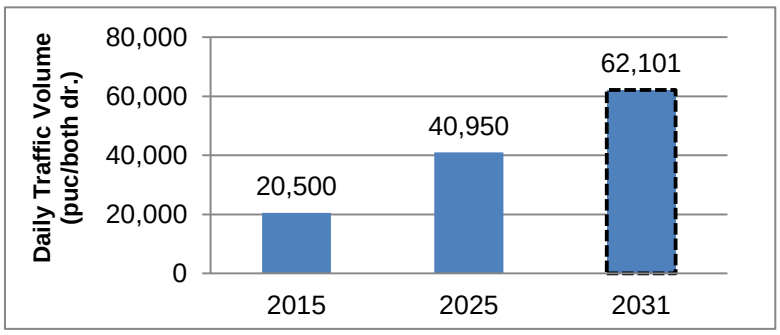
The location of Padma Bridge and the route of AH1 are shown in Figure 5.2.4. After the construction of Padma Bridge, vehicles will be able to move between Dhaka and western Bangladesh/India without the need for a car ferry. In addition, this improved connectivity is expected to induce significant traffic volume on AH1.

Source: JICA Survey Team

Figure 5.2.4 Location of Padma Bridge and Route of AH1

(2) Induced Traffic Volume of Padma Bridge

Induced traffic volume on Padma Bridge in 2031 is forecasted assuming of the continuation of the growth rate from 2015 and 2025 as described in “The Feasibility Study of Padma Bridge in the People’s Republic of Bangladesh 2005, JICA”.



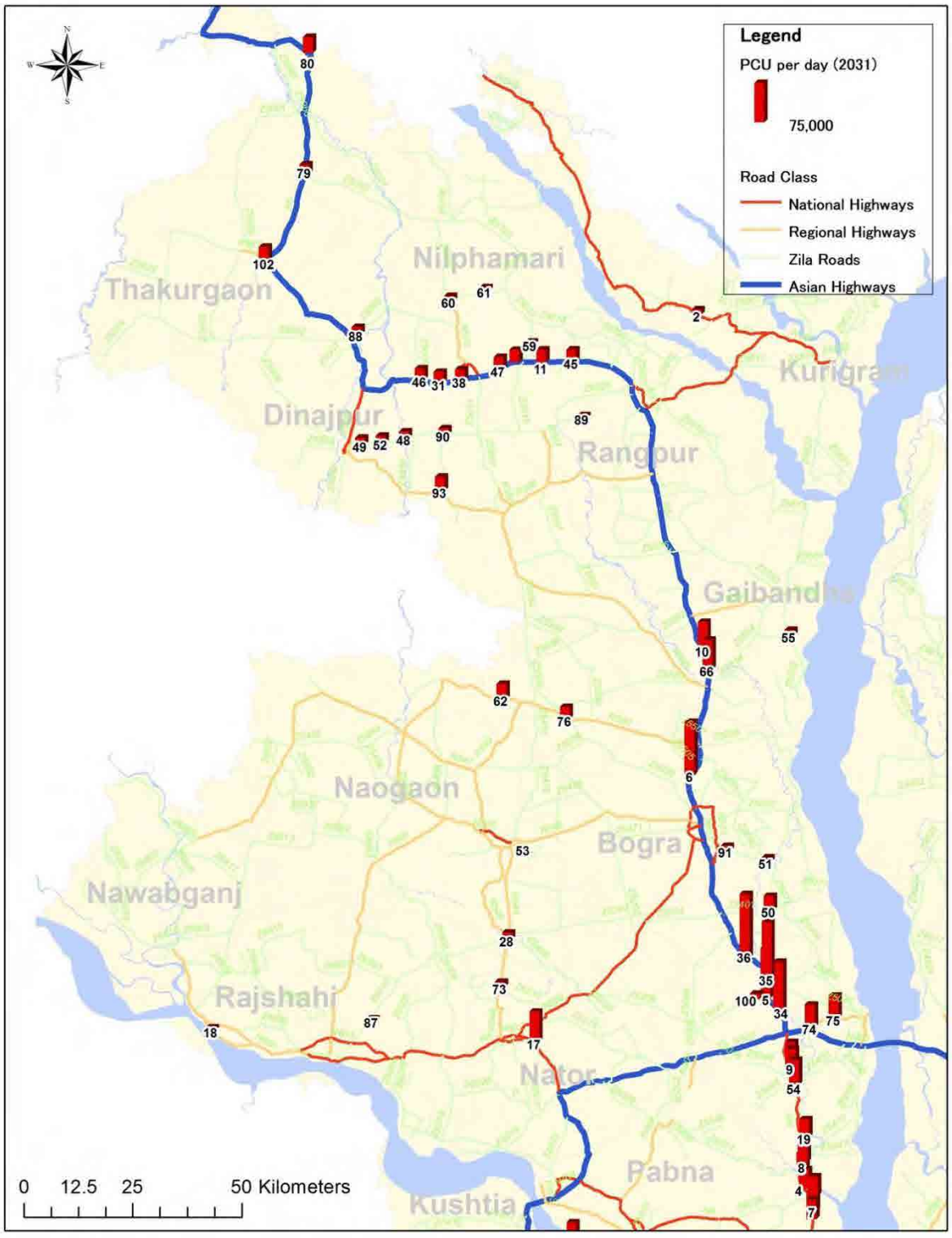
Source: The Feasibility Study of Padma Bridge in the People Republics of Bangladesh, 2005 JICA Study (only 2015 and 2025)

