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

PREPARATORY SURVEY
ON
THE CROSS-BORDER ROAD NETWORK IMPROVEMENT PROJECT (BANGLADESH)

FINAL REPORT

VOLUME 1: MAIN REPORT

FEBRUARY 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.

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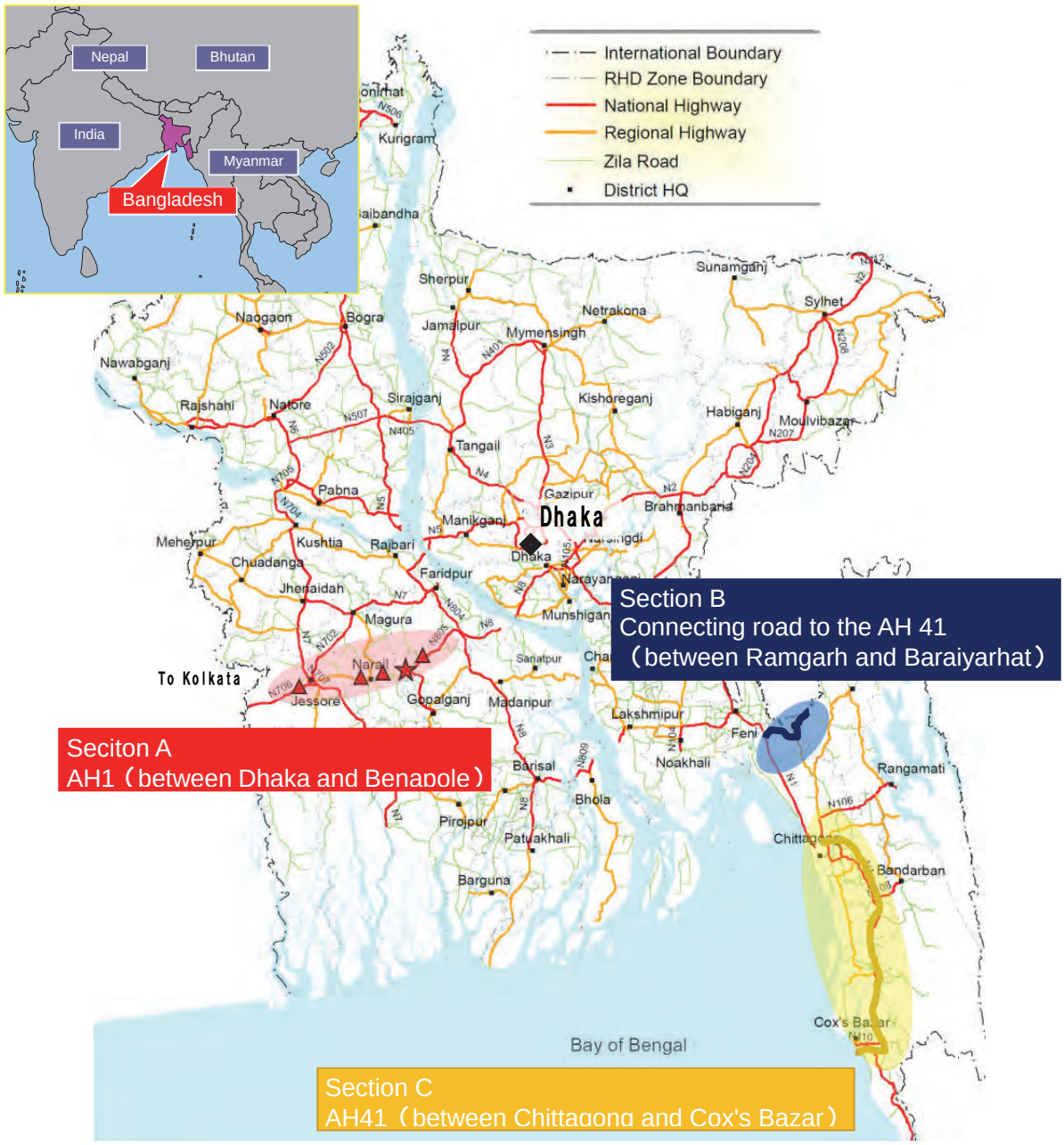
The exchange rates applied in this study are;

USD1.0 = BDT77.8 = JPY120.2 (December, 2015)

BDT: Bangladesh TAKA

People's Republic of Bangladesh



- Area: 144 thousand km^2 (About 0.4 times of Japan)
- Population: 158.06million (March, 2014)
- Capital: Dhaka
- Ethnic: Bangalese
- Language: Bengali
- Religion: Muslim (89.7%), Hinduism (9.2%), Buddhism (0.7%), Christianity (0.3%)
- Major Industry: Apparel Manufacture
- GDP: USD 960 (2013)
- Price Escalation: 7.97% (2012)
- Economic growth: 6.18% (2013)
- Trade (2013)
  1) Export: USD 26.6 billion
  2) Import: USD 33.6 billion
- Main Trade Item (2012)
  1) Export: Garment (39.5%), Knit Wear (39.1%)
  2) Import: Petroleum Products, Fabric, Chemical, Mechanical Component
- Exchange Rate: USD1＝BDT79.10 (2012, Annual Average)
- ODA Perfomance of GOJ (2012)
  1) Government Loans: JPY166.38 billion
  2) Grant Aid: JPY 2.21billion
  3) Technical Assistance: JPY2.84 billion

Location Map of Survey Area

View of Kalna Bridge

View of PC-I Girder Bridge under Section B

View of PC-I Girder Bridge under Section C

Outline of the Project

1. Country: The People's Republic of Bangladesh

2. Project Name:
Preparatory Survey on the Cross-Border Road Network Improvement Project (Bangladesh)

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

4. Survey Objectives:
As Government of Bangladesh is requesting a Japanese ODA Loan for the Cross-Border Road Network Improvement Project (Bangladesh) (hereinafter referred to as "CBRNIP"), the objective of this preparatory survey is to obtain all the data and information required for appraisal of a loan project of Japanese ODA as well as to execute the Project, such as defining the project objectives and preparing a 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:
Understanding of project background and necessity, Extraction of issue in target road and area / Site survey, Selection of target section and optimum plan, Workshop in Bangladesh, Natural condition survey, Traffic count and traffic demand forecast, Social survey (Baseline survey), Project implementation plan, Preliminary design, Construction plan and schedule, Operation and maintenance plan, Environmental and social considerations, Support for preparation of abbreviated resettlement plan (ARP), Climate change countermeasures, Cost estimation, Points of concern for project implementation, Evaluation of project

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 17 bridges construction including approach road, box-Culverts construction and axle load installation.
- Two types of bridges are constructed in the Project, namely, PC-I girder bridge, Nielsen Lohse bridge.
- Special steel, namely, SBHS (Steels for Bridge High Performance Structure) is applied for a part of Nielsen Lohse Bridge.

(2) Recommendations

- Safety measures such as providing road marking, road hump, guardrails, etc. shall be considered in the detailed design.
- 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.
- Technical cooperation project of bridge maintenance under JICA is ongoing and will be updated operation and maintenance manual in 2016. It is recommended that the project bridge should be maintained according to the manual.
- SBHS (Steels for Bridge High Performance Structure) is applied for Nielsen Lohse Bridge, especially at the corner part which is subjected to high stress concentration and needs special care for joining. The more detail use of SBHS shall be studied in the detailed design.

PEOPLE'S REPUBLIC OF BANGLADESH

PREPARATORY SURVEY ON THE CROSS-BORDER ROAD NETWORK IMPROVEMENT PROJECT (BANGLADESH)

FINAL REPORT

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1 Background

The South Asia region is actively undergoing a reform of economic liberalization. In particular, India and the People's Republic of Bangladesh (hereinafter referred to as “Bangladesh”) attract attention as markets of high economic potential. With a population of approximately 1.7 billion, the region is expected to reach the demographic dividend period, and undergo further growth through expansion of domestic demand. On the other hand, intra-regional trade volume of the region is remaining low, at only 3% of total trade (in 2012). A big issue is the maintenance of transportation infrastructure that connects each region. Also, “Bangladesh” is surrounded by countries such as India, Myanmar, Nepal and Bhutan, and hence is vital in connecting each of these countries. Thus, the maintenance of transportation infrastructure in “Bangladesh” through JICA assistance is expected to contribute to the economic development and stabilization of not just the country, but also the surrounding region.

Road transport accounts for around 70% of domestic transportation in “Bangladesh”, and multiple international corridors such as the Asian Highway pass through the country. However, in many sectors, in addition to the inefficiency of customs and border procedures, international corridors are not functioning sufficiently because of deterioration of aged roads and bridges in domestic and border areas. Therefore, regional transit traffic planning based on several regional cooperation frameworks in the region was formulated and maintenance of both soft and hard infrastructure is underway. In the 6th Five Year Plan of “Bangladesh”, creation of a modernized and efficient road transportation system was declared in the highway sector. Though there are road and bridge maintenance projects underway, these are unable to sufficiently deal with the problem due to budget and technical limitations.

Based on this background, the Government of Bangladesh (hereinafter referred to as GOB) requested loan assistance from the Government of Japan for the maintenance of main international highways and connecting roads.

1.2 Objectives of the Survey

As GOB is requesting a Japanese ODA Loan for the Cross-Border Road Network Improvement Project (Bangladesh) (hereinafter referred to as “CBRNIP”), the objective of this preparatory survey is

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

2. EXISTING ROAD NETWOK AND NATIONAL DEVELOPMENT PLANS

2.1 Problems and Issues of Existing Roads and Bridges in Bangladesh

2.1.1 Existing Conditions of Roads in Bangladesh

(1) Road Network

The road network consists of six road categories: National Highways, Regional Highways, Zilla Roads, Upazila Roads, Union Roads and Village Roads. The Roads and Highways Department (RHD), under the Ministry of Road Transport and Bridges (MORTB), manages 21,302 km of roads including National Highways, Regional Highways and Zilla Roads. The total road length managed by RHD makes up 6.5% of the total road network in Bangladesh.

(2) Road Condition

The road condition can be grossly categorized into descriptive bands based on roughness. To make understand on roughness, RHD conducted a road condition survey in 2012 on about 13,000 km of road. It was observed that the roughness is in increasing trend regardless of road class until 2010. Then, in the period of 2011-2012, National Highway roughness has decreased from IRI 6.05 to 5.24, Regional Highway roughness has increased from IRI 3.47 to 6.38 and Zilla Road roughness has decreased from 8.41 to 7.87 indicating an overall improvement of the road network.

2.1.2 Bridge Condition

The number of structures on RHD road network has been increased dramatically since 1991. The number of structures under RHD management, surveyed in 2013, was found to be 21,492 which is approximately seven (7) times the number in 1991.

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. The number of bridges having damage categories A, B, C and D were examined in 2013 through the “Capacity Building Programme for Bridge Maintenance and Management System (BMMS) of RHD under EBBIP”. Total number of bridges under RHD road network was found to be 3,852 which are

summarized in Table 2.1. It was also predicted that the bridges having C and D damage categories are significant in numbers which need repair or replacement in an urgent manner.

Table 2.1 Bridges Condition in Bangladesh

Damage \ Road Type	National Highway	Regional Highway	Zilla Road	Total	
				Nos.	%
A	362	246	731	1,339	34.8
B	272	197	591	1,060	27.5
C	140	230	625	995	25.8
D	45	68	345	458	11.9
Total				3,852	100

Source: Capacity Building Programme for BMMS of RHD under EBBIP (2013)

2.2 National Development Plans and Programs

The National Land Transport Policy (NLTP-2004), National Integrated Multi-modal Transport Policy (NIMTP-2013) and Bangladesh Road Master Plan (RMP, 2009-2029) are the main policy documents which have been guiding policies of transport agencies for the selection of road development and improvement projects. Besides, the Government formulated the Sixth Five Year Plan (6FYP, 2011-2015) and Seventh Five Year Plan (7FYP, 2016-2020) in order to achieve an average GDP growth rate more than 7 percent per annum and to develop a balanced and integrated transport network through the adoption of several strategies/programs. In addition, the Government is aiming to become a middle income country by the year 2021 through implementing Vision 2021.

3. CROSS-BORDER INFRASTRUCTURE DEVELOPMENT

3.1 Cross-Border Points in Bangladesh

The Bangladesh Land Port Authority (BLPA) has identified 20 border crossing points for future development. Their status is summarized in Table 3.1. Five of these land ports are managed by the government, while six are managed by build-operate-transfer (BOT) operators.

Table 3.1 Border Crossing Points Planned and Announced for Development by BLPA

Border Crossing Point	Date Declared	Town on Bangladesh Side	Town on Other Side	Management
Benapole	12 January 2001	Benapole, Sharsla Jassore	Petrapole, Bongaon, India	Own Management
Burimari	12 January 2002	Patgram, Lalmonirhat	Changrabandha, India	Own Management
Akhaura	12 January 2002	Akhaura Brammonbaria	Rumhagor Agortala Tripura, India	Own Management
Sona Masjid	12 January 2002	Shibgonj Chapa, Nobabgonj	Mahadipur, Maldha, West Bangal	BOT

Border Crossing Point	Date Declared	Town on Bangladesh Side	Town on Other Side	Management
Hilli	12 January 2002	Hakimpur, Dinajpur	Hilli, South Dinajpur, West Bengal	BOT
Banglabandha	12 January 2002	Tetulia Punchogar	Phulbari, Jalpaiguri, West Bengal, India	BOT
Birol	12 January 2002	Birol Dinajpur	Radhikapur gaora, West Bengal, India	BOT (No Construction)
Teknaf	12 January 2002	Teknaf, Cox's Bazar	Mongru, Shituway, Myanmar	BOT
Bibir Bazar	18 November 2002	Bibir Bazar, Cumilla, Sadar	Shimastapur Sonatnurah, Tripurah India	BOT
Bhomra	12 January 2002	Bhomra Satkhira	Gojadanga Chobbinporgona, West Bengal India	Own Management
Nakugaon	22 September 2010	Nalitabari, Sherpur	Dalu, Meghaloy, India	Own Management
Biloneya	23 February 2009	Biloneya, Fani	Biloneya, Tripura, India	Land acquisition in progress
Gobrakura and Koraitoli	14 June 2010	Haluaghat, Mymenshing	Gachuspara, Meghaloy, India	Land acquisition and approval of Development project
Tamabil	12 January 2002	Goainghal, Shylet	Dawki, Shilong Meghaloya, India	Development is in progress
Droshona	12 January 2002	Damurhat, Chuadarga	Geday, Krinnongor, West Bengal India	No Construction
Ramgor	7 November 2010	Ramgor, Khagrachori	Subrum, Tripurah, india	No Construction
Sonahat	25 October 2012	Bhurungantari, Kurigram	Sonahat, Dhubri, Assam India	Development project approval is in progress
Tegamukh	30 June 2013	Borokol, Ranyamati	Dernaghree/Kawyapuchiya Mizuram India	No Construction
Chilahaty	28 July 2013	Domar, Nilphamari	Haldi Bari, Kuchbihar, West Bengao, India	No Construction
Doulatgonj	31 July 2013	JibonNagor, Chuadanga	Mazdiya, Kuchlihar Wesr bengal India	No Construction

Abbreviation: BOT = build-operate-transfer
Source: Bangladesh Land Port Authority

3.2 Sub-regional and International Cross-Border Road Plans

- **Asian Highway Network (UN-ESCAP)**: The Asian Highway project was conceived by UN-ESCAP (United Nations Economic and Social Commission for Asia and the Pacific) in 1959 with the aim of establishing regional cooperation among the main land countries of Asia, based on road transport linkages. In Bangladesh, there are three Asian Highway Routes namely, Asian Highway-1 (AH1), Asian Highway-2 (AH2) and Asian Highway-41 (AH41).

- **BIMSTEC (The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation) Road Corridor**: Bangladesh is a member country of Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Co-operation (BIMSTEC). The 8th BIMSTEC Ministerial Meeting was held in Dhaka in December 2005 and it noted that the importance of transport and logistics for successful cooperation and development of the region. On the recommendation of the BIMSTEC Working Group, the Heads of Delegation of the Ministerial

Meeting approved a BIMSTEC Transport Infrastructure and Logistic Study (BTILS). The Asian Development Bank subsequently agreed to provide technical support for its implementation.

- **SASEC (South Asian Sub-regional Economic Cooperation) Corridor**: The South Asia Sub-regional Economic Cooperation (SASEC) Program is dedicated to enhancing such interconnectivity between the Member States by helping them in strengthening their transport links. In doing so, SASEC assists in creating the conditions necessary to boost trade, both intraregional and external trade, thus catering to the needs of the sub-region's growing economies.

- **BBIN MVA (Bangladesh-Bhutan-India-Nepal Motor Vehicle Agreement) Corridor**: Bangladesh, Bhutan, India, and Nepal (BBIN) signed a landmark Motor Vehicles Agreement (MVA) on June 15, 2015 for the regulation of Passenger, Personal and Cargo Vehicular Traffic among the four South, Asian neighbors in Thimpu, Bhutan. The MVA agreement between the sub-grouping of four SAARC nations, Bangladesh, Bhutan, India, and Nepal (BBIN) will pave the way for the seamless movement of people and goods across their borders for the benefit and integration of the region and its economic development. The priority projects for Bangladesh are as follows.
  - ✓ Completion of Dhaka-Chittagong National Highways (N1, AH41)
  - ✓ Construction of new four lane Katchpur, Megna and Gomoti (KMG) Bridges (N1, AH41)
  - ✓ Construction of the new Padma Bridge and immediate approach roads (N8, AH1)
  - ✓ 4 laning of roads between Benapole and proposed new Padma Bridge (N706/R750/Z7503/N805/N8/AH1)
  - ✓ 4 laning of Joydevpur-Elenga-Hatikamrul-Rangpur-Burimari/Banglabandha National Highway (N4,N5)
  - ✓ 4 laning of Dhaka (Katchpur)-Narsingdi- Sarail-Sylhet-Tamabil National Highway (N2)
  - ✓ 4 laning of the Baraierhat- Heako- Ramgarh Highway (R151, R152)

- **Chittagong Port Access from the North East India (Seven Sister States)**: The Seven Sister states also called "Paradise Unexplored" are the contiguous states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland and Tripura in the North East India. Transportation via Bangladesh will be much easier because the road connectivity is a major issue for the mountainous north-eastern states. Keeping them in the background, recently the Government of India and the GOB signed a memorandum of understanding promising that Bangladesh would allow the use of Chittagong sea port for the movement of goods to and from India. Accordingly, both governments agreed to create a regional relationship by laying a foundation stone of the Feni River Bridge on June 6, 2015.

- **BCIM (Bangladesh-China-India-Myanmar) Economic Corridor**: The Bangladesh – China – India - Myanmar (BCIM) forum for regional cooperation aims to recapture for the present day citizens the historic dynamism that had once characterized the flows of goods, people and

cultures over the famed “Southern Silk Route”. Based on several inner-regional discussions and Memorandum of Understanding (MOU), the BCIM road corridor is being planned as the target route following part of AH41.

3.3 Other Cross-Border Road/Infrastructure Projects

- **Dhaka-Tamabil Cross Border Road Project**: In addition to the Project, GOB has several plans to develop cross border road networks with financial assistance from the Asian Development Bank. Of them, Dhaka-Tamabil National Highway (N2) is an important corridor to India.
- **Axle Load Control Plan**: Overloading vehicle will cause premature damage in deck slab and wearing surface first and then the damage will spread gradually over the entire bridge section, which is commonly observed in Bangladesh. To control the overloading, GOB is planning to improve the axle load scale system applicable in Bangladesh.

3.4 Necessity of the Cross Border Project

The implementation of the Project is also important and necessary from the following points of view.

3.4.1 Conformity with Higher Level Plan

1) Vision 2021
2) Sixth Five-Year Plan (6FYP) and Seventh Five Year Plan (7FYP)
3) National Land Transport Policy, NLTP (2004)
4) National Integrated Multimodal Transport Policy (NIMTP-2013)
5) Road Master Plan, RMP (2009-2029)
6) BBIN MVA planned corridor and sub-regional connectivity

3.4.2 Urgency in Improving the Project Sections

The urgency in improving the Project three Sections are described hereunder considering existing road network conditions, international corridor development plan and plan for industrial development as well.

The Section A (Benapole-Dhaka) of the Project will be missing link after opening of Padma Bridge due to traffic crossing the river by Ferry at Kalna. Moreover, the route between Jesssore-Narail-Lohagara is currently Regional Highway and Zilla Road standard and not up to the level of Asian Highway. Therefore this section will not be able to accommodate international traffics when BBIN will be under operation.

The Section B (Baraiyarhat-Heyako-Ramgarh) which is a part of BBIN is now Regional Highway standard and very narrow in some sections including several temporary Bailey as well as damaged

bridges. Therefore, this section will not also be able to cope with international traffics from India when BBIN will be under operation.

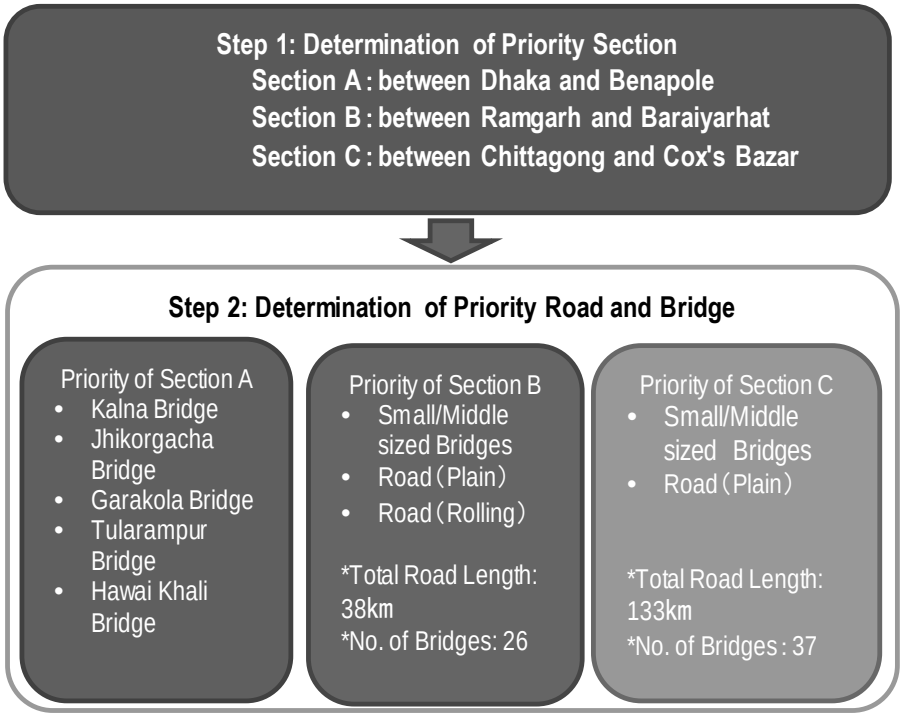
The Section C (Chittagong-Cox's Bazar) is currently 2-lane highway including several bridges, and is planned to upgrade into 4-lane AH41. This section is also a part of BCIM and planned to build industrial hubs surroundings. Therefore, this section will not also be able to cope with high traffic volume to be generated from industrial development and when BCIM will be in execution.

In accordance with the development plans stated above, the improvement of Project Sections would be necessarily executed timely and in a prioritized manner so that it can eliminate any bottlenecks appraised for cross border traffic movement.

4. PRIORITIZATION OF PROJECTS

4.1 Methodology

To determine project policy, the following method in two steps is applied as shown in Figure 4.1.



Source: JICA Survey Team

Figure 4.1 Prioritization Method and Project Candidates

4.2 Prioritization of Target Project Sections

4.2.1 Evaluation Criteria

Considering the current situation and issues regarding the development of cross border infrastructure in Bangladesh, the JICA Survey Team set the following criteria to evaluate the target project sections as shown in Table 4.1.

Table 4.1 Evaluation Criteria

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Included	2
		Not included	0
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	Development of road infrastructures connected to the target project section is committed.	2
		Development of road infrastructures connected to the target project section is planned or under study.	1
		No action is taken for the development of road infrastructure connected to the target project section.	0
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays an important role.	2
		The target project section plays a relevant role.	1
		The target project section plays no role.	0
Economic Effect	Contribution to the industrial development	There are or will be several major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	2
		There are or will be at least one major hub for regional logistics or industrial development for export which will use the target project section as a major transport route.	1
		There are or will be no major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	0
	Contribution to the development of the regional transport network	The target project section is a major route for the cross border transport.	2
		The target project section is planned to be a major route for the cross border transport.	1
		The target project section is not a major route for the cross border transport.	0

Source: JICA Survey Team

4.2.2 Evaluation Results

In the following, the JICA Survey Team evaluates the sections of CBRNIP by the criteria.

(1) Section A (between Dhaka to Benapole)

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Included	2
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	Development of road infrastructures connected to the target project section is committed.	2
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays an important role	2
Economic Effect	Contribution to industrial development	There are or will be no major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	0
	Contribution to regional transport network	The target project section is a major route for the cross border transport.	2
Total Score			10

BBIN MVA includes the target project section:

Section A is included in priority projects of BBIN MVA as “(iv) 4 laning of roads between Benapole and proposed new Padma Bridge (AH1)”.

Status of relevant plans in neighboring countries:

Benapole Land Port is playing an important role for the transactions between Bangladesh and the mainland of India. Although the traffic is close to the capacity of the land port, the land port is working as a main gate for the transactions.

Expected synergies with other potential, planned, or committed projects by development partner:

As construction of Padma Bridge is in progress and improvement of cross border infrastructure is planned to be developed with the assistance of ADB, synergies with them can be expected due to the improvement of Section A for improvement of the cross border transportation between Bangladesh and the mainland of India.

Contribution to industrial development:

There is no EPZ which will use Section A as a main transportation route. On the other hand, it can be expected that smooth logistics between Bangladesh and the mainland of India can encourage Indian companies to invest in Bangladesh, to produce in Bangladesh and to export the products to the mainland of India.

Contribution to the development of the regional transport network:

Section A is expected to be a main route to connect Dhaka and the mainland of India as a part of AH1. It is expected that Section A will improve the transportation through Benapole Land Port. Furthermore it is expected that the cross border traffic will increase due to the improvement of the cross border facilities at Benapole.

Overview

The connection between Dhaka and the mainland of India is recognized as the highest priority section for the cross border infrastructure. As the cross border traffic between Benapole and Dhaka by trucks is forced to make a roundabout trip because of the "missing link" on AH1.[1] The improvement of Section A, along with construction of Padma Bridge, can produce a huge decrease in transportation cost of the traffic and will have a positive impact on GDP. Furthermore, the improvement of the cross border facilities of Benapole land port, which is expected to increase the cross border traffic, can increase the benefit of the project.

(2) Section B (between Ramgarh and Baraiyarhat)

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Included	2
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	Development of road infrastructures connected to the target project section is planned or under study.	1
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays a relevant role.	1
Economic Effect	Contribution to industrial development	There are or will be no major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	0
	Contribution to the development of the regional transport network	The target project section is planned to be a major route for cross border transport.	1
Total Score			5

BBIN MVA includes the target project section:

Section B is included in priority projects of BBIN MVA as "(vii) 4 laning of the Baraiyarhat - Heako- Ramgarh Regional Highway".

Status of relevant plans in neighboring countries:

Currently, there is no cross border facility at Ramgarh. But, Bangladesh and India are cooperating in the development of cross border facility there. Furthermore, India has constructed cross border

[1] Currently, most of the trucks moving between Dhaka and Benapole are using Jamuna Bridge, The distance between Dhaka and Benapole over Jamuna Bridge is 366km. The AH1 route between Dhaka and Benapole is 208km. Therefore, it is expected that improvement of AH1 will reduce the transportation distance of the trucks by 158km.

facility and is constructing a bridge over the river Feni to connect the cross border facilities. Bangladesh Land Port Authority is planning to build a cross border facility there after a study assisted by the World Bank.

Expected synergies with other potential, planned, or committed projects by development partner:

The World Bank will assist the study for the cross border facility at Ramgarh. Although the study has not started yet, but it is expected that the study will completed in 6 months and that the operation of Ramgarh land port will start within 3 years. So far, finance of the development is not confirmed.

Contribution to industrial development:

There is no EPZ which will use Section B as main transportation route. After Ramgarh land port starts its operation, it is expected that some part of traffic at Akhaura land port, which is current main window for traffic between Bangladesh and the North East India. Currently, main import goods at Akhaura land port are bamboo, turmeric, watches, ginger, marble slabs, fruits etc. Main export goods at Akhaura land port are processed stone, bricks, tiles, fish, cement, batteries, furniture, glass sheets etc.

On the other hand, there are 3 economic zones in the North East India (1 economic zone in Manipur and 2 economic zones in Nagaland). As the economic zones locate near Tamabil land port and Akhaura land port rather than Ramgarh land port, it is expected that their influence on the traffic at Ramgarh land port is not so much.

Contribution to the development of the regional transport network:

Currently, traffic on Section B is small, because the road is currently just a local road. But, Section B is expected to be a main route to connect Chittagong and the North East India by the shortest route. In the North East India, several regional connectivity improvement projects are being promoted. Major projects of them are as follows.

- North east connectivity improvement project (loan project by JICA)
- South Asia subregional economic connectivity road connectivity investment program (financed by ADB)
- Misoram state roads – Regional transport connectivity project (financed by the World bank)
- It is expected that Section B can cooperate with these projects to improve regional transport network after Ramgarh land port starts its operation.

Overview

For the North East India, Akhaura Land Port is the largest gate for the import/export. But Akhaura land Port is far from Chittagong and needs long distance truck transportation in Bangladesh or on the inland water way. The development of Section B and Ramgarh land Port can provide the access

in the shortest distance to Chittagong and reduce the transportation load on Bangladesh caused by the cross border traffic to/from the North East India. It is also important that Bangladesh and India are sharing the recognition of the importance of the cross border infrastructure development at Ramgarh.

(3) Section C (between Chittagong and Cox's Bazar)

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Not included	0
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	No action is taken for the development of road infrastructure connected to the target project section.	0
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays a relevant role.	1
Economic Effect	Contribution to the industrial development	There are or will be several major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	2
	Contribution to the development of the regional transport network	The target project section is planned to be a major route for the cross border transport.	1
Total Score			4

BBIN MVA includes the target project section:

Section C is not included in priority projects of BBIN MVA.

Status of relevant plans in neighboring countries:

Although Teknaf Land Port is promoting transactions between Bangladesh and Myanmar, the traffic is pretty small in comparing with other major land ports (1% of total land transport traffic). At this stage, there is no discussion to develop the cross border facility between Bangladesh and Myanmar.[2]

Expected synergies with other potential, planned, or committed projects by development partner:

A feasibility study and detailed design for the improvement of Section C have been completed by the assistance of ADB.

Contribution to industrial development:

There is no EPZ which will use Section C as a main transportation route. But the development of Southern Chittagong Region, Matarbari and surrounding area, is under investigation. GOB is expecting that the development will include an economic zone and a commercial port. If the development is carried out, Section C will become a major transportation route for the economic zone and the port.

[2] Source: Interview with Joint Secretary of Ministry of Road Transport and Bridges on July 8th, 2015

Contribution to the development of the regional transport network:

Currently, although Section C is a part of AH41, traffic on Section C is small. In order for Section C to play an important role as a regional transport network, it is necessary that the land port between Bangladesh and Myanmar be developed and that the traffic at the land port increases. But, at this stage, there is no concrete action to move the situation forward. On other hand, Sections C is a part of the alternative route of BCIM Corridor Plan.

Overview

Although there is no concrete action to develop the cross border facilities between Bangladesh and Myanmar at this stage, Section C is a part of BCIM corridor plan. If the plan is strongly promoted by China initiative and support from AIIB, the importance of Section C will increase.

Furthermore, the development of Matarbari area can change the importance of Section C drastically. As the area is a limited area to develop a large-scale port for Bangladesh, Section C can play an important role for the logistics for Bangladesh and Southern Asia region.

4.2.3 Summary of Evaluation

Total points of the evaluation are as follows.

- Section A: 8 points
- Section B: 5 points
- Section C: 4 points

4.3 Prioritization of Target Bridges and Roads

For details, refer to Chapter 4.4 of main report.

4.4 Selection of Target Project

The road improvement is eliminated from target project for the following reason.

- The bridge improvement shall be prioritized over road improvement to solve the bottle neck.
- The bridge improvement needs to be carried out at an early date because bridge construction period is longer than road.
- GOB has considerable experience of road construction.

The target bridges are described below.

Table 4.2 Target Project Bridges under Section A

No.	ID	Zone	Division	Road No.	Structure Name	Bridge Type	Bridge Length (m)	Chainage (km)	Construction Year	Remarks
A1 (I)	N706_14b	Khulna	Jessore	N-706	Jhikorgacha Bridge	RC Girder	118.67	14.349	1968	
A2 (V)	R750_25a	Khulna	Narail	R-750	Tularampur Bridge	RC Girder	91.5	24.18	1964	
A3 (VI)	Z7503_5a	Khulna	Narail	Z-7503	Hawai Khali Bridge	RC Girder	26.1	5.213	1976	
A4	—	Gopalganj Khulna	Gopalganj Narail	N-806	—	Kalna Ferry Crossing	—	—	—	
A5 (IV)	N805_24a	Gopalganj	Gopalganj	N-805	Garakola Bridge	PC Girder	105.05	24.19	2004	

Source: JICA Survey Team

Table 4.3 Target Project Bridges under Section B

No.	ID	Zone	Division	Road No.	Structure Name	Bridge Type	Bridge Length (m)	Chainage (km)	Construction Year	Remarks
B2	R-151_4a	Chittagong	Chittagong	R-151	Telipool Bridge	Steel Beam & RC Slab	15.24	3.712	1965	
B3	R-151_4c	Chittagong	Chittagong	R-151	Lakshmi Chara Bridge	Steel Beam & RC Slab	15.42	4.013	1965	
B9	R-151_14a	Chittagong	Chittagong	R-151	Kalapani Bridge-2	RC Girder	24.82	12.987	1978	
B12	R-151_16a	Chittagong	Chittagong	R-151	Koilabazar Bridge	Bailey with Steel Deck	36.8	14.886	1994	
B13	R-151_16c	Chittagong	Chittagong	R-151	Balutila Bridge	Bailey with Steel Deck	21.35	15.645	1991	
B16	R-152_Sa	Chittagong	Chittagong	R-152	Heako Bridge	RC Girder	12.4	0.131	1965	
B18	R-152_7a	Chittagong	Chittagong	R-152	Chikon Chara Bridge	RC Girder	24.23	7.207	1986	
B25	R-152_14a	Chittagong	Chittagong	R-152	East baganbazar Bridge	Steel Beam & RC Slab	36.8	13.669	1965	

Note: In addition to listed bridges above, another seven (7) existing bridges (Bridge ID: B14, 15, 19, 20, 22, 23, and 24) are appraised to be improved because their damage level is categorized as C and D. However, according to the results obtained from hydraulic analysis, they can be replaced by box culvert. Thus, they are targeted to include under Project scopes.

Source: JICA Survey Team

Table 4.4 Target Project Bridges under Section C

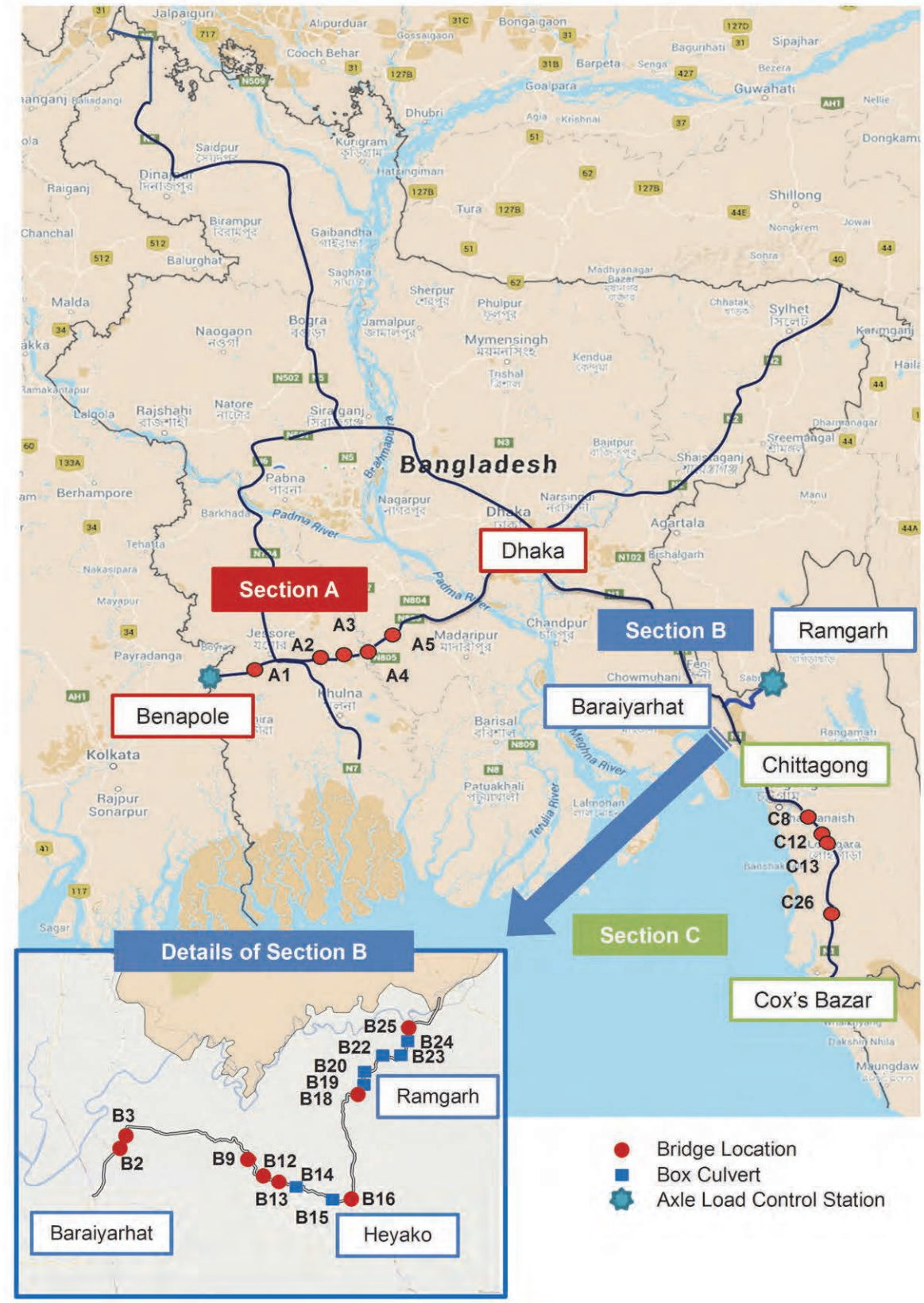
No.	ID	Zone	Division	Road No.	Structure Name	Bridge Type	Bridge Length (m)	Chainage (km)	Construction Year	Remarks
C8	N-1_257a	Chittagong	Dohazari	N-1	Patiya Bridge	RC Girder	50.3	262.116	1977	
C12	N-1_272a	Chittagong	Dohazari	N-1	Mazar Point Bridge	RC Girder	50.8	275.943	1965	
C13	N-1_279a	Chittagong	Dohazari	N-1	Sangu Bridge	RC Girder	211.0	282.994	1960	
C26	N-1_328a	Chittagong	Cox's Bazar	N-1	Mathamuhuri Bridge	RC Girder	294.2	331.259	1960	

Source: JICA Survey Team

Additionally, the axle load scale will be installed at Benapole and Ramgarh in the project for the following reason.

- There is existing land port at Benapole and located under important corridor which has been selected as AH1 (Asian Highway 1). Besides, it is expected that the traffic volume including cross-border transportation will rapidly increase after commencement of Padma and Kalna bridges.
- New land port is planned at Ramgarh because the Indian Government is funding the construction of a bridge crossing Feni River on the Bangladesh-India border. Thus, this is expected to boost international trade between Bangladesh and the northeast state of India, known as the “Seven Sisters State”.
- In above land port of 2 locations, it is effective that the control of overloaded vehicle conducts at land port before travel, because cross-border transportation must be controlled in order to avoid damage to roads and bridges.

The target project is shown in Figure 4.2.



Source: JICA Survey Team

Figure 4.2 Location of the Target Bridges and Axle Load Scale

5. NATURAL CONDITIONS

5.1 Physiography

The survey area covers three distinct physiographic zones. Section A lies in the Ganges river deltaic plain where the meandering behavior of the Madhumati river must be considered. Section B is situated in the northern part of Chittagong hills where hilly terrains are dominant and in the valley scouring due to flash floods must be taken into account. Section C is located in the west of Chittagong Hills between Chittagong in the north and Cox's Bazar in the south.

5.2 Geology

The survey area is comprised of different geology in three sections. Following geotechnical investigation was conducted to collect the data for designing the bridges and road;

- Boring
- Standard penetration test
- Sampling (disturbed, undisturbed)
- Laboratory tests
  Grain size analysis / Water content / Specific gravity / Wet density / Dry density / Liquid limit / Plastic limit / unconfined compression test / Consolidation test
- CBR test (Section B/C only)

5.2.1 Geotechnical Investigation in Section A

In Section A, Kalna was selected for the investigation. In the Madhumati river, silty sand and clayey sand is widely deposited on the banks and on the river bed. The pile bearing strata exists about 55 m below GL (Ground Level) on the banks.

5.2.2 Geotechnical Investigation at Section B

In Section B, soil conditions vary between hilly areas and flood land. Silty sand is dominant in the hilly areas and clayey silt is dominant in the flood land areas. According to borings at 27 locations, pile bearing strata exits at an average 30 m below GL, but 50 m below GL in the flat land near Barayalhat.

5.2.3 Geotechnical Investigation at Section C

In Section C, borings were conducted at 4 bridges where silty/clayey sand is thickly deposited. Pile bearing strata exists at 30 to 55 m below GL. At some locations, shale bedrock is encountered.

5.3 Climate Change

Bangladesh is a low-lying deltaic country in South Asia bounded 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).

5.4 Meteorological and Hydrological Conditions

5.4.1 Hydrological Survey Results

The results of the hydrological statistical analyses, bridge-scour and hydraulic computations can summarize as follows;

- ✓ In the topographic survey, the elevation differences of 'PWD datum of BWDB stations' and 'topographic survey datum (MSL)' were measured at 4 locations which are relatively close the distance of BWDB stations and bridges. The differences for real were 0.55-2.01m, although its official difference is 0.46m. This means that the observed BWDB water-level data of other stations except 4 stations includes the error. Namely, in the calculated water-level, it includes some errors.
- ✓ Under conditions of 'With Bridge' and 'Without Bridge' in case of the Kalna (A-4), Sangu (C-13) and Mathamuhuri (C-26) Bridges, both changes of water-level around bridges are negligible amounts.
- ✓ The contraction scour occurs 0.14m for the Kalna, 0.61m for the Sangu and 0.08m for the Mathamuhuri. This means that the river section flow area is small. However, the value of the contraction scour is not so big, and it might be no problem.
- ✓ The river-bed materials around the Kalna Bridge are very fine. In 2D-modeling of this time, all of materials will be washed out, if the amount of 100-year flood continues.

As the computation results in the local scouring, it occurs in most of piers each bridge. Therefore, the riverbed around piers which are occurred the scouring, have taken costs for the appropriate bed protection work into account.

5.4.2 Hydrological Recommendations

As for hydraulic issues of the proposed bridge from above results, the following points are left as future challenges;

- ✓ In order to secure the accuracy of the elevation and design water-level, the checking of the difference between 'PWD datum of BWDB stations' and 'topographic survey datum' shall be performed in the D/D (detailed design) stage.
- ✓ The hydraulic calculation including the scouring is conducted for only 3 bridges. In the D/D stage, the detailed study of the bridge-hydraulics shall be performed for all bridges furthermore. Especially, regarding the proposed Kalna Bridge, the further detailed hydrological study will be required for verifications of the dynamic river-bed fluctuation, the proper design discharge and the turbulent flow field around piers, etc.
- ✓ There are many kinds of bed protection and revetment works. Therefore several construction methods or comparison for them shall be conducted in the D/D stage. In addition, estimation of scouring is necessary to study further other prediction formulas including the HEC formula.

6. TRAFFIC DEMAND FORECAST

6.1 Forecasting Procedure

6.1.1 Section A

The future traffic demand in the Section-A is expected to grow considerably by the diversion of traffic from another routes, because the Padma Bridge will open after a few years, and ADB has a plan to widen Section-A to a 4-lane road. For this purpose, we implemented the traffic survey to grasp the OD data on Section-A and on the river crossing points of alternative routes, and also we estimated the ideal OD matrix by using the present population by zone and existing observed traffic volumes, and then made the present OD matrix by combining those data. After preparing the present OD matrix, we formulated the mathematical model to reflect the universal relation between present traffic situations and socioeconomic data, and then we forecasted the future traffic demand.

Furthermore, the international transit traffic which will go through Bangladesh were forecasted and added to the related road network, under the premise that BBIN-VBA is concluded and it will be enforced by 2020.

6.1.2 Section B and C

The future traffic volumes in Section-B and C were estimated by multiplying the growth rate of the future vehicle registration number by the present traffic count survey results. In addition, international transit volume was added for Section-B.

6.2 Forecasting Results

6.2.1 Section A

In case all bridges are constructed in 2045, traffic in the Section-A will be 22,500-46,000 pcu/day in the Benapole-Jessore section, 54,200-66,100 pcu/day in the Jessore - Narail section, and 54,200-58,800 pcu/day in the Narail - Bhanga section.

6.2.2 Section B and C

In case all bridges are constructed in 2045, traffic in the Section-B will be 9,200 pcu/day in the Karehat - Herako section and 5,100 pcu/day in the Herako - Ramgarh section, and traffic in the Section-C will be 35,100 - 41,700 pcu/day in the Chittagong - Chandanaish section, 32,200 - 67,700 pcu/day in the Chandanaish - Chunati section and 20,700 - 37,300 pcu/day in the Chunati - Cox's Bazzar section.

7. PRELIMINARY DESIGN FOR ROADS AND FACILITIES

7.1 Design Standards and Criteria

The required numbers of lanes are calculated based on the Bangladesh Standard. For setting of the numbers of lanes, it is desirable to unify it within the each section. And, the maximum traffic demand of sub-section is represented in the each section. Therefore, the design numbers of lanes are decided to apply with 4 lanes in Section A and C and 2 lanes in Section B, respectively.

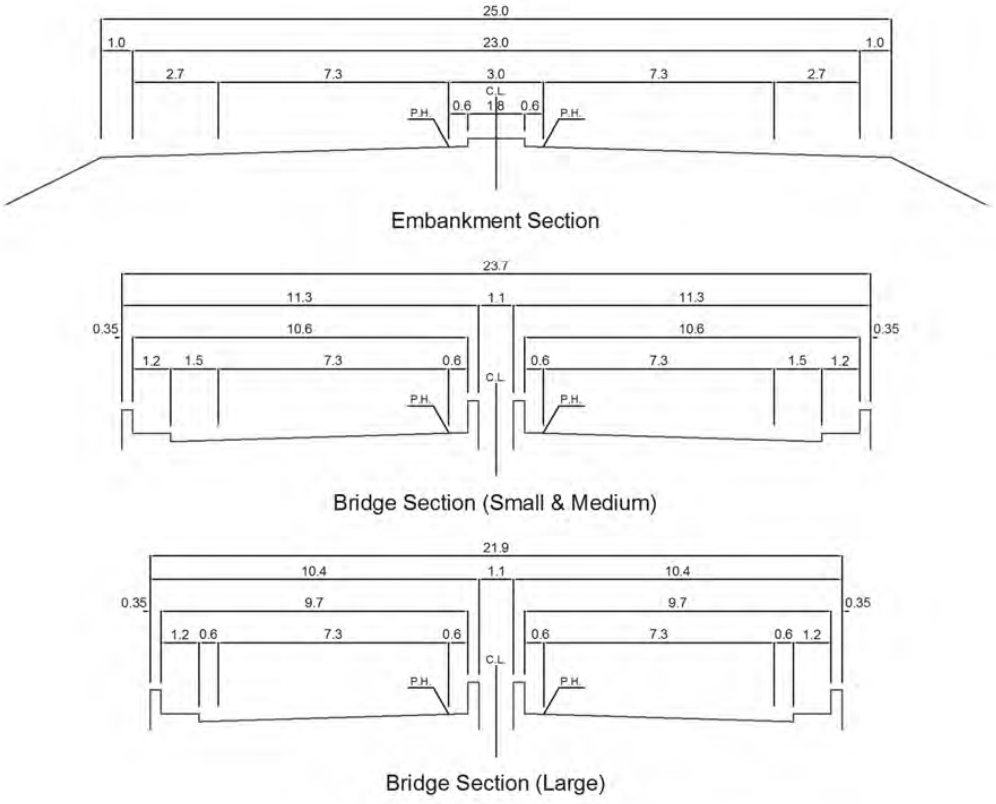
The establishment of design criteria is related to the function of the road, volume of traffic and type of terrain, roadside condition and so forth. At first, 3 sections in this project were classified into 2 types; e.g. Sections A and C are located on the Asian Highway with 4 lanes, and Section B has 2 lanes. And, the related standards of each donner, Asian Highway and/or the related projects are compared. In Sections A and C, the design criteria shall at least satisfy the Asian Highway Standard. On the other hand, Section B, which is categorized as a Mountainous/Hilly Area, is not located on the Asian Highway. However, it will be an important international highway as one of the cross border facilities. Therefore, the adopted design criteria shall at least satisfy Class II of the Asian Highway Standard. Through the discussion with RHD based on the proposed design criteria and typical cross sections, the design criteria and typical cross sections are decided as shown in Table 7.1 and Figures 7.1 and 7. 2.

Table 7.1 Adopted Design Criteria

Criteria		Section A and C	Section B	Remarks
Terrain		Plain	Mountain	
Design Speed (km/h)		100	50	
Stopping Sight Distance (m)		160	55	
Cross Section (m)				
	Carriageway	3.65	3.65	
	Median	3.00	N/A	
	Median Marginal Strips	0.60	N/A	
	Shoulder	2.70	1.85	
	Verge	1.00	1.00	
Carriageway Crossfall (%)		3.0	3.0	
Shoulder Crossfall (%)		3.0	3.0	
Type of Pavement		AC	AC/RCC	
Min. Horizontal Curve Radius (m)		460	100 [120]	
Min. Horizontal Curve Radius without Transition Curves (m)		1,500	350	
Min. Transition Curve Length (m)		85	40	
Max. Superelevation (%)		7.0	7.0	
Max. Vertical Grade (%)		3.0	7.0	
Min. Vertical Curve Length (m)		85	40	
Min. Vertical Curve K-Value		70	9	

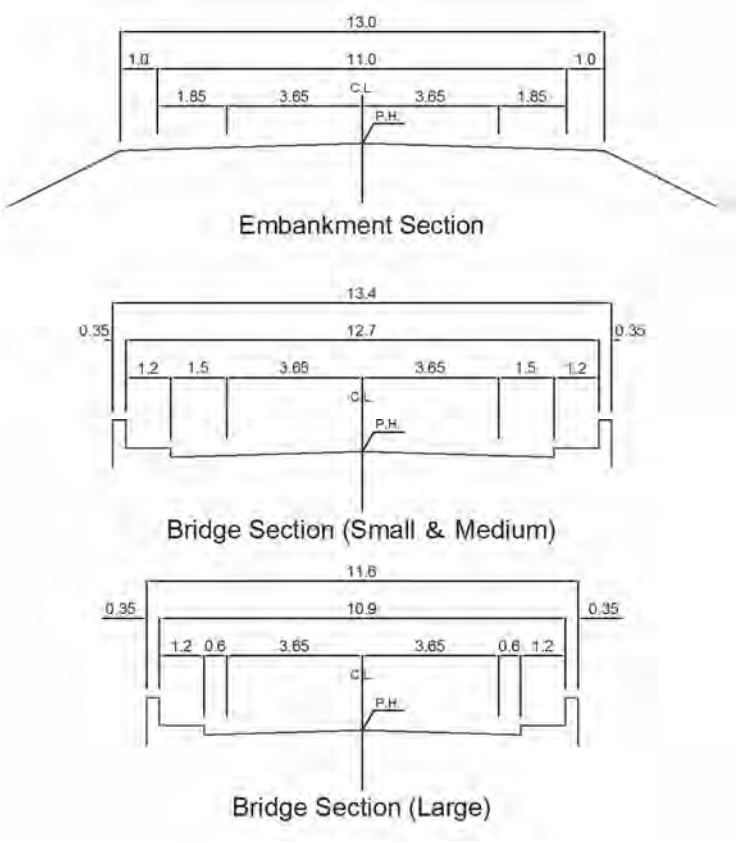
*1: Figure in [ ] shows desirable value.
2: AC/RCC shows Asphalt Concrete/Reinforced Cement Concrete.

Source: JICA Survey Team



Source: JICA Survey Team

Figure 7.1 Adopted Typical Cross Section (Section A and C)



Unit: m

Source: JICA Survey Team

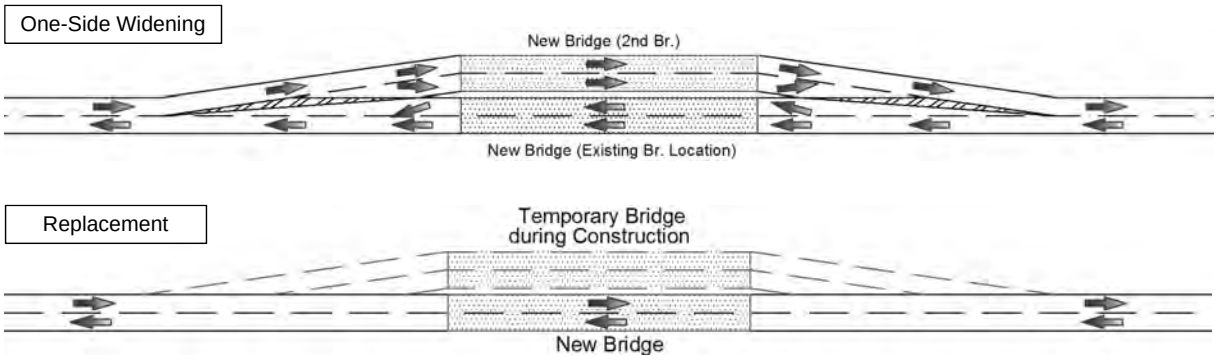
Figure 7.2 Adopted Typical Cross Section (Section B)

7.2 Preliminary Highway Design

7.2.1 Highway Design Concept

Target bridges are 5 locations in Section A and 4 bridges in Section C. All bridges are planned to be 4-lane bridges, however, the existing roads are 2-lane. Therefore, it is required to taper between 2-lane and 4-lane in the approach embankment sections. The widening of the existing road in Section A and C excluding the target bridges is supposed to implement by ADB fund. For setting out of the new bridge location (the 2nd Bridge), it is possible to reduce the construction cost and implementation schedule using the existing bridge (the 1st Bridge) as a temporary bridge for traffic during construction stage. Therefore, the 2nd Bridge location will be constructed beside the existing bridge as shown in Figure 7.3 (One-side widening.).

On the other hand, target projects are 8 bridges and 7 box culverts under Section B. The upgrading of the existing roads and bridges in Section B excluding the above targets is supposed to implement by GoB fund or ADB fund. For the preliminary highway design, it is desirable to utilize the ROW of the existing as far as possible. The design policy is basically to follow the existing road (replacement) with temporary bridge beside of the existing one as shown in Figure 7.3.



Source: JICA Survey Team

Figure 7.3 Concept of Bridge Location

As of definition, the upgrading of the whole section is called as "the Completion Stage", and the improvement of targets only is as "the Initial Stage". In consideration with economy and practicability, the design speed for the Initial Stage is allowed to apply 80 km/h in Section A and C, 40 km/h in Section B. Table 7.2 shows the adopted design criteria for the Initial Stage.

Table 7.2 Adopted Design Criteria in Initial Stage

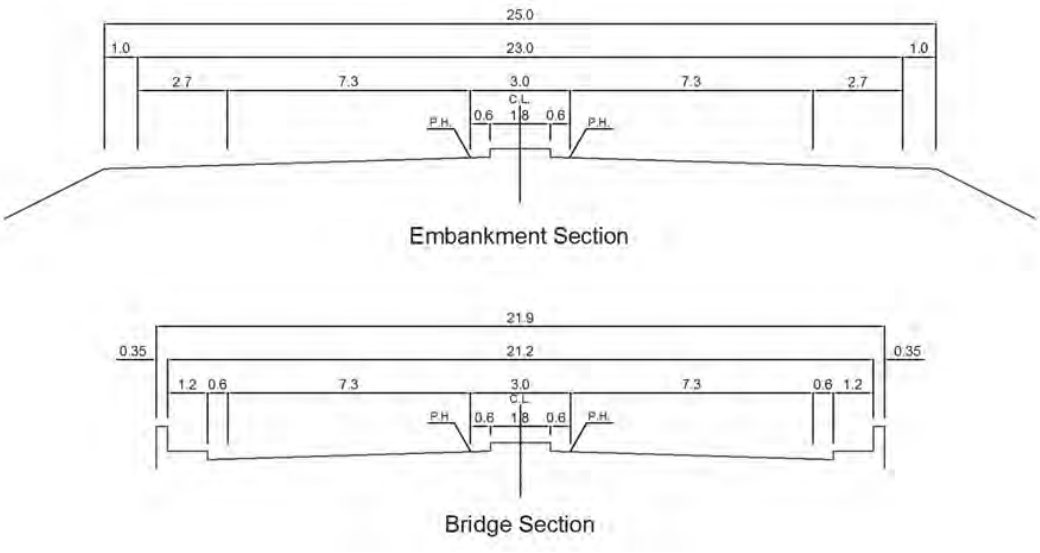
Criteria	Section A and C	Section B	Remarks
Terrain	Plain	Mountain	
Design Speed (km/h)	80	40	
Stopping Sight Distance (m)	110	40	
Min. Horizontal Curve Radius (m)	280	60	
Min. Horizontal Curve Radius without Transition Curves (m)	900	250	
Min. Transition Curve Length (m)	70	35	
Max. Superelevation (%)	7.0	7.0	
Max. Vertical Grade (%)	4.0	6.0	
Min. Vertical Curve Length (m)	70	35	
Min. Vertical Curve K-Value	35	4.5	

*1: Figure in [ ] shows desirable value.

Source: JICA Survey Team

(1) Kalna Bridge

Bridge type of main bridge is selected special type (Nilsen type; refer to Chapter 8). Typical cross sections for Kalna Bridge are shown in Figure 7.4.



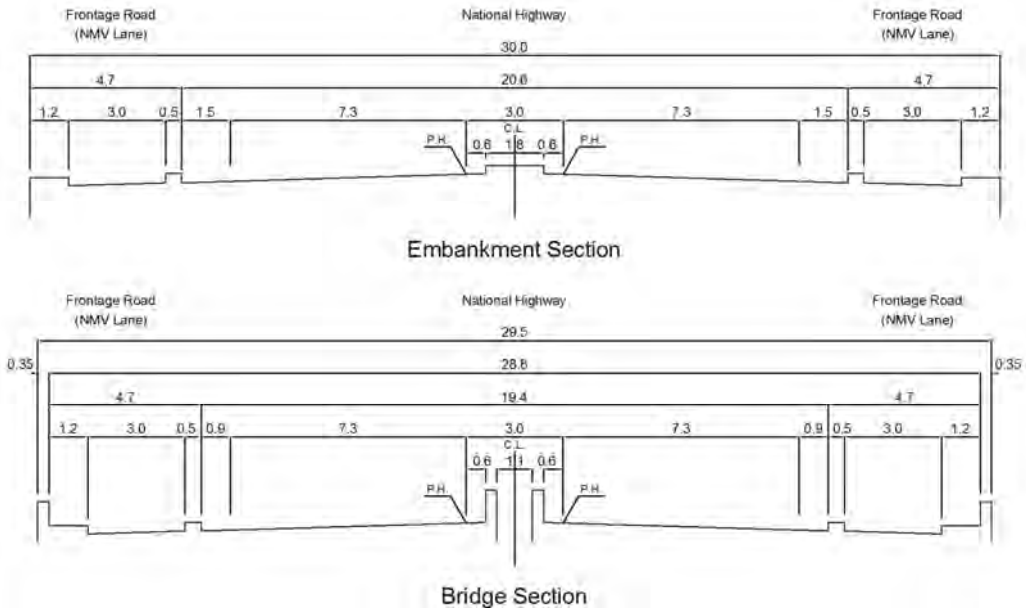
Unit: m

Source: JICA Survey Team

Figure 7.4 Applied Typical Cross Section for Kalna Bridge

(2) Jhikorgach Bridge

There are a series of shops along the approach roads before/after Jhikorgacha Bridge. Therefore, the provision of frontage roads in the both sides is desirable in the view of traffic safety. However, it is difficult that the ROW will be widened more than 30 m in width which had been acquired. Finally, the 30.0 m width with NMV lane in the both sides on the fill section is adopted as the results of the meeting with RHD. Figure 7.5 shows the applied typical cross sections for Jhikorgacha Bridge.



Unit: m

Source: JICA Survey Team

Figure 7.5 Applied Typical Cross Section for Jhikorgacha Bridge

7.2.2 Highway Design Results

Based on the above method, preliminary highway design was conducted and the design summary in each bridge is shown in Table 7.3.

Table 7.3 Highway Design Summary

Sl. no.	Bridge name	Road No	Applied Design Speed (km/h)					Approach Road Length (m)		
			Bridge		Approach Road			A1 Side	A2 Side	Total
			Horizontal	Vertical	Horizontal	Vertical	Taper			
Section A (Dhaka-Benapole)										
A1	Jhikorgacha Bridge	N-706	100	100	100	80	60	205.000	205.000	410.000
A2	Tularampur Bridge	R-750	100	100	100	100	80	325.000	411.821	736.821
A3	Haw ai khali Bridge	Z-7503	100	100	100	80	80	325.000	330.000	655.000
A4	Kalna Bridge	N-806	100	100	100	100	80	325.000	3,897.457	4,222.457
A5	Garakola Bridge	N-805	100	100	100	80	80	315.000	366.405	681.405
Section B (Baraiyarhat-Ramgarh)										
B2	Telipool Bridge	R-151	50	50	50	40	40	141.707	144.200	285.907
B3	Lakshmi chara Bridge	R-151	50	50	50	40	40	91.807	120.025	211.832
B9	Kalapani Bridge-2	R-151	50	50	50	40	40	90.402	103.363	193.765
B12	Koilabazar Bridge	R-151	50	50	40	40	40	89.440	118.597	208.037
B13	Balutila Bridge	R-151	50	50	50	40	40	94.873	93.017	187.890
B16	Heako Bridge	R-152	50	50	50	40	40	102.179	82.168	184.347
B18	Chikon Chara Bridge	R-152	50 (40)	50	40	40	40	85.431	137.435	222.866
B25	East baganbazar Bridge	R-152	50	50	40	40	40	128.962	107.877	236.839
Section C (Chittagong-Cox's Bazar)										
C8	Patiya Bridge	N-1	100	100	100	100	80	354.016	325.000	679.016
C12	Mazar Point Bridge	N-1	100	100	100	80	80	325.000	352.407	677.407
C13	Sangu Bridge	N-1	100	100	100	100	80	434.312	341.339	775.651
C26	Mathamuhuri Bridge	N-1	100	100	100	100	80	300.000	410.134	710.134

Note: ( ) show s the initial stage.

Source: JICA Survey Team

7.3 Other Facility Plans

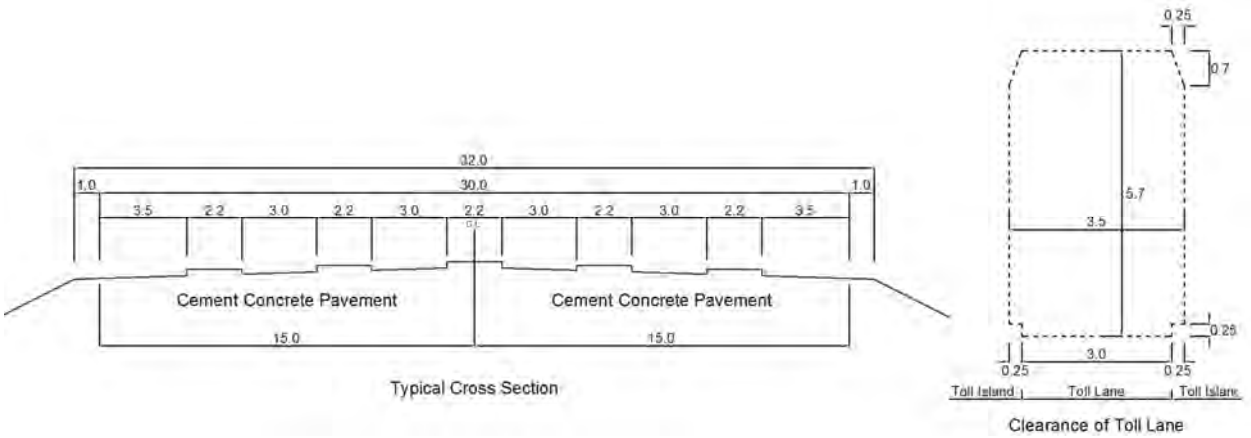
7.3.1 Toll Collection Facility

Kalna Bridge has a plan to be toll bridge because Kalna Bridge will be newly constructed instead of the existing Dauladia Ferry on Madhumati River. The design standard is not available in Bangladesh, and then, the toll collection facilities are planned to refer with the Japan Standard.

Based on the traffic demand results, the target traffic volume is estimated, and the minimum number of lanes is estimated as 2-lane per one direction. Finally, the necessary number of lanes is determined as 3-lane per one direction in consideration with 2-lane per one direction on the main road. The location of toll collection facilities is set out to close to the bridge as much as possible on the straight section of

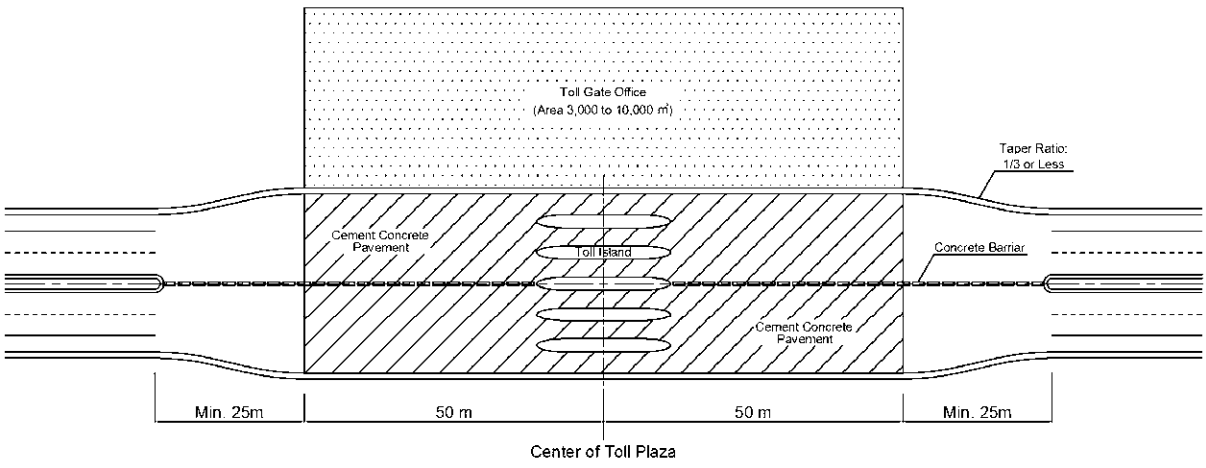
the North-South axle at the left bank (East side) of Madhumati River in the view of the economy, traffic safety and social environment.

The layout of toll facilities is also referred with Japan Standard. The length of toll plaza is 50 m before/after the center of toll gates, totally 100 m where should be paved by the cement concrete. Figures 7.6 and 7.7 show the typical cross section at toll gate and the sample layout of toll plaza.



Source: JICA Survey Team

Figure 7.6 Typical Cross Section of Toll Gate



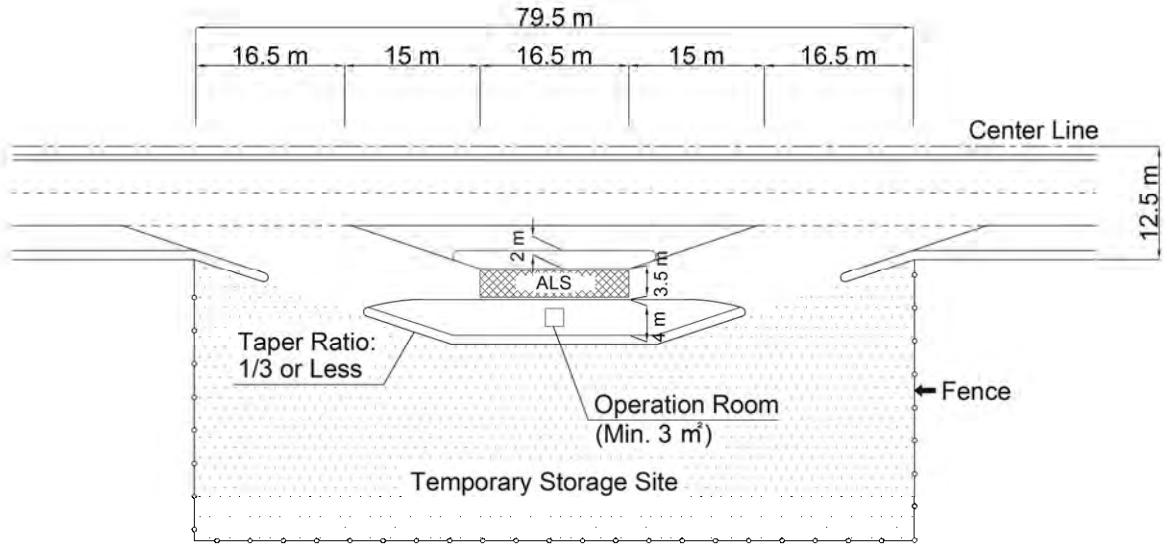
Source: JICA Survey Team

Figure 7.7 Sample Layout of Toll Plaza

7.3.2 Axle Load Control Facility

As mentioned in Chapter 4, the axle load control facilities are planned at Benapole in Section A and Ramgarh in Section B. Bangladesh has been issued the Notification regarding maximum permissible axle and laden weighs limit for motor vehicle. However, the design standard is not available in Bangladesh, and then, the axle load control facilities are planned to refer with the Japan Standard.

Applying with the future international cargo traffic as the results of the traffic demand, the target traffic volume is estimated, and the necessary number of axle load scale lane is determined as 1-lane per one direction at Benapole and Ramgarh, respectively. The layout of the axle load control facility in the Completion Stage, in reference with Japan Standard, is illustrated in Figure 7.8.



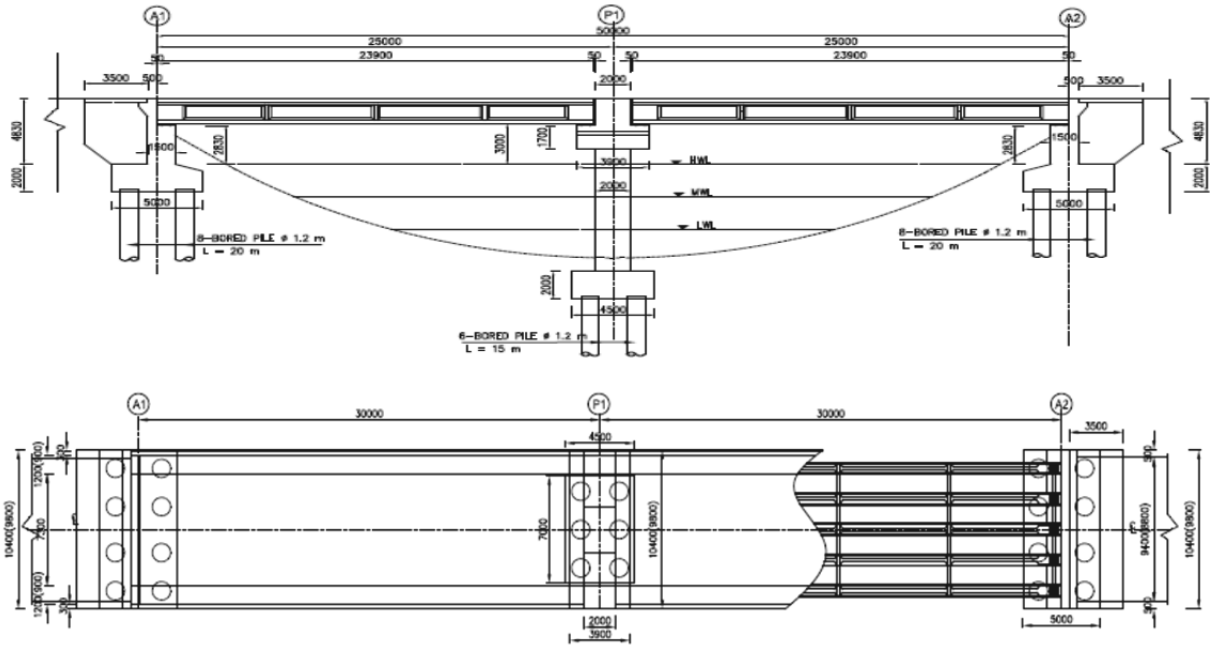
Source: JICA Survey Team

Figure 7.8 Layout of Axle Load Control Facility

8. PRELIMINARY DESIGN FOR BRIDGE

8.1 Small Size Bridges (PC-I girder)

As small size bridges PC-I girder is widely recognized as the most suitable and economical bridge type in any site conditions, and this is true in Bangladesh therefore many PC-I girder bridges have been constructed by RHD. In this Survey PC-I girder can be selected as small size bridges without special comparison, and standard general view is shown in Figure 8.1. The bridge list in Table 8.1 shows all bridges excepting Kalana Bridge are PC-I girders with span length between 25 – 45 m.



Source: JICA Survey Team

Figure 8.1 PC-I Girder Bridge

8.2 Middle Size Bridge (Kalna Bridge)

Only Kalna Bridge is categorized as middle size bridge with required conditions as follows.

- Normal river width is approximately 300 m, and maximum 600 m with high water level
- Required navigation clearance is horizontally 35.0 m and vertically 7.62 m
- Span length at river center is required more than 100 m to avoid river scoring (by BUET)
- Symbolic bridge is preferred by GOB and RHD

By bridge type comparison in Table 8.1, Nielsen-Lohse Bridge is selected with main reasons below.

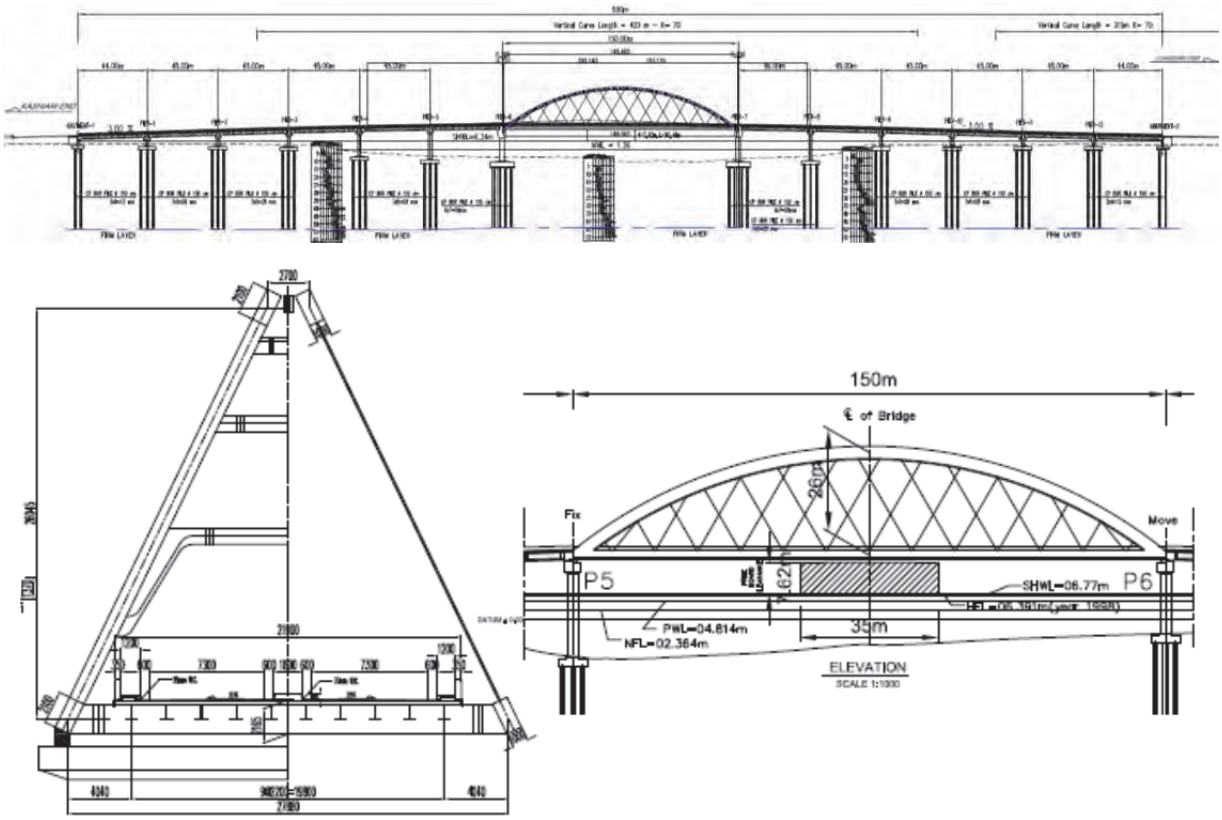
- Cost efficiency with high-cost main span bridge is only single span 150 m length, and no need three (3) continuous spans to take balance as other bridges require
- Symbolic landscape with arch and cable shape, and no experience in Bangladesh
- Less maintenance works are required, by applying heavy painting system on steel plates and galvanized with coating cable system

Table 8.1 Bridge Type Comparison for Kalna Bridge

Main Span Bridge	Type	PC-Box Br	Steel-Box Br	Truss Br	Arch Br	Nielsen Br	Extra-Dosed Br	Cable-Stayed Br
	Material	Concrete	Steel (weathering steel)	Steel-Concrete (composite)	Steel	Steel	Concrete	Steel-Concrete (composite)
	length (m)	230	230	230	150	150	230	230
	Image							
Side Span Bridge	Type		Concrete PC-I Girder Bridge (because of economical feature)					
	Material							
	length (m)	430	430	430	510	510	430	430
Experience in Bangladesh (Main span Br)		done	on-going	on-going	not yet	not yet	done	not yet
Landscape point		moderate	moderate	good	good	Excellent	Excellent	Excellent
Initial Cost Ratio (Main & Side Br)		1.00	1.26	1.23	1.13	1.14	1.32	1.34
Maintenance feature		less	less	moderate	moderate	moderate	less	moderate
Maintenance works		cable re-painting	use weathering-steel	use heavy-painting system	use heavy-painting system	use heavy-painting system	cable re-painting	use heavy-painting system
Recommendation						recommended		
Reason		New bridge type in Bangladesh, economical by special bridge type at main span only with 150 m length						
Comment		Good landscape are gotten by using cable or curved shape with flexible steel material, and not so much maintenance works are required for steel structures by using heavy-painting system which is applied to on-going Megna, Kanchpur, Gumti bridge project						

Source: JICA Survey Team

The bridge type for main span of Kalna Bridge is selected as Nielsen-Lohse type with span length 150 m. Based on the result of preliminary design, the general view is shown in Figure 8.2.



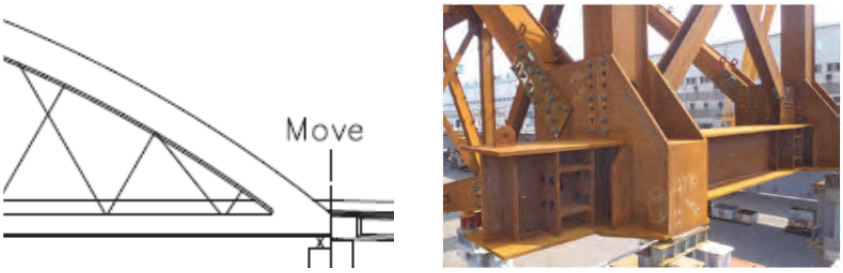
Source: JICA Survey Team

Figure 8.2 General View of Kalna Bridge

As the most important structural part of Kalna main bridge, arch corners must support concentrated large forces as shown in Figure 8.3, then require complicated structures with thicker (30-50 mm) and high strength (grade SM570) steel plates being welded each other.

If using standard steel material grade SM570, special treatment of pre-heating 80-100℃ is definitely required before starting welding and this treatment can affect to welding quality and bridge design life.

"Steels for Bridge High Performance Structure (SBHS)" was developed to ensure quality of welding without pre-heating, then SBHS-500 is applied for arch corners of Kalna main bridge to keep quality.



Source: JICA Survey Team

Figure 8.3 Arch Corner of Kalna Main Bridge

8.3 Summary of Preliminary Design

The summary of preliminary design for PC-I bridges (18 bridges) and Kalna Bridge are shown in Table 8.2 and the civil cost calculation will be done accordingly.

Table 8.2 Summary of Preliminary Design

					Existing Bridge			New Bridge							Total Length Increase	
No.	Bridge ID	Zone	Road No	Bridge Name	Span Arrangement	Width (m)	Total length (m)	Bridge type	No of Spans	Span Arrangement	Total Length	Width	Abutment Pile Length	Pier Pile Length	New / Exist	New - Exist
A1	N-706_14b	Khulna	N-706	Jhikorgacha Bridge	18.3+14.35+11.8+29.20+12.15+14.30+18.38	7.30	118.7	PC-I	4	30+30+35+30	125	14.2+14.2	42	38	1.05	6
A2	R-750_25a	Khulna	R-750	Tularampur Bridge	13.40+64.70+13.40	8.23	91.5	PC-I	3	30+35+35	100	10.4+10.4	39	30	1.09	9
A3	Z-7503_5a	Khulna	Z-7503	Hawai khali Bridge	4.50+17.10+4.50	7.90	26.1	PC-I	1	35	35	11.3+11.3	43		1.34	9
A4	N-806	Gopalganj	N-806	Kalna				PC-I + Steel	13	44+45*4+46 +150+ 46+45*4+44	690	21.9	55	39		
A5	N-805_24a	Gopalganj	N-805	Garakola Bridge	35.00 + 35.00 + 35.00	10.00	105.1	PC-I	3	35+40+35	110	10.4+10.4	39	29	1.05	5
B1	R-151_3a	Chittagong	R-151	Purbo Hinguli Bridge	18.5	7.83	18.5	PC-1 (GOB)	2	30+25	55	13.4	36		2.97	37
B2	R-151_4a	Chittagong	R-151	Telipool Bridge	15.24	4.18	15.2	PC-I	1	25	25	13.4	36		1.64	10
B3	R-151_4c	Chittagong	R-151	Lakshmi chara Bridge	15.42	4.21	15.4	PC-I	1	40	40	13.4	59		2.59	25
B4	R-151_11a	Chittagong	R-151	Tulatuli Lohar Bridge	24.45	5.03	24.5	Embankment								
B5	R-151_11c	Chittagong	R-151	tulatuli Bridge	24.3	7.15	24.3	Embankment								
B6	R-151_12a	Chittagong	R-151	Buro Camp Bridge	24.2	7.20	24.2	Embankment								
B7	R-151_12c	Chittagong	R-151	Bangra Tabor Bridge	24.32	7.18	24.3	Embankment								
B8	R-151_12e	Chittagong	R-151	Kalapani Bridge-1	24.4	7.18	24.4	Embankment								
B9	R-151_14a	Chittagong	R-151	Kalapani Bridge-2	6.22+12.2+5.95	4.07	24.8	PC-I	1	35	35	13.4	10		1.41	10
B10	R-151_14c	Chittagong	R-151	Niharkanti Das Bridge	42	8.63	42.0	Box Culvert	1	1 cell@B2.0 ×H2.0						
B11	R-151_15a	Chittagong	R-151	Koilapara Bridge	24.4	7.10	24.4	Embankment								
B12	R-151_16a	Chittagong	R-151	Koilabazar Bridge	36.8	4.85	36.8	PC-I	2	30+25	55	13.4	10	10	1.49	18
B13	R-151_16c	Chittagong	R-151	Balutila Bridge	21.35	4.03	21.4	PC-I	1	30	30	13.4	10		1.41	9
B14	R-151_18a	Chittagong	R-151	Fulchari Bridge	15.3	4.12	15.3	Box Culvert	2	2 cell@B3.0 ×H3.0						
B15	R-151_22a	Chittagong	R-151	Heaku Bazar B ridge	12.5	4.08		Box Culvert	1	1 cell@B3.0 ×H3.0						
B16	R-152_Sa	Chittagong	R-152	Heako Bridge	12.4	4.06		PC-I		25	25	13.4	38			25
B17	R-152_3a	Chittagong	R-152	Amtali Bridge	3.8+12.16+3.8	7.22	19.8	Box Culvert	1	1 cell@B6.0xH4.0						
B18	R-152_7a	Chittagong	R-152	Chikon Chara Bridge	4.46+15.27+4.45	7.30	24.2	PC-I	1	30	30	13.4	13		1.24	6
B19	R-152_8a	Chittagong	R-152	Chikon Chara Bridge	6.02+6.52	4.24		Box Culvert	1	1 cell@B3.0 ×H3.0						-
B20	R-152_8c	Chittagong	R-152	Banglabazar bridge	6.08+6.58	4.31		Box Culvert	1	1 cell@B3.0 ×H3.0						-
B21	R-152_10a	Chittagong	R-152	Borobil Bridge	6.18+18.31+6.12	7.16	30.6	PC-I (GOB)	1	35	35	13.4	13		1.14	4
B22	R-152_10c	Chittagong	R-152	Borobil Bridge	7.60+7.60	4.13		Box Culvert	1	1 cell@B2.0 ×H2.0						-
B23	R-152_11b	Chittagong	R-152	Gadar dokan Bridge	6.7+6.5	4.20		Box Culvert	2	2 cell@B3.0 ×H3.0						-
B24	R-152_13a	Chittagong	R-152	Bagan Bazar Bridge	18.37	4.15	18.4	Box Culvert	1	1 cell@B3.0 ×H3.0						
B25	R-152_14a	Chittagong	R-152	East baganbazar Bridge	12.3+12.25+12.2	4.20	36.8	PC-I	2	25+25	50	13.4	20	20	1.36	13
B26	R-152_15a	Chittagong	R-152	Sonaipool Bridge	12.3+12.16+12.43	4.13	36.9	under construction by GOB fund								
C8	N-1_257a	Chittagong	N-1	Patiya Bridge	25.15+25.15	8.40	50.3	PC-I	2	25+30	55	11.3+11.3	50	46	1.09	5
C12	N-1_272a	Chittagong	N-1	Mazar Point Bridge	12.7+12.7+12.7+12.7	7.20	50.8	PC-I	2	35+25	60	11.3+11.3	34	29	1.18	9
C13	N-1_279a	Chittagong	N-1	Sangu Bridge	36.3+45.8+47+46.4+35.2	7.20	211.0	PC-I	6	2@40+4@35	220	10.4+10.4	37	27	1.04	9
C26	N-1_328a	Chittagong	N-1	Mathamuhuri Bridge	42+42+42+42+42+42+42	7.20	294.2	PC-I	8	6@40+2@35	310	10.4+10.4	29	21	1.05	16
18	Bridges without Kalna				Total of 18 Bridges (without Kalna) =		1,450			Total of 18 Bridges (without Kalna) =	1,395	Ave. =	32.3	28.9	1.42	10.2

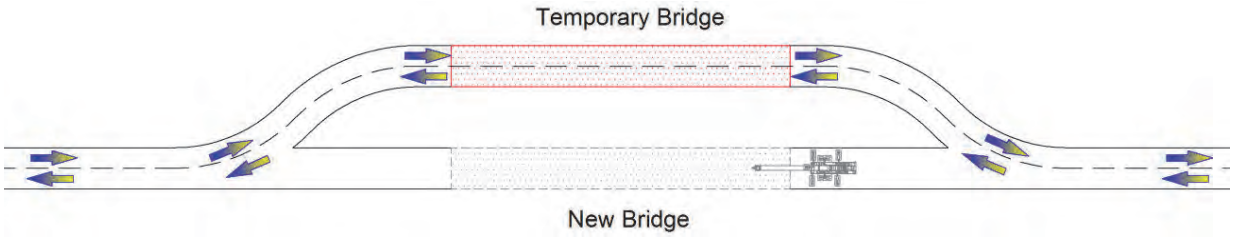
Source: JICA Survey Team

9. CONSTRUCTION PLAN

9.1 Traffic Diversion Measures during Construction

The bridges under section B have been planned at the same location of existing bridges considering the impact to existing houses and shops etc. Therefore, the bridges under Section B need traffic diversion during construction. However, the bridges under section A and C are selected on Asian Highway and have been planned to construct separately next to the existing one. Thus, traffic diversion during construction becomes unnecessary.

In addition, Jhikorgacha Bridge under Section A is planned to construct at the same location of existing bridge so that center line of new bridge will coincide with that of existing one. Therefore, the temporary bridge construction becomes necessary in order to divert the existing traffics during construction, which is panned below in Figure 9.1 (b).

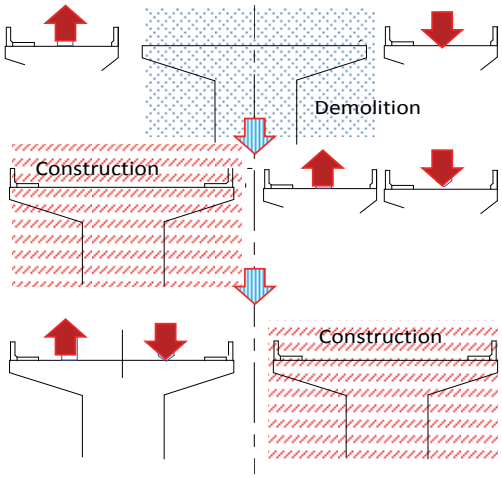


(a) Diversion Plan of Section B

Step-1:
- Temporary diversion in both sides
- Existing bridge demolition

Step-2:
- 2-lane new bridge construction

Step-3:
- Traffic diversion through new bridge
- Another 2-lane new bridge construction at next



(b) Arrangement Plan of Jhikorgacha Bridge

Source: JICA Survey Team

Figure 9.1 Diversion Plan during Construction

9.2 Erection Method of Nielsen Lohse Bridge (Kalna Bridge)

Whole steel portion of Nielsen-Lohse Bridge will be constructed at river side and lifted onto the floating barge. Then, the barge will transport the bridge to the center of river and the bridge will be

jacked up on the bridge piers. In particular, this erection of steel arch section shall be followed in three steps:

- Step-1: Arch Assemblage
- Step-2: Lateral transfer using floating barge
- Step-3: Jack Down

The detailed construction method is shown elsewhere in Chapter 9 of this report.

9.3 Construction Schedule

9.3.1 PC-I Girder Bridges/ RC Box Culverts

The overall construction schedule of PC-I Girder bridges (excluding Kalna) and RC Box Culverts is shown in Figure 9.2 where Bar Chart with two different colors represents 2-lane new bridge construction followed by existing bridge replacement or vice versa. The construction of bridges under Package A2 and B are planned to complete by 33 months, whereas those under Package C are scheduled to complete by 36 months.

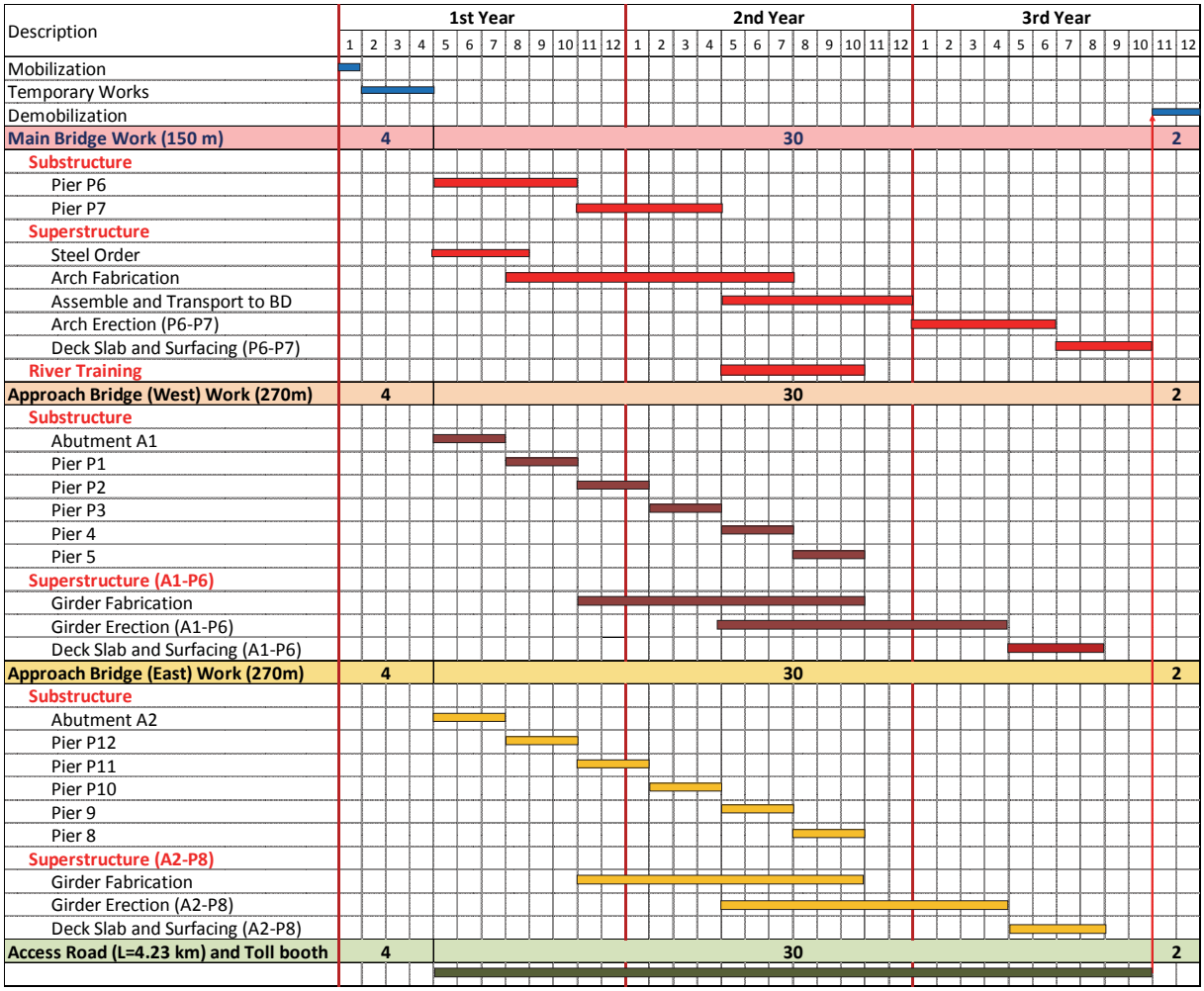
Bridge Name	No. of	Construction Sequence (months)									Package Total
[A2 Package] 2-Party	Lane	4	8	12	16	20	24	28	32	36	(months)
A1:Jhikorgacha Bridge (125m)	4										33
A3: Hawai khali Bridge (35m)	4										
A2:Tularampur Bridge (100m)	4										
A5:Garakola Bridge (110m)	2										
[B Package] 5-Party											
B2: Telipool Bridge (25m)	2										33
B3: Lakshmi chara Bridge (40)	2										
B9: Kalapani Bridge-2 (35m)	2										
B14,B15,B19&B20(Box Culverts)	2										
B13: Balutila Bridge (35m)	2										
B16: Heako Bridge (25m)	2										
B18: Chikon Chara Bridge (30m)	2										
B22, B23 and B24 (Box culverts)	2										
B12: Koilabazar Bridge (55m)	2										
B25:East baganbazar Bridge (50m)	2										
[C Package] 2-Party											
C13: Sangu Bridge (215m)	4										36
C8: Patiya Bridge (55m)	4										
C26: Mathamuhuri Bridge (310m)	4										
C12: Mazar Point Bridge (60m)	4										

Note: Bar Chart with two different colors represents 2-lane new bridge construction followed by existing bridge replacement or vice versa
Source: JICA Survey Team

Figure 9.2 Overall Construction Schedule for PC-I Girder Bridge

9.3.2 Construction Schedule of Kalna Bridge (PC-I +Steel)

The construction of Kalna Bridge is planned to complete by three (3) years through which the construction of approach bridges on sides, main bridge and access road including the installation of toll collection system will start simultaneously.



Source: JICA Survey Team

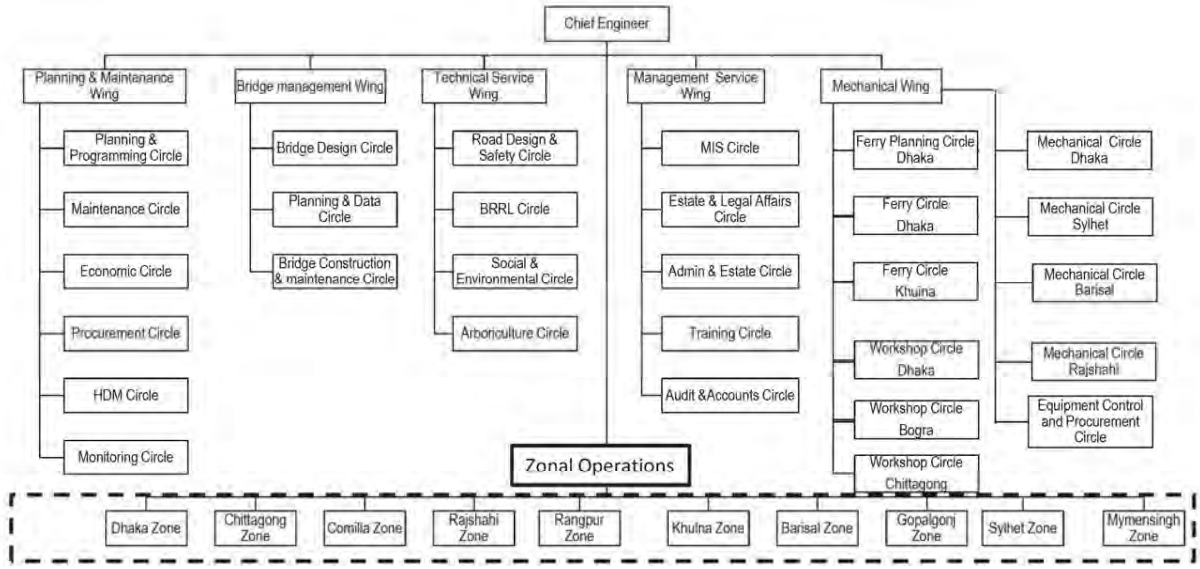
Figure 9.3 Kalna Bridge Construction Schedule

10. OPERATION AND MAINTENANCE PLAN

10.1 Operation and Maintenance Organization

The Roads and Highways Department (RHD) under Ministry of Road Transport and Bridges (MORTB) will implement this Project and will be responsible to manage the operation and maintenance of bridges after opening to the road users. This department is headed by one (1) Chief Engineer (CE) who is supported by fifteen (15) Additional Chief Engineers (ACEs). The recent structure for RHD consists of 5 headquarter wings and 10 field zones, each headed by an additional

chief engineer who reports directly to the Chief Engineer. In addition, 8 ACEs are assigned to manage foreign-aided projects. The Training and Bridge Design functions are now located in the Management Service Wing and Bridge Management Wing respectively.



Source: RHD Web site

Figure 10.1 Organization Chart of Roads and Highways Department

10.2 Operation and Maintenance Plan

The Project bridges should be maintained in sound conditions to sustain smooth and safe traffic flow. In general, bridges are administered by road/bridge management system which consists of such major activities as “Preparation of Inventory Data”, “Inspection”, and “Rating and Prioritization based on inspection results for actual Maintenance (Repair) work”, and also documentation of all the records of the activities.

Table 10.1 Classification of Inspection Work

Inspection Type	Major objects	Purpose	Methods
Routine (once or twice daily)	Road surface	Road safety	Visual inspection from vehicle-on board
Periodic (yearly)	All components	Damage Repair and Safety	Mainly close visual inspection, using basic equipment (crack measures, hand tape, etc.) if required
Emergency (at time of accident/disaster)	All damaged components	Damage Repair and Safety	Immediate inspection visually and using equipment

Source: JICA Survey Team

10.2.1 Special Maintenance Plan for Kalna Bridge

Addressing to above, it is recommended to conduct following additions at certain intervals so as to monitor the traffic condition on bridge and access road sections and assess the state of Kalna Bridge

health. This can be achieved through the frequent road patrol, the detailed visual inspection and the health monitoring by equipment.

(1) Road Patrol

As Kalna will be under toll operation, frequent road patrol on board is necessary to observe the traffic condition on bridge and access road sections. The road patrol must be conducted 24 hours a day considering with the traffic issue. Each party should include at least 3 members who will be under shifting duty and managed by toll operation administration. They will be responsible for daily inspection of bridge and road sections, and also provide the current condition of structure from their on-board observation.

(2) Detailed Visual Inspection (at least every two years)

Generally a detailed visual inspection is necessary in order to grasp the damage on the structure. It can be conducted from a short distant visual inspection by means of inspection vehicle or preparing temporary scaffolding. For Kalna, this inspection work should be carried out by Aerial Work Platform (AWP) vehicle to check the condition of painted part of steel arch. If any painting part is found exposed to the natural environment due to unforeseen reasons, then instant action should be undertaken in order to restrain further exaggeration of damaged painting.

(3) Health monitoring by equipment (every six years)

The health monitoring should be carried out at every six years for Nielsen Lohse Steel Arch Bridge. Of which, detailed inspection by equipments particularly for cable maintenance work should be carried out. The detailed inspection includes observation of rusting formation on cables and plate connections as well as measuring the tensile force in arch cable.

10.3 Operation and Maintenance Cost of CBRNIP Bridges

Operation and maintenance of PC-I bridges is classified into routine maintenance at every year, periodic maintenance at every 10 years, pavement resurfacing at every 10 years, expansion joint replacement at every 10 years and concrete surface treatment due to carbonation at every 30 years.

In addition, heavy paining at every 30 years and replacement of arch cables at once in life time should necessarily be required for Nielsen Lohse Arch section of Kalna Bridge. Daily operation and inspection of toll booth as well as toll system maintenance at every 10 years should be planned for Kalna toll plaza.

Operation and maintenance costs for the bridges and the approach roads to be constructed under CBRNIP are estimated at around BDT 827 million for first 5 years, BDT 2,882 million for first 10 years and BDT 22,181 million for full life time. Details of O/M cost for full life time are shown in Table 10.2. This estimated cost includes the operation and maintenance of patrol car and AWP vehicle which is necessary for Kalna Bridge health monitoring.

It is to be noted that the costs to be incurred for operation and maintenance of seven (7) box culverts are not disclosed in Table 10.2 This is because their O/M cost, comprising of routine and periodic maintenance only, should be covered from road O/M cost. It is also assumed that their O/M plan should be undertaken simultaneously when that of entire road sections will be implemented.

Table 10.2 Operation and Maintenance Cost of Bridges for Full Life Cycle

Sl. no.	Bridge name	Pavement resurface total@10 years		Routine/Periodic maintenance total@ every year		Concrete Surface Treatment Total @30 Years		Expansion Joint Replacement @ 10 Years		Toll booth operation cost			Steel Surface Painting @30 Years		Replacement of Steel Arch Cable Total @50 Years		Cable Health Monitoring	Patrol Car +AWP O/M	Total O/M Cost (BDT)
		BDT/m2	Total frequency	% of initial cost	Total frequency	Total Frequency	% of Initial Cost	Total Frequency	Total Length (m)	BDT/Year	Total Frequency	Machine Cost 6 Times @10 Years	BDT/m2	Total Frequency	BDT/ Every Time	Total Frequency	Total 12 @ Every 6 Year	Total 74 @ Every Year	
Section A																			
A1	Jhikorgacha Bridge	1,168	6	1.5%	74	2	4%	6	170.4	-			-	-	-	-			1,083,710,580
		94,397,760		839,645,046		49,017,777		100,649,996				-		-		-			
A2	Tularampur Bridge	1,168	6	1.5%	74	2	4%	6	104	-	-	-	-	-	-	-			802,581,678
		133,337,011		581,692,451		26,122,641		61,429,575				-		-		-			
A3	Hawai khali Bridge	1,168	6	1.5%	74	2	4%	6	67.8	-	-	-	-	-	-	-			616,310,608
		110,312,928		452,851,067		13099255.08		40,047,358				-		-		-			
A4	Kalna Bridge	1,168	6	1.5%	74	2	4%	6	328.5	25,000,000	74	307,272,000	4,505	2	85,453,852	1	602,581	2,901,645	12,865,125,789
		842,525,027		6,241,960,937		173,878,113.60		1,457,058,711				3,693,632,000		148,664,439		85,453,852	7,230,968	214,721,742	
A5	Garakola Bridge	1,168	6	1.5%	74	2	4%	6	52	-	-	-	-	-	-	-			837,764,245
		117,847,930		396,717,158		13229621.4		30,714,788				-		-		-			
Section B																			
B2	Telipool Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			282,168,056
		16,454,784		242,681,152		7,202,190		15,829,929				-		-		-			
B3	Lakshmi Chara Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			251,796,018
		18,094,656		206,982,823		10,888,610		15,829,929				-		-		-			
B9	Kalapani Bridge-2	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			158,355,768
		18,627,264		117,865,307		6,033,268		15,829,929				-		-		-			
B12	Koilabazar Bridge	1,168	6	1.5%	74	2	4%	6	53.60	-	-	-	-	-	-	-			222,547,052
		18,424,032		163,050,682		9,412,480		31,659,858											
B13	Balutila Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			197,305,022
		17,695,200		158,302,767		5,477,126		15,829,929				-		-		-			
B16	Heako Bridge	1,168	6	1.5%	74	2	4%	6	40.20	-	-	-	-	-	-	-			182,913,376
		17,765,280		134,025,535		7,377,668		23,744,893											
B18	Chikon Chara Bridge	1,168	6	1.5%	74	2	4%	6	26.80	-	-	-	-	-	-	-			207,063,153
		16,461,792		169,031,090		5,740,342		15,829,929				-		-		-			
B25	East Baganbazar Bridge	1,168	6	1.5%	74	2	4%	6	53.60	-	-	-	-	-	-	-			215,851,352
		20,883,840		154,838,278		8,469,376		31,659,858				-		-		-			
Section C																			
C8	Patiya Bridge	1,168	6	1.5%	74	2	4%	6	90	-	-	-	-	-	-	-			671,958,909
		118,154,880		479,729,767		20,677,785		53,396,477				-		-		-			
C12	Mazar Point Bridge	1,168	6	1.5%	74	2	4%	6	90	-	-	-	-	-	-	-			660,411,049
		117,818,496		470,954,640		18,241,437		53,396,477				-		-		-			
C13	Sangu Bridge	1,168	6	1.5%	74	2	4%	6	166	-	-	-	-	-	-	-			1,379,452,169
		156,257,376		1,067,289,036		57,618,437		98,287,320				-		-		-			
C26	Mathamuhuri Bridge	1,168	6	1.5%	74	2	4%	6	208	-	-	-	-	-	-	-			1,546,101,342
		163,657,824		1,188,801,825		70,782,542		122,859,150				-		-		-			

Source: JICA Survey Team

11. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

11.1 Environmental Impact Assessment (EIA)

Various impacts of the project which will be expected during pre-construction, construction and operation stages are indicted in following table.

Table 11.1 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-	C	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-	B-	B-	B-
6	Ground subsidence	D	D	D	D
7	Offensive odors	D	D	D	D
8	Global warming/Climate change	D	C	D	D
9	Topography and geology	D	D	D	D
10	Bottom sediment	B-	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	(B-:Section B), D	D
15	Involuntary resettlement	B-	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	B-	D	B-	D
19	Poor	A-	A-	B-	B-
20	Indigenous or ethnic minority people	D	D	D	D
21	Misdistribution of benefits and damages	D	D	D	D
22	Local conflicts of interest	D	D	D	D
23	Gender	C	C	D	D
24	Children’s right	C	C	D	D
25	Cultural heritage	D	D	D	D
26	Infectious diseases such as HIV/AIDS	B-	D	D	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 Positive/Serious Negative Impact is predicted.
B+/-: Positive/Negative Impact is expected to some extent.
C: Extent of Impact is unknown. (A 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

11.2 Land Acquisition and Resettlement

The selected 17 bridges are identified in in three sections i.e. Section A, Section B, and Section C and located in different parts of the country. A total of 5 bridges are located in Section A and covers Dhaka –Kolkata (India) road in south west region of the country, 8 bridges in Section B, Ramgarh – Baraiyarhat road in the southeast region of the country and 4 bridges in Section C, Chittagong –Cox's Bazar roads are in the south east region of Bangladesh. Distribution of sub-project wise number of bridges and project affected units are shown in the Table 11.2 The total of 149 households are identified within the Corridor of Impact (COI) and 755 people have to be displaced, accordingly. These areas account for 14,066 m^2 out of the total 302,903 m^2 of affected area. In total 477 households are going to lose their income as wage earners in the business and commercial enterprises affected by the project.

Table 11.2 Sub-project Wise Number of Bridges and Project Affected Units

Serial No.	Bridge ID	Number of Residence lose Households (PAHs)	Number of Residence lose People (PAPs)	Affected Residence, Residence/Commerce (category 1)	Affected Agriculture/Others (category 2)
Section A					
Jhikotgacha	N-706_14b	30	164	0	4,512
Garakola	N-805_24a	6	36	0	148
Tularampur	R750_25a	5	14	0	1,339
Hawai khali	Z7503_5a	0	0	1,373	1,679
Kalna	New bridge	39	183	6,554	231,677
	Sub-total	80	397	7,927 m^2	239,355 m^2
Section B					
B2,B3	R-151_4a/4c	13	78	1,206	5,392
B9	R-151_14a	0	0	0	3,567
B12	R-151_16a	5	29	269	1,761
B13	R-151_16c	0	0	0	3,115
B16	R-152_Sa	8	57	648	2,825
B18	R-152_7a	1	5	70	4,271
B25	R-152_14a	7	43	769	4,366
	Sub-total	34	212	2,962 m^2	25,297 m^2
Section C					
C8	N-1_257a	3	10	422	5,604
C12	N-1_272a	1	9	149	14,223
C13	N-1_279a	20	67	1,061	3,948
C26	N-1_328a	11	60	1,545	410
	Sub-Total	35	146	3,177 m^2	24,185 m^2

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 Preparatory Survey on the Cross-Border Road Network Improvement Project (Bangladesh) Draft Final Report requirements of Development Partner (such as JICA's) Policy on Involuntary Resettlement.

12. PRELIMINARY COST ESTIMATES

To estimate the civil cost of Project bridges under Sections A, B and C, following general conditions are followed.

12.1 Term of Cost Estimation

The unit rates of material, equipment, labor and other costs adopted for this cost estimation are based on November 2015.

12.2 Exchange rate

The exchange rate adopted for this cost estimate is the prevailing average rate of exchange in November 2015 (adopted by JICA as a General Guideline of Appraisal for FY 2015) as shown hereunder:

US$ 1 = Yen 120.2

US$ 1 = BDT 77.8

BDT 1 = Yen 1.55

12.3 Civil Cost

The civil work cost is estimated on the basis of quantities of each bridge component multiplied by its unit price which is derived from basic unit rates of major items. The basic unit rate excludes contractor's overhead, profit, Value Added Tax (VAT), income tax, physical contingency and price escalation etc.

12.4 Civil Cost of Project Bridges (Excluding Kalna Bridge)

Table 12.1 Civil Cost of PC-I Bridges with Approach Road (Excluding Kalna Bridge)

Exchange Rate 1 USD=77.8 BDT		New Bridge Inventory		Base Civil Cost							
				Bridge Civil Cost			Road Civil Cost		Civil Cost (Bridge+Road)		Section Total (BDT)
Sl. No.	Bridge Name	Total Length (m)	Width (m)	Local (BDT)	Foreign (USD)	Comb. Total (BDT)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	
Section A (Excluding Kalna)											
A1	Jhikorgacha Bridge	125	28.4	326,018,783	3,685,134	612,722,218	133,022,464	137,433	459,041,247	3,822,567	2,045,861,011
A2	Tularampur Bridge	100	20.8	164,050,747	2,088,461	326,533,018	178,964,541	238,428	343,015,287	2,326,889	
A3	Hawai Khali Bridge	35	22.6	85,601,398	1,004,361	163,740,688	225,127,271	245,578	310,728,669	1,249,939	
A5	Garakola Bridge	110	10.4	79,619,012	1,102,201	165,370,268	174,571,329	224,438	254,190,340	1,326,639	
Section B (Excluding Box Culverts)											
B2	Telipool Bridge	25	13.40	52,080,988	487,743	90,027,381	125,601,708	38,594	177,682,695	526,336	1,213,313,184
B3	Lakshmi Chara Bridge	40	13.40	78,276,848	743,326	136,107,628	47,592,099	35,621	125,868,947	778,947	
B9	Kalapani Bridge-2	35	13.40	43,319,419	412,551	75,415,855	27,865,768	37,318	71,185,187	449,869	
B12	Koilabazar Bridge	55	13.40	67,471,559	645,044	117,655,998	26,980,071	29,003	94,451,630	674,047	
B13	Balutila Bridge	30	13.40	39,451,868	372,907	68,464,070	71,266,990	37,070	110,718,858	409,977	
B16	Heako Bridge	25	13.40	53,349,962	499,626	92,220,850	25,697,851	36,311	79,047,813	535,937	
B18	Chikon Chara Bridge	30	13.40	41,355,330	390,732	71,754,274	77,363,335	40,651	118,718,666	431,383	
B25	East Baganbazar Bridge	50	13.40	52,295,533	688,582	105,867,198	30,254,600	43,344	82,550,133	731,926	
Section C											
C8	Patiya Bridge	55	22.60	135,009,642	1,586,924	258,472,310	157,713,287	205,699	292,722,929	1,792,623	2,888,986,727
C12	Mazar Point Bridge	60	22.60	115,901,968	1,441,080	228,017,957	178,102,455	233,458	294,004,424	1,674,538	
C13	Sangu Bridge	215	20.80	396,639,473	4,159,267	720,230,459	222,017,012	247,740	618,656,484	4,407,007	
C26	Mathamuhuri Bridge	310	20.80	466,599,037	5,375,100	884,781,781	168,105,629	232,715	634,704,666	5,607,815	

Source: JICA Survey Team

Table 12.2 Civil Cost of Box Culverts under Section B

							Base Civil Cost										
		Culvert Inventory					Box section		Approach Road		Temporary Bridge & Bridge Demolition		Overhead		Culvert_Civil Cost		
Sl. No	Bridge Name	Culvert Type	Vent No.	Section (m×m)	Total Length (m)	Approach total (m)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Local (BDT)	Foreign (USD)	Equivalent (BDT)
B14	Fulchari	Box	2	B3.0×H3.0	16	200	3,797,856	-	56,924,003	39,198.87	17,571,478	-	11,744,001	5,880	90,037,338	45,079	93,544,460
B15	Heaku Bazar	Box	1	B3.0×H3.0	16	200	1,898,928	-	56,924,003	39,198.87	17,333,120	-	11,423,408	5,880	87,579,458	45,079	91,086,581
B19	Chikon Chara	Box	2	B3.0×H3.0	16	200	3,797,856	-	56,924,003	39,198.87	17,336,525	-	11,708,758	5,880	89,767,141	45,079	93,274,264
B20	Banglabazar	Box	1	B3.0×H3.0	16	200	1,898,928	-	56,924,003	39,198.87	17,346,740	-	11,425,451	5,880	87,595,122	45,079	91,102,245
B22	Borobil	Box	1	B2.0×H2.0	16	200	843,968	-	56,924,003	39,198.87	17,565,519	-	11,300,024	5,880	86,633,514	45,079	90,140,636
B23	Gadar Dokan	Box	2	B3.0×H3.0	16	200	3,797,856	-	56,924,003	39,198.87	17,395,263	-	11,717,568	5,880	89,834,690	45,079	93,341,813
B24	Bagan Bazar	Box	1	B3.0×H3.0	16	200	1,898,928	-	56,924,003	39,198.87	17,832,821	-	11,498,363	5,880	88,154,115	45,079	91,661,238
														Grand Total	**619,601,377**	**315,551**	**644,151,237**

Source: JICA Survey Team

12.5 Kalna Bridge (PC-I + Steel)

Table 12.3 Break Down of Civil Cost for Kalna (Bridge and Access Road)

Exchange Rate 1 USD = 77.80 BDT	Approach Bridge (A1 side) 6-span		Main Bridge		Approach Bridge (A2 side) 6-span		Total	
	270 m		150 m		270 m		690 m	
	Cost(BDT)	Cost(USD)	Cost(BDT)	Cost(USD)	Cost(BDT)	Cost(USD)	Cost(BDT)	Cost(USD)
Bridge Section 21.90m								
Abutment	11,970,742	75,955			11,970,742	75,955	23,941,483	151,910
Pier	90,196,377	719,873	84,172,016	643,893	85,059,686	680,659	259,428,079	2,044,425
Superstructure	136,869,617	1,618,648	141,056,566	14,390,268	136,869,617	1,618,648	414,795,799	17,627,565
Pile	393,839,761	1,646,853	90,053,800	980,308	395,987,187	1,625,307	879,880,748	4,252,468
Contractor Overhead+Profit 15%	94,931,474	609,199	47,292,357	2,402,170	94,483,085	600,086	236,706,916	3,611,455
Total cost	727,807,970	4,670,529	362,574,740	18,416,639	724,370,316	4,600,656	1,814,753,026	27,687,823
a. Combined cost (BDT)	1,091,175,093		1,795,389,249		1,082,301,327		**3,968,865,669**	
Access Road	Length= 4,238m							
Earth Work							393,835,421	650,125
Pavement Work							746,104,568	1,080,285
Soft Soil Treatment 100m							40,125,000	-
Box Culvert							35,130,168	-
Retaining Wall							6,661,502	-
Miscellaneous							82,232,738	-
Contractor Overhead+Pro 15%							195613409.5	259,561
							1,499,702,806	1,989,971
b. Combined cost (BDT)							**1,654,522,576**	
River Training Works								
Sand filled Geo-bag							54,817,914	-
Gabion works							16,427,000	-
Riprap works							6,078,300	-
Granular filter							155,953	-
Geotextile fabric							4,405,800	-
Contractor Overhead+Pro 15%							12,282,745	-
c. Combined cost (BDT)							**94,167,711**	
Grand Total (BDT) Bridge+Road+River Training a+b+c							**5,717,555,957**	

Source: JICA Survey Team

13. PROJECT IMPLEMENTATION PLAN

13.1 Contract Package

It is recommended that the Project should be implemented with four (4) contract packages in order to ensure ease of Project management by RHD. The list of the target Projects with contract package is shown in Table 15.1 and their locations are shown in Figure 15.1.