Figure 5.2.5 Projection of Induced Traffic Volume on Padma Bridge

5.3 Result of Traffic Demand Forecast in 2031

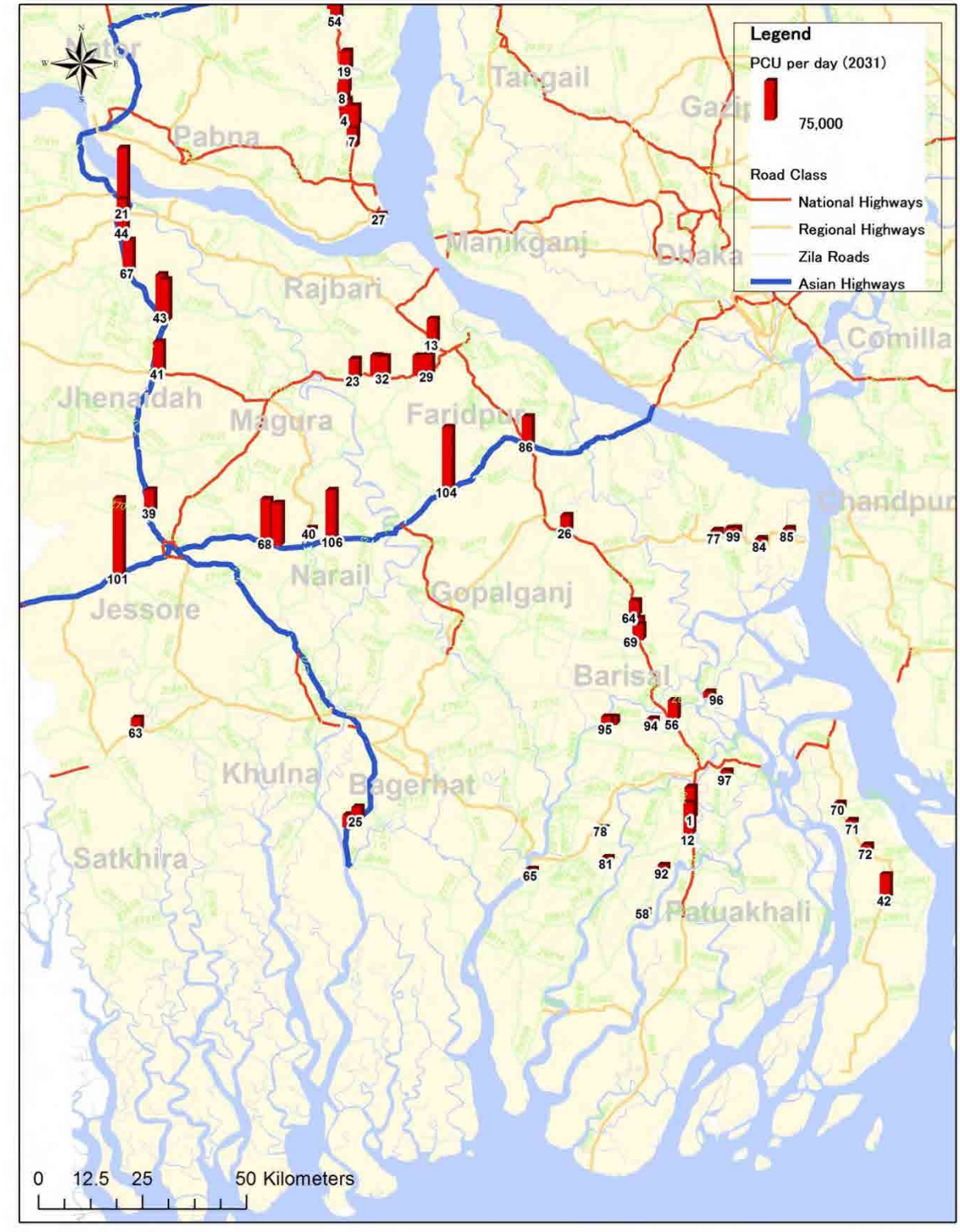
The traffic demand forecast for 2031 is summarized in Figure 5.3.1 and Figure 5.3.2. The estimated peak hourly traffic volume was used in the determination of the required number of lanes. The peak rate was calculated to be 8% for national roads and 10% for both regional roads and zilla roads based on RHD road standards.

As shown in Figure 5.3.1 and Figure 5.3.2, Bangladesh can be divided into 3 parts (eastern Bangladesh, northwestern Bangladesh, and southwestern Bangladesh) by two major rivers: the Padma which divides east and west, and the Jamuna which divides western Bangladesh into north and south. It was predicated that, Asian Highways and national roads will have high peak traffic volume in both directions (north-south and east-west) due to the concentration of vehicles on bridges crossing these rivers.



Note: The number in the map indicates the serial number of the project candidate bridges.
Source: JICA Survey Team

Figure 5.3.1 Result of Traffic Demand Forecast (North area)



Note: The number in the map indicates the serial number of the project candidate bridges.
Source: JICA Survey Team

Figure 5.3.2 Result of Traffic Demand Forecast (South area)

Table 5.3.1 Result of Traffic Demand Forecast (1)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Asian Highway	Induced Traffic	2014	2031			
							Daily Traffic Volume (pcu/day)	Base Traffic Volume (pcu/day)	Induced Traffic (pcu/day)	Daily Traffic Volume (pcu/day)	Peak Hour Traffic Volume (pcu/hr.)
2	Rangpur	N509_19a	Barodia Khali Bridge	National Road			3,487	9,777	-	9,777	782
6		N5_235a	Bahagili Bridge		✓		35,903	100,671	-	100,671	8,054
10		N5_265a	Shakdaha bridge		✓		20,082	56,308	-	56,308	4,505
11		N5_350b	Souderkhal bridge		✓		8,466	23,738	-	23,738	1,899
24		N5_356a	Paprail Bailey Bridge		✓		8,466	23,738	-	23,738	1,899
31		N5_378a	Gazipur Bridge		✓		7,882	22,099	-	22,099	1,768
36		N5_188a	Shampur Bridge.		✓		43,832	122,904	-	122,904	9,832
38		N518_4a	Khottapara Bridge		✓		7,882	22,099	-	22,099	1,768
45		N5_344c	Gollamari bridge		✓		8,466	23,738	-	23,738	1,899
46		N5_382a	Shajonpur Bailey Bridge		✓		7,882	22,099	-	22,099	1,768
47		N5_360a	Debokbazar Bridge		✓		8,466	23,738	-	23,738	1,899
66		N5_260b	Katakhali Bridge		✓		20,082	56,308	-	56,308	4,505
79		N5_458a	Pathoraj Bridge		✓		8,088	22,678	-	22,678	1,814
80		N5_488a	Chawai Bridge		✓		10,904	30,574	-	30,574	2,446
102		N5_435a	Sattapir Bridge		✓		10,383	29,114	-	29,114	2,329
62		R545_115c	Mongle bari kuthibari Bridge	Regional Road			11,493	29,110	-	29,110	2,911
76		R550_28b	Bottoli Bridge				9,269	23,478	-	23,478	2,348
93		R585_80a	Bhela Bridge				10,847	27,475	-	27,475	2,747
48		Z5025_55a	Jhikorgacha Bridge	Zilla Road			5,672	13,317	-	13,317	1,332
49		Z5025_64a	Sattapir Bridge				5,672	13,317	-	13,317	1,332
50		Z5401_45a	Chandi Pur Bridge				11,990	28,149	-	28,149	2,815
51		Z5072_14a	Garakola Bridge				3,423	8,035	-	8,035	803
52		Z5025_60a	Tularampur Bridge				5,672	13,317	-	13,317	1,332
53		Z5472_6a	Hawai khali Bridge				201	472	-	472	47
55		Z5552_10a	Barodia Khali Bridge				4,713	11,065	-	11,065	1,107
59		Z5015_22a	Bahagili Bridge				2,027	4,759	-	4,759	476
60		Z5701_1a	Anandababur Pool				3,872	9,090	-	9,090	909
61		Z5701_9a	Duhuli Bridge				2,725	6,398	-	6,398	640
88		Z5008_1a	Choto Dhepa bridge.				6,017	14,126	-	14,126	1,413
89		Z5024_5c	Shampur Bridge.				1,978	4,643	-	4,643	464
90		Z5025_46a	Bondorer pool Bridge				5,056	11,870	-	11,870	1,187
91		Z5040_4a	Khottapara Bridge				3,716	8,724	-	8,724	872
3	Rajshahi	N5_119a	Rahamatpur bridge	National Road			13,371	37,492	-	37,492	2,999
4		N5_127a	gounagata bridge				13,371	37,492	-	37,492	2,999
5		N5_176a	Gabtala Steel Bridge		✓		34,053	95,482	-	95,482	7,639
7		N5_120a	Anandababur Pool				13,371	37,492	-	37,492	2,999
8		N5_128a	Duhuli Bridge				12,437	34,873	-	34,873	2,790
9		N5_158a	Mongle bari kuthibari Bridge				17,310	48,536	-	48,536	3,883
16		N5_134a	Asokoti bridge				12,437	34,873	-	34,873	2,790
17		N6_97a	Bangla Bazar Bridge				21,033	58,974	-	58,974	4,718
19		N5_140a	Sheyali Bailey Bridge				12,437	34,873	-	34,873	2,790
20		N5_118a	Mohis Mari Bridge				13,371	37,492	-	37,492	2,999
27		N505_2a	Chawai Bridge				2,346	6,579	-	6,579	526
33		N5_156a	Kumar Bridge				17,310	48,536	-	48,536	3,883
34		N5_172a	Faliarbil Bridge		✓		34,053	95,482	-	95,482	7,639
35		N5_179a	Choto Dhepa bridge.		✓		43,832	122,904	-	122,904	9,832
37		N5_126a	Bondorer pool Bridge				13,371	37,492	-	37,492	2,999
54		N5xx_Sa	Pura Mukto Monch Bridge				17,310	48,536	-	48,536	3,883
18		R681_10a	Boksheali Bridge	Regional Road			2,513	6,364	-	6,364	636
28		R548_28b	Satani Bridge				5,298	13,418	-	13,418	1,342
73		R548_40a	Mohis Mari Bridge				4,040	10,232	-	10,232	1,023
74		R451_1a	Naiori Bridge				17,433	44,155	-	44,155	4,415
75		R451_7a	Chondi Das Bridge				17,433	44,155	-	44,155	4,415