13.2 Project Cost

The entire Project cost is estimated and shown in Table 13.1.

Table 13.1 Project Cost

Breakdown of Cost	Foreign Currency Portion (million JPY)			Local Currency Portion (million JPY)			Total (million JPY)		
	Total	JICA Portion	Others	Total	JICA Portion	Others	Total	JICA Portion	Others
A1	4,112	4,112	0	5,313	5,313	0	9,425	9,425	0
A2	1,147	1,147	0	2,146	2,146	0	3,294	3,294	0
B	644	644	0	2,359	2,359	0	3,003	3,003	0
C	1,621	1,621	0	2,882	2,882	0	4,503	4,503	0
Dispute Board	24	24	0	0	0	0	24	24	0
Civil Works Sub Total	7,547	7,547	0	12,702	12,702	0	20,249	20,249	0
Price Escalation	595	595	0	3,671	3,671	0	4,266	4,266	0
Physical Contingency	407	407	0	819	819	0	1,226	1,226	0
Consulting Services	1,452	1,452	0	1,505	1,505	0	2,957	2,957	0
Land Acquisition	0	0	0	3,327	0	3,327	3,327	0	3,327
Administration Cost	0	0	0	1,601	0	1,601	1,601	0	1,601
VAT (Contractor & Consultant)	0	0	0	1,389	0	1,389	1,389	0	1,389
Import Tax	0	0	0	2,565	0	2,565	2,565	0	2,565
Corporate Tax	0	0	0	0	0	0	0	0	0
Income Tax (Contractor)	0	0	0	1,287	0	1,287	1,287	0	1,287
Income Tax (Consultant)	0	0	0	296	0	296	296	0	296
Interest during Construction	14	0	14	0	0	0	14	0	14
Total	10,015	10,001	14	29,162	18,697	10,465	39,177	28,698	10,478

Source: JICA Survey Team

13.3 Implementation Schedule

The implementation plan is established based on the month/year for the milestones of key events of the Project. The plan includes the stage of detailed design, tender procedure, and construction work. The construction period was estimated as 3 years for A1 (Kalna Bridge) and C package and 2.75 years (33 months) for A2 and B package.

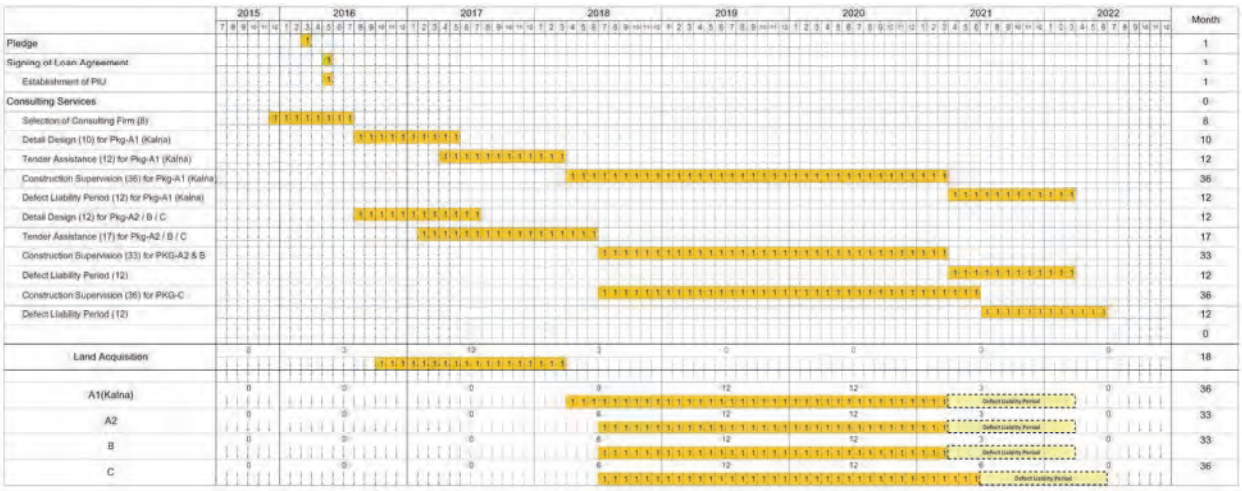
It is assumed that International Competitive Bidding (ICB) should be applied for the procurement of the contractor and consultant for the Project. The time required the procurement is assumed based on the procedure for a financing scheme of a Japanese ODA Loan. The milestones for the implementation of the Project undertaken by a Japanese ODA Loan are formulated as follows:

- Loan Agreement (L/A) is expected to be signed in May 2016.
- 8 months will be required for the selection of a consultant for the detailed design, tender assistance, and construction supervision.

- The period of detailed design will be 10 months for Package A1 and 12 months for Package A2 / B / C.
- 12 months for Package A1 and 17 months for Package A2 / B / C will be required for the procurement of a contractor.
- The construction period will be 36 months for Package A1 / C and 33 months for Package A2 / B.

The total implementation period is from signing of L/A (expected in May 2016) to completion of construction (in June 2021).

The implementation schedule for the Project is shown in Figure 13.1.



Source: JICA Survey Team

Figure 13.1 Implementation Schedule

14. ASSESSMENT OF PROJECT VIABILITY AND EFFECTS

14.1 Project Operation and Effect Indicator

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 are summarized at Table 14.1.

Table 14.1 Selection of Operation and Effect Indicators

Indicator			Baseline	2 years after project completion
Operation Indicators	(1) Traffic volume	Total traffic volume (pcu/day)	2015	2023
		Freight vehicle traffic volume (pcu/day)		
		Passenger vehicle traffic volume (pcu/day)		
	(2) Transit transportation	Transit freight vehicle transportation (vehicle/day)		
		Transit passenger vehicle transportation (vehicle/day)		
Effect Indicators	(3) Average travel time	Average travel time (for Section A, hour)		
	(4) Travel Cost saving	Travel cost accruing from detour when bridge collapsed (mil. BDT/year)		
	(5) Improvement of detour days	Detour days caused by flooding (day)		
	(6) Improvement of unserviceability rate	Unserviceability rate by collapse of bridge (%)		

Source: JICA Survey Team

The calculated operation and effect indicators for each bridge are set. Among them, project operation indicators for A1 and A4 are summarized in Table 14.2, and project effect indicators for A1 and A4 are summarized in Table 14.3

Table 14.2 Project Operation Indicator for A1 and A4

No.	Bridge Name	Traffic Volume (pcu/day)						Transit Transportation (vehicle/day)			
		Total		Freight Vehicle		Passenger Vehicle		Freight Vehicle		Passenger Vehicle	
		2015	2023	2015	2023	2015	2023	2015	2023	2015	2023
A1	Jhikorgacha Bridge	8,857	19,958	5,142	15,620	3,715	4,338	0	761	0	9
A4	Kalna Bridge	2,088	22,199	1,569	17,043	519	5,156	0	761	0	9

Source: JICA Survey Team

Table 14.3 Project Effect Indicator for A1 and A4

No.	Bridge Name	Travel Cost Accruing from Detour when Bridge Collapsed (mil. BDT/year)		Detour Days Caused by Flooding (day)		Unserviceability rate by Collapse of Bridge (%)		Road user cost (mil. BDT/year)	
		2015	2023	2015	2023	2015	2023	2015	2023
A1	Jhikorgacha Bridge	1,964	0	60	0	44	0	35	88
A4	Kalna Bridge	NA	0	NA	0	NA	0	143	1,093

Source: JICA Survey Team

14.2 Financial and Economic Evaluation

In this section, the financial and economic feasibility of construction of the selected bridges is evaluated in terms of the national economy. The financial analysis of the Project is performed through comparisons of financial benefit gained by the toll of the bridge from passengers with financial cost of

the project. The economic analysis of the Project is performed through comparison of the economic cost of the project with the economic benefit derived from the bridge construction.

It is planned that only A4 (Kalna bridge) collects toll from passengers in the Project. Therefore, an evaluation target of the financial analysis is A4 (Kalna bridge), and evaluation targets of the economic analysis is all 17 bridges (A1-5, B2, 3, 9, 12, 13, 16, 18, 25 and C8, 12, 13, 26).

Results of financial and economic evaluation are shown in Table 14.4. According to the results, it can be said that all bridge project are economically feasible. On the other hand, financial evaluation of A4 (Kalna bridge) is not feasible, because FIRR of A4, 8.7%, is lower than hurdle rate, 10.36%.

Table 14.4 Results of Financial and Economic Evaluation

No.	Structure Name	Bridge Type	Year of Construction	Economic Internal Rate of Return (EIRR) (%)	Financial Internal Rate of Return (FIRR) (%)
A1	Jhikorgacha Bridge	RCC Girder Bridge	1968	53.5	-
A2	Tularampur Bridge	RCC Girder Bridge	1964	53.3	-
A3	Hawai khali Bridge	RCC Girder Bridge	1976	50.4	-
A4	Kalna Bridge	-	-	33.8	8.7
A5	Garakola Bridge	PC Girder Bridge	2004	27.8	-
B2	Telipool Bridge	Steel Beam & RCC Slab	1965	26.1	-
B3	Lakshmi chara Bridge	Steel Beam & RCC Slab	1965	27.8	-
B9	Kalapani Bridge-2	RCC Girder Bridge	1978	28.9	-
B12	Koilabazar Bridge	Bailey with Steel Deck	1994	12.1	-
B13	Balutila Bridge	Bailey with Steel Deck	1991	12.0	-
B16	Heako Bridge	RCC Girder Bridge	1965	45.3	-
B18	Chikon Chara Bridge	RCC Girder Bridge	1986	28.6	-
B25	East baganbazar Bridge	Steel Beam & RCC Slab	1965	42.5	-
C8	Patiya Bridge	RCC Girder Bridge	1977	17.3	-
C12	Mazar Point Bridge	RCC Girder Bridge	1965	27.7	-
C13	Sangu Bridge	RCC Girder Bridge	1960	51.5	-
C26	Mathamuhuri Bridge	RCC Girder Bridge	1960	41.8	-

Source: JICA Survey Team

Furthermore, the results of economic evaluation by package and all are summarized in the following table.

Table 14.5 Results of Economic Evaluation by Package and All

Package	A1	A2	B	C	All
Economic Internal Rate of Return (EIRR) (%)	33.8	49.8	30.7	41.8	39.7

Source: JICA Survey Team

15. CONCLUSION AND RECOMMENDATION

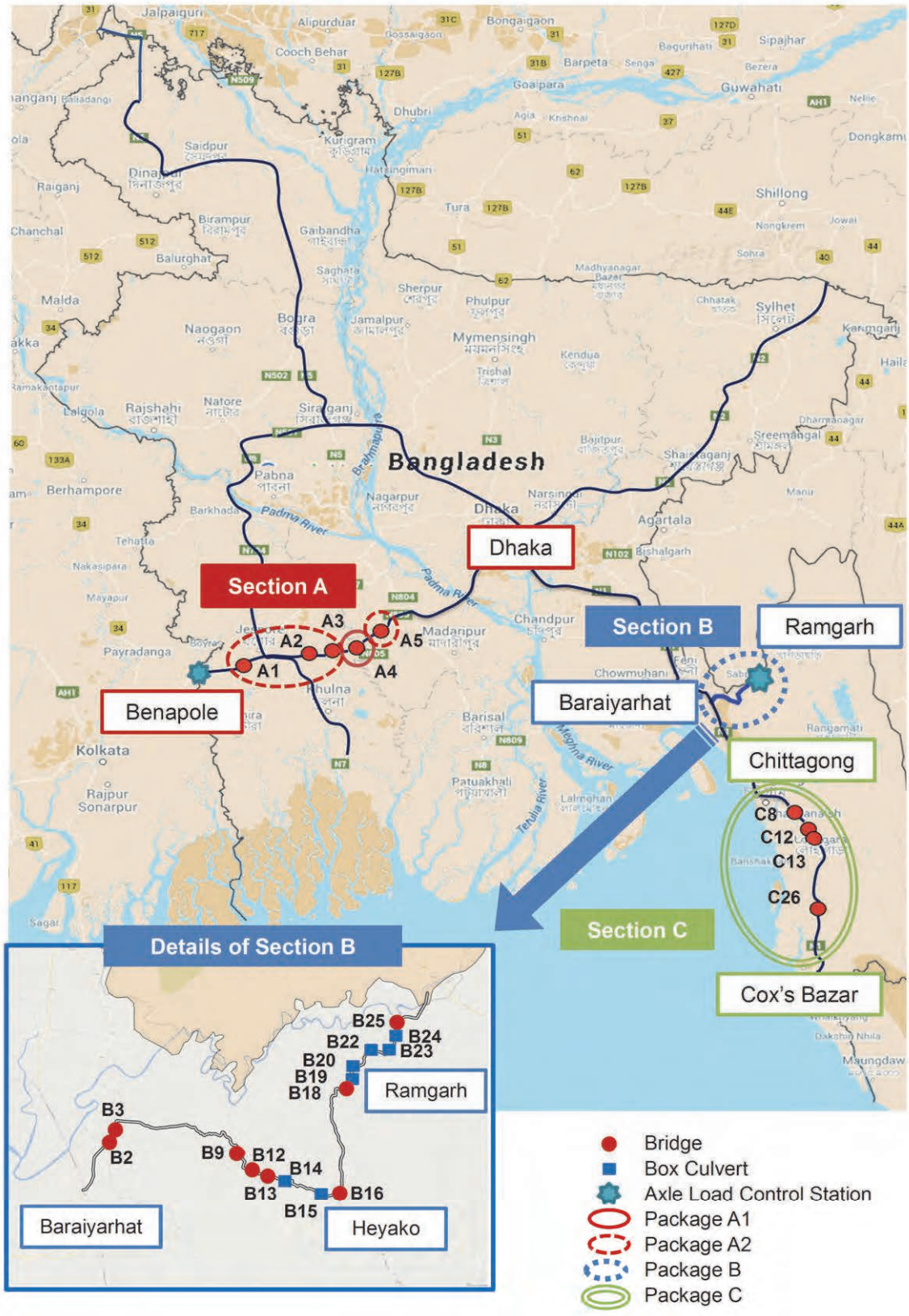
15.1 Conclusion

A summary of the Project is shown in the following table and figure.

Table 15.1 Summary of the Project

Package	Name	Project Contents
A1	Kalna Bridge (4-lane)	-PC-I: L=540m -Nielsen Lohse Bridge: L=150m -Road: Approximately 4,000m -Tollgate -Vehicle for Operation and Maintenance
A2	Jhikorgacha Bridge	PC-I: L=125m
	Tularampur Bridge	PC-I: L=100m
	Hawai khali Bridge	PC-I: L=35m
	Garakola Bridge	PC-I: L=110m
	Axle Load Scale at Benapole	No. : 2 for both way traffics
B	Telipool Bridge	PC-I: L=25m
	Lakshmi Chara Bridge	PC-I: L=40m
	Kalapani Bridge-2	PC-I: L=35m
	Koilabazar Bridge	PC-I: L=55m
	Balutila Bridge	PC-I: L=30m
	Heako Bridge	PC-I: L=25m
	Chikon Chara Bridge	PC-I: L=30m
	East Baganbazar Bridge	PC-I: L=50m
	Box Culverts	No.: 7
	Axle Load Scale at Ramgarh	No. : 2 for both way traffics
C	Patiya Bridge	PC-I: L=55m
	Mazar Point Bridge	PC-I: L=60m
	Sangu Bridge	PC-I: L=215m
	Mathamuhuri Bridge	PC-I: L=310m

Source: JICA Survey Team



Source: JICA Survey Team

Figure 15.1 Location Map of the Project

15.2 Recommendation

Recommendations for further studies and tasks are as follows:

- Safety measures such as providing road marking, road hump, guardrails, etc. shall be considered in the detailed design.
- 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.
- Technical cooperation project of bridge maintenance under JICA is ongoing and will be updated operation and maintenance manual in 2016. It is recommended that the project bridge should be maintained according to the manual.
- SBHS (Steels for Bridge High Performance Structure) is applied for Nielsen Lohse Bridge, especially at the corner part which is subjected to high stress concentration and needs special care for joining. The more detail use of SBHS shall be studied in the detailed design.

People's Republic of Bangladesh

Preparatory Survey on the Cross-Border Road Network Improvement Project (Bangladesh)

Final Report

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List of Abbreviations

AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway and Transportation Officials
ACE	:	Additional Chief Engineer
ADB	:	Asian Development Bank
ADP	:	Annual Development Program
AH	:	Asian Highway
AIDS	:	Acquired Immune deficiency Syndrome
AIIB	:	Asian Infrastructure Investment Bank
ALS	:	Axle Load Scale
ALTIDP	:	Asian Land Transport Infrastructure Development Project
ARP	:	Abbreviated Resettlement Action Plan
ATB	:	Asphalt Treated Base Course
BBA	:	Bangladesh Bridge Authority
BBIN MVA	:	Bangladesh-Bhutan-India-Nepal Motor Vehicle Agreement
BBS	:	Bangladesh Bureau of Statistics
BC	:	Binder Course
BCIM	:	Bangladesh-China-India-Myanmar
BCS	:	Bridge Condition Survey
BDT	:	Bangladeshi Taka
BIMSTEC	:	Bay of Bengal Institute for Multi-sectoral Technical and Economic Cooperation
BLPA	:	Bangladesh Land Port Authority
BMW	:	Bridge Management Wing
BMMS	:	Bridge Maintenance Management System
BOT	:	Build-Operate-Transfer
BRTA	:	Bangladesh Road Transport Authority
BRTC	:	Bangladesh Road Transport Corporation
BTILS	:	BIMSTEC Transport Infrastructure and Logistic Study
BP	:	Beginning Point
CAAB	:	Civil Aviation Authority, Bangladesh
CBR	:	California Bearing Ratio
CBRNIP	:	Cross-Border Road Network Improvement Project (Bangladesh)
CE	:	Chief Engineer
CIP	:	Cast-in-Place
C.L.	:	Center Line
CNG	:	Compressed Natural Gas Vehicle
COI	:	Corridor of Impact
CPD	:	Center for Policy Dialogue
CPI	:	Consumer Price Index

DTCB	:	Dhaka Transport Co-ordination Board
DLP	:	Defect Liability Period
EBBIP	:	Eastern Bangladesh Bridge Improvement Project
ECNEC	:	Executive Committee of the National Economic Council
EE	:	Executive Engineer
EIRR	:	Economic Internal Rate of Return
EP	:	Ending Point
ETC	:	Electronic Toll Collection
FIRR	:	Financial Internal Rate of Return
F/S	:	Feasibility Study
FY	:	Fiscal Year
FYP	:	Five Years Plan
GDP	:	Gross Domestic Product
GED	:	General Economic Division
GMS	:	Greater Mekong Sub-region
GOB	:	Government of Bangladesh
GOI	:	Government of India
GOJ	:	Government of Japan
GRDP	:	Gross Regional Domestic Product
HDM	:	Highway Design Manual
HQ	:	Head Quarter
IRI	:	International Roughness Index
IT	:	Import Tax
JDCF	:	Japan Debt Cancellation Fund
JICA	:	Japan International Cooperation Agency
LEF	:	Load Equivalent Factor
LPA	:	Land Port Authority
LGED	:	Local Government Engineering Department
MOC	:	Ministry of Communication
MOF	:	Ministry of Forest
MOU	:	Memorandum of Understanding
MSL	:	Mean Sea Level
MTO	:	Multi-Modal Transport Operators (MTO)
MV	:	Motorized Vehicle
NEXCO	:	Nippon Expressway Company Limited
NH	:	National Highway
NIMTP	:	National Integrated Multimodal Transport Policy
NLTP	:	National Land Transport Policy
NMV	:	Non-Motorized Vehicle
OD	:	Origin-Destination

ODA	:	Official Development Assistance
OM	:	Operation and Maintenance
PC	:	Prestressed Concrete
PCP	:	Project Concept Paper
PCU	:	Passenger Car Unit
PIU	:	Project Implementation Unit
PP	:	Project Proforma
PPP	:	Public Private Partnership
PSB	:	Portable Steel Bridges
PWD	:	Public Works Department
RHD	:	Road and Highways Department
RC	:	Reinforced Concrete
RFID	:	Radio-frequency identification (RFID)
RMP	:	Road Master Plan
RMMS	:	Road Maintenance Management System
RHD	:	Road and Highways Department
ROW	:	Right Of Way
RTHD	:	Road Transport and Highway Division
RUC	:	Road User Cost
SAARC	:	South Asian Association for Regional Cooperation
SAPROF	:	Special Assistance for Project Formation
SASEC	:	South Asia Sub-regional Economic Cooperation
SC	:	Surface Course
SE	:	Superintending Engineer
SH	:	Stake Holder(s)
SHM	:	Stake Holder Meeting
SHWL	:	Standard High Water Level
SN	:	Structural Number
SO2	:	Sulfur Dioxide
TA	:	Technical Assistance
TAPP	:	Technical Assistance Project Proforma
TAR	:	Trans-Asian Railway
TTC	:	Travel Time Cost
VAT	:	Value Added Tax
VOC	:	Vehicle Operation Cost
SRTPPF	:	Sub Regional Road Transport Project Preparatory Facility
UN ESCAP	:	United Nations Economic and Social Commission for Asia and the Pacific
WB	:	World Bank
WBBIP	:	Western Bangladesh Bridge Improvement Project

1. INTRODUCTION

1.1 Background

The South Asia region is actively undergoing a reform of economic liberalization. In particular, India and the People's Republic of Bangladesh (hereinafter referred to as “Bangladesh”) attract attention as markets of high economic potential. With a population of approximately 1.7 billion, the region is expected to reach the demographic dividend period, and undergo further growth through expansion of domestic demand. On the other hand, intra-regional trade volume of the region is remaining low, at only 3% of total trade (in 2012). A big issue is the maintenance of transportation infrastructure that connects each region. Also, “Bangladesh” is surrounded by countries such as India, Myanmar, Nepal and Bhutan, and hence is vital in connecting each of these countries. Thus, the maintenance of transportation infrastructure in “Bangladesh” through JICA assistance is expected to contribute to the economic development and stabilization of not just the country, but also the surrounding region.

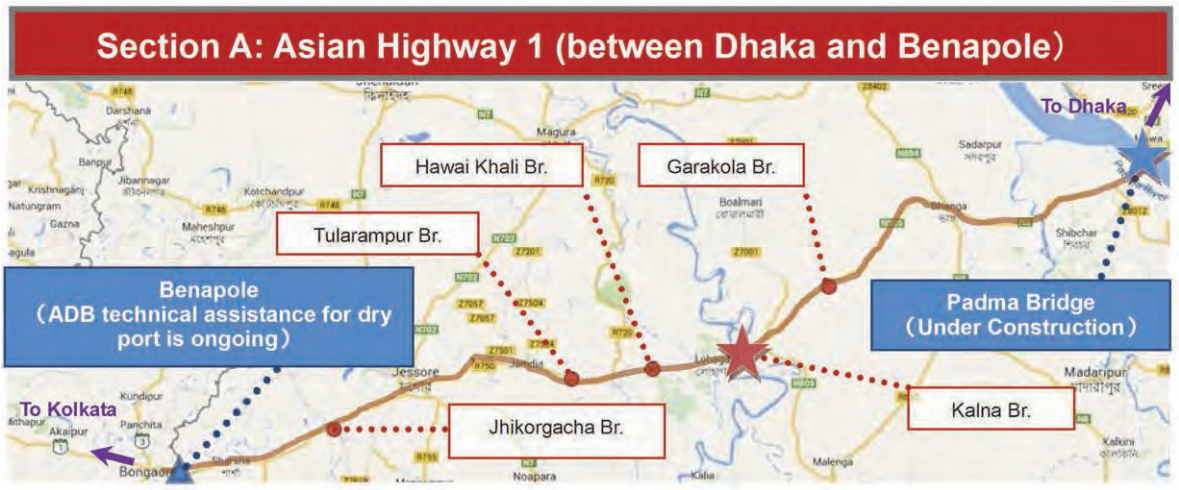
Road transport accounts for around 70% of domestic transportation in “Bangladesh”, and multiple international corridors such as the Asian Highway pass through the country. However, in many sectors, in addition to the inefficiency of customs and border procedures, international corridors are not functioning sufficiently because of deterioration of aged roads and bridges in domestic and border areas. Therefore, regional transit traffic planning based on several regional cooperation frameworks in the region was formulated and maintenance of both soft and hard infrastructure is underway. In the 6th Five Year Plan of “Bangladesh”, creation of a modernized and efficient road transportation system was declared in the highway sector. Though there are road and bridge maintenance projects underway, these are unable to sufficiently deal with the problem due to budget and technical limitations.

Based on this background, the Government of Bangladesh (hereinafter referred to as GOB) requested loan assistance from the Government of Japan for the maintenance of main international highways and connecting roads.

1.2 Project Area

The preparatory survey (hereinafter referred to as the survey) is comprised of 3 sections in Bangladesh, section A (between Dhaka to Benapole), section B (between Ramgarh and Baraiyarhat), section C (between Chittagong and Cox's Bazar).

The location maps of each section are shown in the following Figures, respectively.



Source: JICA Survey Team

Figure 1.2.1 Location Map of Section A

Source: JICA Survey Team

Figure 1.2.2 Location Map of Section B

Source: JICA Survey Team

Figure 1.2.3 Location Map of Section C

1.3 Objectives of the Survey

As GOB is requesting a Japanese ODA Loan for the Cross-Border Road Network Improvement Project (Bangladesh) (hereinafter referred to as "CBRNIP"), the objective of this preparatory survey is to obtain all the data and information required for appraisal of a loan project of Japanese ODA as well as to execute the Project, such as defining the project objectives and preparing a 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 Scope of the Survey

1.4.1 Survey Schedule

The survey schedule is shown in Table 1.4.1. The survey commenced in mid-April 2015, and the final preparatory survey report will be submitted in February 2016.

Table 1.4.1 Survey Schedule

Task \ Period	2015									2016	
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
【1】Preparation and Discussion of Inception Report	▲										
【2】Understanding of Background, Collection of Information											
【3】Uncovering Issues through Survey of Target Roads and Surrounding Areas											
【4】Selection of Project items and Optimum Plan											
【5】Workshop in Bangladesh			▲ Workshop in Bangladesh								
【6】Preparation and Discussion of Interim Report					▲						
【7】Natural Condition Survey											
【8】Traffic Count and Traffic Demand Forecast											
【9】Social Survey (Baseline Survey)											
【10】Outline of Implementation Plan											
【11】Preliminary Design											
【12】Construction Techniques											
【13】Construction Plan and Schedule											
【14】Implementation Structure											
【15】Operation and Maintenance Plan											
【16】Social and Environmental Considerations											
【17】Support for Preparation of Abbreviated Resettlement Plan (ARP)											
【18】Climate Change Countermeasures											
【19】Cost Estimation											
【20】Points of Concern for Project Implementation											
【21】Evaluation of Project											
【22】Preparation and Discussion of Preparatory Survey Final Report (Draft)									▲		
【23】Submission of Preparatory Survey Final Report											

Note : ■ Work in Bangladesh □ Work in Japan ▲ Meeting

Source: JICA Survey Team

The scope of the survey is the following;

- Understanding of project background and necessity
- Extraction of issue in target road and area / Site survey
- Selection of target section and optimum plan
- Workshop in Bangladesh
- Natural condition survey
- Traffic count and traffic demand forecast
- Social survey (Baseline survey)
- Project implementation plan
- Preliminary design
- Construction plan and schedule
- Operation and maintenance plan
- Environmental and social considerations
- Support for preparation of abbreviated resettlement plan (ARP)
- Climate change countermeasures
- Cost estimation
- Points of concern for project implementation
- Evaluation of project

2. EXISTING ROAD NETWOK AND NATIONAL DEVELOPMENT PLANS

2.1 Problems and Issues of Existing Roads and Bridges in Bangladesh

2.1.1 Existing Conditions of Roads in Bangladesh

(1) Road Network

The road network consists of six road categories: National Highways, Regional Highways, Zilla Roads, Upazila Roads, Union Roads and Village Roads. The Roads and Highways Department (RHD), under the Ministry of Road Transport and Bridges (MORTB), manages 21,302 km of roads including National Highways, Regional Highways and Zilla Roads (see Table 2.1.1). The total road length managed by RHD makes up 6.5% of the total road network in Bangladesh.

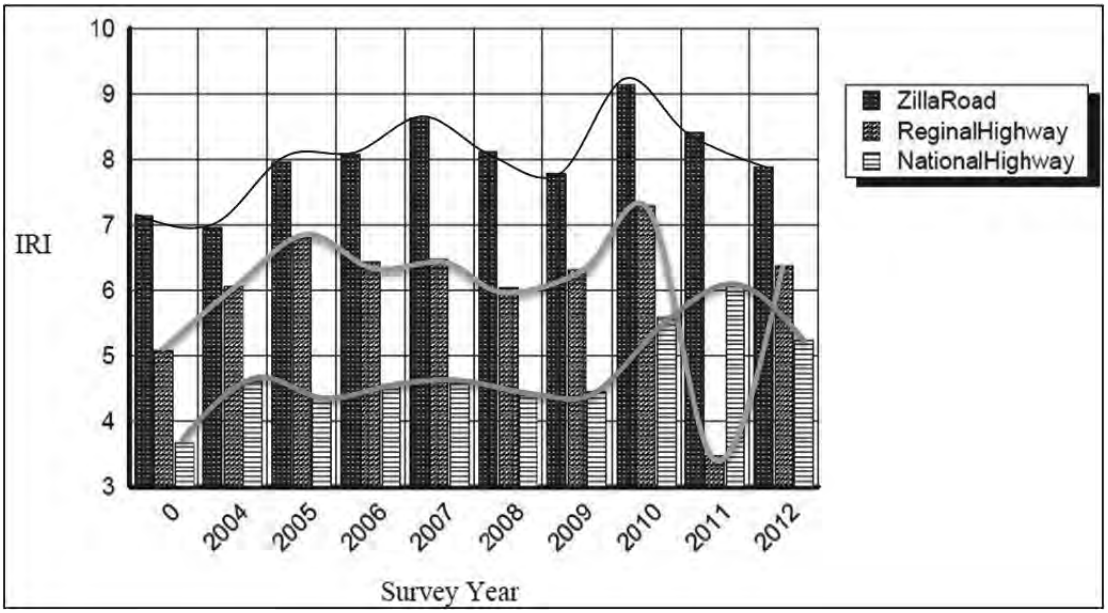
Table 2.1.1 Total Road Network in Bangladesh

Road Class	Definition	Length (km)	Management by
National Highways	Highways connecting National capital with Divisional HQ's /sea ports / land ports / Asian Highway.	3,813	RHD
Regional Highways	Highways connecting District HQ's / main river / land ports / with each other not connected by National Highways.	4,247	RHD
Zilla Roads	Roads connecting District HQ's with Upazilla HQ's / connecting one Upazilla HQ to another Upazilla HQ by a single main connection with National/Regional Highway, through shortest distance/route.	13,242	RHD
	a. Sub-Total	21,302	
Upazila Roads	Roads connecting Upazila HQs with growth center with another growth center by a single main connection / connecting growth center to higher road system through shortest distance/route	37,335	LGED
Union Roads	Roads connecting Union HQs with Upazila HQs, growth centers / local markets / with each other	44,202	LGED
Village Roads	a) Roads connecting villages with Union HQs local markets, farms and ghats / with each other. b) Roads within a village	222,842	LGED
	b. Sub-Total	304,379	
	c. Total (a+b)	325,681	

Source: Preparatory Survey on WBBIP (2015) and www.rhd.gov.bd (accessed in Nov., 2015)

(2) Road Condition

The road condition can be grossly categorized into descriptive bands based on roughness. To make understand on roughness, RHD conducted a road condition survey in 2012. About 13,000 km of road were surveyed and the results were expressed by International Roughness Index (IRI) which is implicitly shown by bar chat in Figure 2.1.1. A comparison between IRIs obtained in 2004 and in 2012 is shown in Figure 2.1.1. It represents that the roughness is in increasing trend regardless of road class until 2010. Then, in the period of 2011-2012, National Highway roughness has decreased from IRI 6.05 to 5.24, Regional Highway roughness has increased from IRI 3.47 to 6.38 and Zilla Road roughness has decreased from 8.41 to 7.87 indicating an overall improvement of the road network.



Source: HDM circle report (2013)

Figure 2.1.1 Average Roughness by Road Class and in Different Years

2.1.2 Bridge Condition

The number of structures on RHD road network has been increased dramatically since 1991. The number of road structures over last 20 years is shown in Table 2.1.2. The number of structures under RHD management, surveyed in 2013, was found to be 21,492 which is approximately seven (7) times the number in 1991 (Figure 2.1.2).

Table 2.1.2 Number of Road Structures under RHD Road Network

Road Class	Year								
	No. of culverts			No. of Bridges			Total No. of Road Structures		
	1991	2006	2013	1991	2006	2013	1991	2006	2013
National Highways	N/A	2,753	3,526	N/A	864	819	1,012	3,617	4,345
Regional Highways	N/A	2,689	3,377	N/A	846	741	302	3,535	4,118
Zilla Roads	N/A	5,477	10,737	N/A	2,083	2,292	1,843	7,560	13,029
Total	N/A	10,919	17,640	N/A	3,793	3,852	3,157	14,712	21,492

Source: RMP (2009), BMMS database (RHD), SAPROF Report on EBBIP and EBBIP Bridge Condition Survey

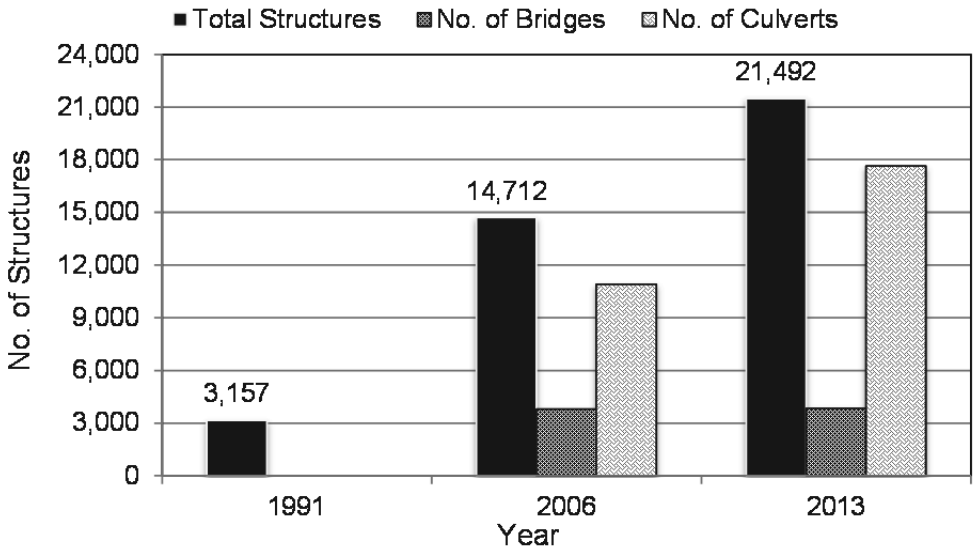


Figure 2.1.2 Increasing Trend of No. of Structures under RHD Road Network

Bridge Maintenance Management System (BMMS), an application-based database on the management of information regarding all structures undertaken by RHD in Bangladesh, is used to evaluate the bridge condition in Bangladesh. To this regard, RHD adopted a simple but effective way of reporting the existing 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

The definition of damage category C stated above represents that the bridges having damage require repair or replacement to some extents to limited parts but major structural components. Whereas the bridges having damage category D require repair or replacement of entire structure.

The number of bridges having damage categories A, B, C and D were examined in 2013 through the "Capacity Building Programme for Bridge Maintenance and Management System (BMMS) of RHD under EBBIP". Total number of bridges under RHD road network was found to be 3,852 which are summarized in Table 2.1.3. It was also predicted that the bridges having C and D damage categories are significant in numbers which need repair or replacement in an urgent manner.

Table 2.1.3 Bridges Condition under RHD

Damage \ Road Type	N	R	Z	Total	
				Nos.	%
A	362	246	731	1,339	34.8
B	272	197	591	1,060	27.5
C	140	230	625	995	25.8
D	45	68	345	458	11.9
Total				3,852	100

Note: N= National, R=Regional, Z=Zilla,
Source: Capacity Building Programme for BMMS of RHD under EBBIP (2013)

2.2 National Development Plans and Programs

The National Land Transport Policy (NLTP-2004), National Integrated Multi-modal Transport Policy (NIMTP-2013) and Bangladesh Road Master Plan (RMP, 2009-2029) are the main policy documents which have been guiding policies of transport agencies for the selection of road development and improvement projects. Besides, the Government formulated the Sixth Five Year Plan (6FYP, 2011-2015) in order to achieve an average GDP growth rate of 7 percent per annum and to develop a balanced and integrated transport network through the adoption of several strategies/programs. In addition, the Government is aiming to become a middle income country by the year 2021 through implementing Vision 2021.

2.2.1 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 achievement 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 building of a 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 use of the mega port. It is also planned that the highway network will extend southwards to Cox's Bazar so that it can further be connected with Myanmar, Thailand, and China through a southern route.

2.2.2 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 are undertaken in accordance with the 6FYP are outlined as:

i. Inclusion of a limited number of projects into the Annual Development Program (ADP) on a priority basis
ii. Allocation of adequate funds for domestically funded projects
iii. Implementation of RHD Road Master Plan (2009-2029)
iv. Selection of locally funded projects in consideration of socio-economic merits
v. Establishment of a 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 is actively pursuing an open-door policy to international traffic by taking advantage of its strategic location in terms of easy access to the sea and being the gateway between the 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 the 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 (AH) Network on 8 November 2009. The physical alignment of the 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 networks 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 making 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 6FYP, RHD took up several new projects under the following programs and subsequently set up physical targets which are summarized in Table 2.2.1.

- General Road Network Development
- Congestion Reduction in Greater Dhaka and other big cities
- Inter-regional connectivity
- Construction of Bypass Roads
- Construction of Zilla Roads (new project)
- Construction of Bridges
- Development of Asian Highway Network
- Construction of Padma Bridge Access Roads/Bridges
- Technical Assistance (TA) Projects

Table 2.2.1 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: 6FYP (2011-2015)

2.2.3 Seventh Five Year Plan, 7FYP (2016-2020)

General Economics Division (GED) of the Planning Commission is in the process of preparing the 7th Five Year Plan (FY2016-FY2020). It would be put into implementation after the end of the 6th Five-Year Plan next year. The 7FYP would carry forward the development programs by ensuring the economic stability in the country. In particular, this plan includes graduating Bangladesh as a developed country by 2041 and reducing the number of ultra-poor to 13 percent.

In 7FYP, the Road Transport and Highways Division has a vision to build sustainable, safe & quality road infrastructure and integrated modern mass transport system for achieving desired socio-economic development in the country. An efficient and modern road transport system can play a unique role to achieve the targets set for Vision 2021. With a view to increasing the share of road transport sector to Gross Domestic Product at the end of the 7FYP period, RHD has set the physical targets as shown in Table 2.2.2.

Table 2.2.2 RHD Physical Targets for the 7FYP

Physical Activities	7th FYP Targets
Construction of 4 lane roads	300 km
Construction of roads other than 4 lane	340 km
Improvement/ Rehabilitation of roads	2,500 km
Construction of Flyover/Overpass	7,000 m
Construction of bridges/culverts	14,800 m
Reconstruction of bridges/culverts	6,800 m

Source: MORTB

Moreover, The GOB accords the highest priority to the completion of the Padma Bridge project by 2018 which is underway. Regarding highways, the topmost priority is to convert important national highways into four (4) lanes. The initial effort will focus on completing the ongoing highway projects; especially the upgrading of the Dhaka-Chittagong Highway is of utmost importance. Early completion of the Dhaka-Chittagong 4-lane highway (along with the double tracking of the railway connection) could raise productivity of the Chittagong port, which could provide dividend of generating substantial extra value added along the supply chains. Furthermore, feasibility study to construct a road-rail tunnel under the river Jamuna would be completed during the 7FYP period.

2.2.4 National Land Transport Policy, NLTP (2004)

The government's policy for the transport sector is spelt out in the National Land Transport Policy which was approved in April 2004. The Land Transport Policy has been formulated to meet the needs of the twenty first century. Accordingly Government 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 (2009-2029)
- 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 is 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 Highways up to the carriageway width is developed, and where demand exists, non-motorized vehicle lanes are considered. This program aims to:

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

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

2.2.5 National Integrated Multimodal Transport Policy, NIMTP (2013)

The economic expansion and social development witnessed in Bangladesh since independence was accompanied by rapid growth in transport demand at 9 percent per year. Much of this growth was met by road transport, which emerged as a dominant mode of transport over the years. Table 2.2.3 shows the evolution of the modal composition of transport demand. The share of passenger transport demand provided by road transport increased from 54 percent in 1975 to 69 percent in 2009, while rail declined from 30 to 12 percent and Inland Water Transport (IWT) increased from 16 to 19 percent. A similar change also happened for freight transport demand.

Table 2.2.3 Evolution of Transport Demand Mode Share (1975-2009)

Year	Passenger				Freight			
	Mode Shares (%)				Mode Shares (%)			
	Total Ton-km (billion)	Road	Rail	IWT	Total Ton-km (billion)	Road	Rail	IWT
1975	17	54	30	16	2.6	35	28	37
1985	35	64	20	16	4.8	48	17	35
1989	57	68	17	15	6.3	53	17	30
1997	90	72	11	17	12	65	7	28
2005	112	88	4	8	20	80	4	16
2009	155	69	12	19	28	74	7	19

Source: Bangladesh Transport Sector Review (The World Bank publications), People's Republic of Bangladesh: Revival of Inland Water Transport-Options and Strategies, 2007

Keeping in mind the trend of traffic demand modal sharing stated in above table and following the regulatory and legal framework of NLTP (2004), the Government of Bangladesh first introduced and drafted the National Integrated Multimodal Transport Policy (NIMTP) in 2008. It helps in achieving more rational and balanced investments across transport modes and achieves better coordination among road, rail and inland water transport. The draft version was revised on the basis of opinions from relevant Ministries and Divisions in NIMTP. The Cabinet approved the draft version on 20th July 2015, which is abbreviated hereinafter as NIMTP-2013 and summarized as follows.

(1) Objectives

The objectives of NIMTP-2013 are to:

- Reduce cost of transporting goods, so as to make goods and services within Bangladesh less costly
- Aid export competitiveness through lower transport costs
- Improve safety
- Reduce accident rate
- Take advantage of Bangladesh's geographical position to trade in transport services
- Reduce the worst environmental effects of transport
- Ensure that transport meets social needs – in terms of its cost and accessibility to all sectors of society
- Improve integration of the overall transport network and foster measures to make interchange between modes easier
- Reduce the need for travel by better land use planning
- Use transport as means to assist poverty reduction
- Improve fuel and energy security
- Increase alternative options for passenger and freight transport.

(2) NIMTP Emphasis

The integrated multi modal transport policy emphasizes the following:

- Maintenance of existing assets and infrastructure
- Encouraging more investment in rail and inland water transport
- Adopting integrated transport strategies
- Improved integration and interchange between modes of transport
- Improving regional connectivity
- Fostering the role of Multi-modal Transport Operators (MTO's)
- Setting specific targets for improving air quality, road safety, public transport provision and efficiency, and road traffic growth reduction
- A firm commitment from the government to provide adequate levels of funding
- Greater private sector participation in the sector
- Greater use of traffic management
- Innovative funding mechanisms, including road user charging and levies to fund road maintenance, and proper and efficient use of Road Fund
- Establishing rational tariff for international traffic to ensure quality service in regional connectivity
- Ensuring physical and operational integration between different modes of transport
- Establishing a more rational regulatory framework
- New coordinating mechanisms to advise on integration at the national level and act as a force for change
- Meeting the transport needs of women and girl-children
- Applying digital technology in the management of integrated transport policy
- Improved research, education, training and technology to support integrated transport objectives
- Limiting damage of roads through enforcement at axle load control stations on highways
- Modernizing dry ports to enhance efficiency in the management of freight and passenger movement
- Bringing navigability of rivers through enforcement, removing encroachment of river banks, permanent stopping of river pollution, upgrading of river ports and ensuring an environment conducive to transportation through river ports.

(3) Sub-sectoral NIMTP Policy

Within the framework of the NIMTP, polices are set out for five sub sectors. The main sub-sectoral policies by mode are set out:

Table 2.2.4 Sub-sectoral Policy under NIMTP

Sector	Policies Undertaken
Railways	√ Upgrading infrastructure of Bangladesh Railway √ Improving inter-city service quality, timetable and capacity √ Increasing container movement efficiency and capacity √ Establishing more inland container depots in harmony with railway network √ Releasing pressure on roads by enhancing service quality for passengers through close coordination with other modes √ Developing multimodal corridors between major economic centers which give priority to freight and highspeed network for passengers √ Establishing technical harmonization and interoperability between various logistics and systems, including regional traffic √ Reorganizing the organization into lines of business with a focus on operations in multimodal environment √ Establishing regional links, including those of Trans-Asian Railway, to facilitate trade in goods and services √ Corporatizing BR in order to bring in efficiency and modern business practices √ Planning for financing and preparing projects to achieve the objectives √ Enhancing operating capacity of Bangladesh Railway alongside improving quality of service √ Extending rail service to the doorsteps of people through expansion of rail network in all regions of the country √ Introducing modern system (Electric traction, ticket punching, chord line, monorail, etc.) √ Gradual conversion of dual guage with subsequent converstion to broad gauge for increasing speed and enhancing comfort
Inland Water Transport	√ Increasing government allocation for dredging √ Applying advanced technology along with introducing modern management and developing skilled human resources in dredging √ Modernizing hydrographic survey to provide updated information of waterways of all classes √ Investing in existing river ports to improve cargo and passenger handling √ Investing in existing river ports to improve interchange between water transport and other modes √ Investing in new port to better serve increasing passenger and bulk cargo needs √ Providing door-to-door service in passenger and freight movement through coordination with cargo operator and other operators √ Constructing inland container depots to facilitate freight movement through waterway from seaports √ Enhancing efficiency and safety of country boat √ Improving navigational aids and vessels tracking √ Rationalizing regulatory agencies and updating regulations in the sector √ Strengthening research into more fuel-efficient vessels √ Introducing digital techniques in ensuring better service in water transport √ Ensuring uninterrupted movement of inland water transports √ Updating protocol for transit and trade to increase trade and modernize inland water transport √ Introducing water bus to provide door-to-door service to people
Road Transport	√ Attaching highest priority on improved road maintenance √ Paying rational user charges by roads users for using quality roads √ Making the best use of existing roads by improving traffic management measures √ Promoting carefully targeted capacity improvements to address existing congestion on the network √ Conducting full social and environmental appraisals of road projects √ Empowering concerned agencies and ensuring transparency in their activities to prevent illegal encroachment √ Increasing human resources in Bangladesh Road Transport Authority (BRTA) and other related agencies on priority basis √ Earmarking road projects for private sector participation √ Ensuring strict control on axle load limits through installation of axle load stations and bringing transparency in their operations √ Motivating people to learn about road safety √ Applying modern technology in transport system

Sector	Policies Undertaken
River Ports, Dry Ports and Sea Ports	√ Identifying the key infrastructure improvements for future √ Ensuring that multimodal plans are implemented and working together √ Introducing modern procedures to create new employment in this sector, enhance capacity and raise wage √ Developing relationship with trade unions based on mutual trust √ Increasing capacity and efficiency of Chittagong and Mongla seaports, including consideration of a deep sea port √ Developing ports as a gateway for freight movement among neighboring countries √ Streamlining customs procedures and regulations in line with the requirements for the introduction of multimodal transport √ Introducing new legislation and obligations for multimodal transport operation, including insurance provisions needed to cover all risks √ Improving regulatory control of shipping using Bangladesh ports and waters √ Expanding the capacity of Chittagong port and improve its operational efficiency through greater private sector participation √ Fostering shrimp and fish export industry through improvements to operations at Mongla Ports √ Making best utilization of Mongla Port through inland water transport and rail connections for general cargo and containers √ Following International Maritime Organization (IMO) protocols and conventions to prevent marine pollution √ Utilizing local and foreign expertise and investment to increase port capacity and efficiency √ Ensuring safe berthing of ships by dredging of channels to increase navigability √ Promoting Bangladesh competitiveness by encouraging reliable and efficient distribution and access to markets √ Enhancing environmental and operational performance by encouraging the provision of multimodal access to markets √ Making the best use of private sector for investment and operations √ Promoting best environmental standards in the design and operation of ports √ Creating a database to manage and control vessels
Air Transportation	√ Ensuring rapid growth of air cargo services. The government will commission new research to formulate future policies. √ Improvement of cargo handling at Hazrat Shahjalal International Airport and Hazrat Shah Amanat International Airport √ Improve access to airports by all modes of transport √ Immigration services at international airports will be improved through training of staff and the introduction of improved IT systems √ Fostering the operation of more international flights at Chittagong and Sylhet √ Greater private sector participation in the operation of air flights on both international and domestic route √ Modernization and expansion of Cox's Bazar Airport to develop tourism sector √ Introduction of helicopter services with district towns and important places under government and private operators √ Greater private sector participation in the activities of CAAB

Note: CAAB stands for Civil Aviation Authority, Bangladesh
Source: NIMTP (2013)

2.2.6 Road Master Plan, RMP (2009-2029)

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.

The GOB prepared a Road Master Plan, RMP (2009-2029) 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. The following subsections briefly demonstrate the overall objectives, issues and policy development and implementation plan under RMP.

(1) Objectives

The overall objectives of RMP have been set out in 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 to be required for RHD

(2) 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:

- The strength of the national and regional highway networks is largely affected by inadequate maintenance
- Vehicle overloading considerably deteriorates the target life span of road/bridge
- The operation of the National Highway network is severely affected by poor local traffic management.
- The Zilla Road network is not fulfilling its role in rural connectivity and also suffering from lack of maintenance.
- Bridges that have not been properly maintained shortly need replacement or major repairs
- Traffic was increased 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 a road sector policy and their implementation plans which are stated hereunder in Table 2.2.5.

Table 2.2.5 Implementation Plan according to Road Sector Policy by RMP

Road Sector Policy	Implementation Plan
Govt. will create Road Fund and autonomous Board	Government had already decided to promulgate a Road Maintenance Fund
RHD road network to be maintained to a set of agreed standards	Upgrading the 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 under the supervision of Executive Engineer b) For Regional Highways 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 are empowered to stop and weigh vehicles, and are equipped with portable weighing pads

Road Sector Policy	Implementation Plan
The Zilla Road network will be rehabilitated over the next ten years to ensure minimum accessibility level	- All growth centers, Upazilla headquarters, and 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 every five years
Bridges in poor condition will be replaced or undergo major works to ensure safety and accessibility over the next 10 years	- 2,091 Bridges with minor damage (Category B) are considered as repairable to bring their status up to Category A. - 418 bridges with major damage (Category C) are being planned to repair. - 133 bridges with major damage, narrow carriageway (Category D) are being planned to replace.
All narrow bridges (less than 7.3m) on National Highways will be replaced over the next 20 years by bridges having at least 7.3m carriageway	- 18 bridges on National Highways and 108 bridges on Regional Highways are undertaken in the narrow bridge replacement program - A Bridge Replacement Program (BRP) project replacing narrow bridges mainly on Zilla Roads began in 2003-04.
All Portable Steel Bridges (PSB) will be replaced by permanent structures over the next 20 years	- 262 bridges on highways (D category=62, and C category=200) are undertaken in the PSB replacement program
Regular bridge maintenance will be introduced and enhanced	- A comprehensive bridge survey is recommended to update the BCS database - Maintenance manuals for different types of bridge structures are being planned to prepare - Maintenance is given high priority and separate provision of budget is recommended

Note: BCS stands for Bridge Condition Survey

Source: RMP (2009-2029)

(3) Axle Load Control Policy (2012)

According to RMP (2009-2029), overloading of trucks and buses causes excessive damage to pavements particularly on National and Regional Highways. Axle load control involves a combination of punishment through the prevention of further passage, and on the spot tolls or fines related to the amount of overloading. In parallel with axle load control, fully computerized and controlled toll collection system is suggested to implement, if and where necessary.

- Emerging Issues Taken into Consideration
  - There are too high a proportion of 2-axle medium trucks, which cause severe pavement damage. Government is actively encouraged to import/manufacture of multi-axle trucks and ban imports of 2-axle trucks above a certain weight.
  - Pavements constructed to the highest standards show signs of distress well before the end of design life.
- Load Limit
  - Following legal load limits can be imposed:
    - Front 2-tyre single axle: 6,000 kg
    - 4-tyre single axle: 10,200 kg
    - 8-tyre tandem axle: 20,000 kg

- A maximum tire pressure of 80 psi (5.5 kg/cm^2) should be allowed.

- Actions Required
  - The following actions are suggested to underpin axle-load control
    - A ban on the import of 2 axle trucks with gross weight over 6 tons
    - Enhanced enforcement
    - Placing the Highway Police under RHD
    - Issuing penalty tickets for overloading
    - Direct charging using toll mechanism
    - Fine and tolls should be more than the benefit of overloading
    - Allowing a small margin of overloading (say, 0.5 tons)

In addition to RMP (2009-2029), Bangladesh Road Transport Authority (BRTA) under Road Transport and Highway Division (RTHD) of the Ministry of Road Transport and Bridges (MORTB) has taken initiatives to publish 'Axle Load Control Centers Administration Policy-2012'. According to this policy, all the axle load control centers will be managed by Roads and Highways Department under the supervision of RTHD.

- Axle Load and Total Weight Limit by BRTA

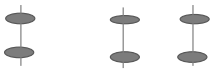
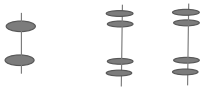
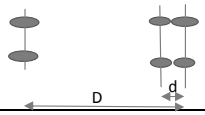
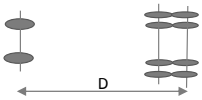
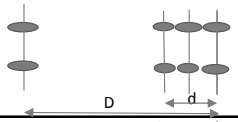
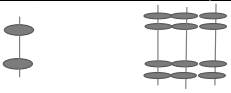
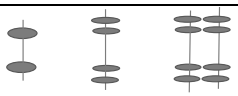
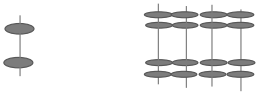
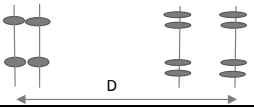
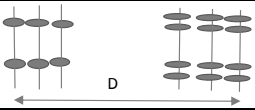
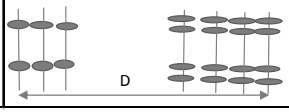
  The MORTB (former Ministry of Communication, MOC) promulgated a notification no. RRD/BRTA/Overload-38/96(P-1)-653, dated 16 November 2003 which was published in the additional edition of the Bangladesh Gazette on 5 May 2004 on maximum permissible weight limits for Motor Vehicles which is summarized in Table 2.2.6. According to this Notification, both axle load and weight limit of motor vehicles are stipulated. The maximum axle load is 10 ton and minimum axle load is 4.5 ton depending on the axle number of classified vehicles.