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: JICA Survey Team

Table 5.3.2 Result of Traffic Demand Forecast (2)

SN	Zone	Bridge ID	Name of Bridge	Road Class	Asian Highway	Induced Traffic	2014	2031			
							Daily Traffic Volume (pcu/day)	Base Traffic Volume (pcu/day)	Induced Traffic (pcu/day)	Daily Traffic Volume (pcu/day)	Peak Hour Traffic Volume (pcu/hr.)
87	Rajshahi	Z6010_12b	Faliarbil Bridge	Zilla Road			2,004	4,704	-	4,704	470
100		Z5041_2a	Debokbazar Bridge				4,317	10,135	-	10,135	1,013
1	Barisal	N8_178a	Pura Mukto Monch Bridge	National Road			21,401	60,008	-	60,008	4,801
12		N8_182a	Bottala Bridge				21,401	60,008	-	60,008	4,801
26		N8_095a	Pathoraj Bridge				10,835	30,382	-	30,382	2,431
56		N8_152c	Rahamatpur bridge				13,152	36,878	-	36,878	2,950
57		N8_127b	gounagata bridge				10,600	29,721	-	29,721	2,378
64		N8_123a	Souderkhal bridge				10,600	29,721	-	29,721	2,378
69		N8_129a	Asokoti bridge				10,600	29,721	-	29,721	2,378
86		N8_69a	Kumar Bridge		✓		19,408	54,419	-	54,419	4,353
104		N805_24a	Garakola Bridge		✓	✓	21,119	59,215	62,101	121,316	9,705
42		R890_45a	Masrong bridge	Regional Road			18,584	47,070	-	47,070	4,707
70		R890_16a	Bangla Bazar Bridge				5,221	13,223	-	13,223	1,322
71		R890_21a	Boksheali Bridge				5,221	13,223	-	13,223	1,322
72		R890_28a	Sheyali Bailey Bridge				5,221	13,223	-	13,223	1,322
77		R860_31a	Paprail Bailey Bridge				4,857	12,303	-	12,303	1,230
83		R860_34a	Jajihar Bridge				4,857	12,303	-	12,303	1,230
84		R860_44c	Gazipur Bridge				4,857	12,303	-	12,303	1,230
85		R860_53d	Balar Bazar Bridge				4,857	12,303	-	12,303	1,230
99		R860_35a	Shajonpur Bailey Bridge				4,857	12,303	-	12,303	1,230
58		Z8052_009d	Gabtala Steel Bridge	Zilla Road			5,494	12,898	-	12,898	1,290
65		Z8701_3d	Bottala Bridge				4,066	9,546	-	9,546	955
78		Z8708_1c	Algy Bridge				1,246	2,925	-	2,925	293
81		Z8708_12b	Satani Bridge				3,979	9,340	-	9,340	934
82		Z8033_017a	Raiyer hat bridge				6,563	15,407	-	15,407	1,541
92		Z8810_13a	Madhabkhali bridge				5,494	12,898	-	12,898	1,290
94		Z8033_008a	Kalijira bridge				4,127	9,688	-	9,688	969
95		Z8033_019a	Masrong bridge				8,358	19,622	-	19,622	1,962
96		Z8034_011a	Padarhat bridge				4,785	11,232	-	11,232	1,123
97		Z8044_004a	Talukdarhat Bailey Bridge				6,127	14,385	-	14,385	1,438
13	Khulna	N7_025a	Katakhali Bridge	National Road			16,392	45,963	-	45,963	3,677
14		N7_039a	Bittipara Bridge				13,494	37,835	-	37,835	3,027
15		N7_049a	Bhangura Bridge				13,713	38,451	-	38,451	3,076
21		N704_43a	Naiori Bridge		✓		44,923	125,961	-	125,961	10,077
22		N7_248c	Chondi Das Bridge		✓		8,532	23,924	-	23,924	1,914
23		N7_054a	Bottoli Bridge				13,713	38,451	-	38,451	3,076
25		N7_246a	Algy Bridge		✓		8,532	23,924	-	23,924	1,914
29		N7_036c	Raiyer hat bridge				13,494	37,835	-	37,835	3,027
30		N7_048a	Jajihar Bridge				13,713	38,451	-	38,451	3,076
32		N7_047a	Balar Bazar Bridge				13,713	38,451	-	38,451	3,076
39		N7_141b	Madhabkhali bridge		✓		14,864	41,679	-	41,679	3,334
41		N703_Sd	Kalijira bridge				20,795	58,307	-	58,307	4,665
43		N704_14a	Padarhat bridge		✓		28,169	78,986	-	78,986	6,319
44		N704_33b	Talukdarhat Bailey Bridge		✓		21,466	60,191	-	60,191	4,815
67		N704_27b	Bittipara Bridge		✓		21,466	60,191	-	60,191	4,815
101		N706_14b	Jhikorgacha Bridge		✓	✓	31,265	87,665	62,101	149,766	11,981
103		N704_12c	Chandi Pur Bridge		✓		28,169	78,986	-	78,986	6,319
40		R720_44a	Bhela Bridge	Regional Road	✓		2,442	6,847	-	6,847	548
63		R760_049c	Shakdaha bridge				9,566	24,229	-	24,229	2,423
68		R750_22c	Bhangura Bridge		✓	✓	7,059	19,794	62,101	81,895	6,552
105		R750_25a	Tularampur Bridge		✓	✓	7,059	19,794	62,101	81,895	6,552
106		Z7503_5a	Hawai khali Bridge	Zilla Road	✓	✓	11,793	33,066	62,101	95,167	7,613

*SN(Serial Number) is equivalent to rank in selection of 106 project candidate bridges
Source: JICA Survey Team

5.4 Traffic Capacity

Traffic capacity is set based on Geometric Design Standard for RHD. The traffic capacities and required lane numbers for national roads, regional roads and zilla roads are shown in below table.

Table 5.4.1 Traffic Capacity and Number of Lane

Road Type	Traffic Capacity (pcu/direction/peak hour)	Number of Lanes
National Roads	4500 - **8500**	6 lanes (Design Type 1)
	2100 - **4500**	4 lanes (Design Type 2)
	800 - **2100**	2 lanes (Design Type 3 or 4)
Regional Roads	2100 - **4500**	4 lanes (Design Type 2)
	400 - **2100**	2 lanes (Design Type 3, 4 or 5)
Zilla Roads	400 - **1600**	2 lanes (Design Type 4 or 5)
	- **400**	1 lanes (Design Type 6)

Source: Geometric Design Standard for RHD

5.5 Number of Lanes

5.5.1 Required Number of Lanes based on Traffic Demand Forecast

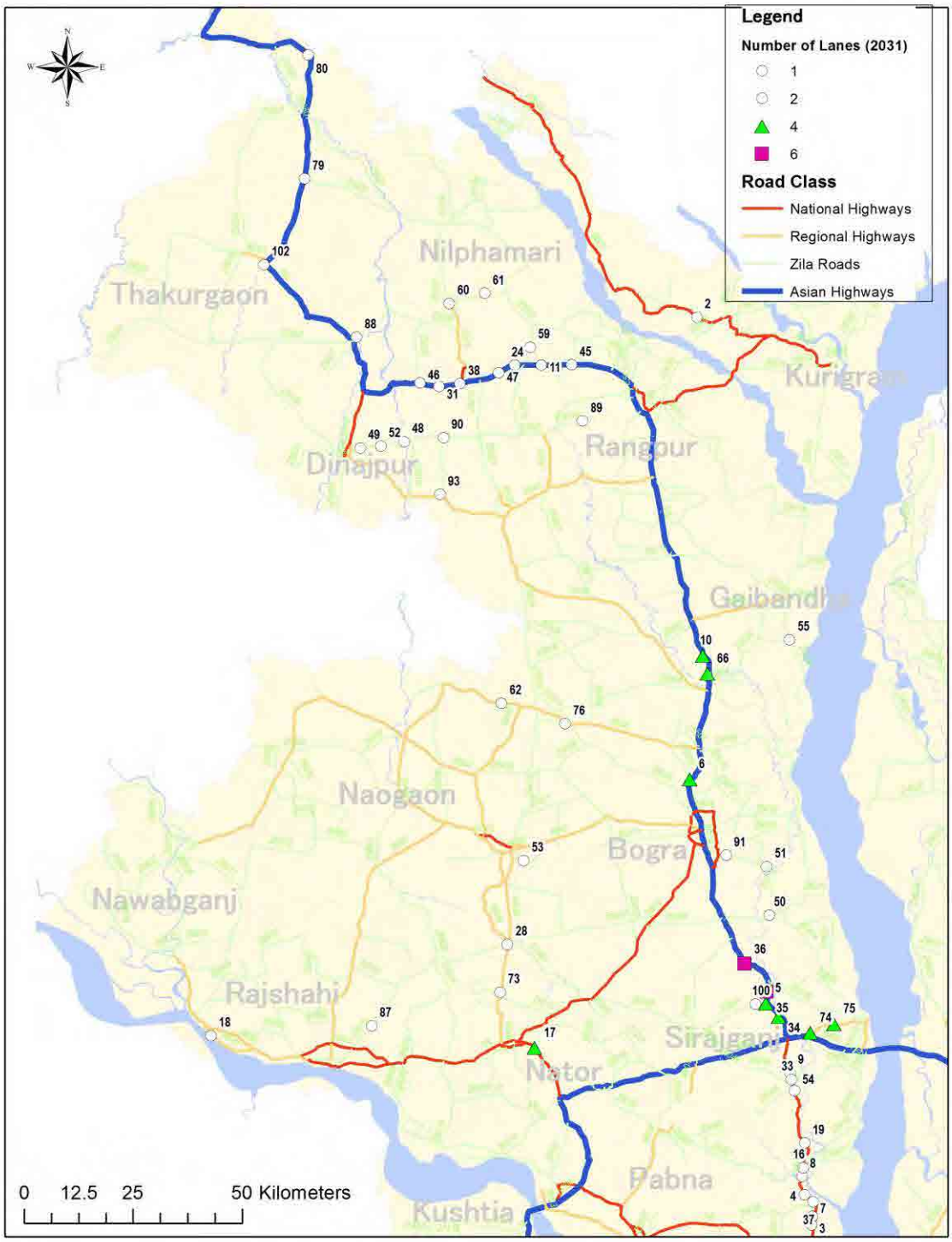
The required number of lanes for each of the 105 Project bridges estimated based on the traffic demand forecast and traffic capacity is shown in Table 5.5.1 and Figure 5.5.1 to Figure5.5.2.

25 bridges (19 bridges for national roads, 5 bridges for regional roads and 1 bridge for zilla road) out of 105 bridges require 4 or 6 lanes. On the Asian Highway network, 18 bridges (15 bridges for national roads, 2 bridges for regional roads and 1 bridge for zilla roads) out of 32 bridges require 4 or 6 lanes.