- Installation of Axle Load Control Stations

  The Roads and Highways Department with the permission of RTHD of MORTB will install axle load control stations at strategic locations of road network.

  - Technologies involved in axle load control stations might vary from practical point of view.
  - The policy is applicable to all axle load control stations regardless of the technology involved in axle load control stations.
  - In case of any problem in enforcement of the policy due to technology, the coordination committee will take immediate steps to address it.

Table 2.2.6 Regulated Axle Load and Total Weight of Vehicle in Ton

Axle Load Item No.in Regulation	Total Weight Item No.in Regulation	Remarks	Axle configuration of Large Truck	d(m) and D(m)	Permissible Axle Load by Regulation			Permissible Total Weight by Regulation
					Front Axle	Intermediate Axle	Rear Axle	
1	-	Rigid		single	5.5	-	5.5	-
2	-	Rigid		single	5.5	-	10	-
3	3	Rigid		2.5≧d≧1.02 D≧4	5.5	-	6.25	22
-	4	Trailer		D≧5	5.5	-	10	25
4	3	Rigid		d closely spaced	5.5	-	8.25	22
5	5	Rigid		d<3.25	5.5	-	4.5	25
6	-	Rigid		d closely space	5.5	-	6.5	25
-	6	Rigid			5.5	10	8.25	30
-	7	Articulated		D≧8	5.5	-	8.25	32
7	-			d closely space	5.5	-	5.5	-
-	8	Trailer not closely spaced		d not closely spaced. D≧8	5.5	-	10	33
-	9	Articulated		closely spaced. D≧9	5.5	-	6.5	35
-	10	Articulated		d closely spaced. D≧10	5.5	-	8.25	38
-	11	Articulated		d closely spaced. D≧10	5.5	-	6.5	41
-	12	Articulated		d closely spaced. D≧10	5.5	-	5.5	44

Source: BRTA (Bangladesh Road Transport Authority)

(4) Toll Policy (2014)

In addition to axle load policy, MORTB has already approved tariffs related to overloading at weighbridge installed at Auskandi toll plaza on N2, but the tariffs do not meet the objective of recovering damage done by the various levels of overloading. Accordingly recommended tariffs by RMP are set out as shown in Table 2.2.7.

Table 2.2.7 Proposed level of Fine/Toll at Auskandi Weighbridge

Axle Overload (ton)	Current Level of Tariff (BDT)	Proposed Level of Tariff (BDT)
1	50	300
2	120	720
3	200	1200
4	300	1800
5	700	4200
6	1,100	6,600
7	1,700	10,200
8	2,500	15,000

Source: RMP (2009-2029)

Assuming that toll shall be imposed in order to ensure funding for construction, maintenance and operation of the expensive infrastructures. Addressing this issue, a new Toll Policy is established by MORTB in 2014 in order to modernize and update existing toll collection method and also to increase the government revenue. Some key points from this toll policy which is applicable for Kalna Bridge are taken out and summarized as below:

Table 2.2.8 Toll Collection Policy

Section no. as shown in regulation	Description
4.2	Road Bridge
4.2.2	Permanent bridges having a length more than 200 meters.
5	Toll Collection Method
5.1	Operation and Management (O & M)
5.1.1	An operator will be recruited based on fee for 3 (Three) years through open bidding. The successful operator will have to deposit money equal to 30 days average daily toll collected in the previous year for important road and 90 days average daily toll for other roads.
5.1.2	Toll will be collected based on government prescribed rates for vehicles;
5.1.3	Applicable Tax, VAT, duty, surcharge, etc. on the proceeds from toll will be deposited timely to respective economic code separately.
5.1.5	The Roads and Highways Department will conduct traffic count survey at each toll plaza at least twice in a year. The survey report should correspond to the toll proceeds.
5.1.6	Proceeds from toll must be deposited to the designated account in the next banking day by pay order/demand draft. The money deposited to this designated account must be deposited to the Government Treasury on first and fourth working day in each week.
5.1.7	Installations, equipment and software for collection of toll will be supplied by the Roads and Highways Department and the same department will be responsible for their control and management.

Section no. as shown in regulation	Description
5.1.8	The maintenance of toll bridges and their approach, toll plaza, etc. will be done by the Roads and Highways Department.
5.1.9	Electronic toll collection method (RIF ID tag, smart Card, touch and go system, ETC) will be introduced in phases.
5.2	Leasing
5.2.1	Except for "O & M" method for toll collection, leasing method will be used for all other cases;
5.2.3	The contract period will be 1 (One) year;
5.2.4	The recruitment process for a new leaseholder will have to be commenced minimum 4 (Four) months prior to expiry of the lease period and completed 1 (one) month prior to termination of the expiry lease period.
5.3	Departmental
5.3.3	Applicable Tax, VAT, duty, levy, etc. on the collected toll will be deposited separately to relevant economic code;
5.3.4	Money collected daily from toll will have to be deposited next day in banking hours to the bank account administered by the office of the Sub-Divisional Engineer. The money deposited to the bank will be withdrawn on the first working day of each week and it must be deposited to a designated economic code through treasury chalan. The treasury chalan will have to be preserved in the office of the Sub-Divisional Engineer after Cash Transaction Report (CTR)
6.	Depositing collected toll
6.1	For the purposes of Road Maintenance Board Act, 2013, money collected from toll will be deposited in the designated economic code of the 'Road Maintenance Board';
7.	Considerations for determining toll
7.2	Basis of determining toll rates
7.2.2	For roads, bridges and installations, the rates of toll will be determined based on construction cost, maintenance cost, design life, number of traffic, size of traffic, classification of roads (traffic fleet) and different applicable tax, VAT, duty, levy, surcharge;
7.2.3	The rate of toll will be fixed per kilometer of a toll road. For roads and bridges, the length classification will be as follows:

Length class (meter)	>1,000	751-1,000	501-750	201-500

7.2.4	If two or more bridges are located in a short distance, combined tolls for two or more bridges may be collected at one bridge to reduce traffic congestion;
7.2.5	If a bridge is constructed to replace a ferry, the toll for the bridge will be collected at least for 1 year at a rate that was applicable for ferry crossing even if the length of the bridge is less than 200 meter;
7.3	Vehicle Class

Vehicle class	Types of Vehicle	Description
A.	Trailer	Vehicles capable of carrying container/heavy machinery/heavy goods or equipment
B.	Heavy truck	Trucks having three or more axles, covered trucks/vans, container carrying trucks and other articulated vehicles
C.	Medium truck	Rigid trucks having two axles/ tractors and trailers used for commercial purposes
D.	Large bus	Motor vehicles having 31 or more seats excluding the driver's seat
E.	Mini truck	Vehicles having capacity up to 3 tons payload
F.	Vehicles for agricultural works	Power tillers, tractors, etc
G.	Minibus/Coaster	Motor vehicles suitable for carrying 30 passengers excluding the driver

Section no. as shown in regulation	Description	
H.	Microbus	Motor vehicles suitable for carrying minimum 8 and maximum 15 passengers excluding the driver
I.	Four wheel drive vehicles	Pick-up, conversion jeep, jeep, racker, crane, etc
J.	Sedan car	All types of sedan car—private or operated on rent
K.	3/4 wheel motorized vehicle	Auto tempos, CNGs, auto rickshaws, auto vans, any battery driven motorized vehicles having 3/4 wheels
L.	Motor cycle	Motor driven two wheeler s
M	Rickshaw van	Rickshaw van for carrying goods and passengers
	Rickshaw	Passenger carrying cycle rickshaw having three wheels
	Bicycle	Paddle run two wheeler
	Pull cart	Animal or hand driven Pull/Push carts
7.4	Toll rates based on vehicle classification	
7.4.1	Toll bridges	
7.4.1.1	Toll based on road classification will be as follows:	
	Classification of roads	Base toll
	Important Highways	400
	National Highways	300
	Regional Highways	200
	District Roads	100
7.4.1.2	Toll based on vehicle class will be as follows	

Vehicle Class	A	B	C (Base Rate)	D	E	F	G	H	I	J	K	L	M
Ratio of toll rate	250%	200%	100%	90%	75%	60%	50%	40%	40%	25%	10%	5%	2.5%

7.4.1.3	Toll rates as per different length class of bridges	
	Length of bridge	Toll rate
	Length: >1000 meters	125%
	Length: >751-1000 meters	100%
	Length: >501-750 meters	75%
	Length: >201-500 meters	50%
7.4.1.4	The following formula will be used to determine toll for bridges Formula: Toll based on road classification x toll based on vehicle class x toll based of length class of bridge = Toll	
7.6	Minimum amount of toll The amount of toll shall not be below Taka 5.00 in any case.	

Source: Toll Policy (2014) by MORTB

According this toll policy, bridges having length more than 200m should be under toll operation. In this Project, two bridges (C13, C26) except Kalna are planned to reconstruct with 4-lane width and more than 200m length. However, these two bridges are not currently under toll operation and RHD does not have any specific plan to operate them under toll policy in future. Therefore, C13 and C26 are exempted from the application of toll policy (2014).

3. CROSS-BORDER INFRASTRUCTURE DEVELOPMENT

3.1 Current Situation of Cross-Border Activities

3.1.1 Import and Export

The import and export of Bangladesh is shown in Table 3.1.1. The table shows that although there are fluctuations in amount after financial crisis of 2008, both the amount of import and export has been increasing in recent years. Therefore, it can be said that demand for cross border transport over land is increasing.

Table 3.1.1 Import and Export

Year	Import		Export	
	Amount (bil. USD)	Growth rate	Amount (bil. USD)	Growth rate
2000-2001	8.54		5.99	
2001-2002	9.66	13.11%	6.55	9.35%
2002-2003	10.90	12.84%	7.60	16.03%
2003-2004	13.15	20.64%	8.65	13.82%
2004-2005	14.75	12.17%	10.53	21.73%
2005-2006	17.16	16.34%	12.18	15.67%
2006-2007	20.37	18.71%	14.11	15.85%
2007-2008	22.51	10.51%	15.57	10.35%
2009-2010	23.74	5.46%	16.20	4.05%
2010-2011	33.66	41.79%	22.92	41.48%
2011-2012	35.52	5.53%	24.30	6.02%
2012-2013	33.97	-4.36%	27.03	11.23%
2013-2014	36.99	8.89%	30.18	11.65%

Source: Foreign Exchange Policy Department, Bangladesh Bank, CCI&E and EPB

3.1.2 Cross-Border Points in Bangladesh

(1) Status of Land Ports

The Bangladesh Land Port Authority (BLPA) has identified 20 border crossing points for future development. Their status is summarized in Table 3.1.2 and locations of major land ports are mapped in Figure 3.1.1. Five of these land ports are managed by the government, while six are managed by build-operate-transfer (BOT) operators.

Table 3.1.2 Border Crossing Points Planned and Announced for Development by BLPA

Border Crossing Point	Date Declared	Town on Bangladesh Side	Town on Other Side	Management
Benapole	12 January 2001	Benapole, Sharsla Jassore	Petrapole, Bongaon, India	Own Management
Burimari	12 January 2002	Patgram, Lalmonirhat	Changrabandha, India	Own Management
Akhaura	12 January 2002	Akhaura Brammonbaria	Rumhagor Agortala Tripura, India	Own Management
Sona Masjid	12 January 2002	Shibgonj Chapa, Nobabgonj	Mahadipur, Maldha, West Bangal	BOT
Hilli	12 January 2002	Hakimpur, Dinajpur	Hilli, South Dinajpur, West Bengal	BOT
Banglabandha	12 January 2002	Tetulia Punchogar	Phulbari, Jalpaiguri, West Bengal, India	BOT
Birol	12 January 2002	Birol Dinajpur	Radhikapur gaora, West Bengal, India	BOT (No Construction)
Teknaf	12 January 2002	Teknaf, Cox's Bazar	Mongru, Shituway, Myanmar	BOT
Bibir Bazar	18 November 2002	Bibir Bazar, Cumilla, Sadar	Shimastapur Sonatnurah, Tripurah India	BOT
Bhomra	12 January 2002	Bhomra Satkhira	Gojadanga Chobbinporgona, West Bengal India	Own Management
Nakugaon	22 September 2010	Nalitabari, Sherpur	Dalu, Meghaloy, India	Own Management
Biloneya	23 February 2009	Biloneya, Fani	Biloneya, Tripura, India	Land acquisition in progress
Gobrakura and Koraitoli	14 June 2010	Haluaghat, Mymenshing	Gachuspara, Meghaloy, India	Land acquisition and approval of Development project
Tamabil	12 January 2002	Goainghal, Shylet	Dawki, Shilong Meghaloya, India	Development is in progress
Droshona	12 January 2002	Damurhat, Chuadarga	Geday, Krinnongor, West Bengal India	No Construction
Ramgor	7 November 2010	Ramgor, Khagrachori	Subrum, Tripurah, india	No Construction
Sonahat	25 October 2012	Bhurungantari, Kurigram	Sonahat, Dhubri, Assam India	Development project approval is in progress
Tegamukh	30 June 2013	Borokol, Ranyamati	Dernaghree/Kawyapuchiya Mizuram India	No Construction
Chilahaty	28 July 2013	Domar, Nilphamari	Haldi Bari, Kuchbihar, West Bengao, India	No Construction
Doulatgonj	31 July 2013	JibonNagor, Chuadanga	Mazdiya, Kuchlihar Wesr bengal India	No Construction

Abbreviation: BOT = build-operate-transfer
Source: Bangladesh Land Port Authority

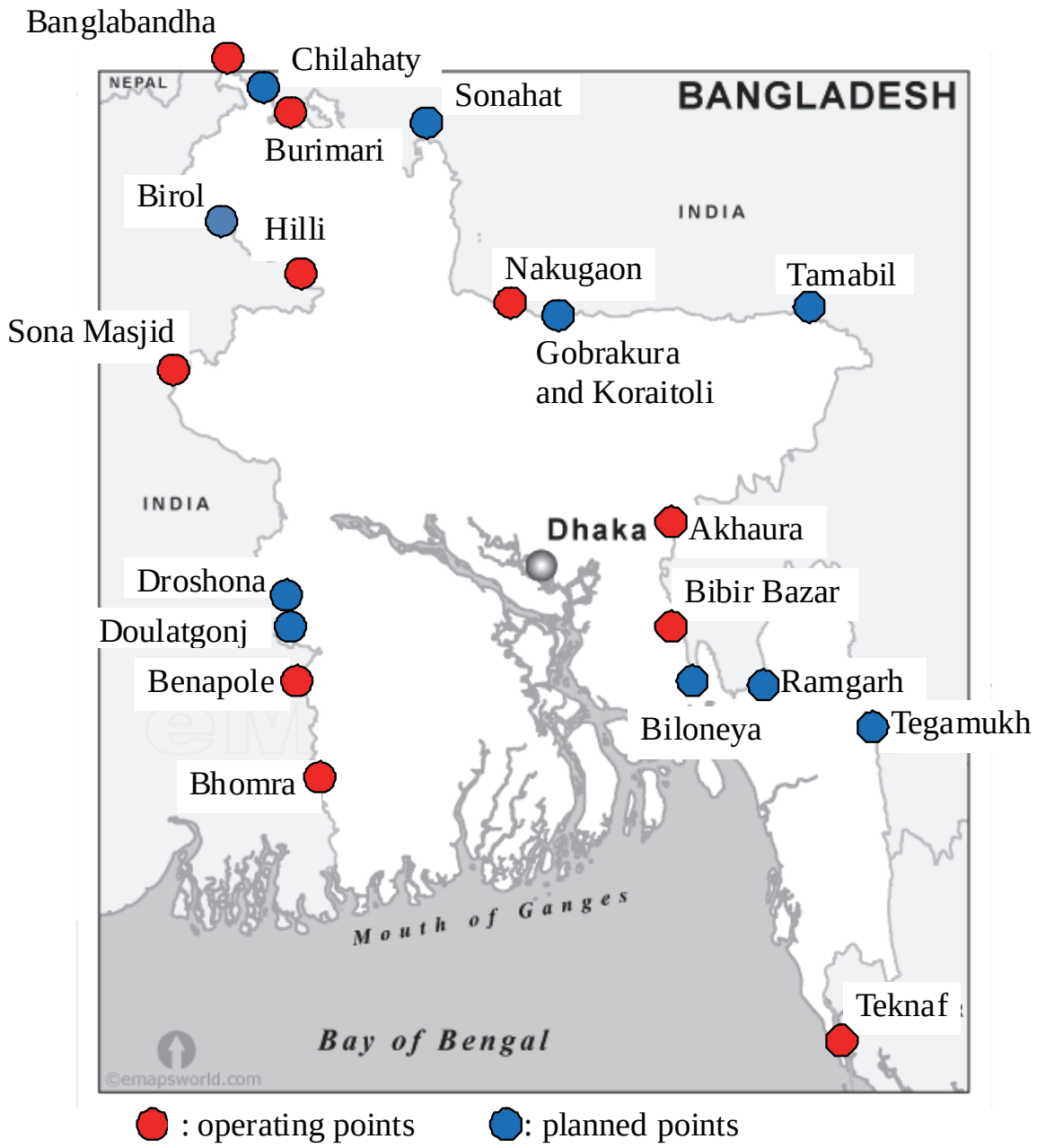


Figure 3.1.1 Location of Main Border Crossing Points in Bangladesh

(2) Details of Main Land Ports

The details of main land ports are as follows. The information is provided by LPA.

Benapole Land Port

- Storage capacity: 40,000 metric ton
- Total land area: 61.7 acre (249,691 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Transshipment yard, Truck terminal, Weighbridge scale, International bus terminal
- Manpower: Administrative personnel: 160, Security personnel: 263, Handling labor: 1,400

- Note: Benapole is the main gate from Bangladesh to the mainland of India for land trade. Benapole is a major land supply gate for Dhaka and cargo even comes from distant origins in India. There are about 500 customs and forwarding agents and 50 truck companies operating at this border crossing point. The reloading of cargo from truck-to-truck (i.e., transshipment) is undertaken in the "no-man's land" along the border and in the warehouse in the land port on the Bangladeshi side. On average, about 100-150 trucks are waiting their clearance in the port area and cause traffic congestion. Main import goods are cotton, chemicals, motor cars, motorcycles, tires-tubes, machinery & spare parts etc. Main export goods are jute & jute goods, fish, soap, plastic goods, batteries, construction materials etc.

Figure 3.1.2 Photo at Benapole Cross Border Point (in August 2015)

In August 2015, the JICA Survey Team visited Benapole land port. At that time, there was a long line of Indian trucks on the road in Bangladesh. Although these trucks can get into the area with transship yard and warehouses, the trucks were waiting for custom procedures conducted at the cross border point. It can be guessed that the custom procedure of Bangladesh can be one of the bottlenecks for cross border transaction at Benapole. Furthermore, as immigration is set there, busses for cross border travelers are in operation. The busses also increase the congestion in Benapole.

Burimari Land Port

- Storage capacity: 2,000 metric ton
- Total land area: 11.15 acre (45,122 m^2)
- Main Infrastructure: Warehouse, Transit shad, Open stack yard, Transshipment yard, weighbridge scale
- Manpower: Administrative personnel: 10, Security personnel: 15, Handling labor: 600
- Note: Goods are mainly imported from Bhutan. Under a mutual arrangement, the Bhutanese trucks are allowed to ply through India to Burimari to unload goods. Main import goods are rice, wheat, lentils, onions, fruits, tobacco, etc.

Akhaura Land Port

- Storage capacity: 2,000 metric ton
- Total land area: 15.0 acre (60,703 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Transshipment yard, Weighbridge
- Manpower: Administrative personnel: 4, Security personnel: 7, Handling labor: 200
- Note: Main import goods are bamboo, turmeric, watches, ginger, marble slabs, fruits etc. Main export goods are processed stone, bricks, tiles, fish, cement, batteries, furniture, glass sheets etc.

Sona Masjid Land Port

- Storage capacity: 1,000 metric ton
- Total land area: 19.13 acre (77,416 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Transshipment yard, Weighbridge
- Note: Sona Masjid Land Port is operated by Panama Sonamosjid Port Link Ltd. on a BOT basis. Main import goods are rice, wheat, onions, fruits, fly ash etc. Due to absence of quarantine facilities on the Indian side, Bangladesh exporters face difficulties in exporting agri-products.

Hilli Land Port

- Storage capacity: 2,000 metric ton
- Total land area: 21.86 acre (88,464 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Transshipment yard, Truck Terminal, Weighbridge
- Note: Hilli Land Port is operated by Panama Hili Port Link Ltd. on a BOT basis. Main import goods are rice, wheat, onions, fruits, fish etc. Main export goods are molasses, cement, batteries etc.

Banglabandha Land Port

- Storage capacity: 500 metric ton
- Total land area: 10.48 acre (42,411 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Truck Terminal, Weighbridge scale
- Note: Banglabandha Land Port is operated by Banglabandha Land Port Ltd. on a BOT basis. Main import goods are lentils, wheat, onions, fruits etc. Main export goods are jute, glass sheets, medicine, food products etc. Presently, only import-export of goods is carried on. There is no immigration.

Teknaf Land Port

- Storage capacity: 1,000 metric ton
- Total land area: 24.0 acre (97,125 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Transit shed, Truck parking yard, Weighbridge scale
- Note: Teknaf Land Port is operated by United Land Port Teknaf Ltd. on a BOT basis. Main import goods are lentils, spices, fish, wood, shoes, bamboo, leather etc. Main export goods are cement, readymade garments, potatoes, eggs etc.

Bibir Bazar Land Port

- Storage capacity: 500 metric ton
- Total land area: 10.0 acre (40,469 m^2)
- Main Infrastructure: Warehouse, Open stack yard
- Note: Bibir Bazar Land Port is operated by Shefferd Comilla land Port Ltd. on a BOT basis. Main exports are crushed stone, cement, beverages etc.

Bhomra Land Port

- Total land area: 15.73 acre (63,657 m^2)
- Main Infrastructure: Warehouse, Open stack yard, Transshipment yard, Weighbridge scale
- Note: Main import goods are onion, fruit, rice, wheat, fish, cotton, dry fish, stone, fly ash, sand-stone, china-clay, ball-clay, stone chips, sugar, round capsicum, spices, motor parts, steel products, radio, slab, coffee, dry products, candle etc. Main export goods are jute, washing cloth, plain juice etc. Due to insufficiency of infrastructure under current operation, a further expansion of the port is proposed and under processing for approval by Planning Commission. Under the expansion, truck terminal, yard, warehouse passenger, fire hydrant system and terminal with other infrastructure will be developed within 45.11 acre land area.

Figure 3.1.3 Photo at Bhomra Cross Border Point (in August 2015)

In August 2015, the JICA Survey Team visited Bhomra land port. At that time, there was a long line of Indian trucks on the road in Bangladesh, but the line is much less than the line in Benapole. Although these trucks can get into the area with transship yard and warehouses, the trucks were waiting for custom procedures conducted at the cross border point. On the other hand, the access road to Bhomra is worse condition than that to Benapole. It can be guess that the cross border transaction at Bhomra land port takes less time for the cross border procedures and more time for transportation to Dhaka in comparing with the cross border transaction at Bhomra.

(3) Traffic at Major Land Ports

Table 3.1.3 summarizes traffic data for Bangladesh's major land ports.

Table 3.1.3 Traffic at Bangladesh's Main Land Ports

(in ton)

		2007-08			2008-09			2009-10			2010-11		
	Port	Import	Export	Total	Import	Export	Total	Import	Export	Total	Import	Export	Total
1	Benapole Land Port	1,422,762	234,472	1,657,234	872,819	470,332	1,343,151	1,148,468	286,700	1,435,168	1,147,972	371,798	1,519,770
2	Sona Masjid Land Port	982,956	0	982,956	820,645	0	820,645	876,295	0	876,295	1,401,586	0	1,401,586
3	Hilli Land Port	289,977	15,473	305,450	385,600	12,705	398,305	410,391	11,940	422,331	400,833	43,296	444,129
4	Burimari Land Port	313,423	85,027	398,450	281,671	40,309	321,980	299,222	146,831	446,053	396,333	73,210	469,543
5	Akhaura Land Port	12	298,700	298,712	680	322,800	323,480	557	442,965	443,522	335	546,523	546,858
6	Bibir Bazar Land Port	109	56,768	56,873	39	61,323	61,362	31	48,236	48,267	15	88,200	88,215
7	Banglabandha Land Port	0	0	0	0	0	0	0	0	0	99,639	12,442	112,081
8	Teknaf Land Port	146,712	8,175	154,887	149,968	7,170	157,138	99,039	11,731	110,770	92,538	8,810	101,348
9	Bhomra Land Port												
	Total	3,155,951	698,611	3,854,562	2,511,422	914,639	3,426,061	2,834,003	948,403	3,782,406	3,539,251	1,144,279	4,683,530

		2011-12			2012-13			2013-14			2014-15(Up to April)		
	Port	Import	Export	Total	Import	Export	Total	Import	Export	Total	Import	Export	Total
1	Benapole Land Port	1,221,470	464,040	1,685,510	1,124,126	562,616	1,686,742	1,252,250	300,274	1,552,524	1,379,350	233,303	1,612,653
2	Sona Masjid Land Port	1,401,922	0	1,401922	1,563,718	0	1,563,718	1,746,993	0	1,746,993	1,218,231	7,190	1,225,421
3	Hilli Land Port	603,204	10,721	613,925	853,380	18,691	872,071	851,759	23,870	875,629	752,952	15,593	768,545
4	Burimari Land Port	357,539	0	357,539	227,219	0	227,219	935,141	0	935,141	1,036,205	0	1,036,205
5	Akhaura Land Port	172	575,550	575,722	60	372,381	372,441	251	278,377	278,628	60	1,263,188	1,263,248
6	Bibir Bazar Land Port	0	125,431	125,431	0	124,689	124,689	24	63,596	63,620	28	86,914	86,942
7	Banglabandha Land Port	168,728	4,553	173,281	214,268	40,790	255,058	515,700	14,513	530,213	505,997	49,136	555,133
8	Teknaf Land Port	85,519	633	86,152	66,352	8,391	74,743	105,755	6,504	112,259	59,044	5,946	64,990
9	Bhomra Land Port	792,849	8,320	801,169	941,775	35,129	976,904	1,458,413	44,299	1,502,712	1,507,576	44,625	1,552,201
	Total	4,631,403	1,189,248	5,820,651	4,990,899	1,162,687	6,153,585	6,866,286	731,433	7,597,719	6,459,443	1,705,895	8,165,338

Note: As Nakugaon land port has just started its operation in 2015, the amount for Nakugaon land port is not indicated in this table.
Source: Land Port Authority

The main trends of exports and imports in terms of weight amounts, which are shown in Table 3.1.3, are as follows.

- Benapole Land Port has been the main gate for transactions between Bangladesh and the mainland of India. But, as its traffic is close to its capacity, traffic at Benapole has not increased recently. On the other hand, to deal with the increasing demand of transactions between Bangladesh and the mainland of India, other land ports located between Bangladesh and the mainland of India (Sona Masjid, Hilli and Bhomra) are drastically increasing their traffic in these years. Although traffic for both import and export with West Bengal is increasing, traffic for import increased more than that for export comparing the traffic in 2013-14 to that in 2007-2008.
- Especially, traffic at Bhomra becomes almost same amount as traffic at Benapole. The reasons are (i) as Bhomra started its operation recently, facilities are in good conditions, and (ii) its location is close to Kolkata, the largest city in West Bengal, India. It can be guessed that Bhomra is an alternative for cross border logistics companies between Bangladesh and the main land of India. They mainly transport cargo from Kolkata to Dhaka. From the viewpoint of distance, Bhomra and Benapole are almost same conditions, but both of them have problems in the trasportatoin. The disadvantage for transportation through Benapole is waiting time for custom clearance at the cross border point. The disadvantage for transportation through Bhomra is the bad condition of roads. The logistics companies may be comparing the disadvantages and choose the route which can shorten the transportation time. Therefore, it can be guessed that Bhomra is providing better transportation route for logistics companies in recent years and that the transactions through Bhomra increased drastically.
- Burrimari Land Port, which is the main gate for Bhutan through India, and Banglabandha Land Port, which is the main gate for Nepal through India, are increasing their traffic steadily. On the other hand, trucks of Nepal and Bhutan can drive into Bangladesh without transshipment. Such traffic amount is not counted as export in the table. 7,079 trucks passed through Burimari Land Port in 2014-15.
- Main gates between Bangladesh and the North East India are Akhaura Land Port and Bibir Bazar Land Port. The traffic at those 2 land ports has varied by year during 2007-2014.
- The traffic amount by region in 2013-14 is summarized as follows.
  - ✓ Traffic with mainland of India (through Benapole, Sona Masjid, Hilli and Bhomra): 5,677,858 ton (74% of total amount)
  - ✓ Traffic with the North East India (through Akhaura and Bibir Bazar): 342,248 ton (5% of total amount)
  - ✓ Traffic with Bhutan through India (through Burimari): 935,141 ton (12% of total amount)

- ✓ Traffic with Nepal through India (through Banglabandha): 530,213 ton (7% of total amount)
- ✓ Traffic with Myanmar (through Teknaf): 112,259 ton (1% of total amount)

3.2 Sub-regional and International Cross-Border Road Plans

3.2.1 Asian Highway Network (UN-ESCAP)

The Asian Highway project was conceived by UN-ESCAP (United Nations Economic and Social Commission for Asia and the Pacific) in 1959 with the aim of establishing regional cooperation among the main land countries of Asia, based on road transport linkages. The Asian Land Transport Infrastructure Development Project (ALTIDP), the foremost among the existing pan-Asian infrastructure initiatives, consists of three pillars: the Asian Highway (AH), the Trans-Asian Railway (TAR), and the Facilitation of land transport projects through intermodal transport terminals (dry ports and inland ports). The Asian Highway follows framework for internationally agreed routes and infrastructural standards as of 2002. The technical standards by highway classifications are summarized in Table 3.2.1.

Table 3.2.1 Technical Standards for Asian Highways

Highway Classification		Primary (4 or more lanes)				Class I (4 or more lane)				Class II (2 lanes)				Class III (2 lanes)			
Terrain Classification		L	R	M	S	L	R	M	S	L	R	M	S	L	R	M	S
Design Speed (km/hr)		120	100	80	60	100	80	60		80	60	50	40	60	50	40	30
Width (m)	Right of Way	50				40				40				30 (40)			
	Lane	3.75				3.50				3.50				3.00 (3.25)			
	Shoulder	3.00		2.50		3.00		2.50		2.50		2.00		1.50 (2.0)		1.0 (1.5)	
	Median Strip	4.00		3.00		3.00		2.50		N/A		N/A		N/A		N/A	
Minimum Horizontal Curve (m)		520	350	210	115	350	210	115		210	115	80	50	115	80	50	30
Cross-Fall for Carriageway (%)		2				2				2				2-5			
Cross-Fall for Shoulder (%)		3-6				3-6				3-6				3-6			
Type of Pavement		Asphalt/ cement concrete				Asphalt/ cement concrete				Asphalt/ cement concrete				Dbl. bituminous treatment			
Maximum Combined Super Elevation (%)		10				10				10				10			
Maximum Vertical Grade (%)		4	5	6	7	4	5	6	7	4	5	6	7	4	5	6	7
Structure Loading (Minimum)		HS20-44				HS20-44				HS20-44				HS20-44			

Terrain Classification; L=Level, R=Rolling, M=Mountains, S=Steep, Minimum horizontal curve shall be determined in conjunction with superelevation.
Note: Figures bracket are desirable values.
Source: Asian Highway Classification and Design Standards (2002)

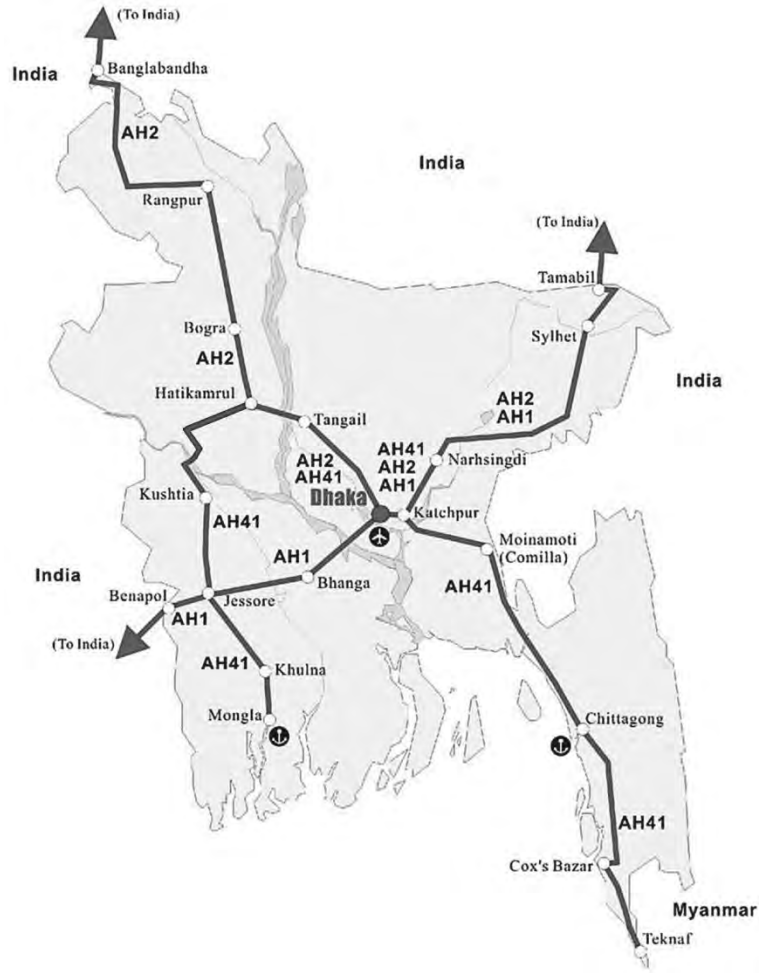


Figure 3.2.1 Location of Asian Highway Route Map in Bangladesh

In Bangladesh, there are three Asian Highway Routes namely, Asian Highway-1 (AH1), Asian Highway-2 (AH2) and Asian Highway-41 (AH41), which are schematically shown in Figure 3.2.1. Of these three routes, AH41 remains within Bangladesh, but could be extended to neighboring countries (Myanmar, India). Total length of the AH routes in Bangladesh is 1,757 kilometer.

- ❖ AH1 Route inside Bangladesh: Guwahati (India) - Dawki (India) / Tamabil – Sylhet – Sherpur – Narshingdi – Kanchpur – Dhaka – Mawa – Charjanajat – Bhanga – Bhatiapara - Kalna Ferry Ghat – Narail – Jessore - Benapole/Petrapole (India) …(Total Road Length 491 km)
- ❖ AH2 Route inside Bangladesh: Guwahati (India) - Dawki (India) – Tamabil – Sylhet – Sherpur – Narshingdi – Kanchpur - Dhaka (South) - Dhaka (North) – Joydevpur – Kaliakoir – Elenga – Hatikamrul – Bogra – Gobindagonj – Rangpur – Beldanga – Panchgarh – Banglabandha / Fulbari (India) … (Total Road Length 512 km)
- ❖ AH41 Route within Bangladesh: Teknaf - Cox's Bazaar – Keranirhat – Feni – Moinamoti – Kanchpur - Dhaka (South) – Dhaka (North) – Joydevpur – Kaliakoir – Hatikamrul – Banpara – Dasuria – Paksey – Kustia – Jeneidah – Jessore – Khulna - Mongla…(Total Road Length 754 km)

The latest status of improvement of AH1, AH2 and AH41 in Bangladesh is shown in Table 3.2.2 - 4.

Table 3.2.2 Status of Asian Highway-1 (AH1)

Sections		km	FS			DD			Upgrade		
			Status	Finance	Date	Status	Finance	Date	Status	Finance	Date
Tamabil	Sylhet	55	Completed	ADB	2015	Completed	ADB	2015			
Sylhet	Sherpur	41	Completed	ADB	2015	Completed	ADB	2015			
Sherpur	Mirpur	43	Completed	ADB	2015	Completed	ADB	2015			
Mirpur	Sarail	61	Completed	ADB	2015	Completed	ADB	2015			
Sarail	Narhsingdi	53	Completed	ADB	2015	Completed	ADB	2015			
Narhsingdi	Katchpur	34	Completed	ADB	2015	Completed	ADB	2015			
Katchpur	Dhaka (South)	8							Under Construction	GOB	2016
Dhaka (South)	Mawa	35	Completed	ADB	2015	Completed	ADB	2015	Plan	GOB	2015-2018
Mawa	Charjanajat	6	Completed	ADB	2015	Completed	ADB	2015	Under Construction	GOB	2018
Charjanajat	Bhanga	22	Completed	ADB	2015	Completed	ADB	2015	Plan	GOB	2015-2018
Bhanga	Bhatiapara	38	Under implementation	ADB-TA	2018	Under implementation	ADB-TA	2018			
Bhatiapara	Kalna FG	3	Under implementation	ADB-TA	2018	Under implementation	ADB-TA	2018			
Kalna FG	Narail	24	Under implementation	ADB-TA	2018	Under implementation	ADB-TA	2018			
Narail	Jessore	32	Under implementation	ADB-TA	2018	Under implementation	ADB-TA	2018			
Jessore	Benapole	38	Under implementation	ADB-TA	2018	Under implementation	ADB-TA	2018			

Source: RHD

Table 3.2.3 Status of Asian Highway-2 (AH2)

Sections		km	FS			DD			Upgrade		
			Status	Donor	Date	Status	Donor	Date	Status	Donor	Date
Dhaka (south)	Dhaka (north)	20							Completed	GOB	2005
Dhaka (north)	Joydevpur	22									
Joydevpur	Kaliakoir	22							Under Construction	ADB, OFID, ADFD	2018
Kariakoir	Elenga	49							Under Construction	ADB, OFID, ADFD	2018
Elenga	Hatikamrul	41	Completed	ADB	2015	Completed	ADB	2015	Included in 2017 Program	ADB	
Hatikamul	Bogra	56	Completed	ADB	2015	Completed	ADB	2015	Included in 2017 Program	ADB	
Bogra	Gonbindaganj	34	Completed	ADB	2015	Completed	ADB	2015	Included in 2017 Program	ADB	
Gonbindaganj	Rangpur	67	Completed	ADB	2015	Completed	ADB	2015	Included in 2017 Program	ADB	
Rangpur	Beldanga	73	Under implementation	ADB	2018	Under implementation	ADB	2018			
Beldanga	Panchagarh	78	Under implementation	ADB	2018	Under implementation	ADB	2018			
Panchagarh	Bangladandha	56	Under implementation	ADB-TA	2018	Under implementation	ADB-TA	2018			

Source: RHD

Table 3.2.4 Status of Asian Highway -41 (AH41)

Sections		km	FS			DD			Upgrade		
			Status	Donor	Date	Status	Donor	Date	Status	Donor	Date
Teknaf	Cox's Bazar	73	Completed	ADB	2015	Completed	ADB	2015			
Cox's Bazar	Keranirhat	101	Completed	ADB	2015	Completed	ADB	2015			
Keranirhat	Chittagong	48	Completed	ADB	2015	Completed	ADB	2015			
Chittagong	Feni	96							On-going	GOB	2015
Feni	Moinamoti	64							On-going	GOB	2015
Moinamoti	Daudkandi	44							On-going	GOB	2015
Daudkandi	Katchpur	30							Completed	ADB	2005
Hatikamrul	Banpara	51	Completed	ADB	2015	Completed	ADB	2015			
Banpara	Dasuria	22	Under implementation	ADB	2018	Under implementation	ADB	2018			
Dasuria	Paksey	12	Under implementation	ADB	2018	Under implementation	ADB	2018			
Paksey	Kushtia	24	Under implementation	ADB	2018	Under implementation	ADB	2018			
Kushtia	Jhenaidah	46	Under implementation	ADB	2018	Under implementation	ADB	2018			
Jhenaidah	Jessore	4	Completed	ADB	2015	Completed	ADB	2015			
Jessore	Khulna	62	Completed	ADB	2015	Completed	ADB	2015			
Khulna	Mongla	44	Completed	ADB	2015	Completed	ADB	2015			

Source: RHD

3.2.2 BIMSTEC (The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation) Road Corridor

Bangladesh is a member country of Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Co-operation (BIMSTEC). The 8th BIMSTEC Ministerial Meeting was held in Dhaka in December 2005 and it noted that the importance of transport and logistics for successful cooperation and development of the region. On the recommendation of the BIMSTEC Working Group, the Heads of Delegation of the Ministerial Meeting approved a BIMSTEC Transport Infrastructure and Logistic Study (BTILS). The Asian Development Bank subsequently agreed to provide technical support for its implementation. The BTILS would identify, evaluate and prioritize legislative and financial measures to relieve the critical transport infrastructure and logistics bottlenecks and increase the efficiency of freight flows among BIMSTEC member countries. Particularly, BIMSTEC can fulfil its key roles of connecting and integrating South and Southeast Asia.

BIMSTEC Secretariat was established in Dhaka in September 2014.

BTILS Policy Framework and Strategies recognized that the lack of road connections between Myanmar and its neighbors restricts trade and the development of a through transport corridor. Therefore, Bangladesh emphasizes establishing a direct link with Myanmar through Chittagong-Cox's Bazar-Gundum corridor. BIMSTEC priority projects in Bangladesh are listed in Table 3.2.5 and planned corridors are schematically shown in Figure 3.2.2.

Table 3.2.5 BIMSTEC Priority Progress 2014-2020

Mode	Country	Project	Timescale
Road	BAN	4-laning Daudkandi-Chittagong	2014-15
Road	BAN	2nd Meghna-Gomati/Katchpur bridges	2014-18
Road	BAN	4 laning Benapole to Jessore	2016-20
Road	BAN	4 laning of Jessore to Magura to Daulatdia	2016-20
Road	BAN	Construction of the 2nd Padma Bridge	2015-20
Road	BAN	4 laning of Paturia-Nabinagar	2016-20
Rail	BAN	Tongi-Bhairab Bazaar extra tracking	2014-15
Rail	BAN	2nd bridges at Bhairab Bazaar and Titas	2014
Rail	BAN	2 more lines Dhaka to Tongi&Tongi-Joydevpur	2014-15
Rail	BAN	Double tracking Laksham/Akhaura link	2016-19
Aviation	BAN	Upgrading of runway at Dhaka Airport	2015-18
Aviation	BAN	Improvement of parking aprons at Dhaka Airport	2014
TF	BAN	Second rail connected ICD in Dhaka	2015-18
TF	BAN	Developments at Benapole and Burimari	2014-17

Source: RHD

In 2011, the BIMSTEC Working Group requested ADB to conduct an update and enhancement of the BTILS reflecting the changes both in relation to global and intraregional trade and in the respective national and regional transport environments. Based on the request, phase 1 of "Updating and Enhancement of the BIMSTEC Transport Infrastructure and Logistics Study" was completed in March

2014. The report of the phase 1 was structured and presented in a manner that it could be used as a comprehensive regional transport database from which to be able to develop the update BIMSTEC policies and strategies. Phase II of the study is designed to provide proposals on future policies and strategies, identification of BIMSTEC priority projects, and so on. The report of the phase II is under preparation as of 2015.

Figure 3.2.2 BIMSTEC Corridors in Bangladesh

3.2.3 SASEC (South Asian Sub-regional Economic Cooperation) Corridor

The South Asia Sub-regional Economic Cooperation (SASEC) Program is dedicated to enhancing such interconnectivity between the Member States by helping them in strengthening their transport links. In doing so, SASEC assists in creating the conditions necessary to boost trade, both intraregional and external trade, thus catering to the needs of the sub-region's growing economies. SASEC's transport sector strategy is designed to: (i) create dynamic multimodal transport networks and effective logistics facilities to increase trade and boost economic growth; (ii) facilitate the planning and implementation of sub regional and national SASEC transport projects that benefit Member States; and (iii) support the strategic transport-related priorities of the SAARC (South Asian Association for Regional Cooperation) and BIMSTEC.

In Bangladesh, the key SASEC transport corridors all radiate out from Dhaka and the overall priority is to gradually upgrade the performance of all of these links. The most important of these is the multimodal link between Dhaka and Chittagong. These two cities represent the major concentrations of trade demand and supply. Following land transport projects were identified as possible priority SASEC land transport projects in Bangladesh for the period 2015-2020.

(i) Completion of Dhaka-Chittagong National Highways (N1)

(ii) Construction of new 4-lane Kanchpur, Meghna and Gumti (KMG) Bridges (N1)

(iii) Construction of the new Padma Bridge and immediate approach roads (N8)

(iv) 4-lane roads between Benapole and proposed new Padma Bridge (N706/R750/Z7503/N805/N8)

(v) 4-lane of Joydevpur-Tangail-Elenga-Hatikamrul-Rangpur-Burimari/Banglabandha N4 /N5

(vi) 4-lane of Dhaka (Kanchpur)-Narsingdi- Sarail-Sylhet-Tamabil National Highway (N2)

(vii) Baraierhat- Heako- Ramgarh regional Highway (R151, R152)

Table 3.2.6 SASEC Priority Project Progress 2015-2020

Project name	Description	Funding source	Progress/status
Joydevpur-Tangail-Elenga-Hatikamrul-Rangpur-Banglabandha/ Burimari • SASEC-1: (Lengh= 70 km Joydevpur-Tangail-Elenga (N4) • SASEC-2: (Length=157 km Hatikamrul-Rangpur (N5) • SASEC-3 Rangpur-Banglabandha (N5) (Length= 172 km) -And- Rangpur-Teesta-Burimari (N506, 509) (Length= 138 km)	• Existing 2-lane road widened to 4-lane • 2-lane new bridge will be next to existing bridge	SASEC-1:ADB SASEC-2:ADB SASEC-3:ADB	SASEC-1: under implementation SASEC-2: To be commenced in 2016 SASEC-3: To be commenced in 2018

Source: JICA Survey Team

3.2.4 BBIN MVA (Bangladesh-Bhutan-India-Nepal Motor Vehicle Agreement) Corridor

Bangladesh, Bhutan, India, and Nepal (BBIN) signed a landmark Motor Vehicles Agreement (MVA) on June 15, 2015 for the regulation of Passenger, Personal and Cargo Vehicular Traffic among the four South, Asian neighbors in Thimpu, Bhutan. The MVA agreement between the sub-grouping of four SAARC nations, Bangladesh, Bhutan, India, and Nepal (BBIN) will pave the way for the seamless movement of people and goods across their borders for the benefit and integration of the region and its economic development. This, in turn, would enable the exchange of traffic rights and ease cross-border movement of goods, vehicles, and people, thereby helping expand people-to-people contact, trade, and economic exchanges between our countries. Therefore, this will potentially increase the intraregional trade within South Asia by almost 60 percent and with the rest of the world by over 30 percent. Several distinct features are outlined herein under;

(1) Milestone to BBIN MVA initiatives

The ministers, as country representatives, are eager to accelerate the preparatory steps for the effective and sustainable implementation of the BBIN-MVA, starting with the formulation, negotiation, and finalization of the necessary legal instruments and operating procedures. The milestones of some key points are set according to:

Milestones to key points

- Bilateral /trilateral/quadrilateral agreements/ protocols by July, 2015.
- Negotiation and approval of agreements/ protocols by September, 2015. Any change in draft protocol on Passenger Vehicle by 23 September.
- Trial runs on cross-border cargo vehicle movement between Kolkata and Agartala through Dhaka on 1st November, 2015.
- A pilot run for regular passenger transport on or before 8 October, 2015.
- BBIN car rally on 14 November to 1 December 2015.
- Installation of prerequisites (IT systems, infrastructure, tracking, regulatory systems by December, 2015
- Joint Working Group (JWG) discussed on BBIN rail agreement in a third meeting held in Dhaka on 19-20 January, 2016.
- The next JWG meeting is set to take place in the second half of 2016 in India.

(2) Target vehicles

The Contracting Parties will allow the following vehicles registered in each Contracting Party to ply in territory of other Contracting Parties, subject to the terms of the Agreement:

a. Cargo vehicles (including trucks, trailers etc. that could carry containerized cargo) for inter-country cargo including third country cargo.

b. Passenger vehicles for both hire and reward; or personal vehicles.

Provided further that all regular passenger/cargo transportation will be allowed only through authorized operator(s).

(3) Target Routes

Four routes are being targeted in BBIN countries:

- ROUTE 1: Kolkata-Petrapole/Benapole-Dhaka-Akhaura. → (India-Bangladesh)
- ROUTE 2: Agartala-Akhaura-Chittagong → (India-Bangladesh)
- ROUTE 3: Samdrup Jonkhar-Guwahati-Shillong-Tamabil-Sylhet-Chittagong → (India-Bangladesh-Bhutan)
- ROUTE 4: Katmandu-Kakarvita/Phulbari-Banglabandha-Mongla/Chittagong → (Nepal-India-Bangladesh)

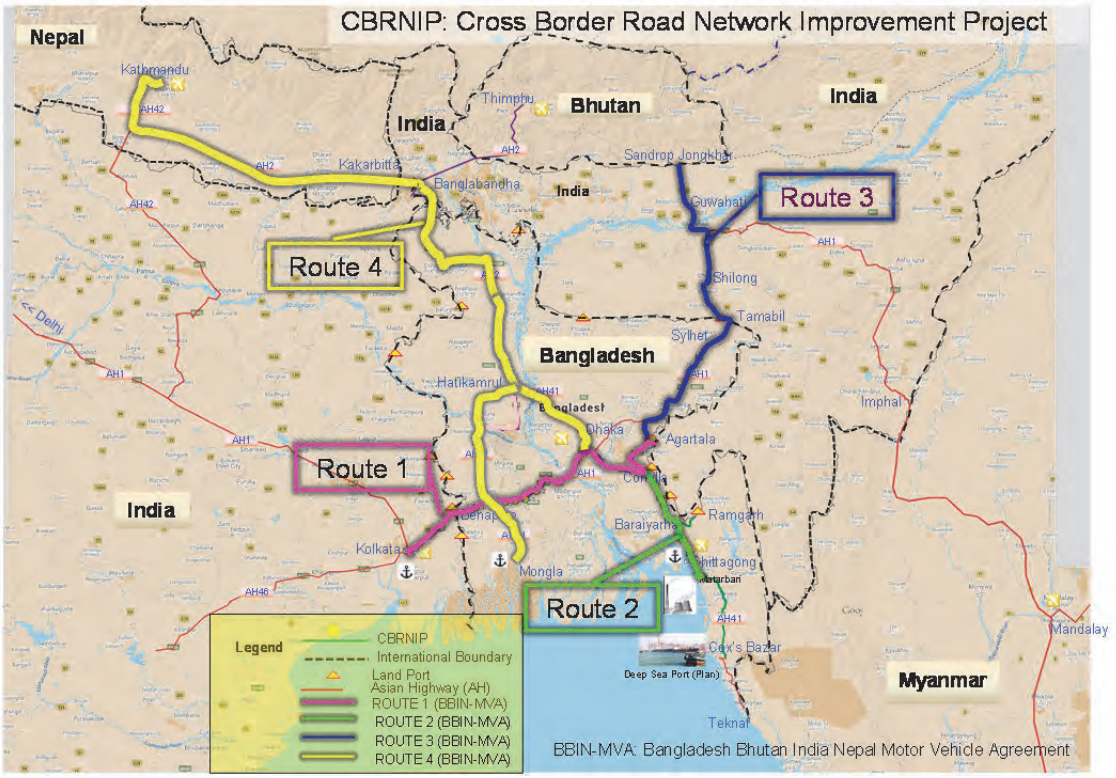


Figure 3.2.3 BBIN-MVA Planned Routes in Sub-regional Countries

The Asian Development Bank (ADB) plays the technical and facilitating role in taking the BBIN MVA initiative and is expected to continue providing much needed technical support and other related arrangements necessary to ensure the effective and efficient implementation of the work plan.

Furthermore, 30 priority transport connectivity projects toward 2020 are indicated for BBIN MVA. The projects have an estimated total cost of over 8 billion US dollars, which will rehabilitate and upgrade the remaining sections of trade and transport corridors in the countries. These corridors and

associated routes were determined based on an analysis of patterns of regional and international trade.

The priority projects for Bangladesh are as follows.

- Completion of Dhaka-Chittagong National Highways (N1, AH41)
- Construction of new four lane Kanchpur, Meghna and Gumti (KMG) Bridges (N1, AH41)
- Construction of the new Padma Bridge and immediate approach roads (N8, AH1)
- 4 laning of roads between Benapole and proposed new Padma Bridge (N706/R750/Z7503/N805/N8/AH1)
- 4 laning of Joydevpur-Elenga-Hatikamrul-Rangpur-Burimari/Banglabandha National Highway (N4,N5)
- 4 laning of Dhaka (Katchpur)-Narsingdi- Sarail-Sylhet-Tamabil National Highway (N2)
- 4 laning of the Baraierhat- Heako- Ramgarh Highway (R151, R152)

GOB formed the “National Land Transport Facilitation Committee” to promote the necessary activities of BBIN MVA. The first meeting of the committee was held on July 7th 2015. To validate the BBIN MVA, the following issues need to be discussed.[3]

- Standard operating procedures
- Vehicle weight, axle load and dimensions
- Road design and construction standards
- Prescribed routes
- Commodity classification system
- Rates of taxes and fees
- Transit (needs to be clarified)

3.2.5 Chittagong Port Access from the North East India (Seven Sister States)

The Seven Sister states also called "Paradise Unexplored" are the contiguous states of Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Na 甘 galand and Tripura in the North East India. These states cover an area of 255,511 square kilometers (98,653 sq. miles), or about seven percent of India's total area. As of 2011, they had a population of 44.98 million, about 3.7 percent of India's total. Although there is great ethnic and religious diversity within the seven states, they bear similarities in the political, social and economic spheres. However, they are far distant from central India and necessitate rapid development, through networking to land-locked Tripura.

[3] Source: Trade Facilitation in South Asia through Transport Connectivity, Center for Policy Dialogue, June 2015

Figure 3.2.4 Eastern Bangladesh Surrounded by the North East India

Source: Tripura News 9th July, 2015 (Layout by Government of India)

Figure 3.2.5 Government of India (GOI) Initiatives to Connect the North East India to Chittagong Port

Transportation via Bangladesh will be much easier because the road connectivity is a major issue for the mountainous north-eastern states. Keeping them in the background, recently the Government of India and the GOB signed a memorandum of understanding promising that Bangladesh would allow the use of Chittagong sea port for the movement of goods to and from India. Accordingly, both governments agreed to create a regional relationship by laying a foundation stone of the Feni River Bridge on June 6, 2015. The construction of 150-meter road bridge over the Feni River will be financed by the Government of India. It will connect the Sabroom border town (135 km south of Agartala) of southern Tripura state in India with Ramgarh town in Bangladesh. After completion, the bridge, located north of the Chittagong international sea port, would provide a significant road link to the North East India and facilitate greater trade and exchanges between the two countries. On the Indian side, the Feni River Bridge will connect to NH44 which is linked to Sabroom-Agartala-Silchar road section and being planned to upgrade to 2-lane under Priority SASEC Road Project by 2015-2020.

In addition, GOB and GOI are discussing the development of Tegamunkh land port. It is expected that the land port will connect Chittagong and Mizoram States. Location of the land port is confirmed, but land acquisition has not been completed. As access road to the land port has not been developed, it is expected that the access road will be developed by the assistance of the World Bank.

3.2.6 BCIM (Bangladesh-China-India-Myanmar) Economic Corridor

The Bangladesh-China-India-Myanmar (BCIM) forum for regional cooperation aims to recapture for the present day citizens the historic dynamism that had once characterized the flows of goods, people and cultures over the famed "Southern Silk Route". Based on several inner-regional discussions and Memorandum of Understanding (MOU), the BCIM road corridor is being planned as the target route following part of AH41:

Kolkata (India) – Jessore (Bangladesh) – Dhaka (Bangladesh) – Chittagong (Bangladesh) – Cox's Bazar (Bangladesh) – Gundum (Bangladesh) – Taungbro(Myanmar) – Bawlibazaar (Myanmar) – Kyauktaw (Myanmar) – Mandalay (Myanmar) – Lashio (Myanmar) – Ruili (China) – Kunming (China).

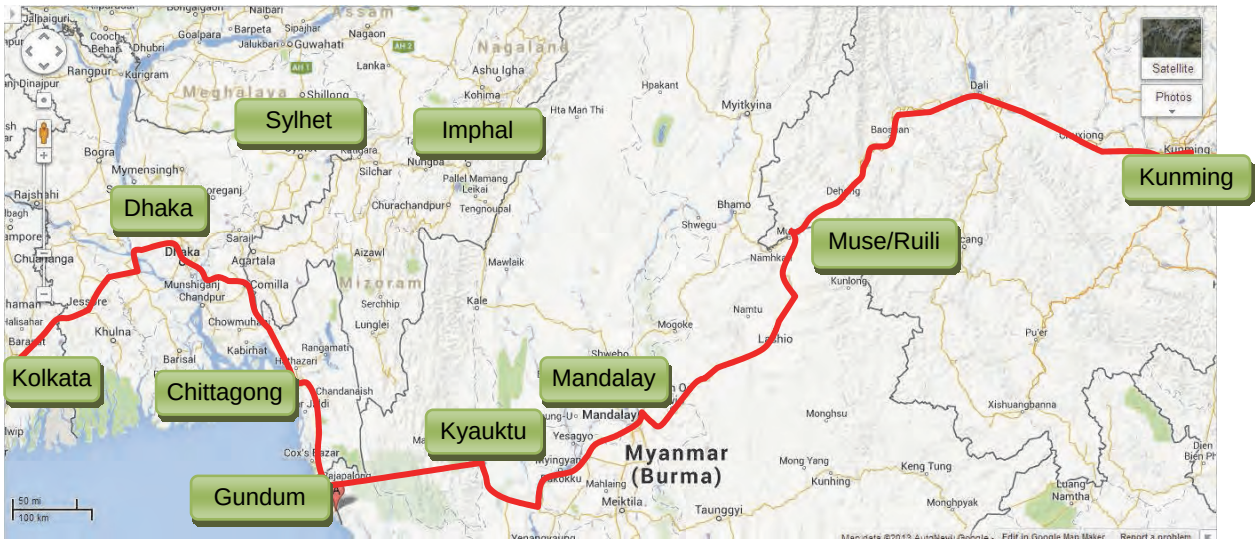


Figure 3.2.6 BCIM Route Map

In Bangladesh this route, which is mostly part of AH41, is fairly well developed. With finance from the Asian Development Bank, the Roads and Highways Department has done the feasibility study and prepared detailed design for upgrading the Chittagong-Cox's Bazar-Ukhia-Balukhali-Gundum stretch. The Memorandum of Understanding (MOU) signed in 2004 and the bilateral agreement signed in 2007 between Bangladesh and Myanmar for a direct road link between the two countries can be reinvigorated in the light of renewed interest of Bangladesh, China, India and Myanmar. The total length of the missing link to be developed to put this alternative route into operation will be less than 140 km, mostly inside Myanmar.

China desires a regional connection from Kunming to a port. BCIM economic corridor can be an effective solution for the desire. China is actively pursuing the realization of the route. Furthermore, Asian Infrastructure Investment Bank (AIIB) will be established this year and Bangladesh, India and Myanmar are prospective funding members of AIIB.

On the other hand, Myanmar is also developing its land transport network. The Department of Public Works (PWD) places a high priority on certain segments of the highway network that link into the regional network, namely, the Asian Highway, ASEAN Highway, GMS Economic Corridor, GMS Highway and Thai-Myanmar-India Tripartite highways. PWD expects that further development of these network segments will accelerate the country's economic growth by encouraging international trade with neighboring counties. Within Myanmar, although the expressway connecting three major growth centers (Yangon, Nay Pyi Taw, and Mandalay) is not included in the segments of the regional road network, the development of the expressway will play an important role in strengthening the Central North – South corridor. The following figure shows road improvement projects in Myanmar proposed in 2010 Brunei Action Plan.

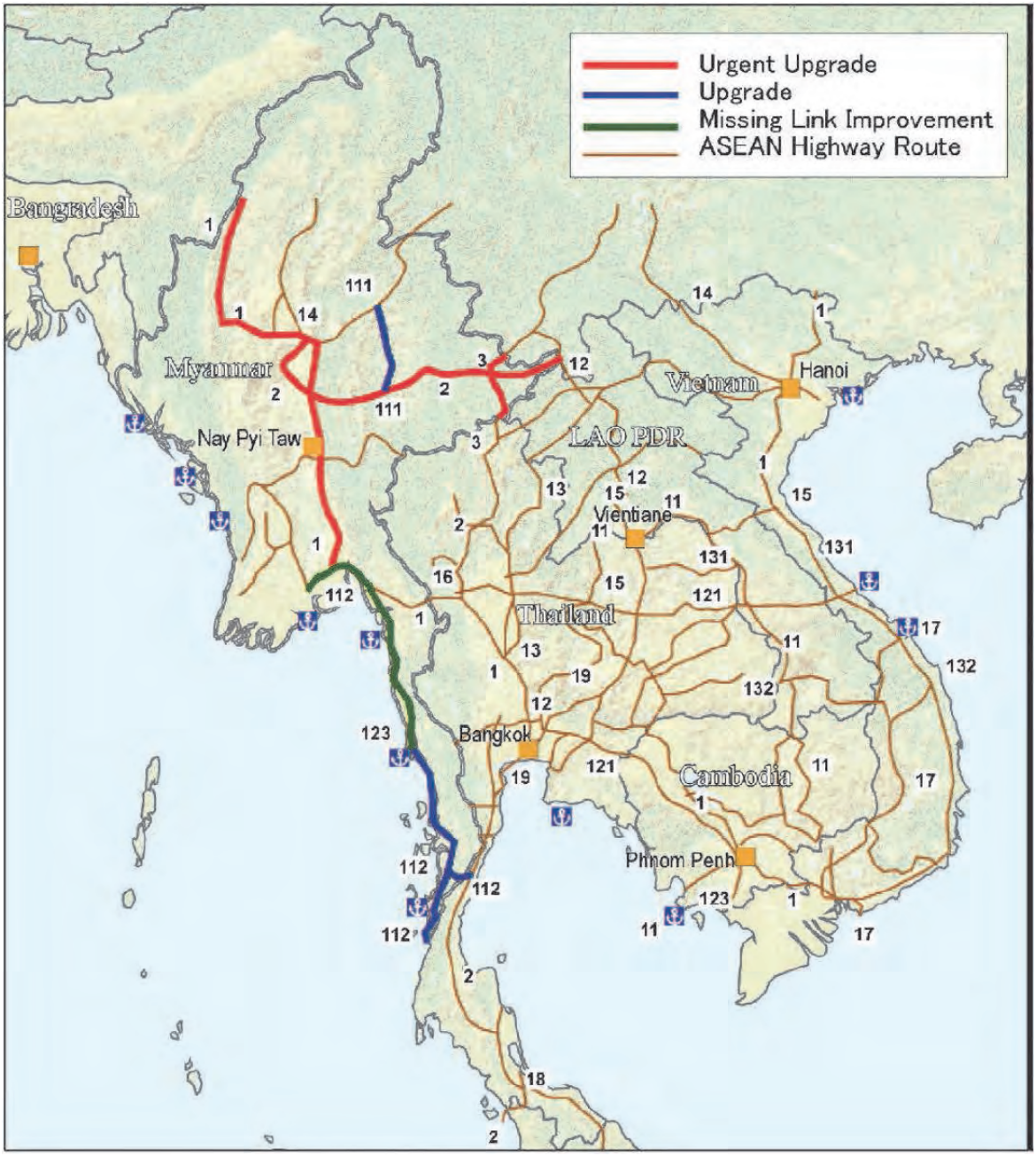


Figure 3.2.7 Road Improvement Projects in Myanmar Proposed in 2010 Brunei Action Plan

3.3 Other Cross-Border Road/Infrastructure Projects

3.3.1 Dhaka-Tamabil Cross Border Road Project

In addition to the Project, GOB has several plans to develop cross border road networks with financial assistance from the Asian Development Bank. Of them, Dhaka-Tamabil National Highway (N2) is an important corridor to India. The Project outlines are summarized and shown in Figure 3.3.1. Major routes will merge with BBIN-MVA corridor, Asian Highways and SASEC corridor.

Figure 3.3.1 Other Cross Border Road Networks/ Infrastructure Development Plans

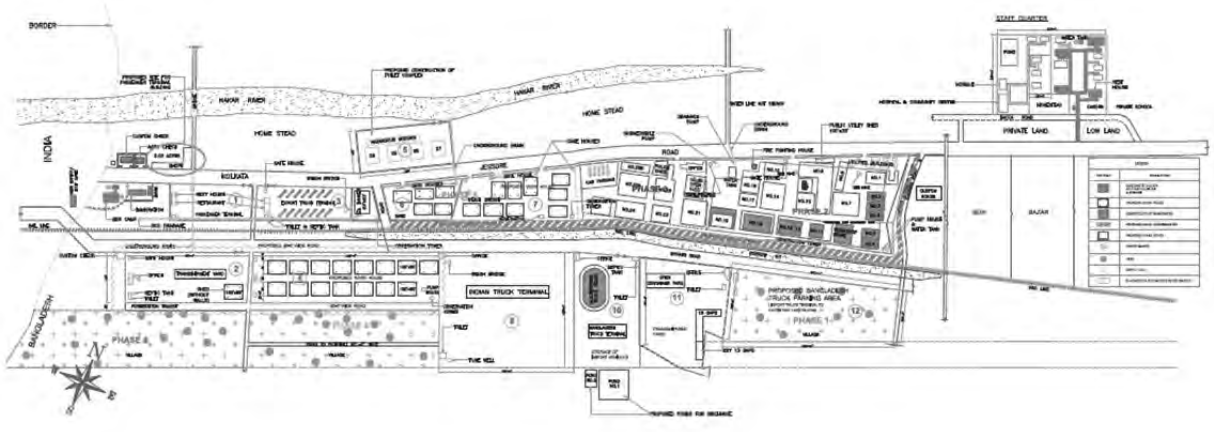
3.3.2 Land Port Facilities

With financial assistance from the Asian Development Bank and World Bank, the land ports at Benapole, Bhomra, Ramgarh and Sherona/Shewla will be facilitated and developed. Of them, land port at Ramgarh and Sherona/Shewla is under planning stage by World Bank (WB), and land port facilitation at Benapole side is under ADB finance. A master Plan of Benapole land port with existing and proposed structure is shown in Figure 3.3.2.

Table 3.3.1 Anticipated Road/Bridge Projects Connecting Target Corridors

Project name	Description	Funding source	Progress/status
Dhaka (Kanchpur)-Narsingdi-Sarail-Sylhet-Tamabil (N2)	Existing 2-lane road widened to 4-lane	ADB-TA	• FS and DD are completed under ADB-TA. • GOB requested ADB for implementation.
Conduct a study for land port facility for Bhomra, Ramgarh, Sherona/Shewla	Cross Border infrastructure development	World Bank	• It is expected that study for Ramgarh will be completed in 6 month. It is expected that operation of Ramgarh will start 3 years later. Finance for the construction has not been confirmed. • A study for the expansion of Bhomra will be conducted. But its details have not been confirmed.
Assistance of land port improvement of Benapole	Cross Border infrastructure development	ADB	• Design and Tender document preparation is complete. • Study for operation improvement will be conducted within 2-3 years • Consultant selection is under processing.
Assistance of land port improvement of Banglanbanda and Burimari	Cross Border infrastructure development	ADB	• Tender for Burimari will be completed in August 2015.

Source: JICA Survey Team



Source: Bangladesh port and efficiency improvement (2011), ADB-TA

Figure 3.3.2 Master Plan of Benapole Land Port with Existing and Proposed Structure

3.3.3 Axle Load Control Plan

Overloading vehicle will cause premature damage in deck slab and wearing surface first and then the damage will spread gradually over the entire bridge section, which is commonly observed in Bangladesh. Some observations are listed in Figure 3.3.3. To control the overloading, GOB is planning to improve the axle load scale system applicable in Bangladesh.

		
Crack in Hawai Khali Bridge (Section A)	Damaged road (Section B)	Damage in Mathamuhuri Bridge (Section C)

Figure 3.3.3 Photographs of Damaged Bridges and Roads

Figure 3.3.4 Existing Weighbridge Station at Benapole to Control Overloaded Truck

Although there is a weighbridge at Benapole on AH1 as shown in Figure 3.3.4, it cannot produce a significant effect due to the BRTA regulation based on axle load scale. Therefore, axle load scales shall be installed considering appropriate locations and systems in order to prevent the passing of overloaded vehicles. Their installation and system are studied in consideration of the currently operating and future plan for axle load control in Bangladesh. In addition, new two axle load stations are proposed at Benapole and Ramgarh, which are schematically shown in Figure 3.3.5.

Source: JICA Survey Team

Figure 3.3.5 Locations of Axle Load Scales under Operation, Construction and Proposal

3.4 On-going Projects Connecting to Target Project Sections

(1) Upgrading Benapole-Bhanga Road (AH1)

Asian Highway Project (Benapole –Bhanga section)

Length: 135 km

This is additional scope planned under SRTPPF. The main objective is to upgrade the 2-lane road to 4-lane. A Feasibility Study and Detailed Design will be conducted from 2016 under ADB-TA grant.

(2) Padma Multi-purpose Bridge Project

Another big budget project "Construction of Padma multi-purpose bridge project" is now under implementation. In the Feasibility Stage from 2003 to 2005, JICA assisted in carrying out survey works. The project has been in the construction stage with GOB's own resource fund since November 2014. The construction is planned to complete by 2018.

Length: 6.15 km

Bridge type: Truss type with double deck Road cum Rail Bridge

4-lane highway on the upper deck and single line broad gauge railway on the lower deck

Contract period: 4 year (construction) + 1year (DLP)

Contractor: China Major Bridge Engineering Corporation, China

(3) Upgrading Bhanga-Dhaka Road (AH1)

Asian Highway Project (Bhanga-Mawa-Jatrabari section with a link to Babu Bazar (Dhaka)

Length: 54 km

The main objective is to upgrade the 2-lane road to 4-lane. It is programmed for the development in line with the construction of the Padma Bridge. GOB has already taken as initiatives from its own resources.

(4) 8-laning of Jatrabari-Kanchpur Road (Polder Road)

The main objective of the project is to widen the Jatrabari-Kanchpur portion of N1 to 8-lanes for minimizing traffic congestion and to establish better road communication.

Length: 9 km

Funding source: GOB

The Project was commenced in January 2011, and was scheduled to be completed in the beginning of June 2013. But, the current progress is slow due to fund crisis and selection of contractor not processed timely. Embankment filling and resettlement are executed to some extent in some sections.

(5) Construction of 2nd Kanchpur, 2nd Meghna and 2nd Gumti Bridges

The main objective of the project is to construct three 2nd bridges so as to cope with the increasing traffic demand on N1.

Bridge length: 2nd Kanchpur 397.3 m, 2nd Meghna 930m, 2nd Gumti 1,410m

Bridge lane: 4-lane 2nd bridge next to the existing bridge.

Funding source: JICA-ODA

The contractor procurement is under processing and the commencement of civil work is scheduled at the end of 2015.

(6) 4-laning of Dhaka-Chittagong Highway

Highway Project (Daudkandi -Chittagong Section)

Road length: 198 km

Funding source: GOB, JDCF (Japan Debt Cancellation Fund)

The 4-laning highway project of N1 (Daudkandi-Chittagong) is a high priority for RHD. Under the project, a new 2-lane carriageway is planned to be constructed along the existing 2-lanes to make it into a 4-lane highway in order to reduce the existing traffic congestion and to increase the road transport efficiency. The project road starts from Daudkandi, 28 km from Dhaka, and ends 226 km away at Chittagong. The construction of the project was started in 2006 and is scheduled to be completed by 2016. The project has been divided into 10 packages / contracts, and the present progress is around 62%.

(7) Dhaka – Chittagong Expressway (PPP) Project

Funding source: ADB-TA loan for F/S and DD. Implementation by PPP basis

N1 is considered to be the most important highway and lifeline of commerce in Bangladesh. Considering the above facts, the Government of Bangladesh has committed to a program for the Feasibility Studies and Detailed Design for a new access controlled expressway with 4-lanes between Dhaka and Chittagong planned as aa PPP. In 2006, a Feasibility Study and Conceptual Design of the project was conducted, however, the new detailed study and design are now being conducting under an ADB-TA loan.

(8) 4-laning of Chittagong-Teknaf Road

Project name: Sub-regional Transport Project Preparatory Facility, SRTPPF (Chittagong-Cox's Bazar-Teknaf section, Road Package-2)

Road length: 225 km

Funding source: FS/DD by ADB-TA and funding for implementation not yet decided

Existing 2-lane carriageway including existing bridges is planned to be widened to a 4-lane highway in order to reduce the existing traffic congestion and to increase the road transport efficiency. Feasibility Study and Detailed Design has already been completed.

Table 3.4.1 Anticipated Road/Bridge Projects Connecting Target Corridors

Project name	Nature of the project	Funding source	Target year of completion	Progress/status
4-laning of Dhaka-Chittagong National Highway Project	N1 widening into 4-lane	GOB-JDCF	June, 2016	Working progress: 62.2%
The Kanchpur, Meghna and Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation Project	4-lane 2nd bridge construction on N1	JICA	October, 2018	Under the procurement of Contractor
Padma Multipurpose Bridge Project	4-lane new bridge construction	GOB	2018	Construction started from Nov. 2014
Detail Study and Design of Dhaka-Chittagong Expressway on Public-Private Partnership Basis	4-lane tolled access	ADB-TA	PPP basis	Detailed Design by Oct. 2016
Benapole-Dhaka Road on AH1 3 sections i) Benapole-Jessore ii) Jessore-Narail-Bhanga iii) Bhanga-Charjanajat-Mawa-Jatrabari	To be upgraded to 4-lane	- Section i) and ii) are under ADB-TA - Section iii) is under GOB fund	-	- FS and DD will be conducted under ADB-TA - Currently under implementation by GOB fund.
Feasibility Study and Detailed Design of Roads and Bridges under SRTPPF (Road-Package-2)	N1 widening into 4-lane in the section of Chtg.-Cox's Bazar-Teknaf	ADB-TA	Funding for implementation not decided	Detailed design completed in 2015

Source: JICA Survey Team

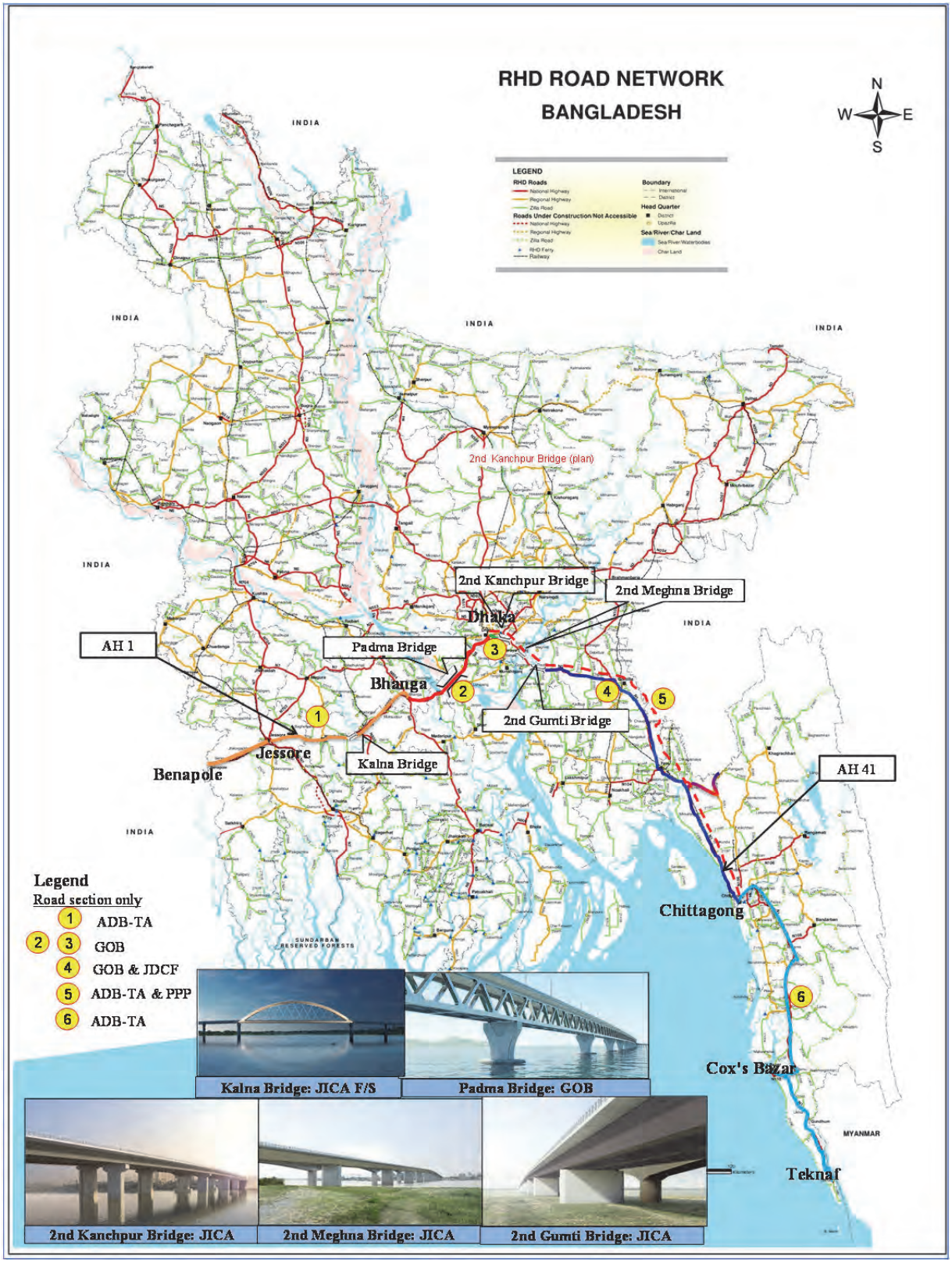


Figure 3.4.1 Relevant Projects Planned along AH1 and AH41

3.5 Necessity of the Cross Border Project

Bangladesh and India are two neighboring countries, and historically and culturally these two nations have been considerably close to each other. The historic land boundary agreement was signed in June 6, 2015 which opened a new era in the relations. Ending a prolonged dispute, the two nations swapped 162 enclaves on the border region, allowing the people living there to stay or opt out to the other country. Of which, Bangladesh citizen residing in 51 enclaves on the Indian side became Indians, and Indian citizen living in 111 enclaves in Bangladesh side preferred to stay with Bangladesh. During his visit to Bangladesh, 22 agreements were signed by two sides, including the opening of foundation stone of a bridge over Feni River which is flowing through between two countries. These stated agreements along with BBIN initiatives will make a tie and good relation between two countries. Their relations will be strengthened though implementation of this Project.

The implementation of the Project is also important and necessary from the following points of view.

3.5.1 Conformity with Higher 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) and Seventh Five Year Plan (7FYP)

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.

In 7FYP, RHD objectives necessary to achieve the road sector vision are:

- To build sustainable, safe & quality road infrastructure and integrated modern mass transport system which can play a unique role to achieve the targets set for Vision 2021.

Addressing to the above objectives set by RHD, it is very important to provide a sustainable, safe & quality road networks including sub-regional and international corridors.

As is mentioned earlier, there is one missing link at Kalna, many temporary bridges and narrow vulnerable bridges under Section B, aged and damaged bridges under Section A and C. Therefore, the Project implementation will contribute to build up safe and quality road infrastructures so as to achieve the road sector's vision timely.

(3) National Land Transport Policy, NLTP (2004)

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

Some bridges on national roads as well as highways 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) National Integrated Multimodal Transport Policy (NIMTP-2013)

NIMTP's objectives which are dealt with in regards to its road infrastructure development are set to:

- Improve road safety
- Take advantage of Bangladesh's geographical position to trade in transport services
- Improve integration of the overall transport network
- Reduce cost of transporting goods
- Use transport as means to assist poverty reduction

Objectives of the Project are fully consistent with NIMTP's objectives. This is because the Project implementation will contribute to improve road safety by widening the existing structures, to reduce transport cost by shortening the travel time, to improve integration of the overall transport network by eliminating missing link and to increase transit freight traffic through Bangladesh's geographical position; which ultimately will take role in reducing the nation's poverty.

(5) Road Master Plan, RMP (2009-2029)

The 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:

- Eliminate missing link in any section
- 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 are consistent with the policy of Road Master Plan . This is because road network will be improved through the construction/reconstruction/replacement of several bridges under this Project. In particular, Kalna Bridge construction will eliminate missing link on N806, Jhikorgacha Bridge on National Highway (N706), Hawai Khali Bridge on Zilla Road (Z7503) will be replaced and widened to 4-lane new bridge. Two temporary bailey bridges (R151_16a and R151_16c) and another six narrow and damaged bridges on Regional Highway under Section B are

planned to replace by permanent structure. Four damaged bridges having small and medium size in length under Section C are in poor condition and will be replaced and widened to 4-lane new bridge.

3.5.2 Urgency in Improving the Project Sections

The urgency in improving the Project three Sections are described hereunder considering existing road network conditions, international corridor development plan and plan for industrial development as well.

The Section A (Benapole-Dhaka) of the Project will be missing link after opening of Padma Bridge due to traffic crossing the river by Ferry at Kalna. Moreover, the route between Jesssore-Narail-Lohagara is currently Regional Highway and Zilla Road standard and not up to the level of Asian Highway. Therefore this section will not be able to accommodate international traffics when BBIN will be under operation.

The Section B (Baraiyarhat-Heyako-Ramgarh) which is a part of BBIN is now Regional Highway standard and very narrow in some sections including several temporary Bailey as well as damaged bridges. Therefore, this section will not also be able to cope with international traffics from India when BBIN will be under operation.

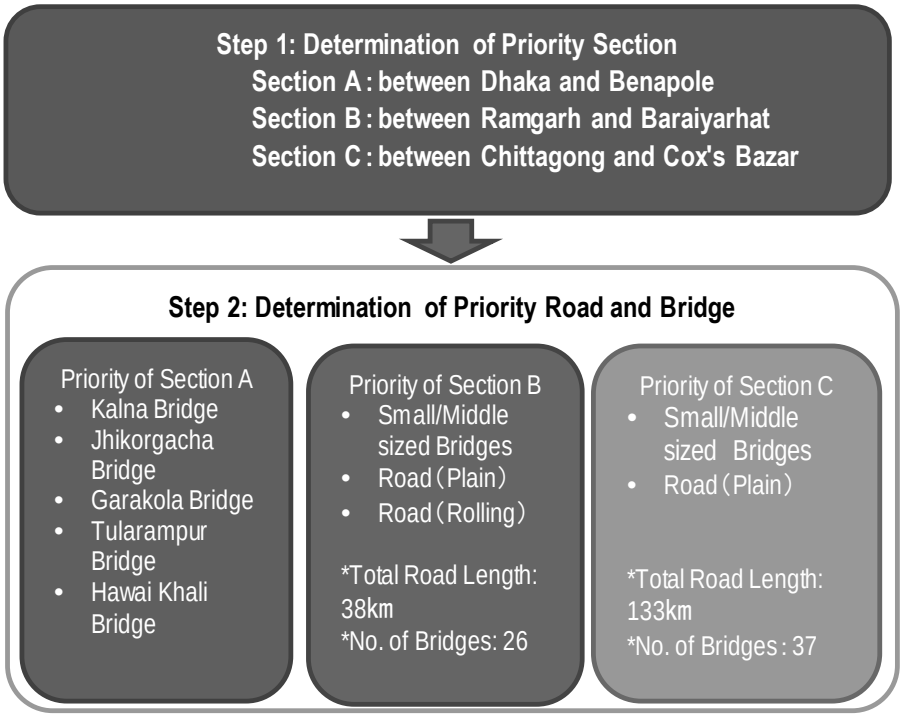
The Section C (Chittagong-Cox's Bazar) is currently 2-lane highway including several bridges, and is planned to upgrade into 4-lane AH41. This section is also a part of BCIM and planned to build industrial hubs surroundings. Therefore, this section will not also be able to cope with high traffic volume to be generated from industrial development and when BCIM will be in execution.

In accordance with the development plans stated above, the improvement of Project Sections would be necessarily executed timely and in a priotized manner so that it can eliminate any bottlenecks appraised for cross border traffic movement.

4. PRIORITIZATION OF PROJECTS

4.1 Methodology

To determine project policy, the following method in two steps is applied as shown in Figure 4.1.1.



Source: JICA Survey Team

Figure 4.1.1 Prioritization Method and Project Candidates

4.2 Present Conditions of Target Project Sections

4.2.1 Section A (between Dhaka and Benapole)

(1) Roads

Section A has not been improved as an Asian Highway yet. Pavement widths are narrower than 7.3 m excluding the Garakola Bridge Sub-section, especially; Tularampur Bridge Sub-section located on Regional Road R750 is a narrow 2-lane road with 5.5 m of pavement width.

Table 4.2.1 Pavement Widths around each Bridge under Section A

Zone	Division	Road No.	Structure Name	Chainage (km)	Approach Road Width (m)
Gopalganj	Gopalganj	N-805	Garakola Bridge	24.19	10.2
Gopalganj	Gopalganj	N-806	Kalna Ferry	-	6.8
Khulna	Narail	Z-7503	Hawai khali Bridge	5.213	7.0
Khulna	Narail	R-750	Tularampur Bridge	24.18	5.5
Khulna	Jessore	N-706	Jhikorgacha Bridge	14.349	6.7

Source: JICA Survey Team

Regarding surface conditions, Tularampur Bridge Sub-section needs a new overlay because IRI is from 5.5 to 9.0. However, other sub-sections are kept in good or better conditions. Table 4.2.2 shows road surface conditions under Section A (sub-section is 2 km before/after the project bridge).

Table 4.2.2 Road Surface Conditions under Section A

Zone	Division	Road No	Road Name	Chainage	Road Class	Length (km)	Damages and Work Items	AADT
Garakola Bridge (KM 24.19)								
Gopalganj	Gopalganj	N805	Bhanga-Mollahhat Road	Km 022.00 - 027.00	National	5.00	Non	2,650
Ferry Crossing at Kalna (KM 3.00)								
Gopalganj	Gopalganj	N806	Bhatiapara-Kalna Road	Km 001.00 - 006.00	National	5.00	Non	2,860
Hawaii Khali Bridge (KM 5.21)								
Khulna	Narail	Z7503	Narail-Naragati Road	Km 003.00 - 008.00	Zilla	5.00	Non	1,205
Tularampur Bridge (KM 24.18)								
Khulna	Narail	R750	Jessore-Narail Road	Km 023.32 - 023.72	Regional	0.40	Overlay 60mm @ IRI 5.5-9	5,170
				Km 024.02 - 024.72	Regional	0.70	Overlay 60mm @ IRI 5.5-9	5,170
Total						1.10	Overlay	
Jhikorgacha Bridge (KM 14.35)								
Khulna	Jossore	N706	Jessore -Benapole Road	Km 012.00 - 017.00	National	5.00	Non	3,292

Source: JICA Survey Team

(2) Bridges and Ferry Crossing

As previously mentioned, Section A is between Dhaka and Benapole in Asian Highway 1 (AH1). The priority of Section A is the highest among the three sections, thus, four bridges and river crossing at Kalna shall be improved from the viewpoint of route importance and bottle neck.

The information of four bridges and river crossing at Kalna under Section A is shown in Table 4.2.3.

Table 4.2.3 List of the Existing Bridges under Section A

No. *( ):WBBIP Serial No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
A1 (I)	N706_14b	Khulna	Jessore	N-706	Jhikorgacha Bridge	14.349	RC Girder	118.67	7.3 (5.5)	1968	C	Shopping Area			
A2 (V)	R750_25a	Khulna	Narail	R-750	Tularampur Bridge	24.18	RC Girder	91.5	8.23 (6.8)	1964	D	Some Residences			
A3 (VI)	Z7503_5a	Khulna	Narail	Z-7503	Hawai khali Bridge	5.213	RC Girder	26.1	7.9 (7.3)	1976	C	Some Residences			
A4 (-)	-	Gopalganj / Khulna	Gopalganj / Narail	N-806	-	-	-	River Width 350	-	-	-	-			
A5 (IV)	N805_24a	Gopalganj	Gopalganj	N-805	Garakola Bridge	24.19	PC Girder	105.05	10 (7.5)	2004	C	Some Residences			

Source: JICA Survey Team

4.2.2 Section B (between Ramgarh and Baraiyarhat)

(1) Roads

Pavement widths under Section B are around 5.5 m and barely 2-lane roads. However, some sub-sections have less than 5.0 m of pavement width, and it is difficult for vehicles to pass each other. Section B won't perform the function as an international road.

Table 4.2.4 Pavement Widths around each Bridge under Section B

Zone	Division	Road No.	Structure Name	Chainage (km)	Approach Road Width (m)
Chittagong	Chittagong	R-151	Purbo Hinguli Bridge	3.121	6.0
Chittagong	Chittagong	R-151	Telipool Bridge	3.712	5.5
Chittagong	Chittagong	R-151	Lakshmi chara Bridge	4.013	5.2
Chittagong	Chittagong	R-151	Tulatuli Lohar Bridge	10.225	5.4
Chittagong	Chittagong	R-151	tulatuli Bridge	10.42	4.0
Chittagong	Chittagong	R-151	Buro Camp Bridge	10.823	5.5
Chittagong	Chittagong	R-151	Bangra Tabor Bridge	11.171	5.4
Chittagong	Chittagong	R-151	Kalapani Bridge-1	11.761	4.4
Chittagong	Chittagong	R-151	Kalapani Bridge-2	12.987	5.7
Chittagong	Chittagong	R-151	Niharkanti Das Bridge	13.73	5.2
Chittagong	Chittagong	R-151	Koilapara Bridge	14.116	4.9
Chittagong	Chittagong	R-151	Koilabazar Bridge	14.886	6.0
Chittagong	Chittagong	R-151	Balutila Bridge	15.645	5.2
Chittagong	Chittagong	R-151	Fulchari Bridge	16.806	4.3
Chittagong	Chittagong	R-151	Heaku Bazar B ridge	20.149	4.9
Chittagong	Chittagong	R-152	Heako Bridge	0.131	5.7
Chittagong	Chittagong	R-152	Amtali Bridge	3.169	4.9
Chittagong	Chittagong	R-152	Chikon Chara Bridge	7.207	5.7
Chittagong	Chittagong	R-152	Chikon Chara Bridge	7.751	5.2
Chittagong	Chittagong	R-152	Banglabazar bridge	8.426	5.5
Chittagong	Chittagong	R-152	Borobil Bridge	10.014	5.3
Chittagong	Chittagong	R-152	Borobil Bridge	10.419	5.1
Chittagong	Chittagong	R-152	Gadar dokan Bridge	11.42	5.4
Chittagong	Chittagong	R-152	Bagan Bazar Bridge	12.709	5.6
Chittagong	Chittagong	R-152	East baganbazar Bridge	13.669	5.4
Chittagong	Chittagong	R-152	Sonaipool Bridge	14.855	5.5

Source: JICA Survey Team

Regarding surface conditions, approximately 22 km which is more than half of the 38 km in the whole stretch, is requires some repair/rehabilitation and Section B is becoming worse. Especially, the section from Km 0 to Km 4.5 needs heavy rehabilitation because the pavement surface is pealing in some parts. Table 4.2.5 shows road surface conditions under Section B.

Table 4.2.5 Road Surface Conditions under Section B

Zone	Division	Road No	Road Name	Chainage	Road Class	Length (km)	Damages and Work Items
Chittagong	Chittagong	R151	Baraiyerhat-Fatikchhari Road	Km 000.30 - 003.50	Regional	3.20	Rehab 150mm @ IRI 9-12
				Km 003.50 - 004.50	Regional	1.00	Rehab 150mm @ IRI 9-12
				Km 005.10 - 011.10	Regional	6.00	Overlay 50mm @ IRI 7-9
				Km 011.10 - 011.70	Regional	0.60	DBST 25mm Traff All
				Km 015.30 - 015.60	Regional	0.30	Overlay 50mm @ IRI 7-9
				Km 015.60 - 016.00	Regional	0.40	Overlay 50mm @ IRI 5-7
				Km 016.00 - 016.20	Regional	0.20	Overlay 50mm @ IRI 7-9
				Km 016.20 - 017.00	Regional	0.80	Overlay 50mm @ IRI 7-9
				Km 017.00 - 018.00	Regional	1.00	Overlay 50mm @ IRI 7-9
				Km 018.00 - 020.50	Regional	2.50	Overlay 50mm @ IRI 5-7
		R152	Heako-Ramgarh Road	Km 002.30 - 005.30	Regional	3.00	Overlay 50mm @ IRI 7-9
				Km 008.40 - 010.40	Regional	2.00	DBST 25mm Traff All
				Km 010.50 - 010.70	Regional	0.20	DBST 25mm Traff All
				Km 013.70 - 014.80	Regional	1.10	Overlay 50mm @ IRI 7-9
				Km 017.50 - 017.53	Regional	0.03	DBST 25mm @ 25% Crk
Total						2.83	Repair
						15.30	Overlay
						4.20	Rehabilitation
						22.33	Ground Total

Source: JICA Survey Team

(2) Bridges

There are 26 bridges under Section B, and the length of the section is 38km. Its anterior section, i.e. between Baraiyarhat and Heyako passes through a hilly area, and its posterior section, i.e. between Heyako and Ramgarh passes through a rolling area.

The information of existing bridges under Section B is shown in the following table.

Table 4.2.6 List of the Existing Bridges under Section B

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
B1	R-151_3a	Chittagong	Chittagong	R-151	Purbo Hinguli Bridge	3.121	PC Girder	18.5	7.83 (6.7)	1978	B	One Residence			
B2	R-151_4a	Chittagong	Chittagong	R-151	Telipool Bridge	3.712	Steel Beam & RC Slab	15.24	4.18 (3.4)	1965	D	No Residence			
B3	R-151_4c	Chittagong	Chittagong	R-151	Lakshmi Chara Bridge	4.013	Steel Beam & RC Slab	15.42	4.21 (3.6)	1965	C	Three Shops			
B4	R-151_11a	Chittagong	Chittagong	R-151	Tulatuli Lohar Bridge	10.225	Bailey with Steel Deck	24.45	5.03 (3.8)	1986	D	Hilly Area			
B5	R-151_11c	Chittagong	Chittagong	R-151	Tulatuli Bridge	10.42	PC Girder	24.3	7.15 (6.65)	1986	C	Hilly Area			
B6	R-151_12a	Chittagong	Chittagong	R-151	Buro Camp Bridge	10.823	PC Girder	24.2	7.2 (6.7)	2006	B	Hilly Area			
B7	R-151_12c	Chittagong	Chittagong	R-151	Bangra Tabor Bridge	11.171	PC Girder	24.32	7.18 (6.7)	2006	C	Hilly Area			
B8	R-151_12e	Chittagong	Chittagong	R-151	Kalapani Bridge-1	11.761	PC Girder	24.4	7.18 (6.7)	1993	C	Hilly Area			

Source: JICA Survey Team

Table 4.2.7 List of the Existing Bridges under Section B

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ): Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
B9	R-151_14a	Chittagong	Chittagong	R-151	Kalapani Bridge-2	12.987	RC Girder	24.82	4.07 (3.7)	1978	D	No Residence			
B10	R-151_14c	Chittagong	Chittagong	R-151	Niharkanti Das Bridge	13.73	RC Girder	42	8.63 (6.8)	1980	B	No Residence			
B11	R-151_15a	Chittagong	Chittagong	R-151	Koilapara Bridge	14.116	PC Girder	24.4	7.1 (6.7)	1980	C	Hilly Area			
B12	R-151_16a	Chittagong	Chittagong	R-151	Koilabazar Bridge	14.886	Bailey with Steel Deck	36.8	4.85 (3.3)	1994	A	No Residence			
B13	R-151_16o	Chittagong	Chittagong	R-151	Balutila Bridge	15.645	Bailey with Steel Deck	21.35	4.03 (3.2)	1991	C	No Residence			
B14	R-151_18a	Chittagong	Chittagong	R-151	Fulchari Bridge	16.806	Bailey with Steel Deck	15.3	4.12 (3.4)	1995	C	No Residence			
B15	R-151_22a	Chittagong	Chittagong	R-151	Heaku Bazar Bridge	20.149	RC Girder	12.5	4.08 (3.7)	1984	C	No Residence			
B16	R-152_5a	Chittagong	Chittagong	R-152	Heako Bridge	0.131	RC Girder	12.4	4.06 (3.7)	1965	C	No Residence			
B17	R-152_3a	Chittagong	Chittagong	R-152	Anitali Bridge	3.169	RC Girder	19.81	7.22 (6.7)	1985	B	No Residence			

Source: JICA Survey Team

Table 4.2.8 List of the Existing Bridges under Section B

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
B18	R-152_7a	Chittagong	Chittagong	R-152	Chikon Chara Bridge	7.207	RC Girder	24.23	7.3 (6.7)	1986	C	No Residence			
B19	R-152_8a	Chittagong	Chittagong	R-152	Chikon Chara Bridge	7.751	RC Girder	12.54	4.24 (3.5)	1965	D	No Residence			
B20	R-152_8c	Chittagong	Chittagong	R-152	Banglabazar Bridge	8.426	RC Girder	12.66	4.31 (3.5)	1965	D	No Residence			
B21	R-152_10a	Chittagong	Chittagong	R-152	Borobil Bridge	10.014	PC Girder	30.6	7.16 (6.7)	1986	B	No Residence			
B22	R-152_10c	Chittagong	Chittagong	R-152	Borobil Bridge	10.419	Steel Beam & RC Slab	15.23	4.13 (3.7)	1978	C	No Residence			
B23	R-152_11b	Chittagong	Chittagong	R-152	Gadar dokan Bridge	11.42	RC Girder	13.23	4.2 (3.5)	1978	D	No Residence			
B24	R-152_13a	Chittagong	Chittagong	R-152	Bagan Bazar Bridge	12.709	Bailey with Steel Deck	18.37	4.15 (3.2)	1996	C	Residential Area			
B25	R-152_14a	Chittagong	Chittagong	R-152	East bagambazar Bridge	13.669	Steel Beam & RC Slab	36.8	4.2 (3.7)	1965	C	No Residence			
B26	R-152_15a	Chittagong	Chittagong	R-152	Sonaipool Bridge	14.855	Steel Beam & RC Slab	36.94	4.13 (3.7)	1965	C	Residential Area			

Source: JICA Survey Team

4.2.3 Section C (between Chittagong and Cox's Bazar)

(1) Roads

Pavement widths before/after bridges in Section C are more than 6.2 m excluding Kanchon Nagar Bridge section at Km 273. However, the 4-lane road length is only a couple of kilometers including 2 bridge sections and the number of bridge sections with more than 7.3 m of pavement width is only 8. Pavement widths in Section C are too narrow to be a part of the Asian Highway.

Table 4.2.9 Pavement Widths around each Bridge under Section C

Zone	Division	Road No.	Structure Name	Chainage (km)	Approach Road Width (m)
Chittagong	Chittagong	N-1	Bakulia Bridge	242.898	6.0
Chittagong	Chittagong	N-1	5 No hafez bazar Bridge	244.367	7.2
Chittagong	Chittagong	N-1	Tulatuli Bridge	244.856	7.4
Chittagong	Chittagong	N-1	Rajakhali Bridge	244.975	7.4
Chittagong	Chittagong	N-1	Sha Amanot Bridge	246.02	> 15.0
Chittagong	Dohazari	N-1	Shikalbaha Bridge	247.637	> 15.0
Chittagong	Dohazari	N-1	Sikolbaha Bridge-1	251.538	6.6
Chittagong	Dohazari	N-1	Patiya Bridge	262.116	8.2
Chittagong	Dohazari	N-1	Srimi Bridge	265.483	8.7
Chittagong	Dohazari	N-1	Korna Bridge	268.954	8.8
Chittagong	Dohazari	N-1	Kanchon Nagar Bridge	273.008	5.6
Chittagong	Dohazari	N-1	Mazar Point Bridge	275.943	6.1
Chittagong	Dohazari	N-1	Sangu Bridge	282.994	9.5
Chittagong	Dohazari	N-1	Pathanerpul Bridge	286.378	6.3
Chittagong	Dohazari	N-1	Noyakhalar Muk Bridge	286.631	6.4
Chittagong	Dohazari	N-1	Raj Ghata Bridge	294.534	6.6
Chittagong	Dohazari	N-1	Khoria Nagar Bridge	295.295	6.6
Chittagong	Dohazari	N-1	Amirabad Bridge	299.434	6.7
Chittagong	Dohazari	N-1	Khasmahal Bridge	304.217	6.9
Chittagong	Dohazari	N-1	Adunagar Bridge	304.857	6.5
Chittagong	Dohazari	N-1	Hatirpul Bridge	305.527	6.8
Chittagong	Dohazari	N-1	Rataykul Bridge	308.652	6.6
Chittagong	Dohazari	N-1	Santi Bridge	309.971	6.6
Chittagong	Cox's Bazar	N-1	Harbang Chora Bridge	320.513	6.8
Chittagong	Cox's Bazar	N-1	Bodoitola Bridge	324.607	6.7
Chittagong	Cox's Bazar	N-1	Mathamuhuri Bridge	331.259	6.7
Chittagong	Cox's Bazar	N-1	Pasiyakali Bridge	336.237	6.7
Chittagong	Cox's Bazar	N-1	Polia Fari Bridge	342.77	6.9
Chittagong	Cox's Bazar	N-1	Dulahajar Bridge	344.531	9.0
Chittagong	Cox's Bazar	N-1	Boyragir Khil Bridge	345.592	6.8
Chittagong	Cox's Bazar	N-1	Khutakhali Bazar Bridge	349.759	6.7
Chittagong	Cox's Bazar	N-1	Eidgaon Bazar Bridge	357.264	6.7
Chittagong	Cox's Bazar	N-1	Goro Bazar Bridge	358.03	6.6
Chittagong	Cox's Bazar	N-1	Joarianala Bazar Bridge	368.129	6.9
Chittagong	Cox's Bazar	N-1	Mitacmari Ramu Bridge	371.848	6.9
Chittagong	Cox's Bazar	N-1	Sarkarpara Bridge	378.492	6.8
Chittagong	Cox's Bazar	N-1	Bakkhali Bridge	380.346	6.9

Source: JICA Survey Team

Regarding surface conditions, approximately 6 km, which is less than 5 % of the 144 km in the whole stretch, requires some repair/rehabilitation only and pavement surfaces are kept in good or better conditions in general because of the large scale of rehabilitation that had been conducted in 2012. The sections that needed some rehabilitation works are located near Chittagong. Among those sections, a 1.24 km section in Chittagong Division will be improved by the on-going project.

Table 4.2.10 Road Surface Conditions under Section C

Zone	Division	Road No	Road Name	Chainage	Road Class	Length (km)	Damages and Work Items
Chittagong	Chittagong	N1	Dhaka - Chittagong - Teknaf Road	Km 244.93 - 246.17	National	1.24	Full Recon 195mm @ IRI 12
	Dohazari	N1	Dhaka - Chittagong - Teknaf Road	Km 246.17 - 249.54	National	3.37	Overlay 80mm @ IRI 4-9
				Km 249.54 - 250.54		1.00	Full Recon 195mm @ IRI 12
Total						3.37	Overlay
						2.24	Full Reconstruction
						5.61	Ground Total

Source: JICA Survey Team

(2) Bridges

There are 37 bridges in Section C, and the length of the section is 133km. Detailed Design (D/D) for the widening of road and the improvement of bridge is conducted by ADB fund. JICA Survey Team shall consider D/D in order to match between D/D and this Study.

The information of existing bridges under Section C is shown in the following table.

Table 4.2.11 List of the Existing Bridges under Section C

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
C1	N-1_238a	Chittagong	Chittagong	N-1	Bakulia Bridge	242.898	RCC Girder	15.8	8.1 (6.0)	1995	A	Residential Area, however they are set-back			
C2	N-1_239a	Chittagong	Chittagong	N-1	5 No hafez bazar Bridge	244.367	RCC Girder	39.67	8.7 (7.2)	1996	C	Residential Area, however they are set-back			
C3	N-1_240a	Chittagong	Chittagong	N-1	Tulatuli Bridge	244.856	RCC Girder	40.38	9.2 (7.4)	1985	B	Residential Area, however they are set-back			
C4	N-1_240c	Chittagong	Chittagong	N-1	Rajakhali Bridge	244.975	RCC Girder	49.31	9.2 (7.4)	1985	C	Residential Area, however they are set-back			
C5	N-1_241a	Chittagong	Chittagong	N-1	Sha Amanot Bridge	246.02	PC Box Girder	954.5	24.3	2009	A	No Residence			
C6	N-1_242b	Chittagong	Dohazari	N-1	Shikalbaha Bridge	247.637	PC Girder	17.3	31.2	2010	A	No Residence			
C7	N-1_247a	Chittagong	Dohazari	N-1	Sikolbaha Bridge-1	251.538	PC Girder	116.13	9.8 (7.4)	1993	B	Some Shops on the right hand side			
C8	N-1_257a	Chittagong	Dohazari	N-1	Patiya Bridge	262.116	RCC Girder	50.3	8.4 (6.8)	1977	C	Some Shops on the right hand side			

Source: JICA Survey Team

Table 4.2.12 List of the Existing Bridges under Section C

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
C9	N-1_261a	Chittagong	Dohazari	N-1	Srimi Bridge	265.483	PC Girder	61	10.0 (7.5)	1992	B	Patula Baptist on the right hand side			
C10	N-1_264a	Chittagong	Dohazari	N-1	Koma Bridge	268.954	RCC Girder	15.2	7.9 (7.1)	1979	C	There is children's institution on the left side of A2.			
C11	N-1_269a	Chittagong	Dohazari	N-1	Kanchon Nagar Bridge	273.008	Steel Beam & RCC Slab	12.7	6.8 (6.1)	1956	C	Residential Area, however they are set-back			
C12	N-1_272a	Chittagong	Dohazari	N-1	Mazar Point Bridge	275.943	RCC Girder	50.8	7.2 (6.6)	1965	D	There is grave on the right side of A1			
C13	N-1_279a	Chittagong	Dohazari	N-1	Sangu Bridge	282.994	RCC Girder	211	7.2 (6.6)	1960	C	Many Shops and Residences			
C14	N-1_282e	Chittagong	Dohazari	N-1	Pathanerpul Bridge	286.378	PC Girder	33.65	11.5 (10.8)	1980	B	No Residence			
C15	N-1_283a	Chittagong	Dohazari	N-1	Noyakhalar Muk Bridge	286.631	RCC Girder	27.9	11.5 (8.4)	1978	B	No Residence			
C16	N-1_291a	Chittagong	Dohazari	N-1	Raj Ghata Bridge	294.534	RCC Girder	30.3	11.5 (8.3)	1992	B	Some Shops			

Source: JICA Survey Team

Table 4.2.13 List of the Existing Bridges under Section C

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
C17	N-1_291d	Chittagong	Dohazari	N-1	Khoria Nagar Bridge	295.295	RCC Girder	38.5	11.5 (8.4)	1993	A	One Residence			
C18	N-1_295b	Chittagong	Dohazari	N-1	Amirabad Bridge	299.434	PC Girder	68.8	11.5 (8.3)	1992	B	Some Residences on the right hand side			
C19	N-1_300d	Chittagong	Dohazari	N-1	Khasmahal Bridge	304.217	PC Girder	58.5	11.6 (8.4)	1987	B	Some Residences			
C20	N-1_301b	Chittagong	Dohazari	N-1	Adunagar Bridge	304.857	RCC Girder	22	10.0 (7.6)	1992	B	There is bailey bridge on the left side of existing br.			
C21	N-1_302a	Chittagong	Dohazari	N-1	Hatirpul Bridge	305.527	RCC Girder	22.4	10.0 (8.3)	1992	C	Some Residences on the right hand side			
C22	N-1_305a	Chittagong	Dohazari	N-1	Rataykul Bridge	308.652	RCC Girder	22.4	10.0 (7.5)	1986	A	No Residence			
C23	N-1_306b	Chittagong	Dohazari	N-1	Santi Bridge	309.971	RCC Girder	22.3	10.0 (7.3)	1986	B	No Residence			
C24	N-1_317a	Chittagong	Cox's Bazar	N-1	Harbang Chora Bridge	320.513	PC Girder	56.4	11.7 (8.4)	1995	B	Some Residences and one Water Gate			

Source: JICA Survey Team

Table 4.2.14 List of the Existing Bridges under Section C

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ) Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
C25	N-1_321b	Chittagong	Cox's Bazar	N-1	Bodoitola Bridge	324.607	RCC Girder	45	11.5 (8.3)	1992	C	Some Residences			
C26	N-1_328a	Chittagong	Cox's Bazar	N-1	Mathamuhuri Bridge	331.259	RCC Girder	294.15	7.2 (6.7)	1960	D	Some Residences and Warehouses			
C27	N-1_332c	Chittagong	Cox's Bazar	N-1	Pasiyakali Bridge	336.237	RCC Girder	38.4	11.6 (8.4)	1998	B	Some Residences			
C28	N-1_339a	Chittagong	Cox's Bazar	N-1	Polia Fari Bridge	342.77	RCC Girder	58.67	11.6 (8.3)	1999	B	One Residence			
C29	N-1_341a	Chittagong	Cox's Bazar	N-1	Dulahajar Bridge	344.531	PC Girder	54.03	11.6 (8.4)	1992	B	Residential and Shopping Area			
C30	N-1_342a	Chittagong	Cox's Bazar	N-1	Boyragir Khil Bridge	345.592	PC Girder	60.03	11.7 (8.5)	1992	B	There is mosque on the right side of A2.			
C31	N-1_346a	Chittagong	Cox's Bazar	N-1	Khutakhali Bazar Bridge	349.759	RCC Girder	44.55	11.6 (8.3)	1992	A	Some Residences and Shops			
C32	N-1_354a	Chittagong	Cox's Bazar	N-1	Eidgaon Bazar Bridge	357.264	PC Girder	46	11.5 (8.3)	1993	B	Some Residences			

Source: JICA Survey Team

Table 4.2.15 List of the Existing Bridges under Section C

No.	ID	Zone	Division	Road No.	Structure Name	Chainage (km)	Bridge Type	Total Length (m)	Width (m) *( ):Traveled Way	Year of Construction	Damage Level	Roadside Conditions	Photo		Remarks
C33	N-1_354d	Chittagong	Cox's Bazar	N-1	Goro Bazar Bridge	358.03	PC Girder	44.63	12.2 (8.3)	1993	A	There is substation on the right side of A2.			
C34	N-1_364d	Chittagong	Cox's Bazar	N-1	Joarianala Bazar Bridge	368.129	PC Girder	57.65	11.6 (8.3)	1993	A	There are Mosque and School on the right side of A2.			
C35	N-1_368c	Chittagong	Cox's Bazar	N-1	Mitacmari Ramu Bridge	371.848	PC Girder	58.6	11.6 (8.3)	1998	A	No Residence			
C36	N-1_375a	Chittagong	Cox's Bazar	N-1	Sarkarpara Bridge	378.492	RCC Girder	13.0	11.6 (8.3)	1992	A	Some Residences			
C37	N-1_377a	Chittagong	Cox's Bazar	N-1	Bakkhali Bridge	380.346	RCC Girder	136.3	8.8 (6.7)	1989	C	Some Residences			

Source: JICA Survey Team

4.3 Prioritization of Target Project Sections

As mentioned in Chapter 3, several regional cooperation organizations are actively working to improve the regional connectivity in South Asia region at the same time, and Bangladesh plays an important role in South Asia region because of its geopolitical importance. Considering this situation, JICA has decided to conduct this survey to implement CBNIP. In the following, JICA Survey Team evaluates the target project sections of CBINP from the viewpoints of cross border infrastructure.

4.3.1 Evaluation Criteria

Considering the current situation and issues regarding the development of cross border infrastructure in Bangladesh, the JICA Survey Team set the following criteria to evaluate the target project sections as shown in Table 4.3.1.

Table 4.3.1 Evaluation Criteria

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Included	2
		Not included	0
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	Development of road infrastructures connected to the target project section is committed.	2
		Development of road infrastructures connected to the target project section is planned or under study.	1
		No action is taken for the development of road infrastructure connected to the target project section.	0
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays an important role.	2
		The target project section plays a relevant role.	1
		The target project section plays no role.	0
Economic Effect	Contribution to the industrial development	There are or will be several major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	2
		There are or will be at least one major hub for regional logistics or industrial development for export which will use the target project section as a major transport route.	1
		There are or will be no major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	0
	Contribution to the development of the regional transport network	The target project section is a major route for the cross border transport.	2
		The target project section is planned to be a major route for the cross border transport.	1
		The target project section is not a major route for the cross border transport.	0

Source: JICA Survey Team

4.3.2 Evaluation Results

In the following, the JICA Survey Team evaluates the sections of CBRNIP by the criteria.

(1) Section A (between Dhaka to Benapole)

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Included	2
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	Development of road infrastructures connected to the target project section is committed.	2
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays an important role	2
Economic Effect	Contribution to industrial development	There are or will be no major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	0
	Contribution to regional transport network	The target project section is a major route for the cross border transport.	2
Total Score			10

BBIN MVA includes the target project section:

Section A is included in priority projects of BBIN MVA as "(iv) 4 laning of roads between Benapole and proposed new Padma Bridge (AH1)".

Status of relevant plans in neighboring countries:

Benapole Land Port is playing an important role for the transactions between Bangladesh and the mainland of India. Although the traffic is close to the capacity of the land port, the land port is working as a main gate for the transactions.

Expected synergies with other potential, planned, or committed projects by development partner:

As construction of Padma Bridge is in progress and improvement of cross border infrastructure is planned to be developed with the assistance of ADB, synergies with them can be expected due to the improvement of Section A for improvement of the cross border transportation between Bangladesh and the mainland of India.

Contribution to industrial development:

There is no EPZ which will use Section A as a main transportation route. On the other hand, it can be expected that smooth logistics between Bangladesh and the mainland of India can encourage Indian companies to invest in Bangladesh, to produce in Bangladesh and to export the products to the mainland of India.

Contribution to the development of the regional transport network:

Section A is expected to be a main route to connect Dhaka and the mainland of India as a part of AH1. It is expected that Section A will improve the transportation through Benapole Land Port. Furthermore it is expected that the cross border traffic will increase due to the improvement of the cross border facilities at Benapole.

Overview:

The connection between Dhaka and the mainland of India is recognized as the highest priority section for the cross border infrastructure. As the cross border traffic between Benapole and Dhaka by trucks is forced to make a roundabout trip because of the "missing link" on AH1.[4] The improvement of Section A, along with construction of Padma Bridge, can produce a huge decrease in transportation cost of the traffic and will have a positive impact on GDP. Furthermore, the improvement of the cross border facilities of Benapole land port, which is expected to increase the cross border traffic, can increase the benefit of the project.

(2) Section B (between Ramgarh and Baraiyarhat)

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Included	2
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	Development of road infrastructures connected to the target project section is planned or under study.	1
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays a relevant role.	1
Economic Effect	Contribution to industrial development	There are or will be no major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	0
	Contribution to the development of the regional transport network	The target project section is planned to be a major route for cross border transport.	1
Total Score			5

BBIN MVA includes the target project section:

Section B is included in priority projects of BBIN MVA as "(vii) 4 laning of the Baraiyarhat - Heako- Ramgarh Regional Highway".