Table 5.5.1 Required Number of Lanes

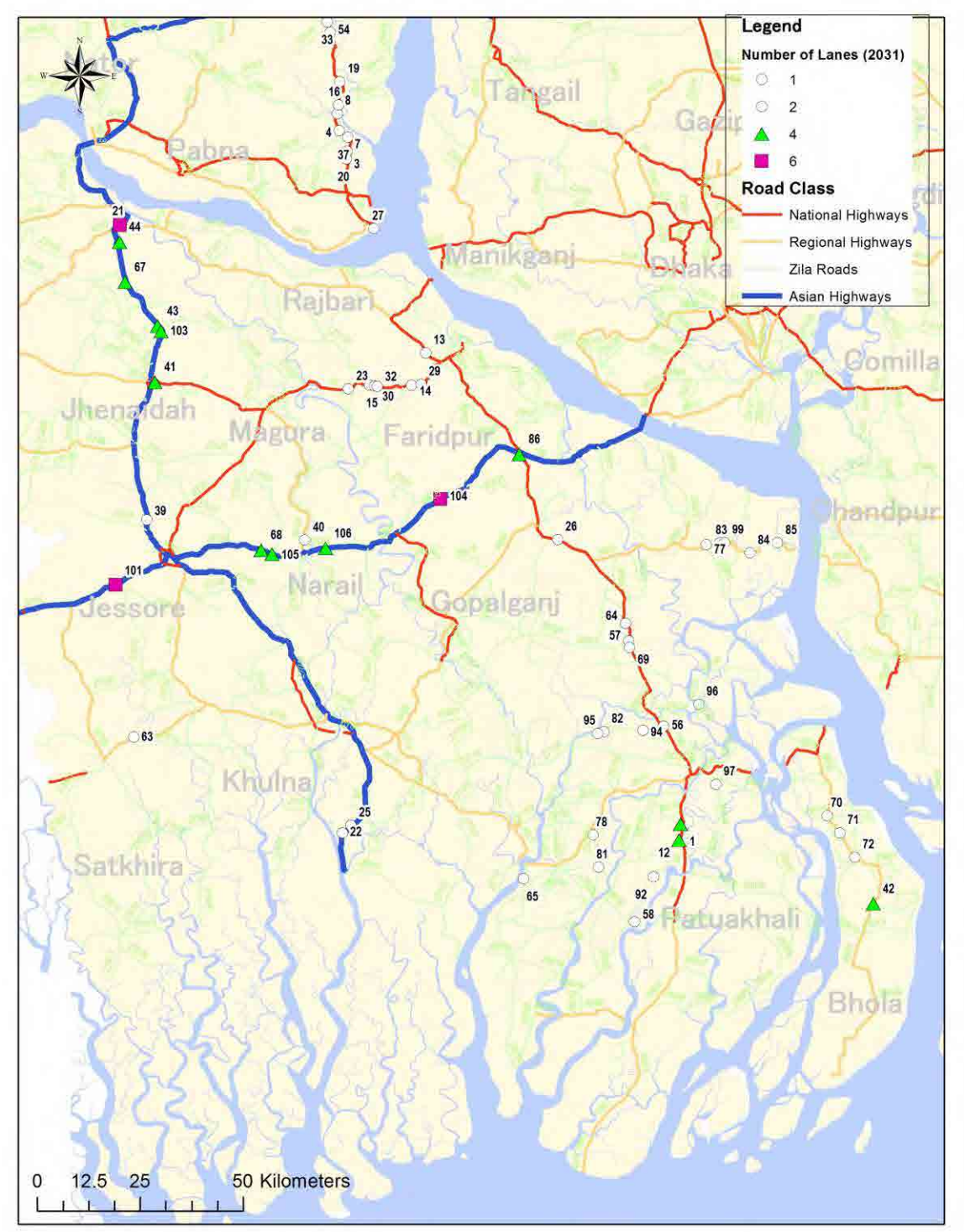
Road Type	Required Number of Lanes	Number of Bridges (Number of Bridge on Asian Highway)
National Roads	6 lanes	5 bridges (AH: 5 bridges)
	4 lanes	14 bridges (AH: 10 bridges)
	2 lanes	38 bridges (AH: 13 bridges)
	Total	**57 bridges (AH: 28 bridges)**
Regional Roads	4 lanes	5 bridges (AH: 2 bridges)
	2 lanes	16 bridges (AH: 1 bridge)
	Total	**21 bridges (AH: 3 bridges)**
Zilla Roads	4 lanes	1 bridges (AH: 1 bridges)
	2 lanes	26 bridges (AH: 0 bridge)
	Total	**27 bridges (AH: 1 bridges)**
Total		**105 bridges (AH: 32 bridges)**

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.5.1 Required Number of Lane (1)



Source: JICA Survey Team

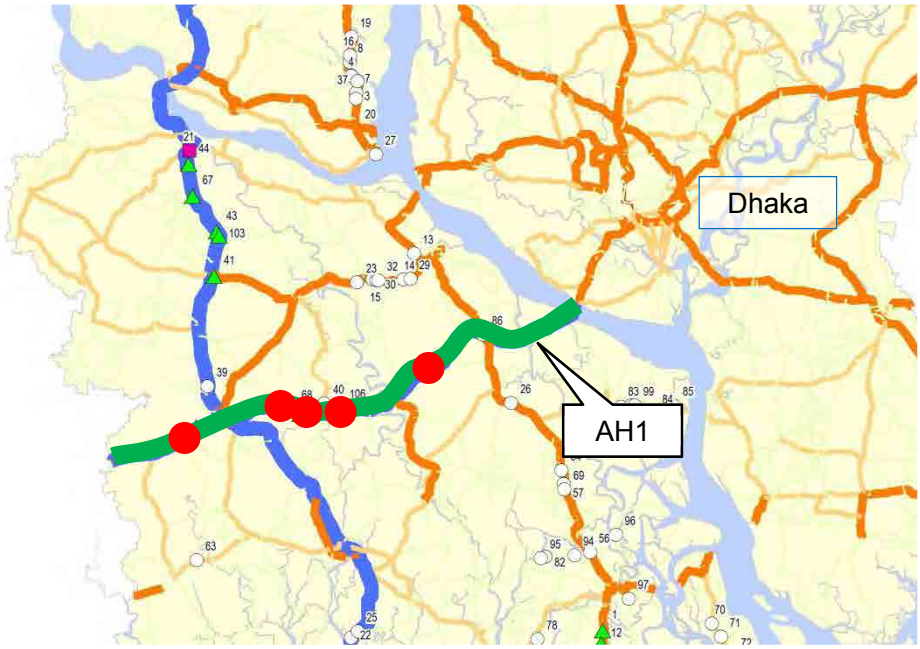
Figure 5.5.2 Required Number of Lane (2)

5.5.2 Number of Lane in the Project

In the Project, the majority the bridges, including those that require more than 4 lanes based on the traffic demand forecast, will be constructed as 2-lane bridges based on the following considerations:

- As many bridges as possible should be constructed on a limited budget.
- Even if 4-lane/6-lane bridges are constructed, only 2 lanes will be used since the approach roads (adjacent embankment section) only have 2 lanes.
- Even if 4-lane/6-lane bridges are constructed in anticipation of widening of the approach roads, this widening may not occur soon. Deterioration of the bridge will progress even if all lanes are not used, meaning funds will have been wasted.

However, in the meeting between JICA, MORTB, RHD and JICA Survey Team held on April 27, 2014, it was determined that 5 bridges on Asian Highway 1 (AH1) will be constructed with 4 lanes in conformity with a future 4-lane widening plan (see Figure 5.5.3).