Status of relevant plans in neighboring countries:

Currently, there is no cross border facility at Ramgarh. But, Bangladesh and India are cooperating in the development of cross border facility there. Furthermore, India has constructed cross border

[4] Currently, most of the trucks moving between Dhaka and Benapole are using Jamuna Bridge, The distance between Dhaka and Benapole over Jamuna Bridge is 366km. The AH1 route between Dhaka and Benapole is 208km. Therefore, it is expected that improvement of AH1 will reduce the transportation distance of the trucks by 158km.

facility and is constructing a bridge over the river Feni to connect the cross border facilities. Bangladesh Land Port Authority is planning to build a cross border facility there after a study assisted by the World Bank.

Expected synergies with other potential, planned, or committed projects by development partner:

The World Bank will assist the study for the cross border facility at Ramgarh. Although the study has not started yet, but it is expected that the study will completed in 6 months and that the operation of Ramgarh land port will start within 3 years. So far, finance of the development is not confirmed.

Contribution to industrial development:

There is no EPZ which will use Section B as main transportation route. After Ramgarh land port starts its operation, it is expected that some part of traffic at Akhaura land port, which is current main window for traffic between Bangladesh and the North East India. Currently, main import goods at Akhaura land port are bamboo, turmeric, watches, ginger, marble slabs, fruits etc. Main export goods at Akhaura land port are processed stone, bricks, tiles, fish, cement, batteries, furniture, glass sheets etc.

On the other hand, there are 3 economic zones in the North East India (1 economic zone in Manipur and 2 economic zones in Nagaland). As the economic zones locate near Tamabil land port and Akhaura land port rather than Ramgarh land port, it is expected that their influence on the traffic at Ramgarh land port is not so much.

Contribution to the development of the regional transport network:

Currently, traffic on Section B is small, because the road is currently just a local road. But, Section B is expected to be a main route to connect Chittagong and the North East India by the shortest route. In the North East India, several regional connectivity improvement projects are being promoted. Major projects of them are as follows.

- North east connectivity improvement project (loan project by JICA)
- South Asia subregional economic connectivity road connectivity investment program (financed by ADB)
- Misoram state roads – Regional transport connectivity project (financed by the World bank)
- It is expected that Section B can cooperate with these projects to improve regional transport network after Ramgarh land port starts its operation.

Overview:

For the North East India, Akhaura Land Port is the largest gate for the import/export. But Akhaura land Port is far from Chittagong and needs long distance truck transportation in Bangladesh or on the inland water way. The development of Section B and Ramgarh land Port can provide the access

in the shortest distance to Chittagong and reduce the transportation load on Bangladesh caused by the cross border traffic to/from the North East India. It is also important that Bangladesh and India are sharing the recognition of the importance of the cross border infrastructure development at Ramgarh.

(3) Section C (between Chittagong and Cox's Bazar)

Area	Evaluation Criteria	Criteria Scoring	Score
Priority	BBIN MVA includes the target project section.	Not included	0
Consistency with development Strategies/Plans	Status of relevant plans in neighboring countries	No action is taken for the development of road infrastructure connected to the target project section.	0
	Expected synergies with other potential, planned, or committed projects by development partners.	The target project section plays a relevant role.	1
Economic Effect	Contribution to the industrial development	There are or will be several major hubs for regional logistics or industrial development for export which will use the target project section as a major transport route.	2
	Contribution to the development of the regional transport network	The target project section is planned to be a major route for the cross border transport.	1
Total Score			4

BBIN MVA includes the target project section:

Section C is not included in priority projects of BBIN MVA.

Status of relevant plans in neighboring countries:

Although Teknaf Land Port is promoting transactions between Bangladesh and Myanmar, the traffic is pretty small in comparing with other major land ports (1% of total land transport traffic). At this stage, there is no discussion to develop the cross border facility between Bangladesh and Myanmar.[5]

Expected synergies with other potential, planned, or committed projects by development partner:

A feasibility study and detailed design for the improvement of Section C have been completed by the assistance of ADB.

Contribution to industrial development:

There is no EPZ which will use Section C as a main transportation route. But the development of Southern Chittagong Region, Matarbari and surrounding area, is under investigation. GOB is expecting that the development will include an economic zone and a commercial port. If the development is carried out, Section C will become a major transportation route for the economic zone and the port.

[5] Source: Interview with Joint Secretary of Ministry of Road Transport and Bridges on July 8th, 2015

Contribution to the development of the regional transport network:

Currently, although Section C is a part of AH41, traffic on Section C is small. In order for Section C to play an important role as a regional transport network, it is necessary that the land port between Bangladesh and Myanmar be developed and that the traffic at the land port increases. But, at this stage, there is no concrete action to move the situation forward. On other hand, Sections C is a part of the alternative route of BCIM Corridor Plan.

Overview

Although there is no concrete action to develop the cross border facilities between Bangladesh and Myanmar at this stage, Section C is a part of BCIM corridor plan. If the plan is strongly promoted by China initiative and support from AIIB, the importance of Section C will increase.

Furthermore, the development of Matarbari area can change the importance of Section C drastically. As the area is a limited area to develop a large-scale port for Bangladesh, Section C can play an important role for the logistics for Bangladesh and Southern Asia region.

4.3.3 Summary of Evaluation

Total points of the evaluation are as follows.

- Section A: 8 points
- Section B: 5 points
- Section C: 4 points

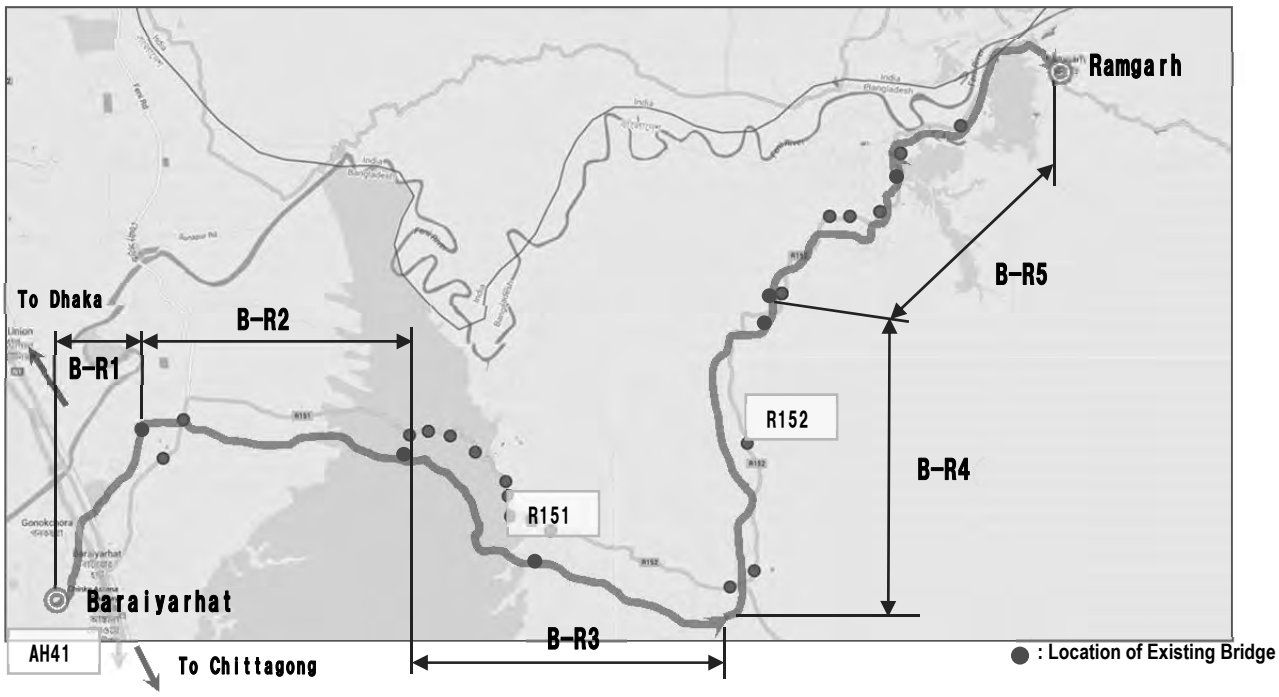
4.4 Prioritization of Target Bridges and Roads

4.4.1 Selection of Priority Roads

(1) Setting out of sub-sections

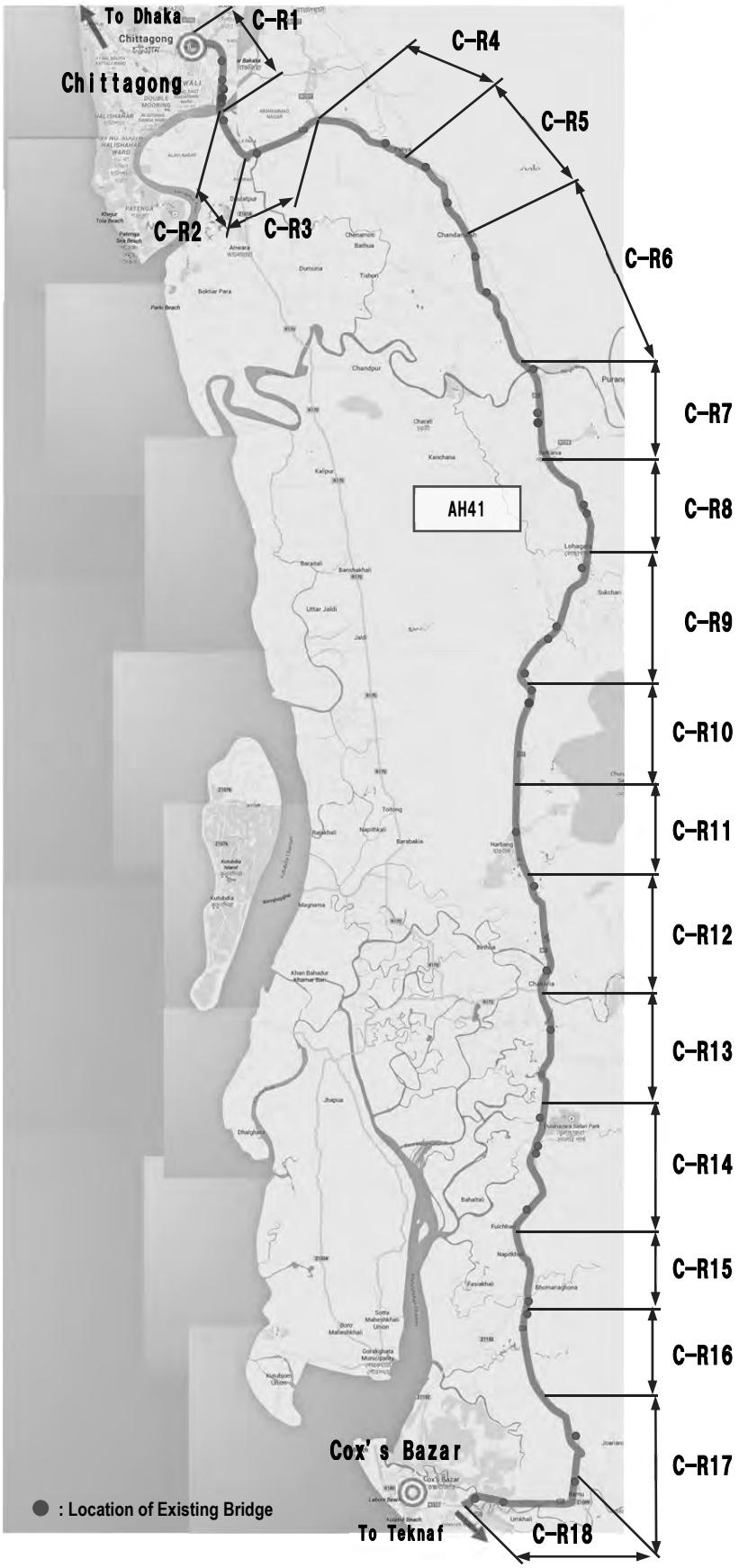
Prior to deciding on the priority of project roads, Sections B and C should be divided into sub-sections. For this sub-division, i) RHD Division, ii) major intersections and iii) less than 10 km are taken into account. As the results, Sections B and C are divided into 5 and 18 sub-sections, respectively, as shown in Figure 4.4.1 and Figure 4.4.2.

On the other hand, Section A doesn't investigate the priority of project roads because there are only approach roads for bridges.



Source: JICA Survey Team

Figure 4.4.1 Layout of Sub-sections in Section B



Source: JICA Survey Team

Figure 4.4.2 Layout of Sub-sections in Section C

(2) Evaluation Indices and Results

The same evaluation indices for the priority of project bridges are applied for the roads. The results of evaluation in Sections B and C are shown in Table 4.4.1 and Table 4.4.2, respectively.

In the entire sub-sections, the evaluation scores are low because existing road conditions are well maintained, current traffic volumes are basically low, therefore, there are no serious issues for driving.

It is difficult to compare Sections B with C because the multi criteria are different. However, the evaluation scores of Section B are higher than the one of Section C. The highest score in Section B is Sub-section B-R2 with 300 points out of 400 because the index of structural damage is given high weight. Also, this sub-section is located in a hilly area with high cut slopes and there is a possibility to apply some Advanced Japanese Technology. Therefore, Sub-section B-R2 has the highest priority among the road sub-sections and the possibility to be a project road as one of the candidates.

The evaluation scores of each of the sub-sections in Section C are 220 points or less out of 400. The index of impacts on social/economic development in the future is given high weight, which lowers the evaluation results. Therefore, it is appropriate that all the sub-sections in Section C are excluded from the project roads.

Table 4.4.1 Priority of Project Road in Section B

Division Name	Description	Road No.	Chainage	Section No.	Cum. Length	Section Length	1. Structual Damage		2. Traffic Demand		3. Traffic Safety		4. Duplication with the Other		5. Expectation of Stakeholders		6. Workability		7. Enviromental Impacts		Evaluation Score	Remarks
					[km]	[km]	Damage Level	Point	AADT	Point	Min. Paved Width	Point	-	Point	Approval or Objection	Point	Hilly or Flat	Point	High or Low	Point		
Chittagong	B.P	R151	KM 0+000																			
				B-R1	4.50	4.50	Poor	2	5,170*	4	5.2	4	-	-	Approval	4	Flat	0	Low	4	260	
	Kararhat		KM 4+500																			
				B-R2	11.10	6.60	Poor	2	1,547*	0	4.0	4	-	-	Approval	4	Hilly	4	Low	4	300	
	Border Control Point		KM 11+100																			
				B-R3	20.50	9.40	Fair	1	1,459	0	4.3	4	-	-	Approval	4	Hilly	4	Low	4	270	
	Heyako		KM 20+500																			
		R152	KM 0+000	B-R4	28.90	8.40	Fair	1	827*	0	4.9	4	-	-	Approval	4	Flat	2	Low	4	230	
	Bangla Bazar		KM 8+400																			
				B-R5	38.03	9.13	Good	0	780	0	5.1	4	-	-	Approval	4	Flat	2	High	0	140	
	E.P		KM 17+530																			

*: HDM Circle Report (2014)

Source: JICA Survey Team

Table 4.4.2 Priority of Project Road in Section C

Division Name	Description	Road No.	Chainage	Section No.	Cum. Length	Section Length	1. Impact on Social/Economic Development		2. Structual Damage		3. Traffic Safety		4. Traffic Demand		5. Roadside Impacts		Evaluation Score	Remarks
					[km]	[km]	Section	Point	Damage Level	Point	Min. Paved Width	Point	AADT	Point	High or Low	Point		
Chittagong	B.P	N1	KM 238+317															
	River		KM 246+170	C-R1	7.85	7.85	Chittagong - Chakaria	4	Good	0	7.4	0	4,504	0	Low	4	160	
Dohazari	Z1018		KM 250+680	C-R2	12.36	4.51	Chittagong - Chakaria	4	Poor	2	7.4	0	4,504	0	Low	4	220	
	N107		KM 256+930	C-R3	18.61	6.25	Chittagong - Chakaria	4	Good	0	6.6	2	4,504	0	Low	4	190	
	Patiya		KM 263+600	C-R4	25.28	6.67	Chittagong - Chakaria	4	Good	0	8.2	0	5,215	2	High	0	150	
	Chandanaish		KM 271+700	C-R5	33.38	8.10	Chittagong - Chakaria	4	Good	0	8.7	0	5,749	2	Low	4	190	
	Dohazari		KM 281+300	C-R6	42.98	9.60	Chittagong - Chakaria	4	Good	0	6.2	2	5,749	2	High	0	180	
	N108 (Satkania)		KM 289+870	C-R7	51.55	8.57	Chittagong - Chakaria	4	Good	0	6.4	2	6,286	2	High	0	180	
	Lohagara		KM 297+450	C-R8	59.13	7.58	Chittagong - Chakaria	4	Good	0	6.6	2	6,286	2	Low	4	220	
	Noapara		KM 307+400	C-R9	69.08	9.95	Chittagong - Chakaria	4	Good	0	6.8	2	5,635	2	High	0	180	
	Boundary		KM 315+170	C-R10	76.85	7.77	Chittagong - Chakaria	4	Good	0	6.6	2	5,635	2	Low	4	220	
Cox's Bazar	Harbang (Janata Bazar)		KM 323+740	C-R11	85.42	8.57	Chittagong - Chakaria	4	Good	0	6.8	2	5,635	2	Low	4	220	
	Chakaria		KM 332+970	C-R12	94.65	9.23	Chittagong - Chakaria	4	Good	0	6.7	2	5,635	2	Low	4	220	
	Dulahazara (Malumghat Bazar)		KM 342+000	C-R13	103.68	9.03	Chakaria - Cox's Bazar	0	Good	0	6.7	2	2,807	0	Low	4	70	
	Khutakhali (Fulchhari)		KM 351+250	C-R14	112.93	9.25	Chakaria - Cox's Bazar	0	Good	0	6.7	2	2,130	0	High	0	30	
	Z1132 (Idgaon)		KM 357+500	C-R15	119.18	6.25	Chakaria - Cox's Bazar	0	Good	0	6.7	2	2,130	0	High	0	30	
	Qadirpara (Mamun Mear Bazar		KM 363+920	C-R16	125.60	6.42	Chakaria - Cox's Bazar	0	Good	0	6.6	2	2,130	0	High	0	30	
	Z1009 (Ramu)		KM 371+510	C-R17	133.19	7.59	Chakaria - Cox's Bazar	0	Good	0	6.9	2	2,130	0	High	0	30	
	E.P		KM 381+340	C-R18	143.02	9.83	Chakaria - Cox's Bazar	0	Good	0	6.8	2	2,130	0	High	0	30	

Source: JICA Survey Team

4.4.2 Selection of Priority Bridges

(1) Section A

Four bridges and river crossing at Kalna under Section A are selected as higher priority to the other two sections because these bridges are located on AH1 which is the most important route among the three sections. Especially, traffic volume will be increased after the completion of Padma Multipurpose Bridge.

(2) Section B

The bridges of Section B are ranked in accordance with the following multi criteria as shown in Table 4.4.3, and the result of the selection is shown in Table 4.4.4.

Table 4.4.3 Multi Criteria for Section B

Item		Weight	Point	Criteria
1. Structural Damage	Damage Level	30	4	Grade-D
			2	Grade-C
			0	Grade-A,B
2. Traffic Demand		10	4	5,000 – 7,000 AADT (4-wheeler & more) (required 7.3m width for 2lanes)
			0	0 – 5,000 AADT (4-wheeler & more) (required less than 7.3m width)
3. Traffic Safety		20	4	Carriageway < 6.2m
			2	6.2m ≤ Carriageway < 7.3m
			0	Carriageway ≥ 7.3
4. Duplication with the Other Projects		-	-	Drop
5. Expectation of Stakeholders		5	4	High
			0	Low
6. Workability		20	4	Hilly Area
			0	Flat Area
7. Environmental Impacts		15	4	Not Significant
			0	Significant
		Total Score = 400		

Note: The existing culverts were eliminated in this selection.
Source: JICA Survey Team

Table 4.4.4 Ranked Bridges of Section B

No.	Structure Name	Construction Year	1.Structual Damage		2.Traffic Demand		3.Traffic Safety		4.Duplication of the Other Projects	5.Expectation of Stakeholdes	6.Workability		5.Roadside Condition		Evaluation Score	Remarks
			Damage Level	Point	AADT	Point	Traveled Way Width (m)	Point			Terrain Condition	Point	Condition	Point		
B4	Tulatuli Lohar Bridge	1986	D	4	1,459	0	3.8	4	—	4	Hilly	4		4	360	Embankment
B19	Chikon Chara Bridge	1965	D	4	780	0	3.5	4	—	4		0	No Residence	4	280	Box Culvert
B2	Telipool Bridge	1965	D	4	1,459	0	3.4	4	—	4		0	No Residence	4	280	
B20	Banglabazar bridge	1965	D	4	780	0	3.5	4	—	4		0	No Residence	4	280	Box Culvert
B23	Gadar dokan Bridge	1978	D	4	780	0	3.5	4	—	4		0	No Residence	4	280	Box Culvert
B9	Kalapani Bridge-2	1978	D	4	1,459	0	3.7	4	—	4		0	No Residence	4	280	
B11	Koilapara Bridge	1980	C	2	1,459	0	6.7	2	—	4	Hilly	4		4	260	Embankment
B5	tulatuli Bridge	1986	C	2	1,459	0	6.65	2	—	4	Hilly	4		4	260	Embankment
B7	Bangra Tabor Bridge	2006	C	2	1,459	0	6.7	2	—	4	Hilly	4		4	260	Embankment
B8	Kalapani Bridge-1	1993	C	2	1,459	0	6.7	2	—	4	Hilly	4		4	260	Embankment
B13	Balutila Bridge	1991	C	2	1,459	0	3.2	4	—	4		0	No Residence	4	220	
B14	Fulchari Bridge	1995	C	2	1,459	0	3.4	4	—	4		0	No Residence	4	220	Box Culvert
B15	Heaku Bazar B ridge	1984	C	2	1,459	0	3.7	4	—	4		0	No Residence	4	220	Box Culvert
B16	Heako Bridge	1965	C	2	780	0	3.7	4	—	4		0	No Residence	4	220	
B22	Borobil Bridge	1978	C	2	780	0	3.7	4	—	4		0	No Residence	4	220	Box Culvert
B25	East baganbazar Bridge	1965	C	2	780	0	3.7	4	—	4		0	No Residence	4	220	
B3	Lakshmi chara Bridge	1965	C	2	1,459	0	3.6	4	—	4		0	Three Shops	4	220	
B6	Buro Camp Bridge	2006	B	0	1,459	0	6.7	2	—	4	Hilly	4		4	200	Embankment
B18	Chikon Chara Bridge	1986	C	2	780	0	6.7	2	—	4		0	No Residence	4	180	
B12	Koilabazar Bridge	1994	A	0	1,459	0	3.3	4	—	4		0	No Residence	4	160	
B24	Bagan Bazar Bridge	1996	C	2	780	0	3.2	4	—	4		0	Residential Area	0	160	Box Culvert
B1	Purbo Hinguli Bridge	1978	B	0	1,459	0	6.7	2	—	4		0	One Residence	4	120	GOB-Br
B10	Niharkanti Das Bridge	1980	B	0	1,459	0	6.8	2	—	4		0	No Residence	4	120	GOB-Box
B17	Amtali Bridge	1985	B	0	780	0	6.7	2	—	4		0	No Residence	4	120	GOB-Box
B21	Borobil Bridge	1986	B	0	780	0	6.7	2	—	4		0	No Residence	4	120	GOB-Br
B26	Sonaipool Bridge	1965	C	0	780	0	3.7	0	Elimination	0		0	Residential Area	0	0	GOB-Br

Source: JICA Survey Team

(3) Section C

The bridges of Section C are ranked in accordance with the following multi criteria as shown in Table 4.4.5, and the result of the selection is shown in Table 4.4.6.

Table 4.4.5 Multi Criteria for Section C

Item		Weight	Points	Criteria
1. Impact on Social / Economic Development	1.1 Accessibility to Planned SEZ	30	4	Sangu River
				Matarbari
	1.2 Accessibility to Regional Development Area			Southern Chittagong Regional Development Area
	1.3 Existing EPZ		2	Karnaphuli EPZ, Chittagong EPZ
	1.4 Others		0	
2. Structural Damage	Damage Level	30	4	Grade-D
			2	Grade-C
			0	Grade-A, B
3. Traffic Safety		15	4	Carriageway < 6.2m
			2	6.2m ≤ Carriageway < 7.3m
			0	Carriageway ≥ 7.3m
4. Traffic Demand (AADT)		15	4	7,000 – 36,000 AADT (4-wheeler & more) (required more than 4 lanes)
			2	5,000 – 7,000 AADT (4-wheeler & more) (required 7.3m width for 2lanes)
			0	0 – 5,000 AADT (4-wheeler & more) (required less than 7.3m width)
5. Roadside Condition (Resettlement Issue)		10	4	Not Significant
			0	Significant
		Total Score=400		

Note:

* The existing bridges whose lengths are less than 30m and the existing culverts were eliminated in this selection.

* The bridges which have been widened to 4 lanes were eliminated in this selection.

Source: JICA Survey Team

Table 4.4.6 Ranked Bridges of Section C

No.	Structure Name	Construction Year	1.Impact on Social/Economic Development		2.Structual Damage		3.Traffic Safety		4.Traffic Demand		5.Roadside Condition		Evaluation Score	Remarks
			Section	Point	Damage Level	Point	Traveled Way Width (m)	Point	AADT	Point	Condition	Point		
C26	Mathamuhuri Bridge	1960	Chittagong - Chakaria	4	D	4	6.7	2	2,807	0	Some Residences and Warehouses	4	310	
C12	Mazar Point Bridge	1965	Chittagong - Chakaria	4	D	4	6.6	2	5,749	2	There is grave on the right side of A1.	0	300	
C8	Patiya Bridge	1977	Chittagong - Chakaria	4	C	2	6.8	2	5,215	2	Some Shops on the right hand sice	0	240	
C13	Sangu Bridge	1960	Chittagong - Chakaria	4	C	2	6.6	2	6,286	2	Many Shops and Residences	0	240	
C25	Bodoitola Bridge	1992	Chittagong - Chakaria	4	C	2	8.3	0	2,807	0	Some Residences	4	220	
C9	Srimi Bridge	1992	Chittagong - Chakaria	4	B	0	7.5	0	5,749	2	Patula Baptist on the right hand side	4	190	
C16	Raj Ghata Bridge	1992	Chittagong - Chakaria	4	B	0	8.3	0	6,286	2	Some Shops	4	190	
C17	Khoria Nagar Bridge	1993	Chittagong - Chakaria	4	A	0	8.4	0	6,286	2	One Residence	4	190	
C19	Khasmahal Bridge	1987	Chittagong - Chakaria	4	B	0	8.4	0	5,635	2	Some Residences	4	190	
C24	Harbang Chora Bridge	1995	Chittagong - Chakaria	4	B	0	8.4	0	5,635	2	Some Residences and one Water Gate	4	190	
C14	Pathanerpul Bridge	1980	Chittagong - Chakaria	4	B	0	10.8	0	6,286	2	No Residence	4	190	
C7	Sikolbaha Bridge-1	1993	Chittagong - Chakaria	4	B	0	7.4	0	4,504	0	Some Shops on the right hand sice	4	160	
C18	Amirabad Bridge	1992	Chittagong - Chakaria	4	B	0	8.3	0	6,286	2	Some Residences on the right hand side	0	150	
C37	Bakkhali Bridge	1989	Chakaria - Cox's Bazar	0	C	2	6.7	2	2,130	0	Some Residences	4	130	
C27	Pasiyakali Bridge	1998	Chakaria - Cox's Bazar	0	B	0	8.4	0	4,068	0	Some Residences	4	40	
C28	Polia Fari Bridge	1999	Chakaria - Cox's Bazar	0	B	0	8.3	0	4,068	0	One Residence	4	40	
C35	Mitacmari Ramu Bridge	1998	Chakaria - Cox's Bazar	0	A	0	8.3	0	2,130	0	No Residence	4	40	
C30	Boyragir Khil Bridge	1992	Chakaria - Cox's Bazar	0	B	0	8.5	0	2,130	0	There is mosque on the right side of A2.	0	0	
C33	Goro Bazar Bridge	1993	Chakaria - Cox's Bazar	0	A	0	8.3	0	2,130	0	There is substation on the right side of A2.	0	0	
C29	Dulahajar Bridge	1992	Chakaria - Cox's Bazar	0	B	0	8.4	0	2,130	0	Residential and Shopping Area	0	0	
C31	Khutakhali Bazar Bridge	1992	Chakaria - Cox's Bazar	0	A	0	8.3	0	2,130	0	Some Residences and Shops	0	0	
C32	Eidgaon Bazar Bridge	1993	Chakaria - Cox's Bazar	0	B	0	8.3	0	2,130	0	Some Residences	0	0	
C34	Joarianala Bazar Bridge	1993	Chakaria - Cox's Bazar	0	A	0	8.3	0	2,130	0	There are Mosque and School on the right side of A2.	0	0	

Source: JICA Survey Team

4.5 Selection of Target Project

The road improvement is eliminated from target project for the following reason.

- The bridge improvement shall be prioritized over road improvement to solve the bottle neck.
- The bridge improvement needs to be carried out at an early date because bridge construction period is longer than road.
- GOB has considerable experience of road construction.

The target bridges are described below.

Table 4.5.1 Target Project Bridges under Section A

No.	ID	Zone	Division	Road No.	Structure Name	Bridge Type	Bridge Length (m)	Chainage (km)	Construction Year	Remarks
A1 (Ⅰ)	N706_14b	Khulna	Jessore	N-706	Jhikorgacha Bridge	RC Girder	118.67	14.349	1968	
A2 (Ⅴ)	R750_25a	Khulna	Narail	R-750	Tularampur Bridge	RC Girder	91.5	24.18	1964	
A3 (Ⅵ)	Z7503_5a	Khulna	Narail	Z-7503	Hawai Khali Bridge	RC Girder	26.1	5.213	1976	
A4	—	Gopalganj Khulna	Gopalganj Narail	N-806	—	Kalna Ferry Crossing	—	—	—	
A5 (Ⅳ)	N805_24a	Gopalganj	Gopalganj	N-805	Garakola Bridge	PC Girder	105.05	24.19	2004	

Source: JICA Survey Team

Table 4.5.2 Target Project Bridges under Section B

No.	ID	Zone	Division	Road No.	Structure Name	Bridge Type	Bridge Length (m)	Chainage (km)	Construction Year	Remarks
B2	R-151_4a	Chittagong	Chittagong	R-151	Telipool Bridge	Steel Beam & RC Slab	15.24	3.712	1965	
B3	R-151_4c	Chittagong	Chittagong	R-151	Lakshmi Chara Bridge	Steel Beam & RC Slab	15.42	4.013	1965	
B9	R-151_14a	Chittagong	Chittagong	R-151	Kalapani Bridge-2	RC Girder	24.82	12.987	1978	
B12	R-151_16a	Chittagong	Chittagong	R-151	Koilabazar Bridge	Bailey with Steel Deck	36.8	14.886	1994	
B13	R-151_16c	Chittagong	Chittagong	R-151	Balutila Bridge	Bailey with Steel Deck	21.35	15.645	1991	
B16	R-152_Sa	Chittagong	Chittagong	R-152	Heako Bridge	RC Girder	12.4	0.131	1965	
B18	R-152_7a	Chittagong	Chittagong	R-152	Chikon Chara Bridge	RC Girder	24.23	7.207	1986	
B25	R-152_14a	Chittagong	Chittagong	R-152	East baganbazar Bridge	Steel Beam & RC Slab	36.8	13.669	1965	

Note: In addition to listed bridges above, the seven (7) existing bridges (Bridge ID: B14, 15, 19, 20, 22, 23, and 24) are appraised to be improved because their damage level is categorized as C and D. However, according to the results obtained from hydraulic analysis, they can be replaced by box culvert. Thus, they are targeted to include under the Project scopes.

Source: JICA Survey Team

Table 4.5.3 Target Project Bridges under Section C

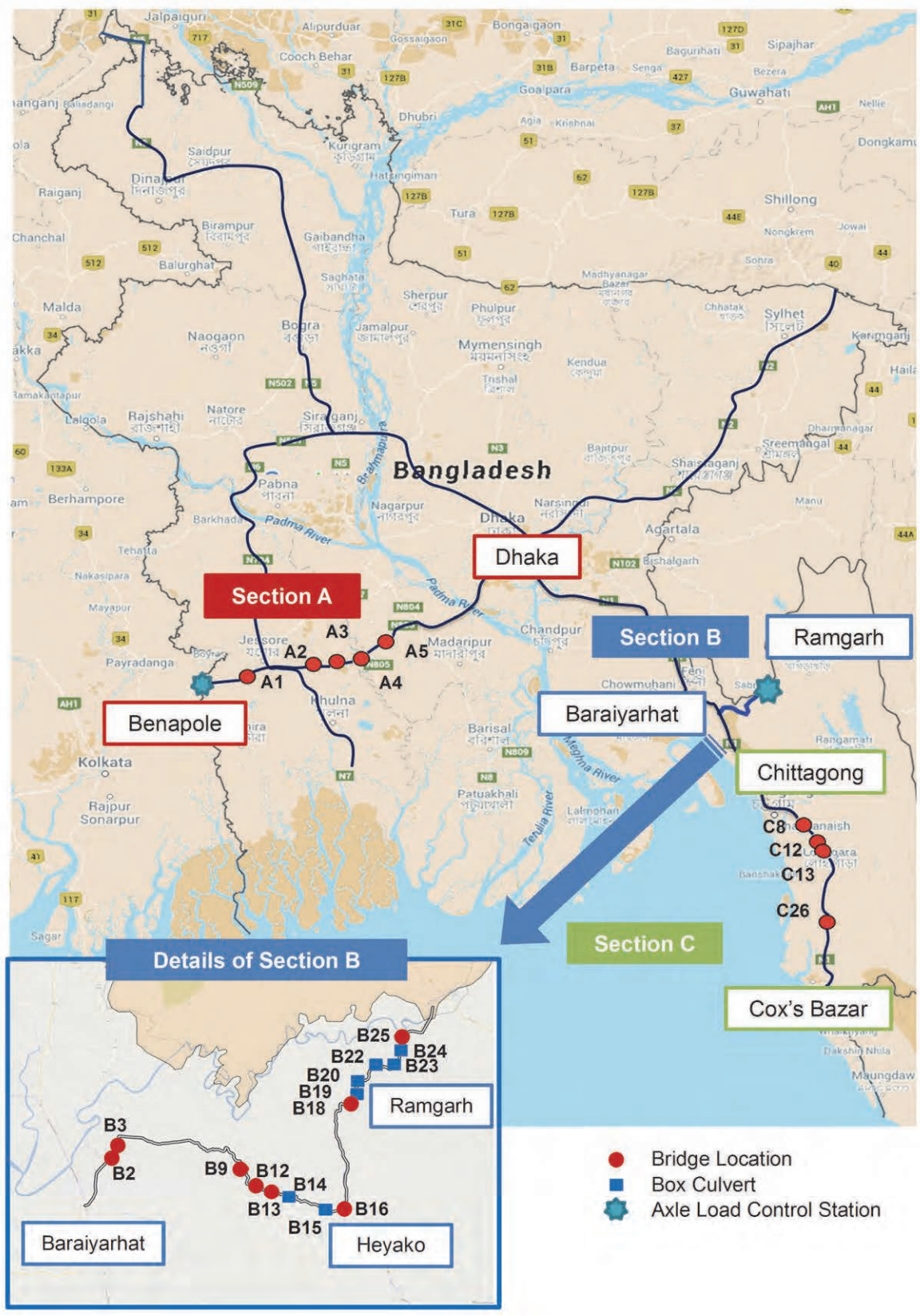
No.	ID	Zone	Division	Road No.	Structure Name	Bridge Type	Bridge Length (m)	Chainage (km)	Construction Year	Remarks
C8	N-1_257a	Chittagong	Dohazari	N-1	Patiya Bridge	RC Girder	50.3	262.116	1977	
C12	N-1_272a	Chittagong	Dohazari	N-1	Mazar Point Bridge	RC Girder	50.8	275.943	1965	
C13	N-1_279a	Chittagong	Dohazari	N-1	Sangu Bridge	RC Girder	211.0	282.994	1960	
C26	N-1_328a	Chittagong	Cox's Bazar	N-1	Mathamuhuri Bridge	RC Girder	294.2	331.259	1960	

Source: JICA Survey Team

Additionally, the axle load scale will be installed at Benapole and Ramgarh in the project for the following reason.

- There is existing land port at Benapole and located under important corridor which has been selected as AH1 (Asian Highway 1). Besides, it is expected that the traffic volume including cross-border transportation will rapidly increase after commencement of Padma and Kalna bridges.
- New land port is planned at Ramgarh because the Indian Government is funding the construction of a bridge crossing Feni River on the Bangladesh-India border. Thus, this is expected to boost international trade between Bangladesh and the northeast state of India, known as the “Seven Sisters State”.
- In above land port of 2 locations, it is effective that the control of overloaded vehicle conducts at land port before travel, because cross-border transportation must be controlled in order to avoid damage to roads and bridges.

The target project is shown in Figure 4.5.1.



Source: JICA Survey Team

Figure 4.5.1 Location of the Target Bridges and Axle Load Scale

5. NATURAL CONDITIONS

5.1 Physiography

The survey area covers three distinct physiographic zones, they are the Ganges river deltaic plain in section A, the northern part of Chittagong hills in section B and Chittagong coastal plain in section C.

5.1.1 Physiographical Conditions in Section A

The area lies in the midst of the Ganges river floodplain comprising the active floodplain of the Ganges and an adjacent meandering floodplain. Madhumati river, where the proposed Kalna bridge is to be constructed, is integrated as tributaries in the Ganges river system, hence thorough consideration must be given to the meandering behavior of the Madhumati river. The Ganges alluvium is calcareous in nature and soil of the area is mainly silt or silty clay loam.

5.1.2 Physiographical Conditions in Section B

Hilly terrains are dominant in the area which is situated in the northern end of Chittagong Hills tracts and bounded by Feni river on the northern border with India. Several small tributaries of Feni river flow through relatively flat floodplains and valleys lie between hill lines which mainly run in the south to north direction. In the valleys there remain traces of scouring due to flash floods. Any structure in the rivers must be designed with full consideration of scouring. The soil is brown sandy to clayey loam and deposited on shale or sandstone bedrock in the hilly area.

5.1.3 Physiographical Conditions in Section C

The area lies west of Chittagong Hills between Chittagong in the north and Cox's Bazar in the south. Chittagong coastal plain extends from Chittagong to the mouth of the Matamuhuri delta. It comprises gently sloping piedmont plains. From the Matamuhri delta to Cox's Bazar narrow floodplains extend adjoining the coastal beaches and dunes. The typical soil is silty sand or clayey sand and is shallow over the shale bedrock in some places.

5.2 Geology

The survey area is comprised of different geology in three sections as previously mentioned. A geotechnical investigation was conducted to collect the data for designing the bridges and roads in each section accordingly. The geotechnical investigation consists of the following items;

- Boring
- Standard penetration test
- Sampling (disturbed, undisturbed)
- Laboratory tests
  Grain size analysis / Water content / Specific gravity / Wet density / Dry density / Liquid limit / Plastic limit / unconfined compression test / Consolidation test
- CBR test (Section B/C only)

5.2.1 Geotechnical Investigation in Section A

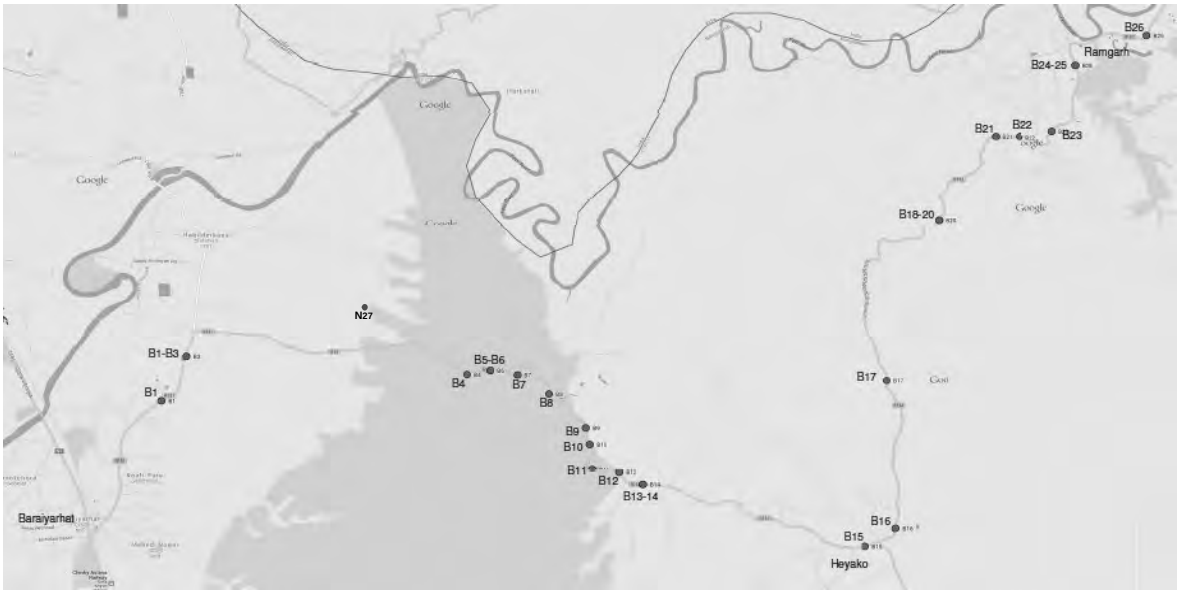
In section A, the location selected for the investigation was in Kalna. In the Madhumati river, silty sand and clayey sand is widely deposited on the banks and on the river bed. Three borings were conducted, two in the banks and one in the center of the river. The boring in the river was performed using a floating platform on a catamaran boat moored by anchors in the river. The pile bearing strata exists about 55 m below GL (Ground Level) on the banks. Boring locations are as indicated in Figure 5.2.1.

Source: JICA Survey Team

Figure 5.2.1 Boring Location Map in Kalna, Section A

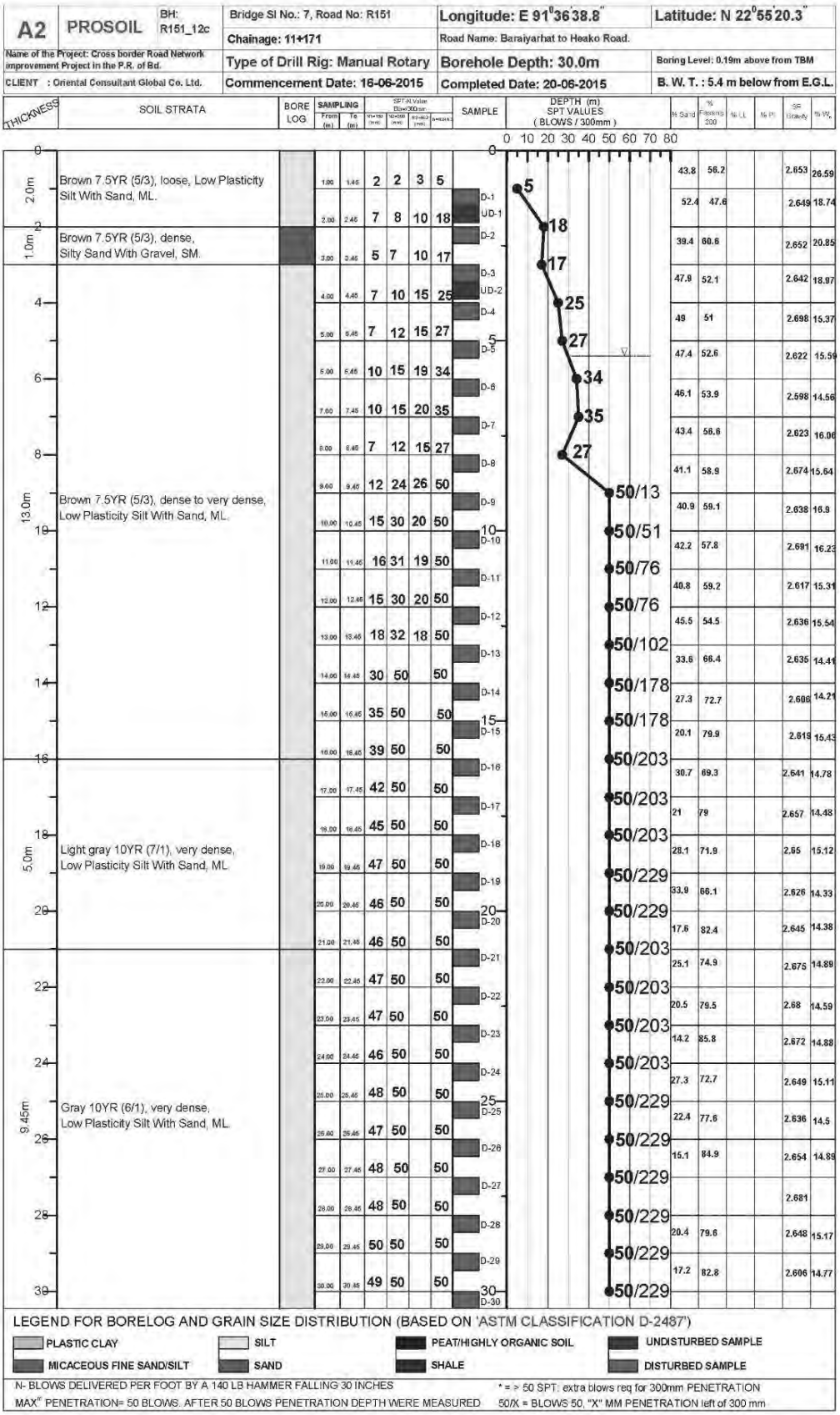
5.2.2 Geotechnical Investigation at Section B

In section B, soil conditions vary between hilly areas and flood land. Silty sand is dominant in the hilly areas and clayey silt is dominant in the flood land areas. Soil borings were conducted at 27 locations (26 bridges and 1 hilly area). Pile bearing strata exits at an average 30 m below GL, but it was 50 m below GL in the flat land near Barayalhat. Boring locations are as indicated in Figure 5.2.2 and sample bore logs for the hilly area B-5 and flat area B-17 are indicated in Figure 5.2.3 and Figure 5.2.4., respectively.



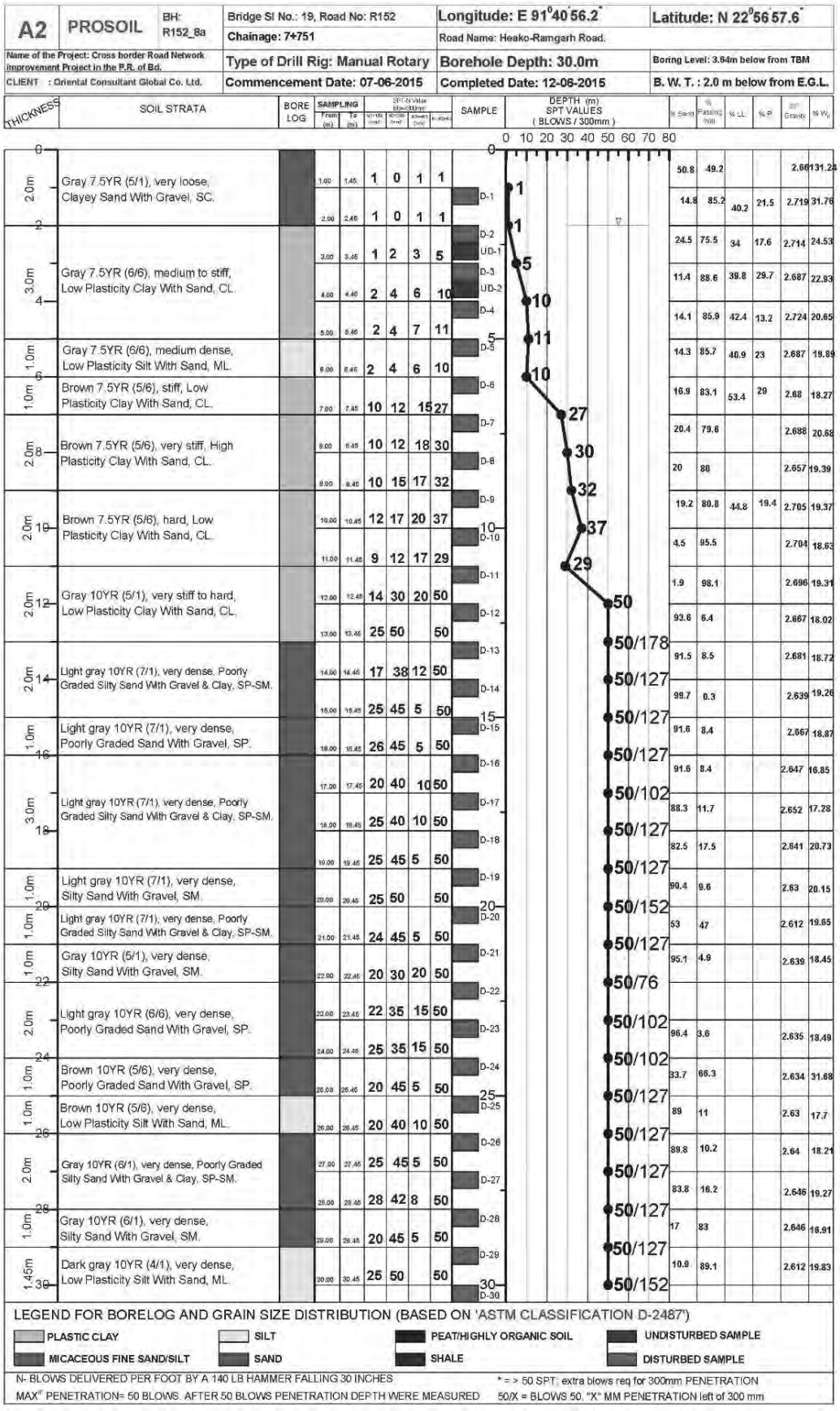
Source: JICA Survey Team

Figure 5.2.2 Boring Location Map in section B



Source: JICA Survey Team

Figure 5.2.3 Sample Bore Log at the Hilly Area



Source: JICA Survey Team

Figure 5.2.4 Sample Bore Log at the Flat Land

5.2.3 Geotechnical Investigation at Section C

In section C the following 4 bridges were selected, they include 2 relatively short bridges and 2 long bridges. Borings were conducted, 1 for each short bridge and 2 for each long one. At all the boring sites, silty/clayey sand is thickly deposited. Pile bearing strata exists at 30 to 55 m below GL. At the long bridge sites, shale bedrock is encountered at 38 m below GL which is common to Chittagong area. Boring locations are as indicated in Figure 5.2.5.

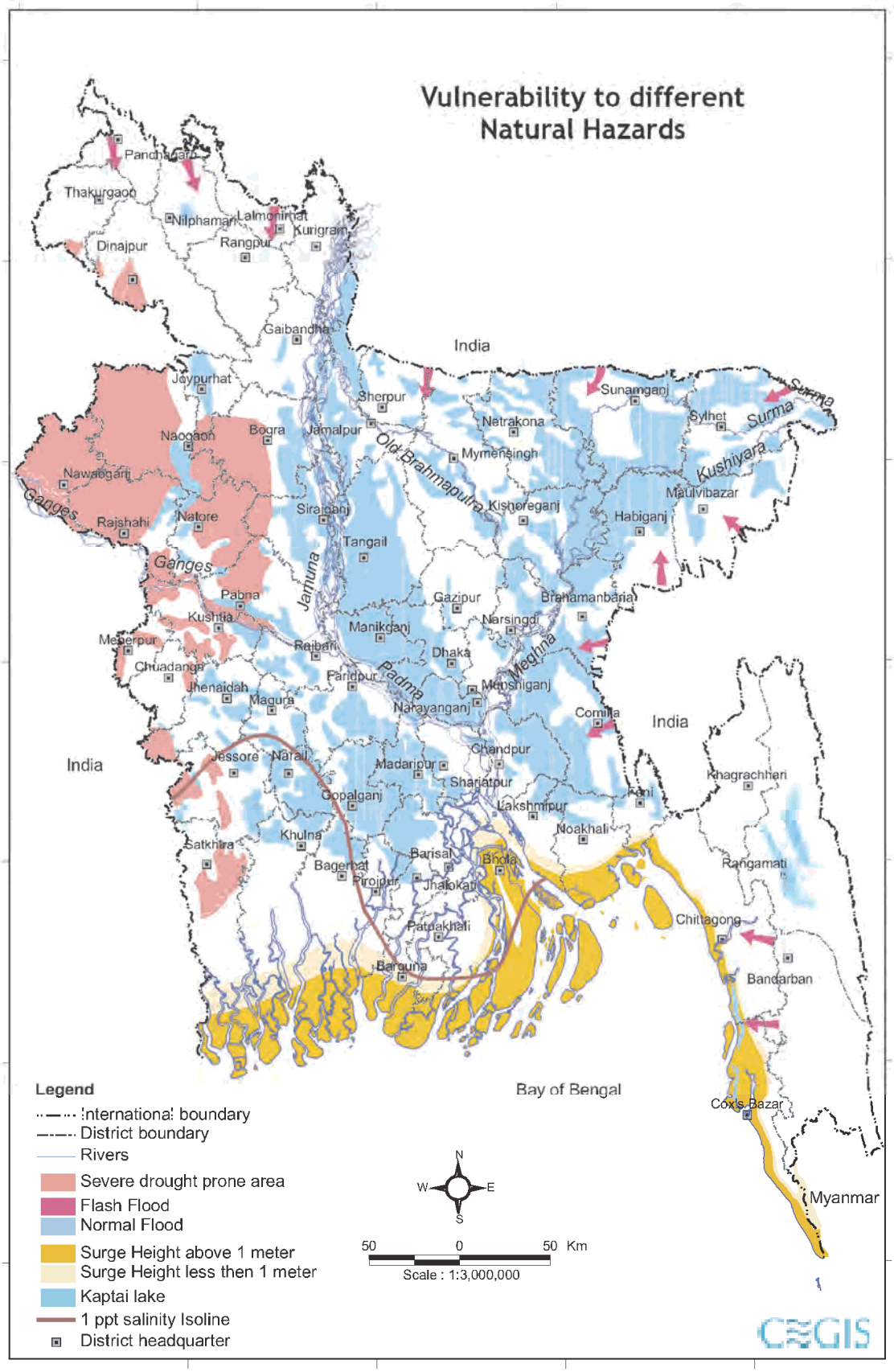
Source: JICA Survey Team

Figure 5.2.5 Boring Locations Map in Section C

5.3 Climate Change

5.3.1 Introduction

Bangladesh is a low-lying deltaic country in South Asia bounded 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).



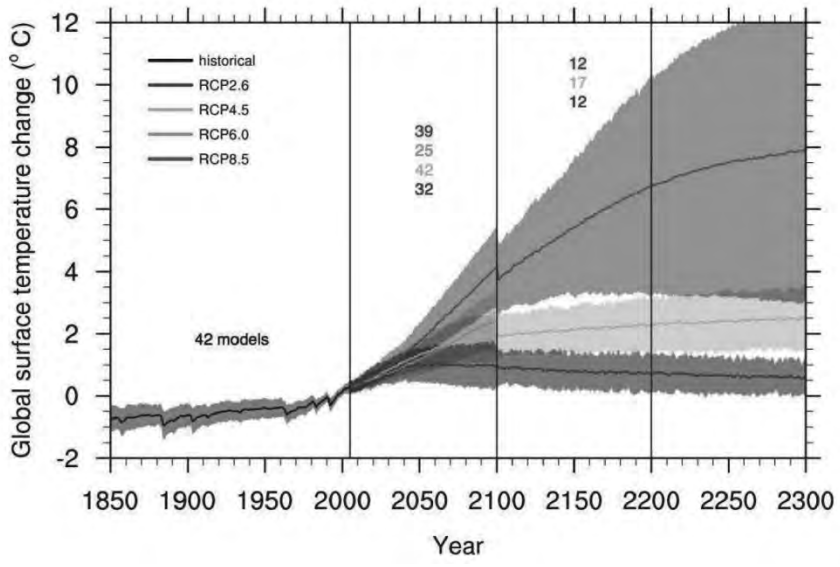
Source: IPCC WGI 5th Assessment Report

Figure 5.3.1 Areas Affected by Different Types of Climate-related Disasters

Figure 5.3.1 shows the areas affected by different types of climate-related disasters. The mid-western areas including Jessore are prone to being affected by normal flood, and the southwestern areas are prone to being affected by storm-surge and flash flood. (source: CEGIS Dhaka, Bangladesh Climate Change Strategy and Action Plan, 2008).

5.3.2 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 5.3.2 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.

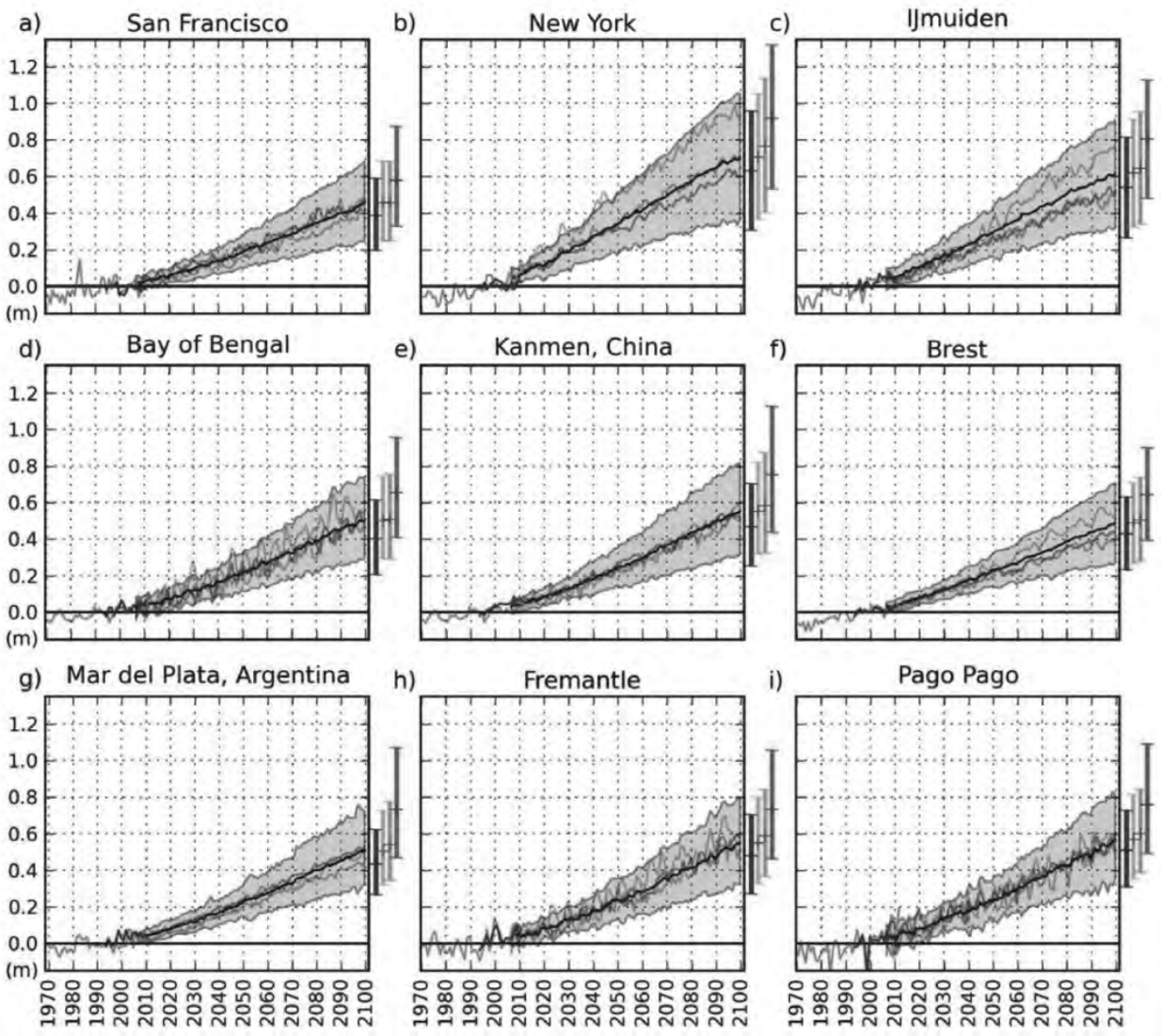


Source: IPCC WGI 5th Assessment Report

Figure 5.3.2 Global Surface Temperature Change

5.3.3 Sea Level Change

Figure 5.3.3 (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 the Bay of Bengal, sea level rise is projected to be in the range of 0.2m to 0.98m.



Source: IPCC WGI 5th Assessment Report)

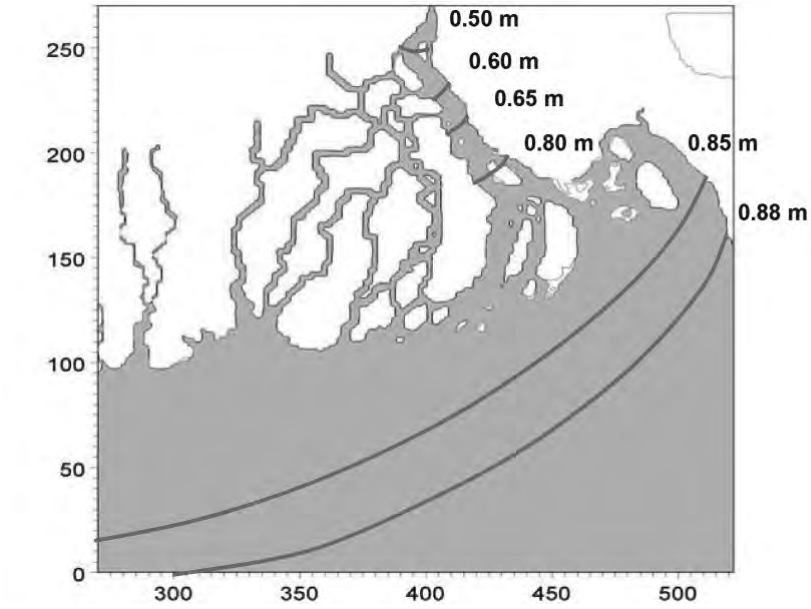
Figure 5.3.3 Global Surface Temperature Change

5.3.4 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 the "Impact Assessment of Climate Changes on the Coastal Zone of Bangladesh (IACCCZB)" by WARPO in 2005 and in the Padma Multipurpose Bridge Project in 2010. The result of IACCCZB shows water level along the Shahbazpur channel (Figure 5.3.4) in the case of a 0.88m-sea level rise.

Table 5.3.1 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 Rivers, but water is not predicted to rise near Jamuna Bridge (at Bahadurabad).



Source: IPCC WGI 5th Assessment Report

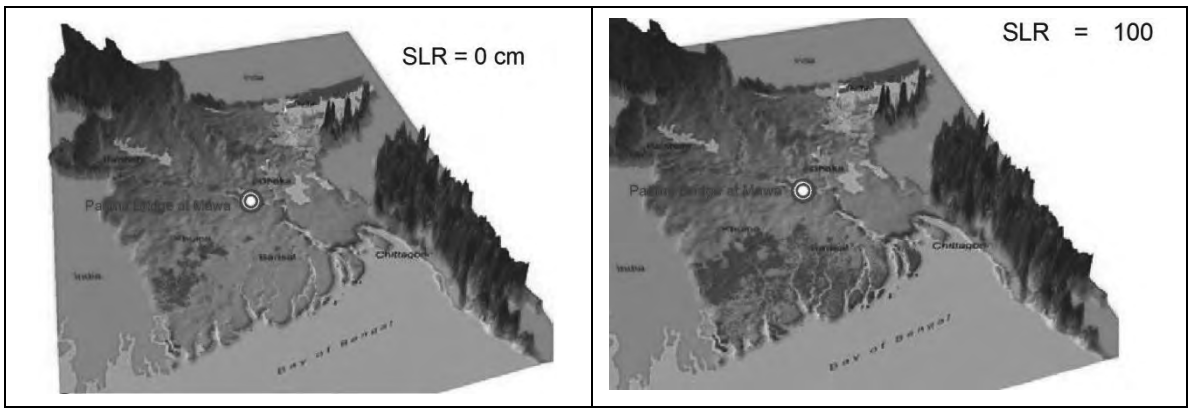
Figure 5.3.4 Increase in Water Level in Meghna Estuary due to 88 cm Sea Level Rise

Table 5.3.1 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: IPCC WGI 5th Assessment Report

Figure 5.3.5 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.

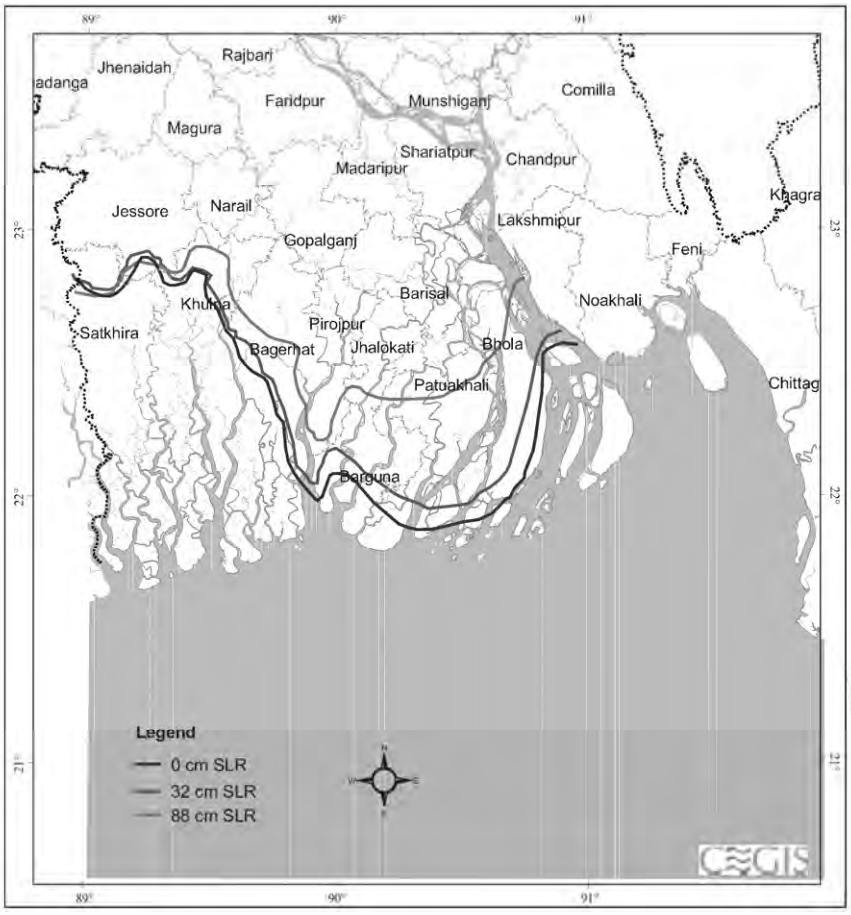


Source: Padma Multipurpose Bridge Project (2010)

Figure 5.3.5 Simulation of Sea Level Rise

(2) Intrusion of Saline Water

Sea level rise leads to saline water intrusion up coastal rivers. Figure 5.3.6 shows salinity ingress in southern coastal areas due to differing sea level rise projections by CEGIS.



Source: Source: BCCSAP, Original source: CEGIS

Figure 5.3.6 Simulation of Sea Level Rise

5.3.5 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 monsoons in 2040. Increase of peak flood level in the Jamuna river was predicted at about 37cm in a moderate flood event (2004 flood event) and 27cm in a normal flood event (2005 flood event) at Bahadurabad.

Table 5.3.2 shows the temperature and precipitation projections by the CMIP5 global models (scenario RCP4.5). The peak flood levels are predicted based on the hypothesis of the proportion of precipitation increase between the 4th IPCC predictions and CMIP5 predictions. In case of precipitation increasing of 33% in the period of June-August of 2065 and 37% in 2100, the increase in peak flood levels in the Jamuna River near Bahadurabad station is predicted at 94cm and 105cm respectively.

Table 5.3.2 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

5.3.6 Data and Expectancy

The considerable impacts due to climate change are shown in Table 5.3.3, which are the severest condition predicted from various surveys and researches.

Table 5.3.3 Impact due to Climate Change

Item	Impact
Temperature[*1]	Min.9.3°C ~ 46.5°C
Increase in Precipitation Projection[*2]	Increasing the precipitation by 27% per annum.
Increase in River High Water Level due to Sea Level Change[*3]	In case the sea level rises 0.98m, the high water level will be increased around 0.2m which is projected at the confluence of the Padma River and the Jamuna River. However, above effect is not projected near to the Jamuna Bridge (at Bahadurabad).
River High Water Level by Precipitation Projection[*4]	In case the precipitation increases by 33% in the period of June-August of 2065 and 37% in 2100, the increase in peak flood levels in the Jamuna River near Bahadurabad station is predicted at 94cm and 105cm respectively.
Wind Speed[*5]	35m/s

Source: *1 : Padma Multipurpose Bridge Design Project Final Report
*2 : IPCC WGI 5th Assessment Report
*3 : Impact Assessment of Climate Changes on the Coastal Zone of Bangladesh (IACCCZB), WARPO
*4 : Caluculated by JICA Survey Team based on IPCC WGI 5th Assessment Report
*5 : F/S Report for the Kanchpur, Meghna, Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation Project

5.3.7 Countermeasure against Climate Change

Considerations/necessary countermeasures against climate change shall be undertaken in detailed design stage, which are summarized in Table 5.3.4.

Table 5.3.4 Considerations/Countermeasures against Climate Change in D/D Stage

Item	Impact	Comparison with Considerations Undertaken in Basic Design	Countermeasure
Temperature Rise	Temperature both in minimum and maximum level rises. Minimum and maximum temperatures are expected to rise at 9.3℃ and at 46.6 ℃ in 2100 respectively.	Temperature change is one of the significant criteria for bridge design. In the basic design stage, the temperature however considered for steel and concrete bridges design remains within the limit specified from impact analysis.	No
Precipitation Projection	Increase in precipitation by 27% per annum.	Details of drainage design for road/bridge structures are not yet conducted. However, their drainage network should be designed on the basis of hourly precipitation intensity which should be predicted following an appropriate manner including the consideration of climate change impact.	To be considered in D/D stage
River High Water Level	Increase in river high water level due to sea level change and flooding effect.	The design high water level shown in Table 8.1.2 (Chap. 8) is determined based on the consideration of sufficient margin. It includes the freeboard provision and the impact of water level rise due to climate change. However, the freeboard provision underneath bridge girder can be increased in D/D stage, if appraised as necessary.	No (if significant, to be considered)
Wind Speed	Wind speed is 35 m/s.	Wind speed according to Japanese specification is determined at 40 m/s for Project Bridges design. However, to ensure additional safety in design, followings can be undertaken during D/D stage: – Confirmation of wind speed of 40 m/s at each bridge location; – Confirmation whether the altitude of design wind speed is necessarily to changed (standard altitude is 10 m); and – Correction of design wind load due to the shape and exposure area of each bridge.	To be considered in D/D stage

Source: JICA Survey Team

5.4 Meteorological and Hydrological Conditions

5.4.1 General

(1) General

Bangladesh is located in a tropical monsoon region, and the climate in the targeted area is characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. The most striking feature of its climate is the reversal of the wind circulation between summer and winter, which is an integral part of the circulation system of the South Asian subcontinent. From the climatic point of view, three distinct seasons can be recognized in Bangladesh: the cool dry season from November through February, the pre-monsoon hot season from March through May, and the rainy monsoon season which lasts from June through October.

Bangladesh is well-known as a low-lying riverine country (water country) located in southern Asia. A flat and 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 an average 20 per cent of Bangladesh is flooded annually.

Bangladesh has three major predominant river systems; (1) the Brahmaputra-Jamuna, (2) the Ganges-Padma, and (3) the Surma-Meghna River system. In total, the Bangladesh has riverine systems with a total number of about 700 rivers including tributaries, which have a total length of about 24,140 km, as shown in Figure 5.4.1.

(2) Flooding Characteristics in Target Areas

In order to understand the flooding characteristics for each area in Bangladesh, an understanding of the principal physiographic conditions for each flooding area is necessary. (See Figure 5.4.1, Figure 5.4.2 and Figure 5.4.3) The targeted areas in this study have the following physiographic characteristics.

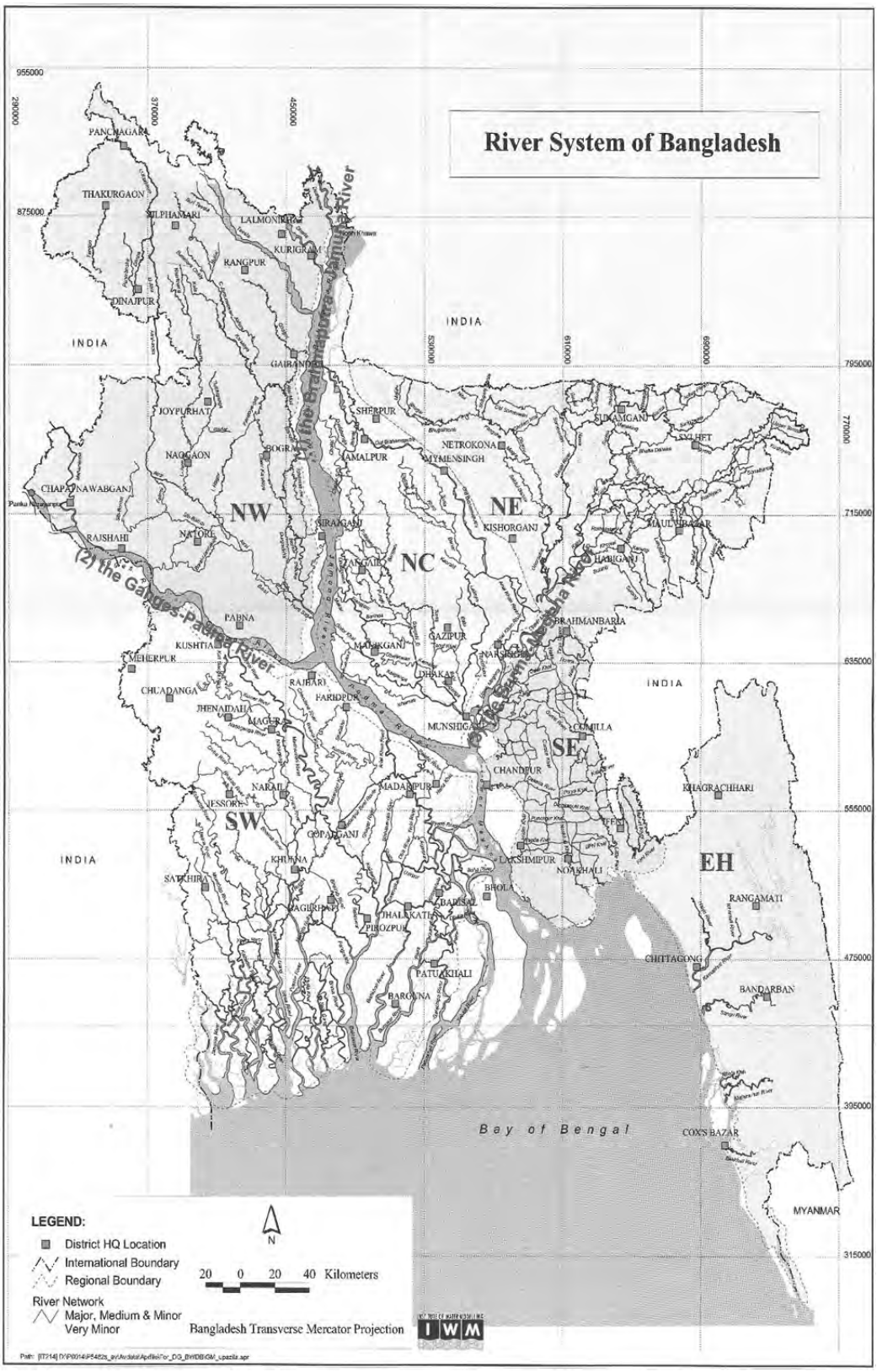
In the areas of Section A of this study, the physiographic features can define as the Deltaic plains. The deltaic plains are drained by innumerable distributaries of the Ganga River. It is characterized by a gentle slope and a complex river system, the river courses crisscrossing each other. These lands continually change in extent and elevation owing to river bank erosion and new alluvial deposition. They are subject to annual flooding by the rivers or rainwater.

The areas of Section B can be defined as a Flood plain or Hills. Hills, tertiary and older, exist only in the east and south-east of the country, in the Comilla and Chittagong areas, with maximum elevations of approximately 700 m. The folded Chittagong Hill Tract Ranges are densely forested, and sparsely populated and the flood plain occupies a large part of the country. The areas close to the major rivers host young alluvial lands with mixed sandy and silty soils. The areas of the floodplain located away from the main river courses are older and more stable. They are characterized by a micro relief, with 2-5 meters of difference in elevation between the ridge tops and

the depressions, and by many active or old river channels. Flooding in these areas is mainly caused by rainwater.

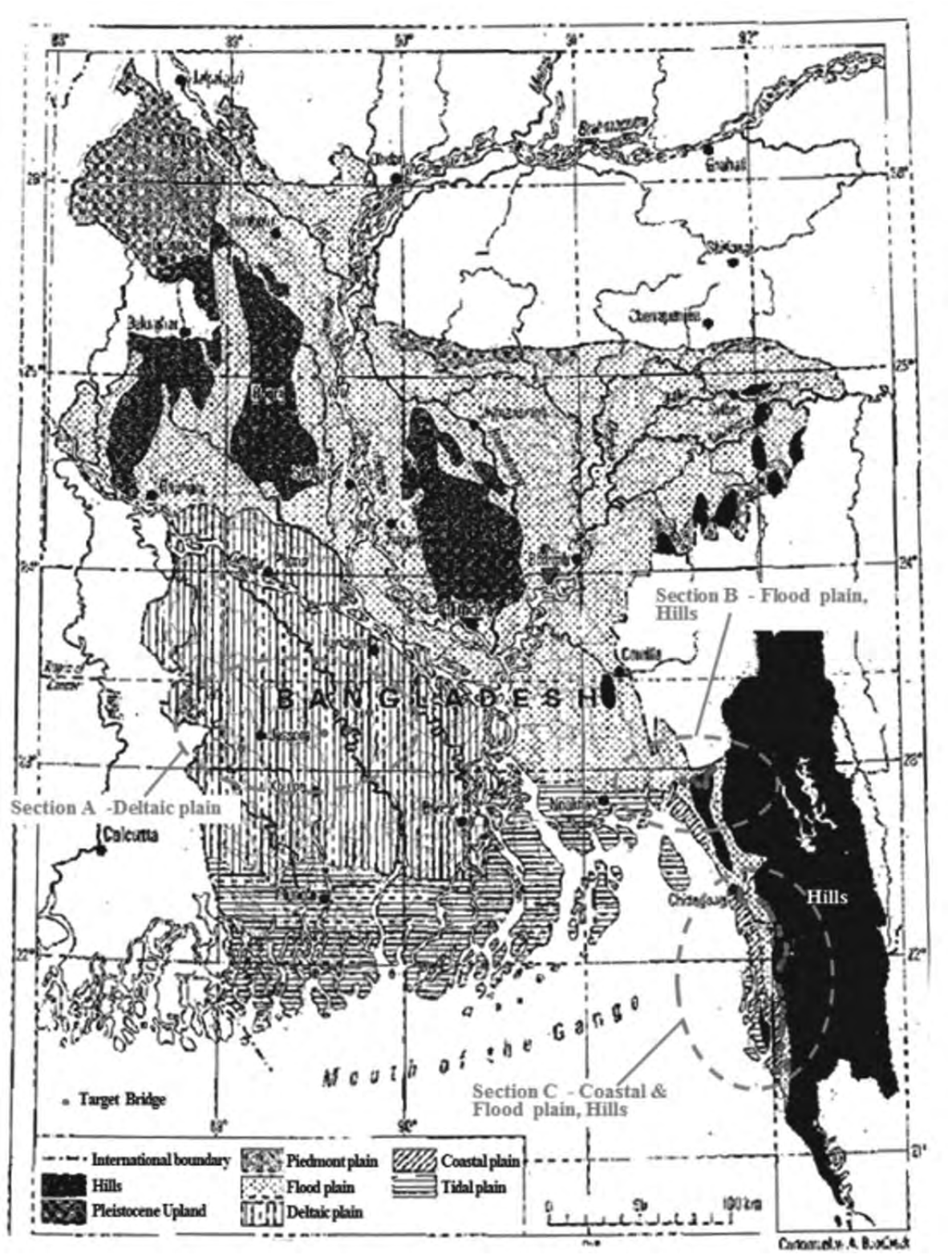
The areas of Section C have all the physiographic characteristics of Section B, and since it is close to the coast, also have the characteristics of the coastal plains. The coastal plains in the Chittagong area occupy a narrow strip of land between the Chittagong Hills and the sea. The area is often subjected to shallow flooding and flash floods from the hills. It is also exposed to the tropical cyclones and the associated storm surges. Ingress of saline water at high tides is a major handicap for agriculture.

Based on these physiographic units, it is evident that large parts of the territory of these study areas are potentially flood-affected areas and that the flooding characteristics need to be regionally differentiated.



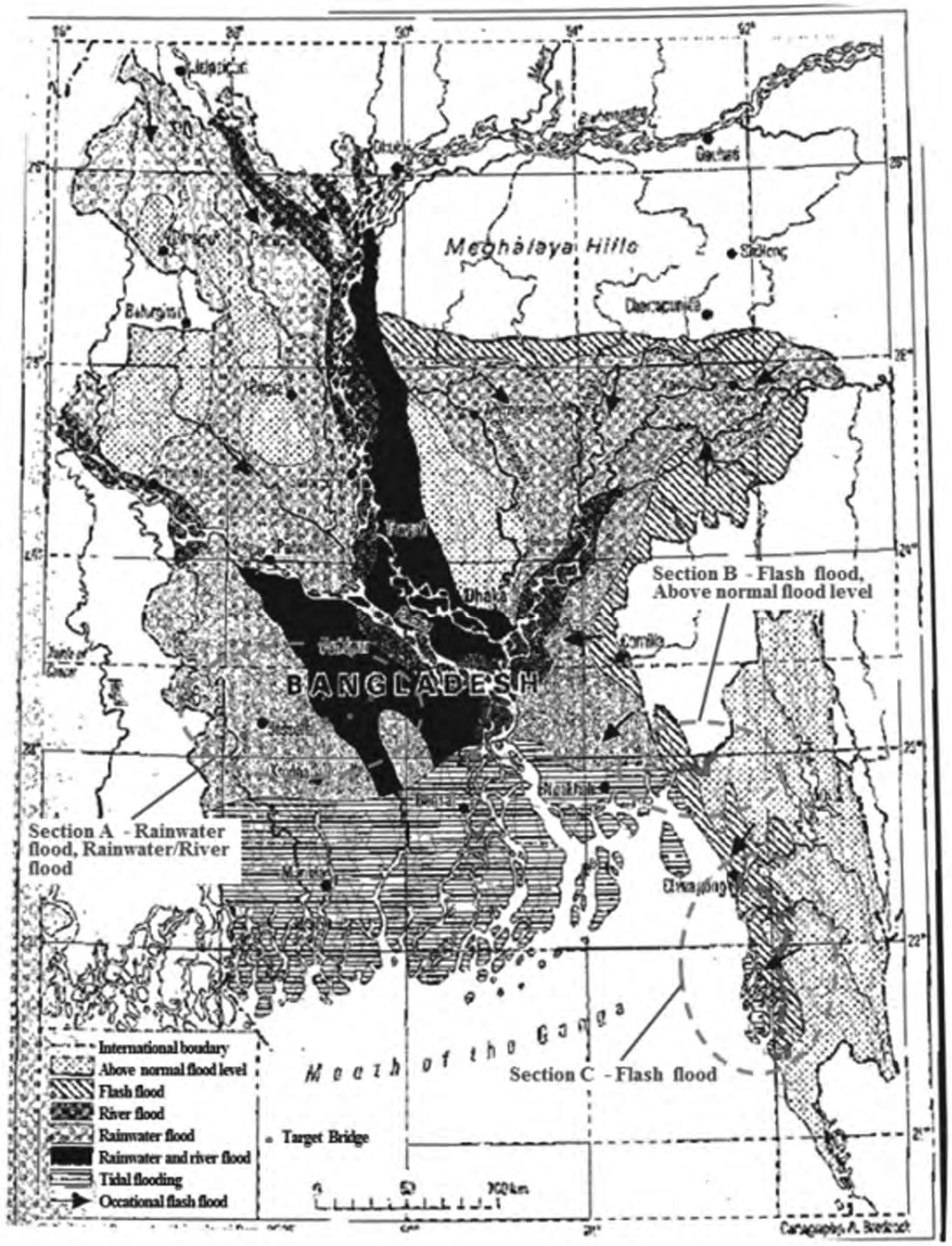
Source: BWDB, Institute of Water Modeling (IWM)

Figure 5.4.1 Riverine Network in Bangladesh



Source: Floods in Bangladesh: History, dynamics and rethinking the role of the Himalayas (Thomas Hofer and Bruno Messerli, United Nations University, 2006)

Figure 5.4.2 Main Physiographical Units of Bangladesh



Source: Floods in Bangladesh: History, dynamics and rethinking the role of the Himalayas (Thomas Hofer and Bruno Messerli, United Nations University, 2006)

Figure 5.4.3 Flood Types in Bangladesh

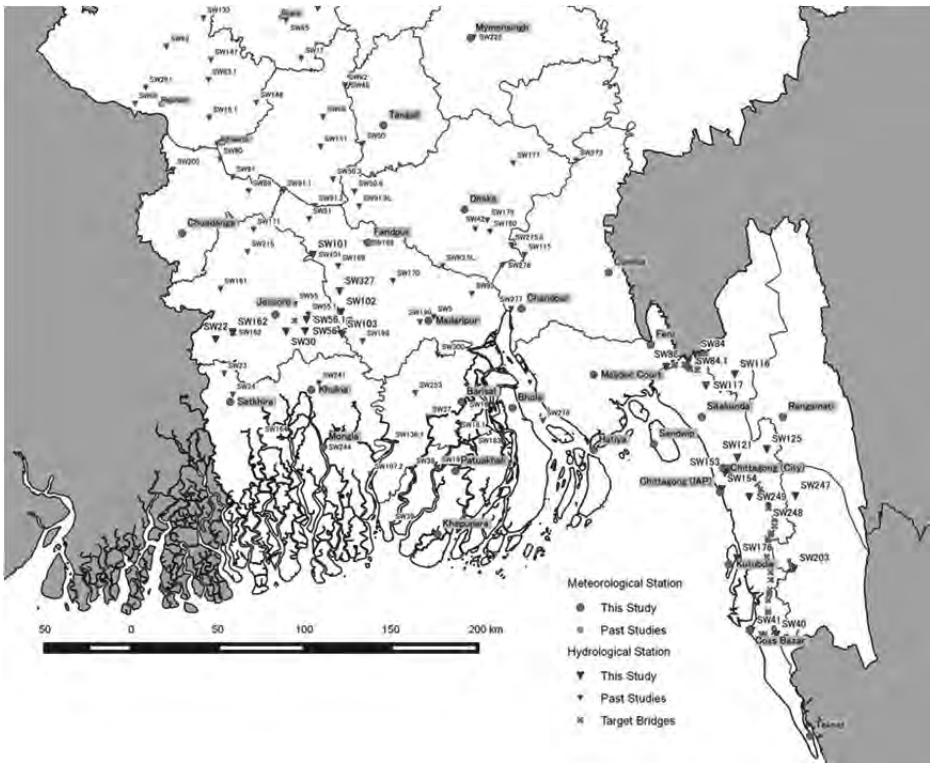
(3) Data Collection Items

Regarding meteorology and Hydrology data in Bangladesh, the meteorological data is handled by BMD (Bangladesh Meteorological Department) under the MoD (Ministry of Defense), and the hydrological data is handled by BWDB (Bangladesh Water Development Board) under the MoWR (Ministry of Water Resources).

There are 35 synoptic observation stations for climatic data under BMD of Bangladesh. Of these stations, the climatic data of the related 27 stations closest to the proposed bridges have been collected, in addition to the data of past JICA studies. The collection data items concerning the climate are temperature, relative humidity, wind speed/direction, sunshine hours, evapotranspiration and rainfall.

There are about 500 gauging stations for hydrological data under BWDB. Of these stations, the hydrological data of the 31 stations closest to the proposed bridges have been collected, in addition to the data of past JICA studies. The collection data items concerning the hydrology are annual maximum water level, annual maximum discharge, daily discharge, and past bathymetric survey results of related rivers. Also, in order to verify the hydrological characteristics etc., field reconnaissance, interviews with the residents, bibliographic investigations, and statistical tidal conditions have been surveyed.

The data collection items and the locations of related stations are shown in Figure 5.4.4 and Table 5.4.1.



Source: JICA Survey Team

Figure 5.4.4 Location of Observed Stations Selected for Data Collection

Table 5.4.1 Data Collection for Meteorological and Hydrological Survey

Survey Items			Unit	Quantity	Survey Contents	Related Organization
Meteorological Survey						
01.	Ovservation data collection					
		Information of Meteorological Stations	-	14 stations	Related Meteorological Stations: Station Code, Coordinates, Height, Period of Records, etc.	BMD (Bangladesh Meteorological Department)
		Monthly Temperature (Average, Max., Min.)	℃	More than 10 years at 14 stations	Related 14 stations	
		Monthly Relative Humidity (Average)	%	Ditto	Ditto	
		Wind Speed, Direction (Max., Average)	m/s (,knots)	Ditto	Ditto	
		Monthly Evaporation (Average)	mm/day-1hr	Ditto	Ditto	
		Monthly Sunshine Hours (Average)	hr/day	Ditto	Ditto	
		Monthly Rainfall	mm/month	More than 20 years at 14 sta.	Ditto	
		Annual Maximum Rainfall / 24hr, (12hr, 6hr, 3hr,) 1hr	mm/day-1hr	Ditto	Ditto	
		Rainfall Intensity Curve (Equation)	-	(If they have it, ...)	Ditto	
Hydrological Survey						
02.	Ovservation data collection					
		Information of Hydrological Stations	-	25-30 stations	Related Hydrological Stations: Station Code, Coordinates, Catchment Area, Type of Gauge, Height, Period of Records, River Cross-section at station, difference between zero of gauge and survey datum, etc.	BWDB (Bangladesh Water Developemt Board)
		Annual Maximum Water Level	m	More than 20 years at 25-30 sta.	Ditto	
		Annual Maximum Discharge	m^3/sec	More than 20 years at 5-8 sta.	Related Hydrological stations	
		Daily Discharge	m^3/sec	More tha 5 years at 5-8 sta.	Ditto	
03.	Ovservation data collection of sea					
		Tidal Condition (Chart datum, etc.)	m	2-3 stations	Water level concerning HHWL, HWL, MSL, LWL, LLWL, etc.. Tidal table, etc.	Hydrographic Department of Bangladesh Navy
04.	Bathymetric Survey Results' data collection					
		Bathymetry Survey Results for Related Rivers of proposed bridges	-	10 (All of Related Rivers)	(Newest and Past bathymetric data)	BIWTA (Bangaladesh Inland Water Transport Authority), BWDB

Source: JICA Survey Team

5.4.2 Meteorology

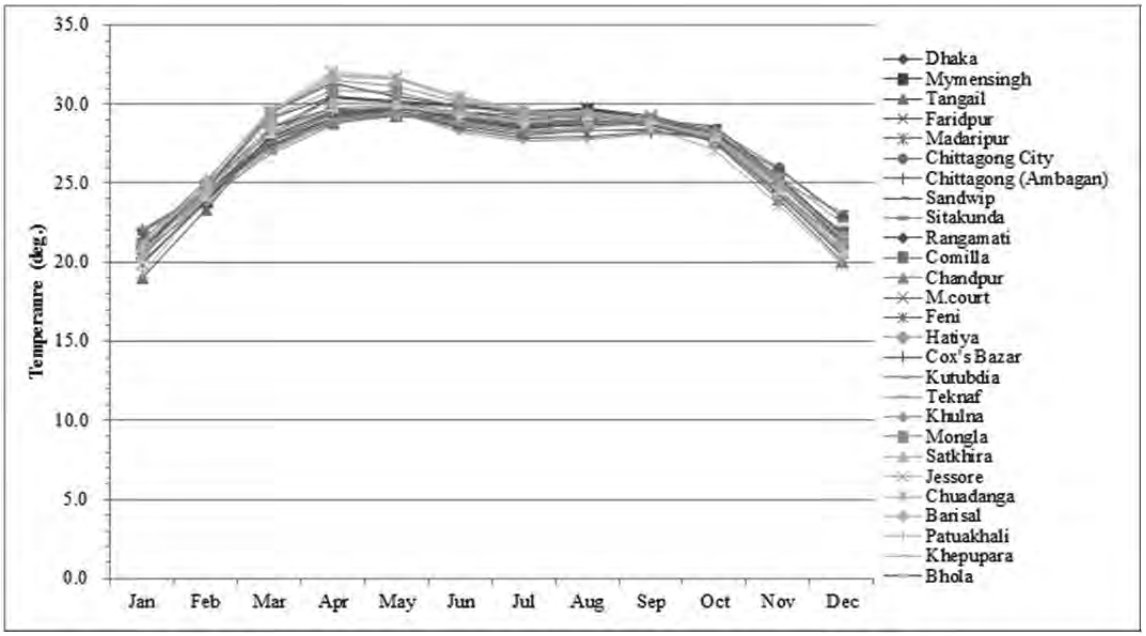
(1) General Weather Conditions

1) Temperature

The mean monthly temperature (at 12:00) during the past 35 years at related stations is shown in Figure 5.4.5. Temperature is observed daily at 0:00, 3:00, 6:00, 9:00, 12:00, 15:00, 18:00 and 21:00 hours at each station.

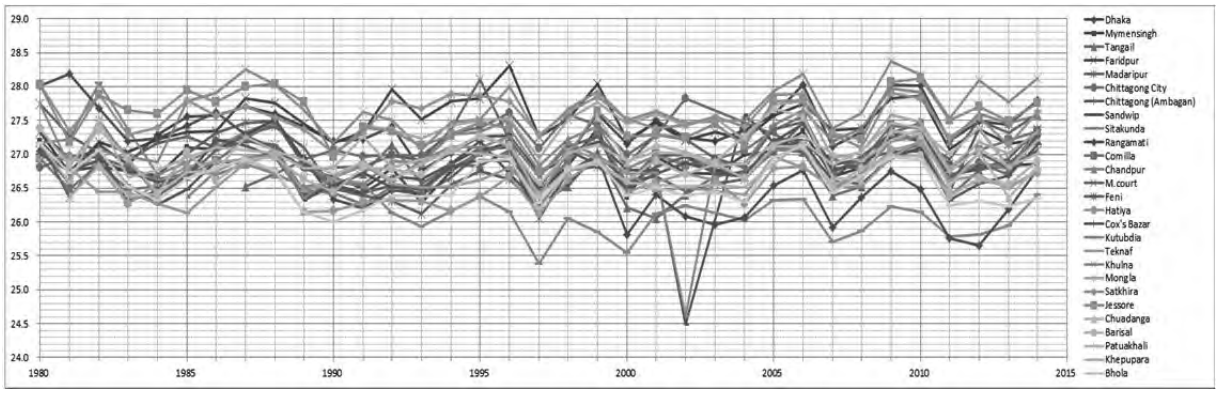
The temperature data of related stations show similar trends. January is the coldest month in the targeted area. On the other hand, the peak for maximum temperature is observed in April-May. The mean temperature in the targeted area varies from roughly 19°C in Western Bangladesh to 32°C in the Southeast.

Also, the long-term fluctuation of annual mean temperature (at 12:00) is shown in Figure 5.4.6. However, from this Figure, it is not recognized that a rising trend of annual mean temperature has been going on in recent years.



Source: BMD

Figure 5.4.5 Mean Monthly Temperature (at 12:00, 27 Stations)



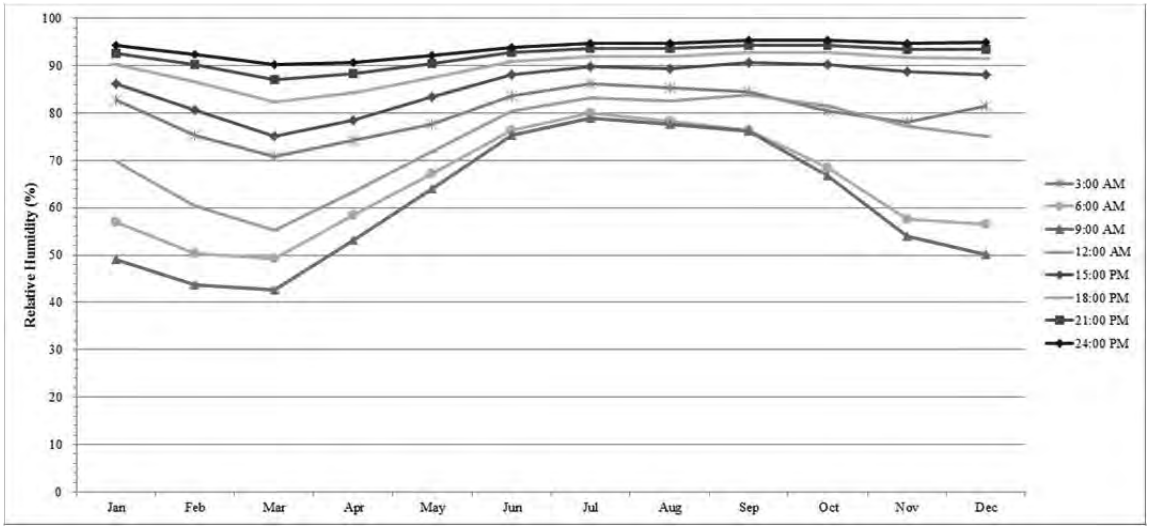
Source: JICA Survey Team

Figure 5.4.6 Long-term Fluctuation of Annual Mean Temperature (at 12:00, 27 Stations)

2) Relative Humidity

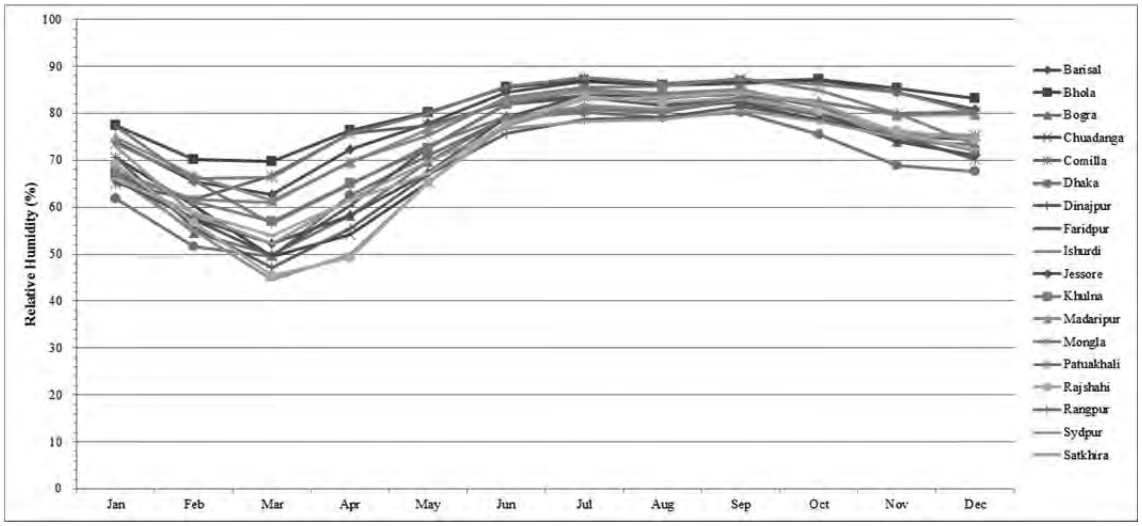
The monthly mean 3 hourly relative-humidity at 18 stations during 1969-2013 is shown in Figure 5.4.7. And the monthly mean relative-humidity at noonday of each station is shown in Figure 5.4.8.

The daily fluctuation of relative-humidity is higher during dry season and is lower at rainy season. The lowest average monthly relative-humidity is occurs in February-March and the highest average relative-humidity occurs throughout the rainy season. However, the relative-humidity is high throughout the entire year, and the maximum humidity reaches 100% a few times a year.



Source: BMD

Figure 5.4.7 Monthly Mean 3 hourly Relative-Humidity at Collected 18 Stations



Source: BMD

Figure 5.4.8 Monthly Mean Relative-Humidity each Station (at 12:00, 18 Stations)

3) Wind Speed and Direction

The monthly maximum and mean wind speed at 18 stations are shown in Table 5.4.2. (Monthly Mean Wind is shown in Figure 5.4.9. And the wind-rose which is reflected the distribution of wind direction and speed at Jessore and Comilla, is shown in Figure 5.4.10 and Figure 5.4.11.)

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, as shown in the wind-rose.

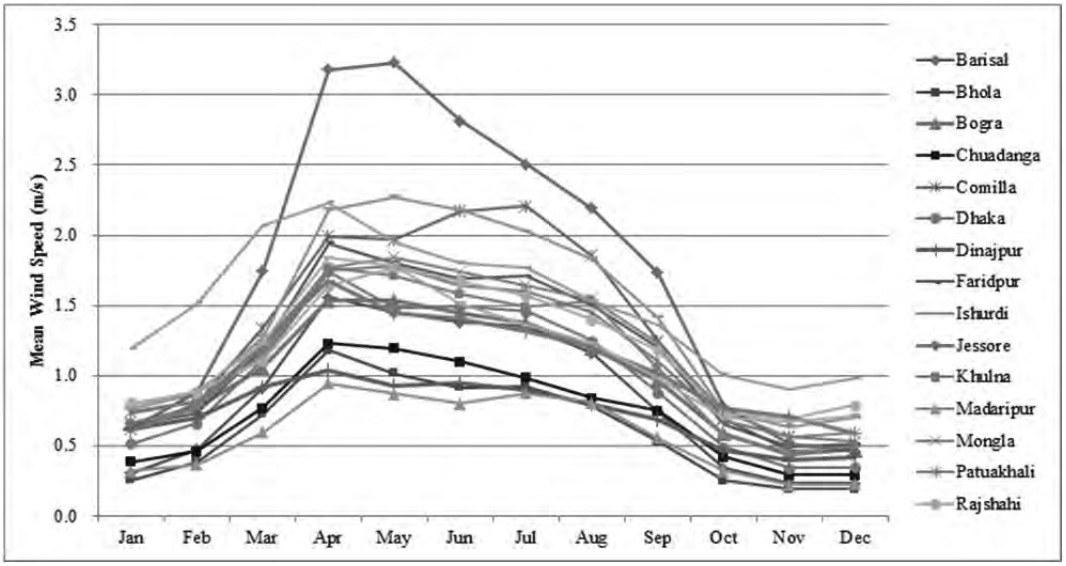
The mean wind speed is in the range of about 0.5-2.5m/s, except in Jessore where it can reach about 3.2m/s. The data given for the maximum wind speed has been affected by a cyclone in Southern Bangladesh, and it varies from 20.6m/s of Dinajpur to 50.9m/s of Jessore.

Table 5.4.2 Monthly Mean and Maximum Wind Speed at 18 Stations (1969-2013)

Station Name	Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Remarks
Barisal	Mean	0.31	0.48	0.91	1.56	1.45	1.38	1.35	1.16	0.74	0.34	0.24	0.23	0.85	
	Max.	18.5	18.5	16.5	20.6	33.4	30.9	26.8	50.9	15.9	36.0	41.2	25.7	**50.9**	
Bhola	Mean	0.26	0.39	0.73	1.18	1.02	0.92	0.93	0.79	0.53	0.26	0.19	0.19	0.61	
	Max.	6.7	11.3	14.4	26.2	19.5	15.4	47.3	12.9	36.0	12.9	25.7	23.7	47.3	
Bogra	Mean	0.65	0.77	1.06	1.53	1.53	1.44	1.37	1.20	0.97	0.59	0.44	0.48	1.00	
	Max.	22.1	25.7	19.0	46.3	26.2	20.6	36.0	46.3	36.0	12.9	34.5	8.7	46.3	
Chuadanga	Mean	0.39	0.46	0.77	1.23	1.20	1.10	0.99	0.84	0.75	0.42	0.29	0.29	0.73	1989-2014
	Max.	18.5	8.2	14.4	28.8	11.3	7.2	6.2	10.3	7.2	7.2	5.1	4.1	28.8	
Comilla	Mean	0.62	0.81	1.34	1.99	1.97	2.17	2.21	1.86	1.25	0.70	0.46	0.47	1.32	
	Max.	12.3	10.3	41.2	28.3	38.6	49.4	37.0	15.9	15.9	10.8	12.9	12.9	49.4	
Dhaka	Mean	0.52	0.66	1.11	1.74	1.49	1.50	1.46	1.25	0.88	0.49	0.34	0.35	0.98	
	Max.	8.7	26.2	19.0	36.0	26.8	12.9	15.9	12.9	26.2	26.2	19.0	13.9	36.0	
Dinajpur	Mean	0.62	0.70	0.91	1.04	0.93	0.95	0.90	0.80	0.69	0.47	0.40	0.42	0.74	1969-1972, 1981-2014
	Max.	5.1	7.7	12.9	20.6	18.0	7.7	6.2	10.8	14.4	10.3	5.1	11.8	20.6	
Faridpur	Mean	0.65	0.73	1.19	1.95	1.80	1.69	1.71	1.50	1.20	0.66	0.49	0.51	1.17	
	Max.	36.0	41.2	30.9	15.9	48.9	36.0	17.0	36.0	25.7	30.9	12.9	46.3	48.9	
Ishurdi	Mean	0.76	0.87	1.28	2.18	2.27	2.18	2.03	1.83	1.41	0.75	0.64	0.70	1.41	
	Max.	10.3	10.3	18.0	20.6	15.9	16.5	26.8	41.2	26.8	15.4	23.1	13.9	41.2	
Jessore	Mean	0.63	0.88	1.74	3.18	3.23	2.82	2.51	2.19	1.73	0.78	0.52	0.46	1.72	
	Max.	46.3	41.2	36.0	37.0	45.3	21.1	47.3	21.1	41.2	46.3	30.9	20.6	47.3	
Khulna	Mean	0.66	0.78	1.17	1.77	1.71	1.58	1.49	1.53	1.05	0.58	0.45	0.50	1.11	1969-1974, 1976-2014
	Max.	15.9	48.9	20.6	47.3	31.4	30.9	26.2	23.1	33.4	23.1	33.4	33.4	48.9	
Madaripur	Mean	0.32	0.37	0.60	0.95	0.87	0.80	0.88	0.81	0.56	0.32	0.23	0.23	0.58	1977-2014
	Max.	6.2	9.8	15.9	10.8	19.0	12.9	12.9	12.9	10.8	11.3	36.0	11.8	36.0	
Mongla	Mean	0.74	0.82	1.13	1.77	1.84	1.74	1.65	1.54	1.24	0.75	0.56	0.59	1.20	1989-2014
	Max.	5.1	7.7	9.3	23.1	12.9	13.4	9.3	12.9	15.4	12.9	19.5	6.2	23.1	
Patuakhali	Mean	0.74	0.81	1.23	1.75	1.78	1.64	1.61	1.45	1.10	0.69	0.57	0.53	1.16	1973, 1975-1979, 1981-2014
	Max.	25.7	20.6	20.6	27.3	27.3	41.2	15.4	47.3	30.9	49.9	32.9	23.1	49.9	
Rajshahi	Mean	0.81	0.88	1.11	1.64	1.77	1.68	1.57	1.40	1.18	0.73	0.70	0.79	1.19	
	Max.	12.9	20.6	9.3	14.9	36.5	13.4	13.4	26.2	23.1	27.3	10.8	10.3	36.5	
Rangpur	Mean	0.61	0.78	1.22	1.68	1.45	1.40	1.32	1.21	1.02	0.77	0.71	0.59	1.06	1969-1973, 1975-2014
	Max.	13.9	47.3	30.9	41.7	23.1	13.4	25.7	46.3	36.0	25.7	46.3	20.6	47.3	
Sydpur	Mean	1.19	1.51	2.07	2.23	1.95	1.80	1.77	1.54	1.36	1.01	0.90	0.98	1.53	1991-2014
	Max.	9.3	13.9	20.6	15.4	18.0	12.3	9.3	13.4	10.3	15.4	12.9	10.3	20.6	
Satkhira	Mean	0.77	0.90	1.23	1.84	1.78	1.52	1.36	1.23	0.98	0.71	0.67	0.72	1.14	
	Max.	11.8	12.9	12.3	18.0	33.4	36.0	26.8	15.9	10.8	14.4	18.0	30.9	36.0	

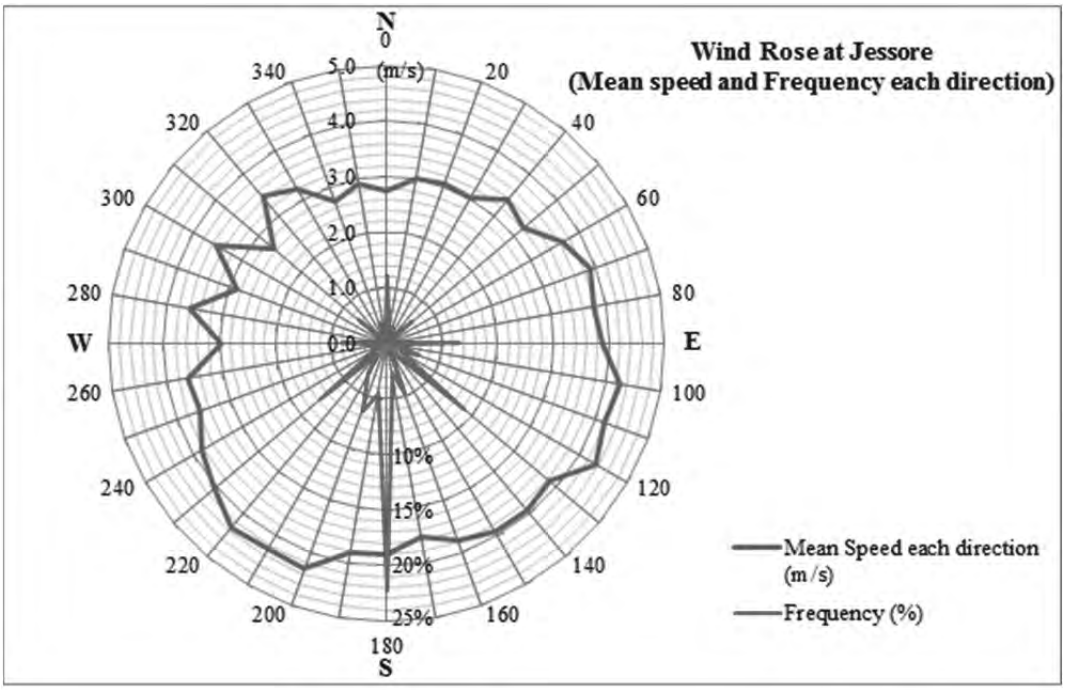
Note. In the mean wind speeds of above Table, it is included the calm (no wind).

Source: BMD



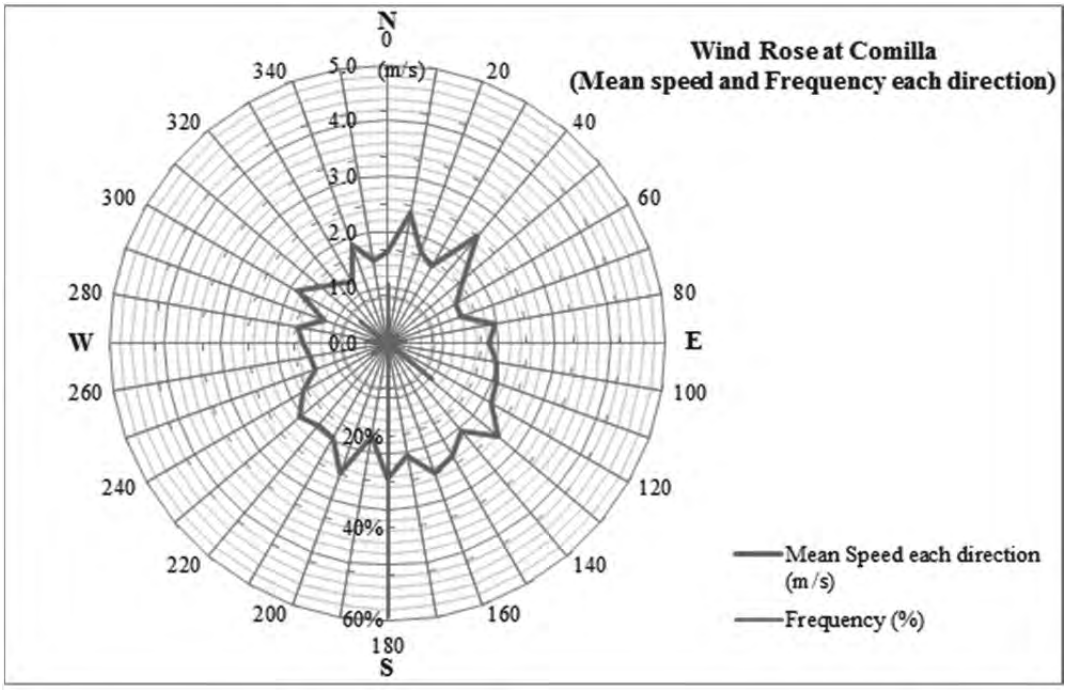
Source: BMD

Figure 5.4.9 Monthly Mean Wind Speed at 18 Stations



Note: In the mean wind speeds of above Figure, it is excluded the calm (no wind).
Source: JICA Survey T,eam, BMD

Figure 5.4.10 Wind Rose at Jessore Station (1969-2013)



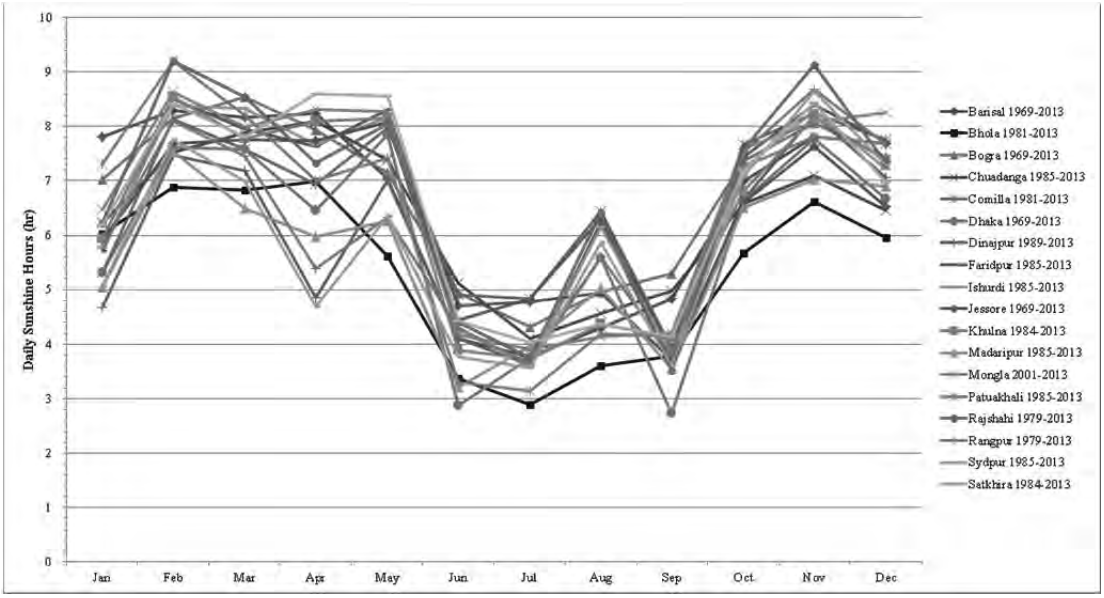
Note: In the mean wind speeds of above Figure, it is excluded the calm (no wind).
Source: BMD

Figure 5.4.11 Wind Rose at Comilla Station (1969-2013)

4) Sunshine Hours

The monthly mean sunshine hours at 18 stations is shown in Figure 5.4.12.