Source: JICA Survey Team

Figure 5.5.3 4-lane Bridges on Asian Highway

6. DETERMINATION OF BRIDGE TYPE

6.1 Methodology of Bridge Type Decision

In the bridge selection process in Chapter 3, 106 bridges were selected as the candidate bridges of the Project. However, the preliminary design was conducted for 105 bridges since it was confirmed that 1 bridge is under construction in another project.

This Project includes the construction of small and mid-sized bridges, but no large bridges.

For small bridges, PC-I girder is widely recognized as the most suitable and economical bridge type in almost all site conditions, and many PC-I girder bridges have been constructed in Bangladesh by RHD.

For mid-sized bridges, the most appropriate bridge type shall be selected upon comparison of multiple bridge type candidates (PC-Box girder and Steel-I girder). Conditions for comparison include earthquake strength, construction difficulties, cost efficiency, owner's maintenance performance, and others.

Small size bridge: PC-I
Middle size bridge: PC-Box, Steel-I (painted or weathering steel) — Range of WBBIP

Large size bridge: PC-extra dosed, Cable-stayed, Suspension, others

Table 6.1.1 Applicable Bridge Span for Bridge Type

Bridge size	Bridge type	Applicable bridge span / Economical bridge span 30 40 50 60 70 80 (m)
Small size	PC-I	
Middle size	PC-Box	
	Steel-I	
	Steel-Box	
		Range of WBBIP

Source: JICA Survey Team

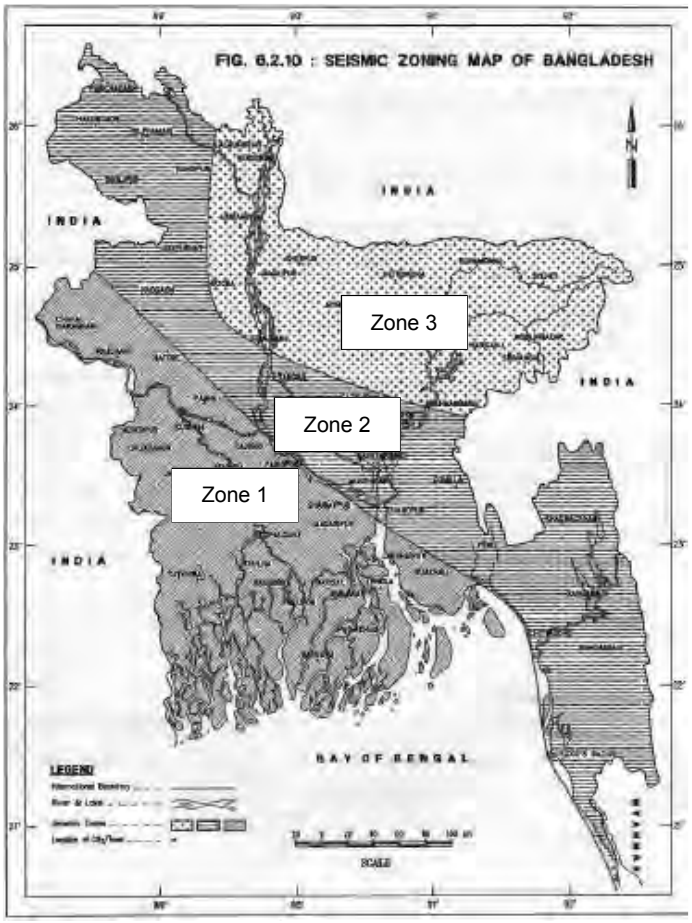
6.2 Grouping for Bridge Design

For bridge design, all bridges are classified into 2 groups: Group A and Group B. Earthquake strength shall be considered for the grouping, since it affects bridge design and its cost. Grouping for bridge design is defined in consideration of bridge length and height as well as seismic coefficient, which is different for each zone.

Table 6.2.1 Earthquake Zone Coefficient Z (BNBC)

Seismic zone	Zone coefficient
1	0.075
2	0.15
3	0.25

Source: Bangladesh National Building Code (BNBC)



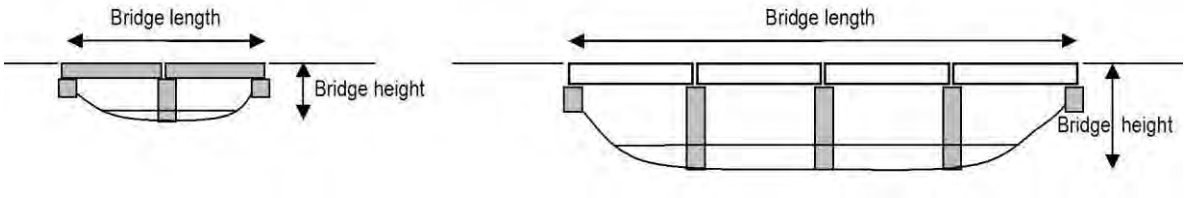
Source: Bangladesh National Building Code (BNBC)

Figure 6.2.1 Seismic Zoning Map (BNBC)

Group A in each zone is defined as follows:

- North zone (Z = 0.15 or 0.25): length < 100 m and height < 10 m
- South zone (Z = 0.075): length < 150 m and height < 15 m

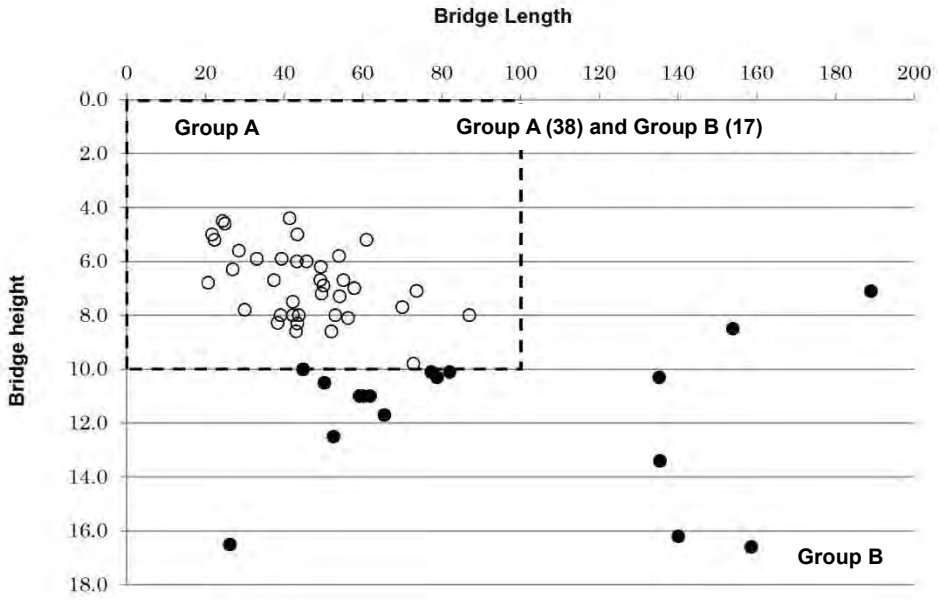
Group B is defined as bridges falling outside of the above definition.



Group A Group B

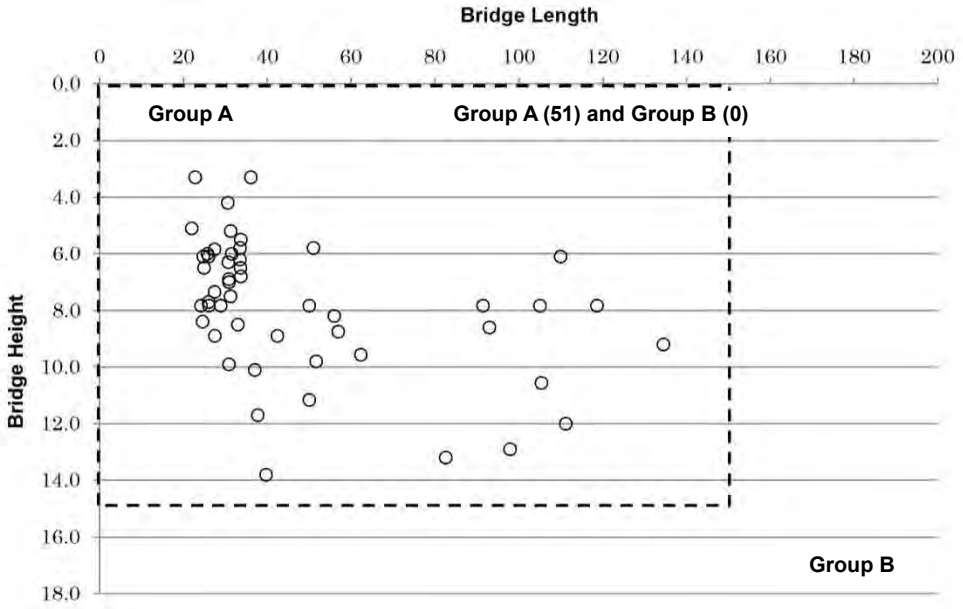
Figure 6.2.2 Grouping of Bridges

Using the above-stated definition, all bridges in the WBBIP are plotted in Figures 6.2.3 and Figure 6.2.4. Note that bridges in northern zones belong to both Group A and Group B bridges, whereas all bridges in the southern zone (zone 1) belong to Group A.



Source: JICA Survey Team

Figure 6.2.3 55 Bridges in Northern Zone



Source: JICA Survey Team

Figure 6.2.4 51 Bridges in Southern Zone

6.3 Bridge Type for Group A

Group A Bridges are shorter and lower. Accordingly, as these are small bridges having short span length (Span < 40m), PC-I girder bridges are to be used for Group A Bridges.

6.4 Bridge Type for Group B in Northern Zone

Group B Bridges (all of which are in the northern zone) are longer and higher. Accordingly as these are mid-size bridge having medium-span length (40m < Span < 60m), both PC-Box girder bridges and Steel-I girder bridges are compared for use. For the Steel-I girders, both ordinary painted steel and weathering steel are considered in the comparison.

As the result of the comparison of PC-Box girder bridges, Painted Steel-I girder bridges and Weathering Steel-I girder bridges (as shown in Table 6.4.1), Weathering Steel-I girder bridges are recommended as the most appropriate bridge type for Group B bridges. Reasons include the following:

- Constructability: While PC box girder bridges require longer construction periods due to on-site girder construction, weathering steel bridges require shorter periods for construction due to the use of pre-fabricated girders. Thus, the negative impact on regional economy due to construction is less in the case of weathering steel.
- Maintenance: In order to increase the durability of bridges, PC box girders may require surface treatment, which in turn requires periodic retreatment. However, weathering steel does not require such treatment or painting.

- Structural performance: Weathering steel bridges have an advantage in earthquake resistance over PC box girder bridges, which have to be heavier and more costly in order to ensure the earthquake resistance. Note that all Group B bridges are in northern Bangladesh, which is categorized as Seismic Zone II (medium-level seismic activity) and III (high-level seismic activity).
- Technology transfer: While Bangladesh already has experience in PC box girder bridge construction, it does not yet have experience in weathering steel bridge construction. Thus, selection of weathering steel bridges as the bridge type would bring weathering steel technology to Bangladesh through good technological transfer from Japan, which has good experience in this technology. The skills gained will surely prove to be indispensable for future bridge construction in Bangladesh.

Table 6.4.1 Comparison of Bridge Type for Group B Bridge in Northern Zone

Bridge type		PC Box Girder	Steel I Girder (Painting)	Steel I Girder (Weathering Steel)
Image				
Structural Performance	Durability	- Enough durability. (Fair)	- Enough durability. (Fair)	- Enough durability. (Fair)
	Earthquake Resistance	- Disadvantage due to heavyweight. (Poor)	- Advantage due to light weight. (Good)	- Advantage due to light weight. (Good)
Constructability	Construction Difficulty	- Normal construction method (Cantilever). (Fair)	- Normal construction method (Erection by truck crane). (Fair)	- Normal construction method (Erection by truck crane). (Fair)
	Quality Control	- Normal quality control. (Fair)	- Normal quality control. (Fair)	- Normal quality control. (Fair)
	Construction Period	- Long period with girder construction at site. (Poor)	- Short period with pre-fabricated girder. (Good)	- Short period with pre-fabricated girder. (Good)
Maintenance	Re-painting/Surface Treatment	- Need surface treatment.(Poor)	- Need painting. (Poor)	- No need painting. (Good)
Environmental Impact		- No specific environmental impact. (Good)	- Special care is required when re-painting. (Poor)	- No specific environmental impact. (Good)
Cost	Initial Cost	- 1.00 (Good)	- 1.15 (Fair)	- 1.19 (Fair)
	Regular Maintenance Cost (% of Initial Cost, Annual)	- 1.5% (Fair)	- 1.5% (Fair)	- 1.5% (Fair)
	Re-painting/Surface Treatment Cost (% of Initial Cost)	- 4.0% (by 30 Years) (Fair)	- 12.0% (by 15 Years) (Poor)	- No painting (Good)
	LCC for 50 Years (Price Increase 6% per Annual)	- 1.00 (Good)	- 1.21 (Fair)	- 1.18 (Fair)
Technical Transfer		- Expected but experienced in Bangladesh. (Fair)	- Expected for new technology in Bangladesh. (Good)	- Expected for new and modern technology in Bangladesh. (Good)
Evaluation				**Recommended** - Advantage to earthquake resistance - Short construction period - Easy maintenance - No specific environmental impact - Fair initial and life cycle costs - Good technical transfer

6.5 Bridge Length and Span Arrangement

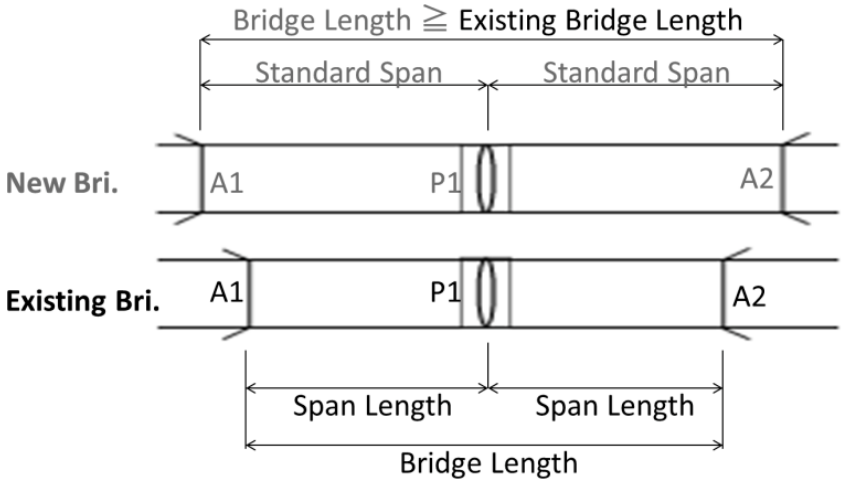
The bridge span lengths are standardized with a series of spans in order to be easily applied to all 105 bridge locations. Standard bridge spans are as follows:

- PC-I : standard span 25, 30, 35, 40 m
- Steel-I : standard span 40, 50, 60 m

The following two points should be considered when determining the bridge length and span arrangement of new bridges.

- Pier locations of new bridges shall be matched with the existing bridges as much as possible so as not to obstruct the river flow.
- Bridge lengths and span lengths shall generally be longer than that of the existing bridges in order to secure sufficient cross-sectional area for the river flow.

Figure 6.5.1 shows the general concept of the span arrangement for new bridges.



Source: JICA Survey Team

Figure 6.5.1 Concept of Span Arrangement of New Bridge

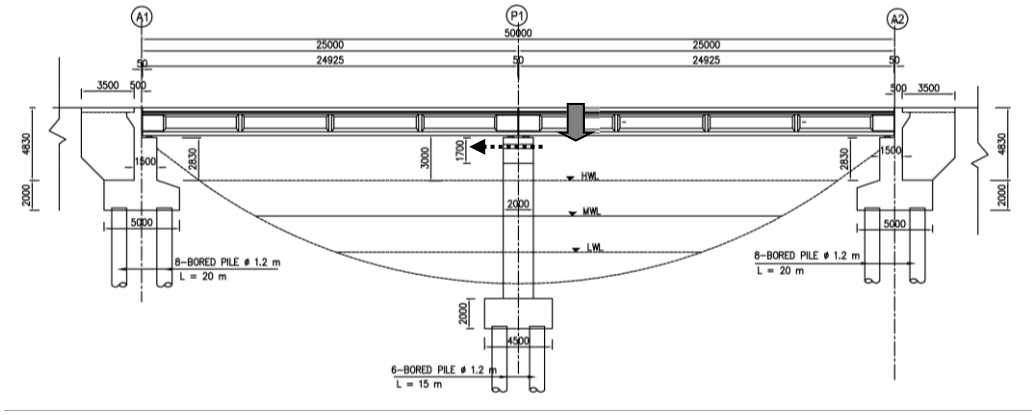
6.6 Girder Type in Consideration of Earthquakes

Seismic design must be considered to avoid crucial disasters in Bangladesh. In order to deal with seismic loading, measures to prevent superstructure collapse shall be considered.

So far PC-I girder bridges in Bangladesh have been constructed as shown in Figure 6.6.1. When a large earthquake occurs, this structure may induce large motion of pier head and there is possibility of girder collapse.

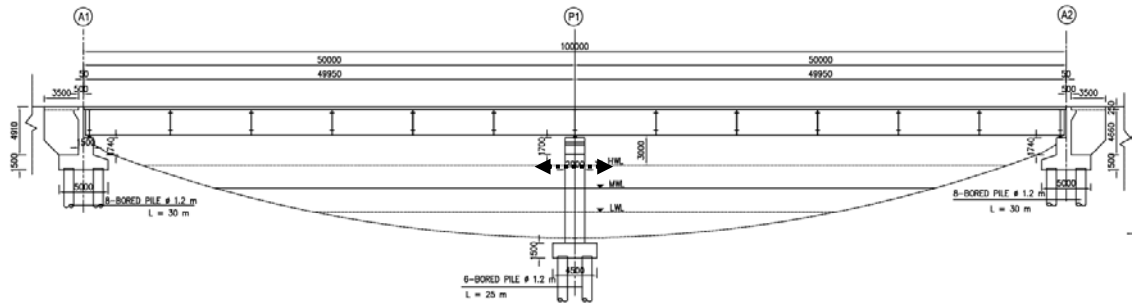
Accordingly, measures to prevent superstructure collapse are proposed for both selected girders types. Continuous girders are proposed for Steel-I girder bridges as shown in Figure

6.6.2. “Chaired girders” (in which pier head movement is restricted by connecting girders) are proposed for PC-I girder bridges as shown in Figure 6.6.3.



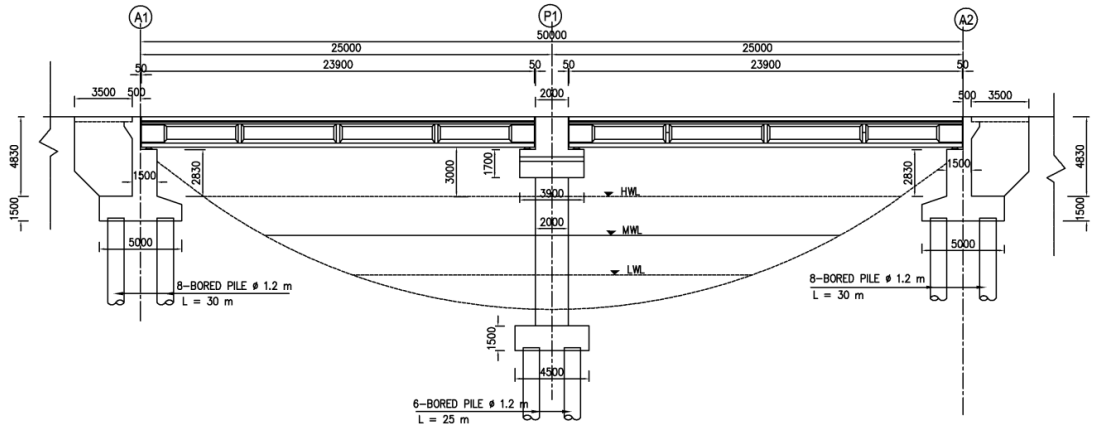
Source: JICA Survey Team

Figure 6.6.1 Traditional PC-I Girder Bridge (Single Span Girders)



Source: JICA Survey Team

Figure 6.6.2 Steel-I Girder Bridge in WBBIP (Continuous Girder)



Source: JICA Survey Team

Figure 6.6.3 PC-I Girder Bridge in WBBIP (Chaired Single Span Girders)