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.

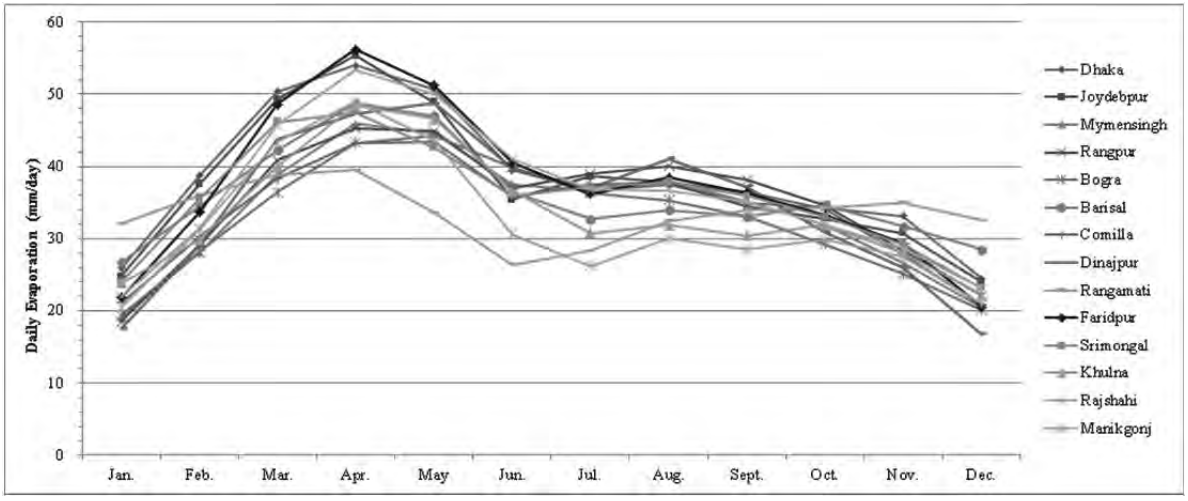


Source: BMD

Figure 5.4.12 Monthly Mean Sunshine Hours at 18 Stations

5) Evaporation

The monthly mean evaporation at 14 stations is shown in Figure 5.4.13. The evaporation is higher at April, and the seasonal pattern is similar to them of temperature.



Source: BMD

Figure 5.4.13 Monthly Mean Evaporation at 14 Stations

(2) Rainfall

1) Monthly and Annual Mean Rainfall

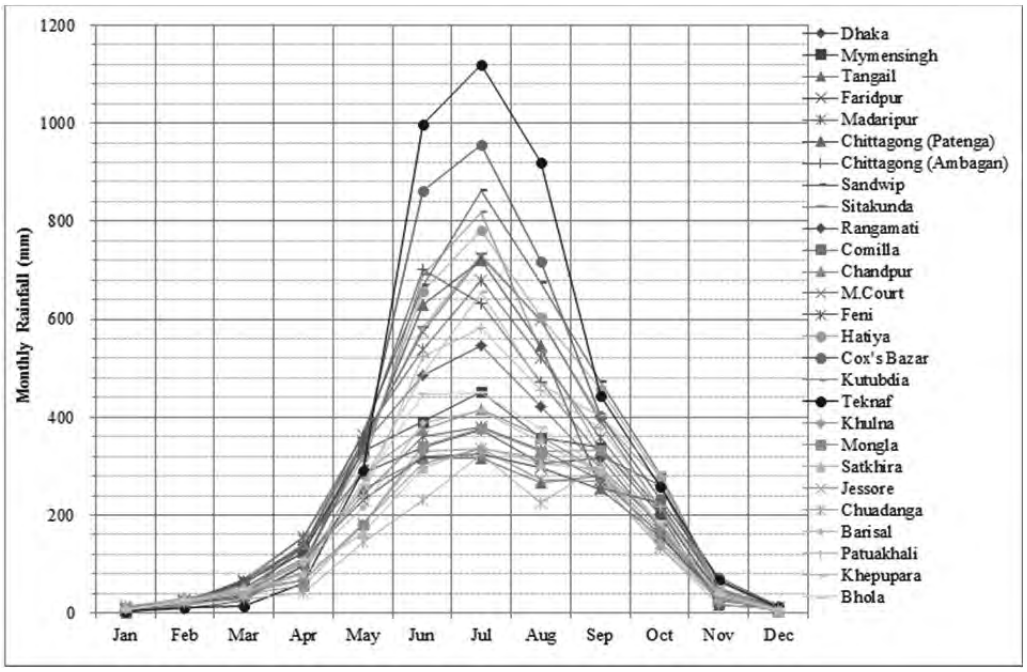
The monthly mean rainfall at 27 stations is shown in Figure 5.4.14 and Table 5.4.3.

Bangladesh is in a 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 cycle of temperature. The winter season accounts for only 2% 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, varies from 101mm in the mid-western Rajshahi to over 1120mm in the south-eastern Teknaf, and its fluctuation range is drastic, as shown in Figure 5.4.15. Geographic distribution of annual mean rainfall in Bangladesh shows a variation from 1456mm in the mid-western Chuadanga to 4203mm in the south-eastern Teknaf, as shown in Table 5.4.3.

Table 5.4.3 Mean Monthly Rainfall at 27 Stations (mm)

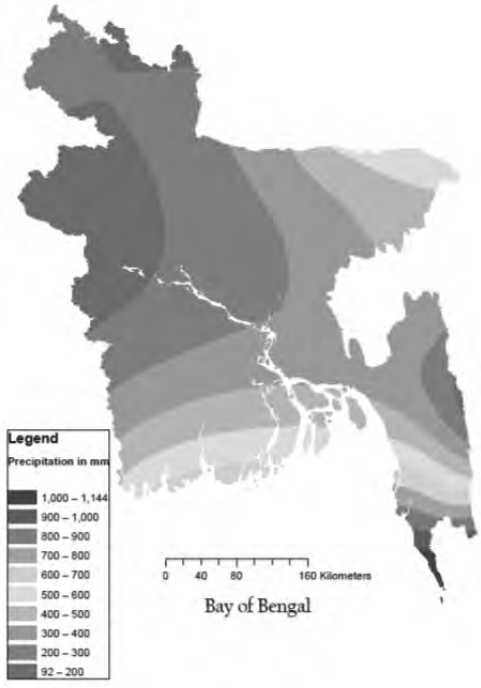
Station	Observed Period	Annual Rainy Days	Monthly Rainfall												Total	Remarks
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Dhaka	1980 - 2014	120.7	7	21	59	139	285	339	375	304	317	173	31	11	2,060	
Mymensingh	1980 - 2014	124.0	7	19	37	136	329	390	451	359	338	200	16	9	2,290	
Tangail	1987 - 2014	109.8	6	23	42	105	253	318	317	267	279	157	26	10	1,802	
Faridpur	1980 - 2014	113.4	7	26	47	111	232	318	326	297	252	156	34	11	1,816	
Madaripur	1980 - 2014	114.3	6	21	47	104	243	361	380	333	272	163	32	4	1,966	
Chittagong (Patenga)	1980 - 2014	116.2	6	23	50	124	331	630	721	547	256	225	50	12	2,974	
Chittagong (Ambagan)	1999 - 2014	119.8	6	8	26	99	359	701	633	472	322	261	37	12	2,936	
Sandwip	1980 - 2014	118.1	9	24	61	133	368	669	862	673	471	284	47	7	3,606	
Sitakunda	1980 - 2014	121.7	5	17	69	155	348	583	733	596	400	264	48	6	3,226	
Rangamati	1980 - 2014	129.9	5	22	64	124	343	487	547	423	297	181	49	11	2,552	
Comilla	1980 - 2014	113.0	7	19	61	133	323	359	393	314	252	158	32	9	2,060	
Chandpur	1981 - 2014	114.9	6	21	59	141	286	375	416	361	289	165	36	6	2,161	
M.Court	1980 - 2014	124.3	10	24	68	136	352	575	727	598	391	214	34	6	3,134	
Feni	1980 - 2014	117.7	5	24	64	156	363	539	678	521	358	205	42	8	2,963	
Hatiya	1980 - 2014	123.4	4	15	34	109	318	656	781	605	456	276	40	8	3,199	
Cox's Bazar	1980 - 2014	128.4	5	20	32	97	335	863	955	717	403	233	73	14	3,747	
Kutubdia	1985 - 2014	112.7	6	22	41	84	298	690	818	534	334	221	63	8	3,119	
Teknaf	1980 - 2014	125.1	3	13	14	61	293	998	1120	920	444	257	68	13	4,203	
Khulna	1980 - 2014	114.6	12	32	51	68	180	331	337	316	289	145	36	6	1,802	
Mongla	1991 - 2014	119.6	10	25	38	57	180	340	378	330	332	178	37	3	1,908	
Satkhira	1980 - 2014	112.8	13	29	40	81	163	296	339	304	294	143	31	7	1,741	
Jessore	1980 - 2014	108.7	14	24	42	67	184	305	335	273	270	132	28	10	1,684	
Chuadanga	1989 - 2014	101.4	11	20	27	43	145	229	325	224	301	135	18	8	1,489	
Barisal	1980 - 2014	119.9	10	23	50	100	217	387	414	350	286	183	43	5	2,068	
Patuakhali	1981 - 2014	125.8	8	22	41	103	243	525	581	455	376	217	49	4	2,625	
Khepupara	1980 - 2014	125.5	9	21	46	82	270	489	653	467	402	287	52	7	2,785	
Bhola	1980 - 2014	121.4	7	26	48	109	262	445	450	376	298	186	37	6	2,250	
Average		118.4	8	22	47	106	278	489	557	442	333	200	40	8	2,525	

Source: BMD



Source: BMD

Figure 5.4.14 Mean Monthly Rainfall at 27 Stations



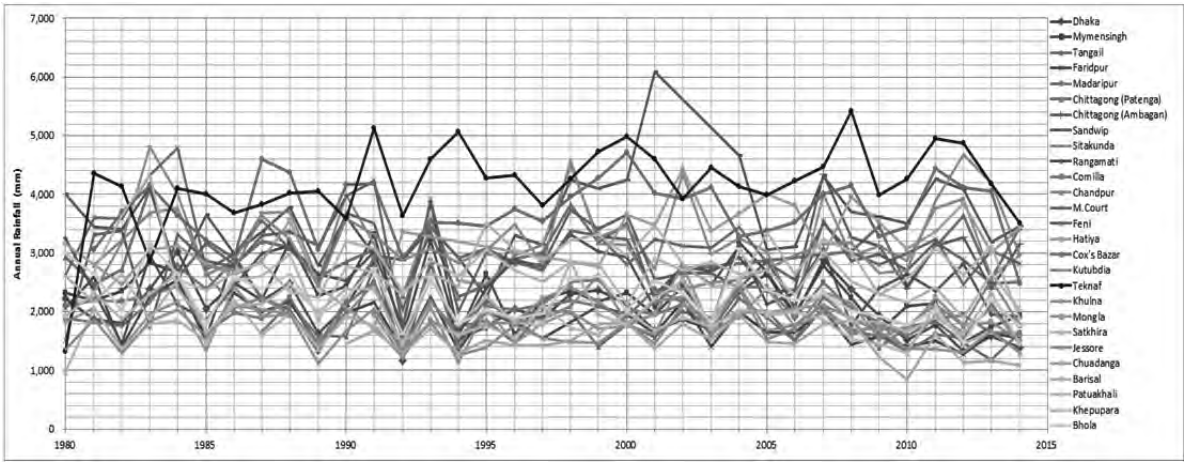
Source: BMD

Figure 5.4.15 Monthly Isopluvial Map for July, 2013

2) Long-term Fluctuation of Annual Rainfall

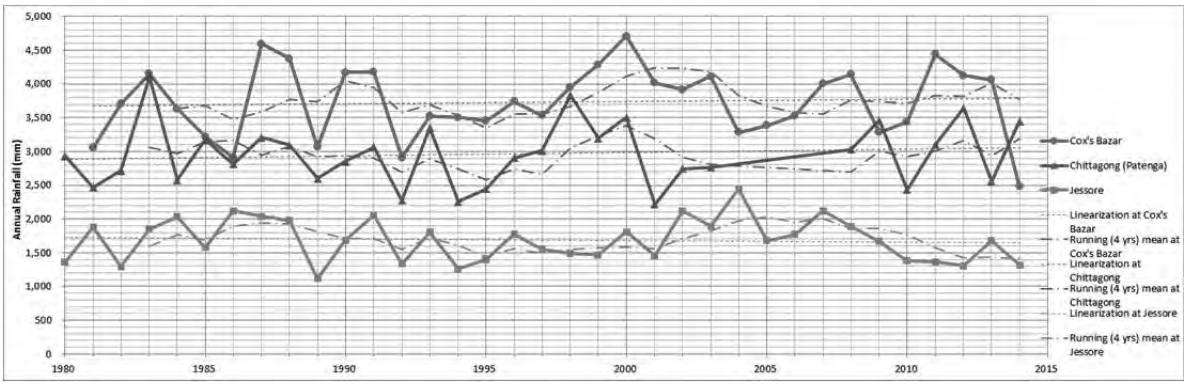
The long-term fluctuation of annual rainfall during the past 35 years at 27 stations is shown in Figure 5.4.16. There are long-term fluctuations of annual rainfall in the 27 stations, and the range of fluctuation varies from 850mm to 6090mm in each station. Here, as an example, Figure 5.4.17 shows the long-term fluctuation of annual rainfall and their approximate optimization by using the 4

year's "running mean (moving average)" and "linearization" at Jessore, Chittagong and Cox's Bazar. Although the cycle of wet and dry periods is not clear, the clear periods of the wet and dry are recognized in this Figure. Also, from this Figure, it is recognized that a marginal upward trend in annual rainfall is going on in Chittagong and Cox's Bazar.



Source: JICA Survey Team

Figure 5.4.16 Long-term Fluctuation of Annual Rainfall at 27 Stations



Source: JICA Survey Team

Figure 5.4.17 Annual Rainfall Fluctuation and Approximate Curve (4 year Running Mean, Linearization) at Cox's Bazar, Chittagong and Jessore

3) Exceedance Probability and Intensity Curve of Rainfall

The annual maximum daily rainfall (extreme value) data at 35 stations of Bangladesh are collected. From the extreme values of the related 16 stations among of them, 24-hour probability rainfall is calculated as shown in Figure 5.4.18.

On the other hand, in order to estimate the intensity of short duration rainfall from the 24-hour rainfall, the rainfall intensity at this study area is estimated in reference to the example at Dhaka calculated by another project ("Detailed Design for Kanchpur, Meghna and Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation", 2015, JICA fund). In concrete terms, the conversion factor is calculated as the ratio of the calculated value of a 24-hour probability rainfall

between Dhaka and each section. And the design rainfall intensity for each Section is estimated by multiplying Dhaka's value by conversion factors for each Section. The conversion factor for each Section and the rainfall intensity formula at Dhaka are follows:

$I = k*a /(T^b + c)$,

Where, I: Rainfall Intensity (mm/hour)

T: Concentration Time (hours, = Inlet Time + Travel Time)

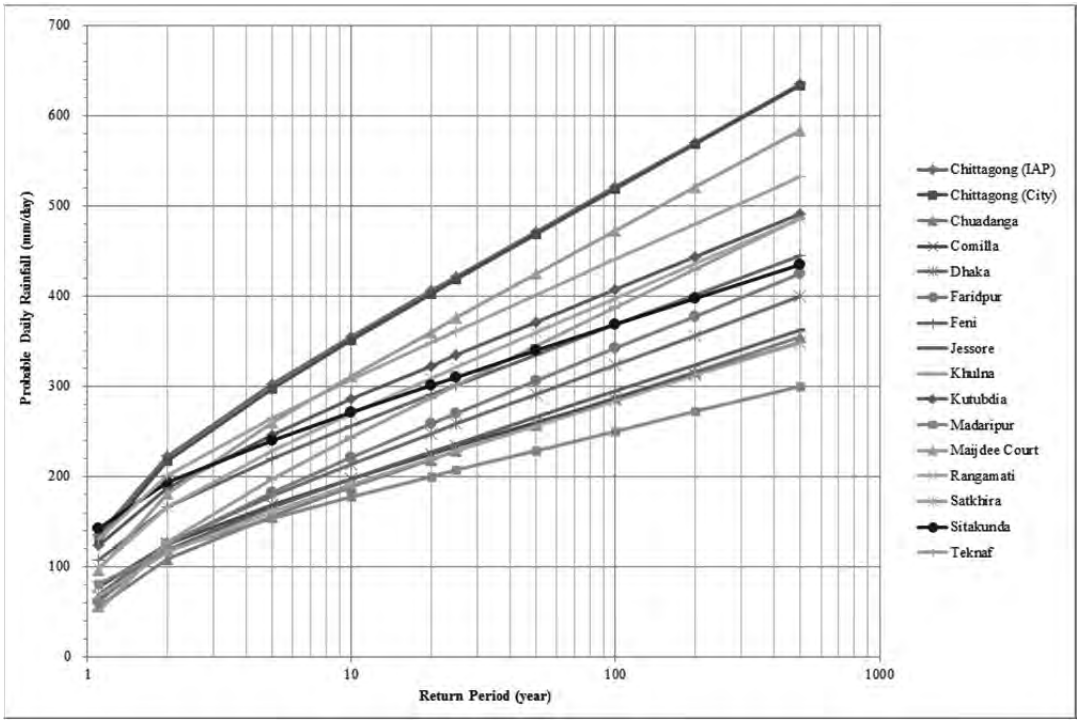
A, b, c: Coefficient (Refer to Table 5.4.4.)

k: Conversion factor (Section A: 0.93, Section B: 1.31, Section C: 1.67)

Table 5.4.4 Coefficient for Rainfall Intensity Formula at Dhaka

Return Period	a	b	c	Remarks
1.1 years	62.953	0.977	0.598	
2 years	107.437	1.064	0.932	
3 years	113.356	0.981	0.910	
5 years	151.116	1.075	1.149	
10 years	179.552	1.059	1.245	
20 years	203.410	1.021	1.304	
25 years	217.399	1.033	1.358	
50 years	245.303	1.009	1.422	
100 years	285.519	1.021	1.521	

Source: "Detailed Design for Kanchpur, Meghna and Gumti 2nd Bridges Construction and Existing Bridges Rehabilitation"



Source: JICA Survey Team, BMD

Figure 5.4.18 24-hour Probability Rainfall at 16 stations

5.4.3 Hydrology

(1) Hydraulic Design Criteria for the Bridges and Culverts

1) Design Return Period

According to the Manual of Roads & Highways Department (2000), roads and bridges connecting with Regional Highways in Bangladesh are designed in consideration of the maximum flood level for 50 year return period. The Manual also mentioned for considering 100 year flood event in case of National Highways (Asian Highways). The design scale of culvert is 20 year return period in this study.

2) Design Freeboard and Clearance

Based on the magnitude of the designed river discharge, the clearance from the bridge girder to high water level shall be compliant. The freeboard in a bridge allows the safe passage of flowing debris during flooding. The freeboard Allowances for bridges is shown in Table 5.4.5 (The clearance for navigation is authorized by BIWTA, as shown in Table 5.4.15.)

Regarding culverts, the design water depth sets lower than 80% of the inner height of culverts.

Table 5.4.5 Freeboard Allowances

Design flood discharge (m^3/s)	Freeboard (m)
Less than 200	0.6
200 and up to 500	0.8
500 and up to 2,000	1.0
2,000 and up to 5,000	1.2
5,000 and up to 10,000	1.5
10,000 and over	2.0

Source: Manual for River Works in Japan

3) Design Criteria of the Bridges

Lateral road drainage is mainly through culverts and bridges. The size of the flood opening is determined by the magnitude of design discharge, and the bridge / culvert is classified by the allowable discharge for assumed maximum culvert size. (Assumed maximum culvert: B 6.0m * H 4.0m, Qa= 54.17m^3/s)

In order to design the opening for the bridge waterway, the following design criteria for hydraulics must be met.

- ✓ The backwater does not significantly increase the flood damage to properties upstream of the bridge.
- ✓ The velocity through the bridge does not damage the road facility or increase the damages to downstream properties.

- ✓ The existing flow distribution is maintained to the greatest extent practicable.
- ✓ The pier and abutment are designed to minimize the flow disruption.
- ✓ Potential local scour is within acceptable limits.
- ✓ Clearance at the structure is adequately designed to safely pass any anticipated debris. (The elevation of the bottom of the bridge girder is higher than "Highest high water level + Navigation channel height".)

In this study, the design standards are based on the HEC series of FHWA[6], which are well-used international standards.

(2) River and Characteristics of River Flow

In order to predict the flow rate / water level in flood season, it is necessary to collect and correlate the collectable data / conditions concerning the hydrology / hydraulics of the related rivers surrounding targeted area. In this clause, river characteristics of main rivers only are examined.

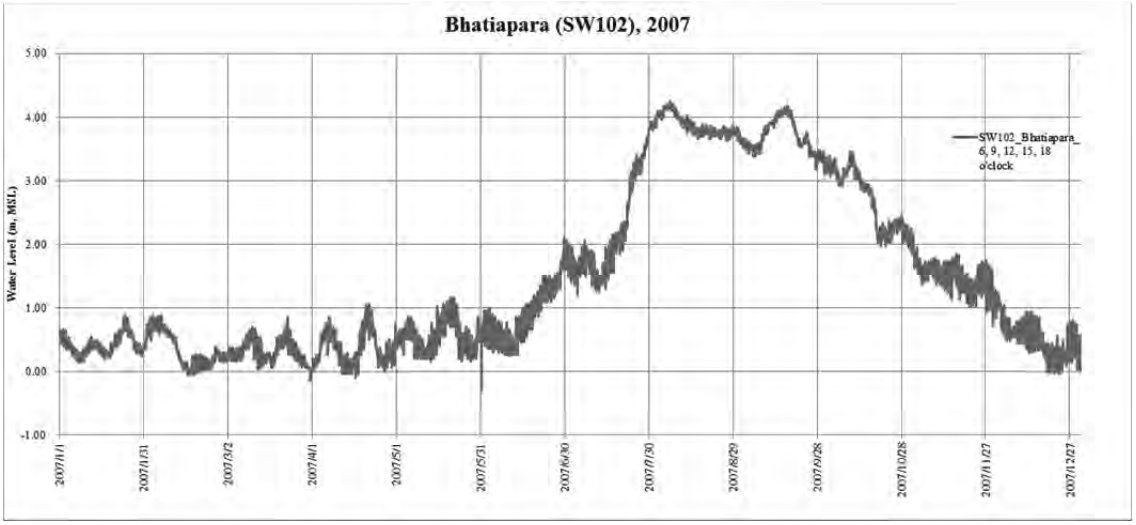
1) Targeted Rivers

Main rivers related to Sections of study area are contained within the Gorai-Madhumati River basin for the Section A, the Feni River basin for the Section B and Sangu River and Mathamuhuri River basins for the Section C. The Gorai-Madhumati River is a distributary of the Ganges, it have a basin of 15,200 km^2. In the upper reaches it is called the Gorai, and the name changes to Madhumati. The Feni River basin is about 2,000 km^2 and it is a trans-boundary river with Tripura State of India. In addition to these major river basins, there are many other small-and-medium-sized rivers in the study area.

2) River Characteristics

The gauging stations of BWDB are classified into the non-tidal and tidal water level stations. Most of gauging stations are entirely the tidal station except for upstream stations of the Feni and Mathamuhuri Rivers, and most of the river-zone to the proposed bridge is affected by the tide. However, the fluctuation range of the tide is very small compared with them of the outer sea. Also, the tidal influence is limited just to the dry season, and the water level of the river is affected by storm water from upstream during most of the rainy season.

[6] Hydraulic Engineering Circular, Federal Highway Administration, USA



Source: BWDB

Figure 5.4.19 Seasonal Fluctuation of Water Level at SW102 Station of 2007 (Kalna Bridge)

The discharge-duration curve is examined in order to understand the potential surface water characteristics of the river through the year. The flow regime shows the annual flow condition using the daily discharge at each hydrological station, and is indicated by the daily discharge and the number of exceeded days. In this study, since the available prolonged daily discharge data of each station are poor, the water-level data apply, and the water-level duration curve is verified. The definition of annual flow regime shows as follows;

- High Water Level (95th daily water-level from the greatest)
- Normal Water Level (185th daily water-level from the greatest)
- Low Water Level (275th daily water-level from the greatest)
- Drought Water Level (355th daily water-level from the greatest)

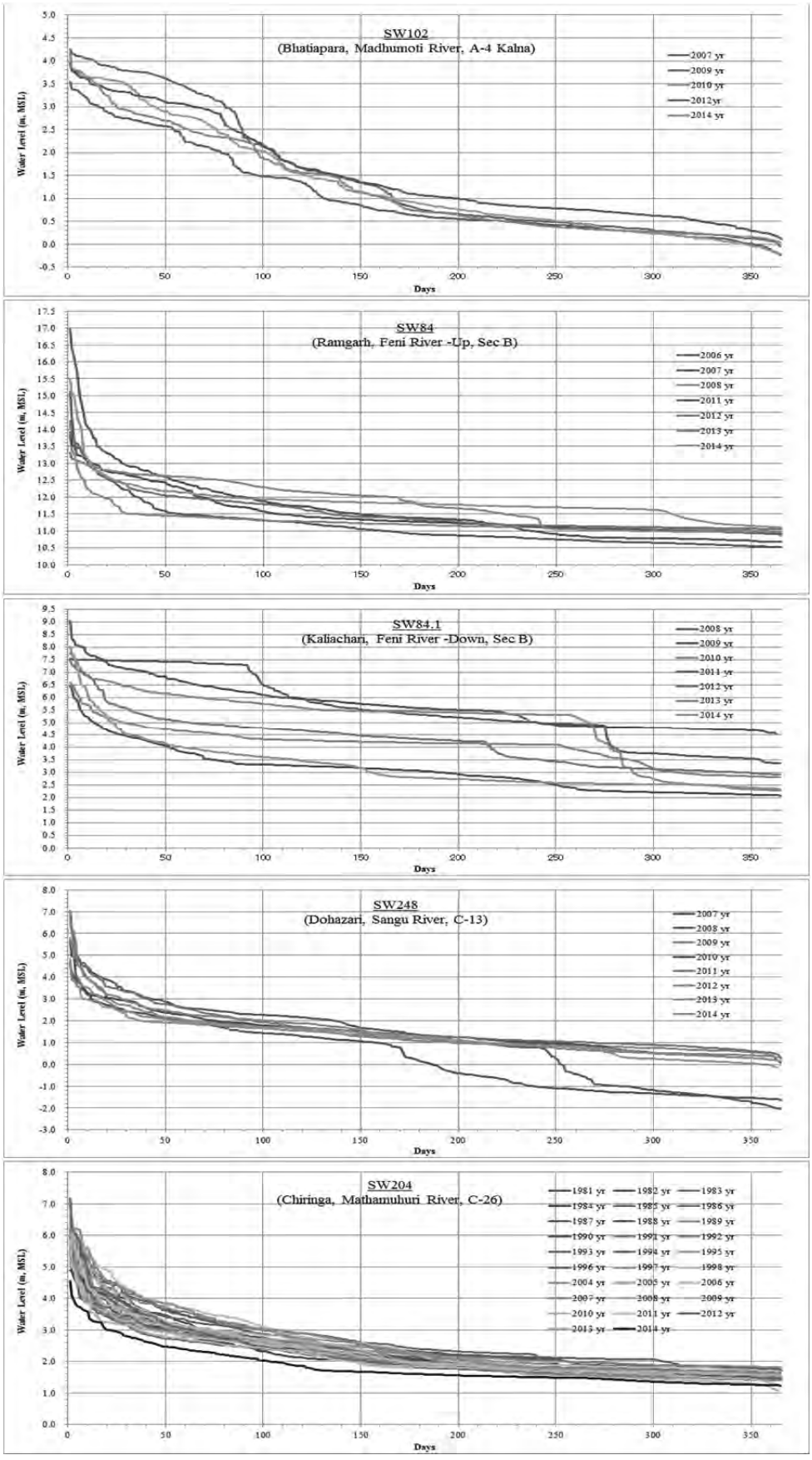
The water-level duration curves at representative stations are shown in Figure 5.4.20, and the typical water level at them is shown in Table 5.4.6.

From these, it is recognized that the annual water-level fluctuations of the Section B and C are bigger compared with the SW102 station (Kalna Bridge) of Section A. Namely, the difference of flooding characteristics between Section A and other Sections can verify as shown in 5.4.1(2).

Table 5.4.6 Typical Water Level at 5 Stations

Bridge Name	Station ID	Station Name	River Name	Sample No.	Annual Maximum Water-level	Plentiful Water-level	Ordinary Water-level	Low Water-level	Drought Water-level	Annual Minimum Water-level	Remarks
					1-day	95-day	185-day	275-day	355-day	365-day	
A-4 (Kalna)	SW102	Bhatiapara	Gorai-Madhumoti	5	3.97	2.05	0.79	0.41	0.08	-0.07	2007, 2009-2010, 2012, 2014
-	SW84	Ramgarh	Feni	7	14.70	11.77	11.36	11.06	10.90	10.87	2006-2008, 2011-2014
-	SW84.1	Kaliachari	Feni	7	7.55	5.00	4.36	3.65	2.96	2.88	2008-2014
C-13 (Sangu)	SW248	Dohazari	Sangu	8	5.69	1.85	1.06	0.29	-0.17	-0.35	2007-2014
C-26 (Mathamuhuri)	SW204	Chiringa	Mathamuhuri	29	5.93	2.70	1.99	1.71	1.55	1.51	1981-1998, 2004-2014

Source: JICA Survey Team, BWDB



Source: BWDB

Figure 5.4.20 Water-Level Duration Curve at Typical Stations

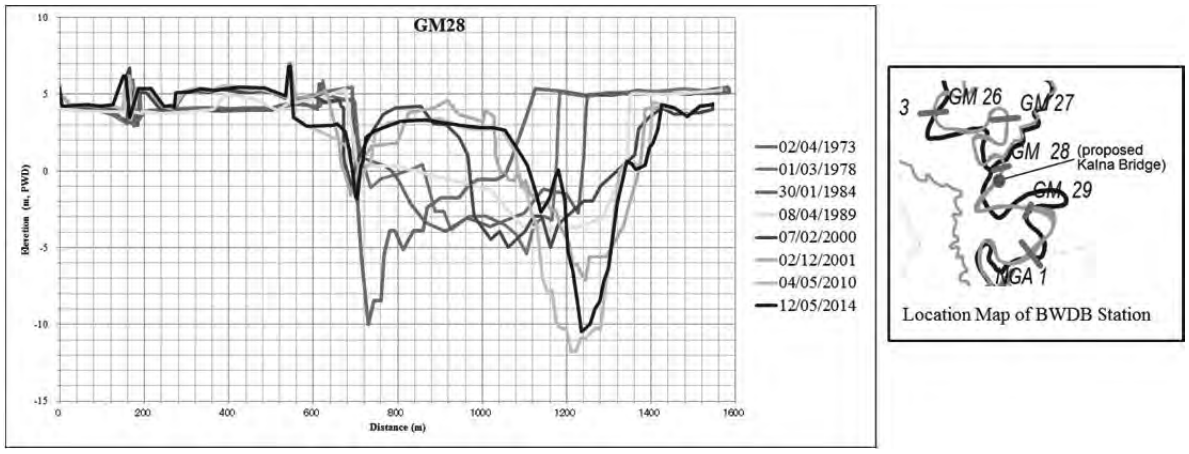
(3) Aggradations, Degradations and River Course Shifting of Rivers

1) Aggradations, Degradations of Rivers

The BWDB has done the bathymetric survey at particular sections of the major rivers on a regular basis. Among of these particular sections, there are two river sections at near Kalna (A-4) and Sangu (C-13) Bridges as shown in Figure 5.4.21 and Figure 5.4.22. These cross-section data are useful to check and understand the change of cross-sectional / longitudinal profile, such as aggradations and degradations of rivers. According to the past bathymetric survey results by BWDB, it is able to recognize that the river cross-section of the 2 rivers have continued to fluctuate even now from this Figure. Especially, the river course and river-bed of Madhumati River around the proposed Kalna Bridge have been changing drastically. Also, the fluctuating range at the time between August 2013 (previous F/S) and July 2015 (this study) is large as shown in Figure 5.4.23 to Figure 5.4.25.

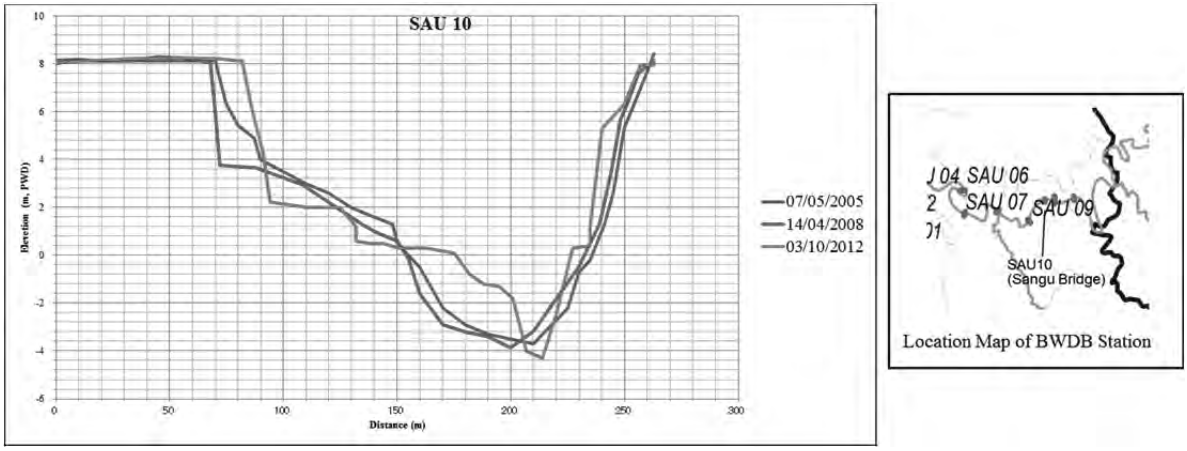
The river cross-section of the river bend at 2.56 km upstream of proposed Kalna Bridge shows a largest change. Even the cross-section near proposed bridge site, it is prone to be eroded / silted. (The maximum fluctuating range of river-bed varies from 3 m to 14m at each cross-section during the period of just 2 years.)

According to the geological investigation and other reference documents, the river-bed material of Madhumati River is very fine sand of 0.17 mm, and it is approached the wash-load with having both characteristics between suspended sand and bed load sediment. Hence, it is presumed that the river-bed fluctuation of the Madhumati River around the proposed Kalna Bridge will continue in the future.



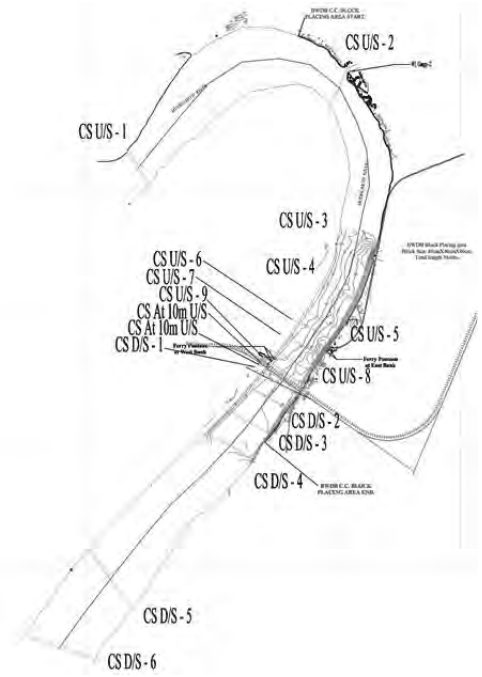
Source: BWDB

Figure 5.4.21 River Bed Fluctuations at near proposed Kalna Bridge (A-4, GM28 section)



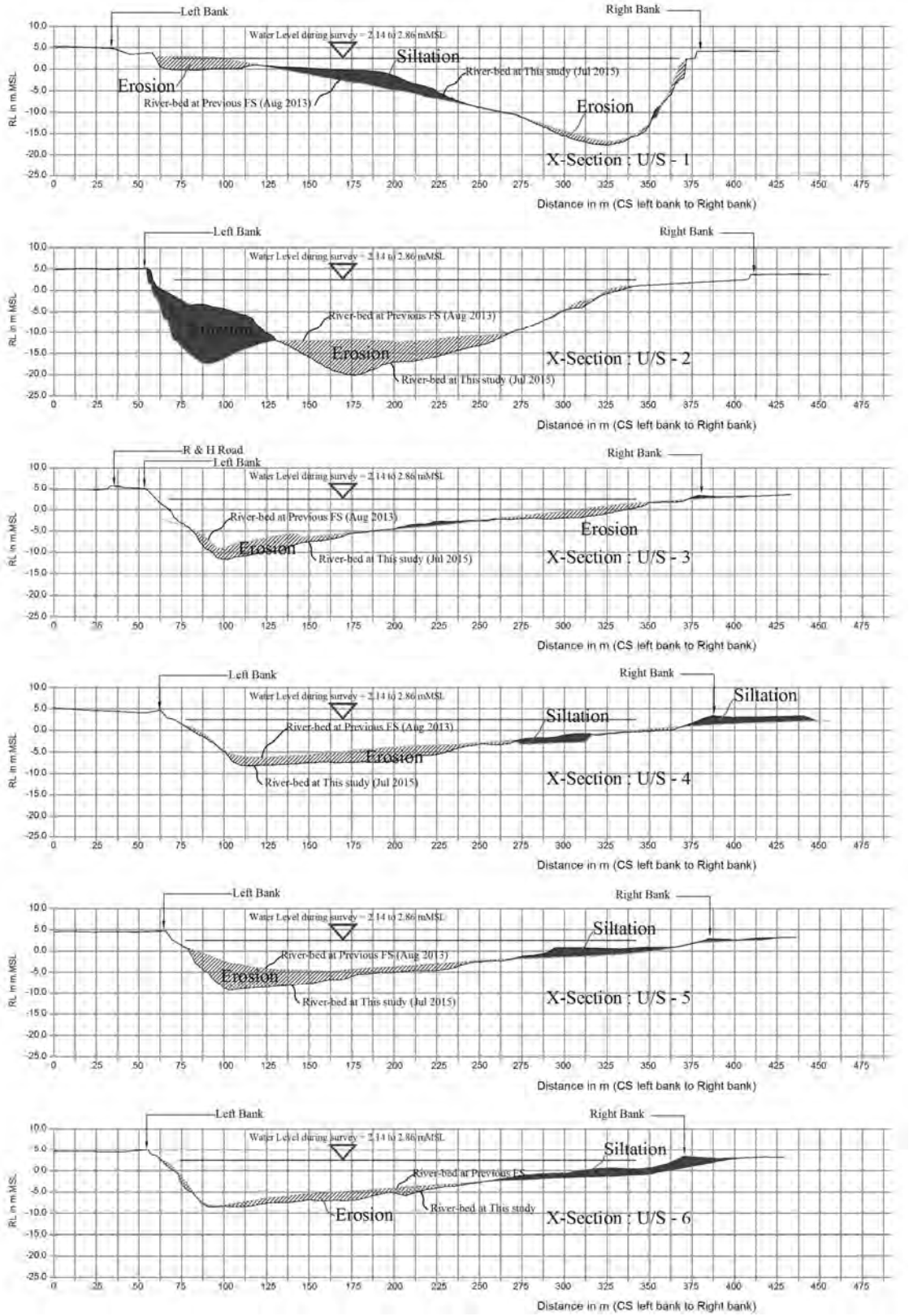
Source: BWDB

Figure 5.4.22 River Bed Fluctuations at near Sangu Bridge (C-13, SAU10 section)



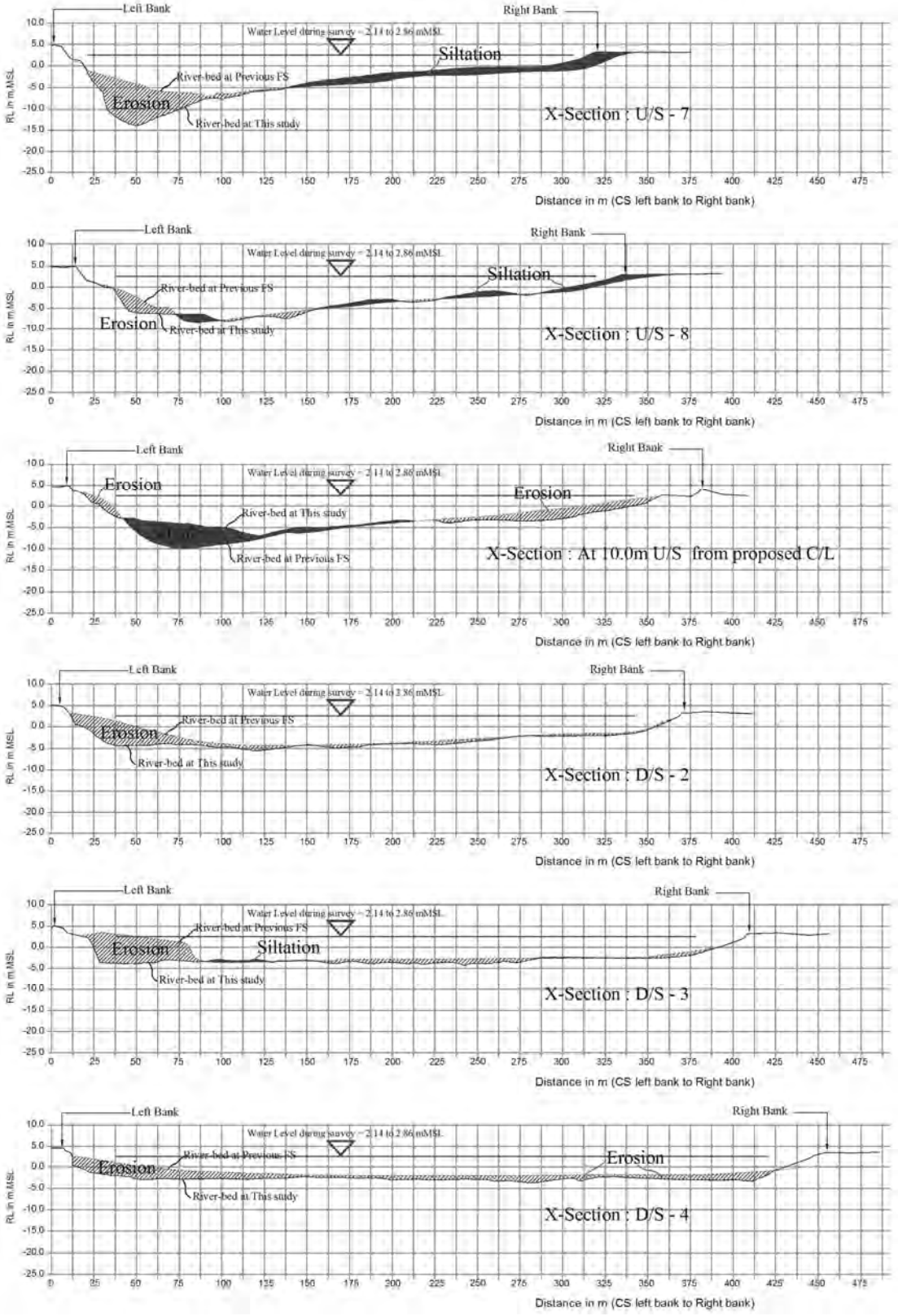
Source: JICA Survey Team

Figure 5.4.23 Location of Bathymetric Survey Cross-Section at Kalna Bridge (Madhumati River)



Source: JICA Survey Team, Hydrological and Morphological Study for the Proposed Kalna Bridge over the River Madhumati at 4th km of Bhatiapara-Kalna National Highway (N806), FINAL REPORT (Sep. 2013, IWFM, BRTC and BUET)

Figure 5.4.24 River-Bed Fluctuation between August 2013 (Previous FS) and July 2015 (This Study) (1)



Source: JICA Survey Team, Hydrological and Morphological Study for the Proposed Kalna Bridge over the River Madhumati at 4th km of Bhatiapara-Kalna National Highway (N806), FINAL REPORT (Sep. 2013, IWFM, BRTC and BUET)

Figure 5.4.25 River-Bed Fluctuation between August 2013 (Previous FS) and July 2015 (This Study) (2)

2) River Course Shifting (Planform Analysis by using Satellite Images)

Historical satellite images have been used to evaluate the characteristic features of channel shifting and to estimate the river bank erosion. As satellite images at different times are available for the study reach, the analysis of the stability of the study river reach using satellite images is presented in this section.

Planform analysis of the proposed bridge was conducted using Landsat Thematic Mapper (TM) images. Seven satellite images (See Appendix.) of the years 1972, 1978, 1988, 1989, 2001, 2010 and 2015 were used. The change in planform over the 43 year period is shown in Figure 5.4.26, and a zoomed view over the bridge site is shown in Figure 5.4.27. Also, historical-changes of both river-banks show in Figure 5.4.28 and Figure 5.4.29.

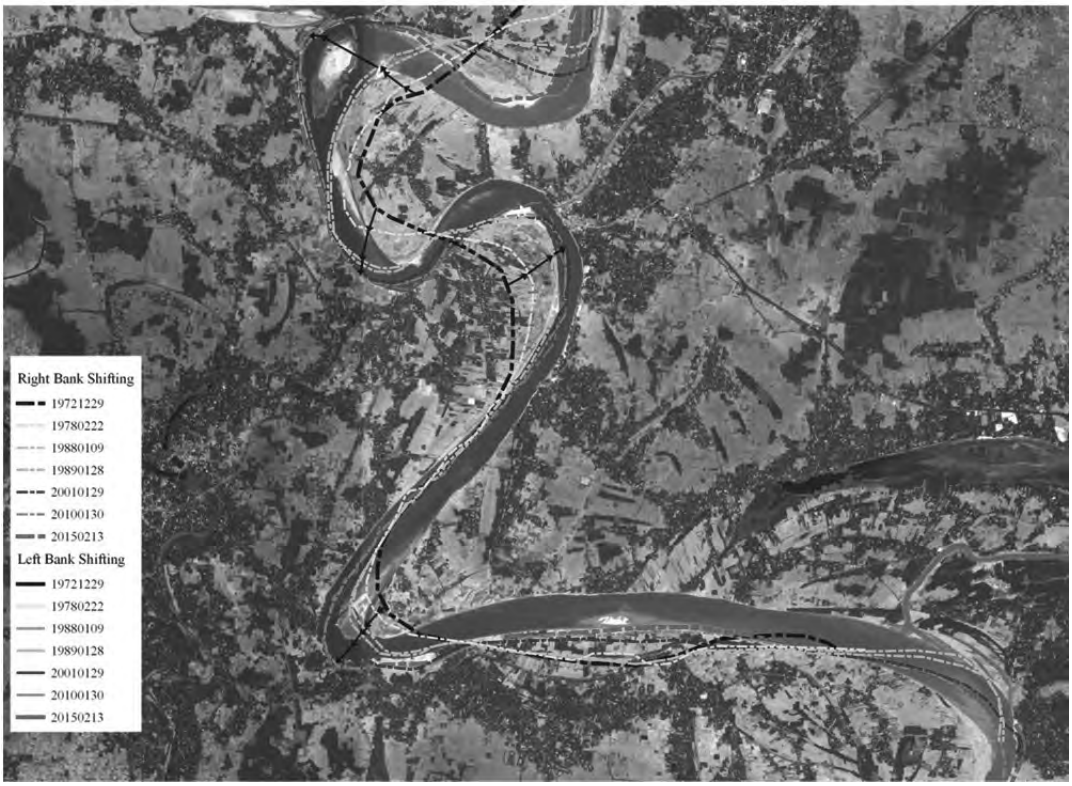
It can be seen in Figure 5.4.26 and Figure 5.4.27 that the river reach has experienced no significant erosion or deposition over the last 43 years at the the alignment of alternative-C as the left bank is protected. However, in the alternatives A, a great deal of river-course shifting has been experienced. (Although alternative-B had also shifted, it is stable at this time after completion of the left-bank revetment.). In addition, due to the existence of bends 1km upstream and 1 km downstream of the river, the erosion and deposition have been observed.

Source: JICA Survey Team, SPARSO

Figure 5.4.26 Shifting of Bank Lines around the Kalna Bridges during Past 43 years

Source: JICA Survey Team, SPARSO

Figure 5.4.27 Zoomed View of Shifting of Bank Lines around the Kalna Bridges during Past 43 years



Source: JICA Survey Team, SPARSO

Figure 5.4.28 Shifting of Right Bank Lines around the Kalna Bridges during Past 43 years

Source: JICA Survey Team, SPARSO

Figure 5.4.29 Shifting of Left Bank Lines around the Kalna Bridges during Past 43 years

(4) Estimation of Probable Water Levels and Floods

1) Design Discharges (Probability Floods) at Gaugin Stations

Past annual maximum discharges (extreme values) of 5 discharge stations for the design discharge, were collected and analyzed as shown in Table 5.4.7 and Figure 5.4.30.

The probable discharges are calculated according to the following:

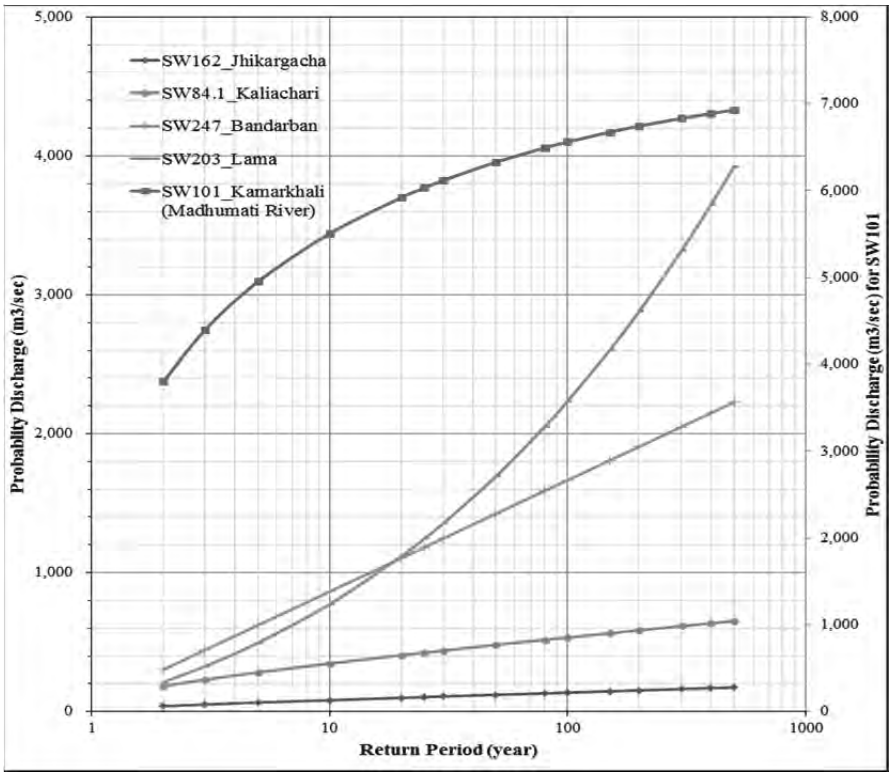
- Appropriate model for probability distribution is chosen from the several methods.
- Distribution model is selected in reference to SLSC (Standard Least Squares Criterion) value or adequacy of probability value, etc. (SLSC value is 0.04 or less is desirable.)
- Calculation of return periods are for 2, 3, 5, 10, 20, 25, 30, 50, 80, 100, 150, 200, 300, 400 and 500 year.

Among of the probability discharge at stations of following table, the SW101 station is located 76 km upstream from the proposed Kalna (A-4) Bridge. The SW247 and SW203 stations are also located upstream from targeted bridges (C-13 and C-26), and the SW162 is nearly located at Jhikargacha Bridge (A-1). The catchment area of other bridges except for the above 4 bridges is relatively small. In this study, following results are referred for the 4 bridges. Regarding the design discharges of other bridges except for 4 bridges, they are calculated by the rational method with the exception of certain bridges. (Regarding the Jhikargacha Bridge, the probability discharge value is slightly small in comparison to the magnitude of river. It might be a little poor in reliability of data.)

Table 5.4.7 Probability Discharge at 5 Stations

Station Name			Jhikargacha	Kamarkhali	Kaliachari	Bandarban	Lama	Remarks
River Name			Kobadak	Gorai-Madhumoti	Feni	Sangu	Mathamuhuri	
Station ID			SW162	SW101	SW84.1	SW247	SW203	
Long. (X)			89.0994	89.5177	91.6263	92.2192	92.2124	
Lat. (Y)			23.1011	23.5389	22.9418	22.1941	21.7926	
Catchment Area (km2)			-	-		2,138	1,010	
Data No. of Extreme Value			25	27	17	21	33	
	(Year)	(%)						
Probable Discharge (m3/s)	1.1	90.9%	10	1916	82	94	57	
	2	50%	39	3798	183	302	212	
	3	33.3%	51	4398	230	444	327	
	5	20%	65	4951	282	622	495	
	10	10%	82	5505	346	864	773	
	20	5%	99	5920	406	1105	1118	
	25	4%	104	6032	424	1183	1245	
	30	3.33%	109	6118	439	1247	1355	
	50	2%	121	6328	480	1425	1694	
	80	1.25%	131	6492	517	1589	2051	
	100	1%	137	6561	534	1666	2236	
	150	0.667%	146	6673	564	1808	2601	
	200	0.5%	153	6744	586	1908	2884	
	300	0.333%	162	6832	615	2049	3316	
	400	0.25%	169	6888	636	2150	3650	
	500	0.2%	174	6928	652	2227	3924	
X-COR(99%)			0.988	0.970	0.977	0.985	0.970	
P-COR(99%)			0.991	0.970	0.991	0.981	0.995	
SLSC(99%)			0.032	0.048	0.031	0.036	0.025	
Probabilistic Distributed model			Gumbel distribution	Generalized extreme value distribution	Log Pearson type III distribution (Logarithmic space method)	Exponential distribution	Iwai's method	

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.30 Probability Discharge at 5 Stations

2) Design Discharge at the proposed Kalna Bridge

The hydraulic design parameters of the "Hydrological and Morphological Study for the Proposed Kalna Bridge" were studied by IWFM, BRTC and BUET at 2013, as shown in the Table below.

Table 5.4.8 Hydraulic Parameter of Previous Study for Proposed Kalna Bridge

Return Period	Probable Water Level at Bhatiapara Station (SW102)		Design Water Level at Proposed Bridge		Hydraulic gradient	Design Discharge	Remarks
	(m, PWD)	(m, MSL)	(m, PWD)	(m, MSL)	(cm/km)	(m^3/s)	
2.33	6.00	5.24	-	-	-	-	
20	6.69	5.93	-	-	-	-	
50	6.90	6.14	6.75	5.99	5.77	5,250	Design Return Period
100	7.04	6.28	-	-	-	-	

Distance downstream from Station 2.7 km

Difference between MSL and PWD datum 76 cm

Source: Hydrological and Morphological Study for the Proposed Kalna Bridge over the River Madhumati at 4th km of Bhatiapara-Kalna National Highway (N806), FINAL REPORT (Sep. 2013, IWFM, BRTC and BUET)

In above Table, the 50-year design discharge is 5,250m^3/s. (In the previous FS study, the discharge corresponding to the water level on the hydraulic calculation model was found to be 5,250 m^3/s.) However, the 50-year flood for the SW101 station which is located at 76 km upstream of Table 5.4.7 is estimated as 6,328m^3/s by the statistical analysis. The (Gorai-) Madhumati River is the distributary of the Ganges River, and it is a special tributary to repeat the confluence with the diversion. Although there is need for hydrological investigation at the detailed design stage furthermore, the 100 year probability discharge of Table 5.4.7 adopts as the design discharge of this study.

- ✓ Design Discharge (100 year flood): 6,561 m^3/s
  (50 year flood): 6,328 m^3/s

3) Design Discharge except the Kalna Bridge

The design discharge except above-mentioned 4 bridges is calculated by the rational formula, and it is calculated by several parameters (runoff coefficient: C, design rainfall: I, catchment area: A). The design discharge except 4 bridges is shown in Table 5.4.9. The criteria of applicable return-period for structures refer to 5.4.3 (1), and the size of flood opening for drainage structures is calculated. (The capacity of culvert flow is calculated by the Manning equation. And the bridge opening is calculated by the Lacey's equation, for reference.)

Table 5.4.9 Design Discharge and Flood Openings (Culvert Dimension, etc.) for Proposed Sites

ID	Chainage	Drainage Area	Design Scale	Rational Formula						Design Discharge	Culvert Type	Remarks
				Concentration Time	Flow Length	Conversion Factor by Region	Rainfall Intensity at Dhaka	Runoff Coefficient	Design Discharge		Necessary Bridge Width	
	(Station No.)	A (km^2)	(year)	(hr)	(m)	-	(mm/hr)	-	(m^3/s)	(m^3/s)	(m)	
<Section A>												
A-1	Jhikorgacha Bridge	-	100yrs	-	-	from Probability Flood Calculation				137.0	55.6	
A-2		-	100yrs	-	-	-	-	-	-	-	-	
A-3		-	100yrs	-	-	-	-	-	-	-	-	
A-4	Kalna Bridge	-	100yrs	-	-	from Probability Flood Calculation				6561.0	384.8	
A-5		-	100yrs	-	-	-	-	-	-	-	-	
<Section B>												
B-1		33.2	50yrs	3.07	20,304	1.31	54.229	0.60	300.3	300.3	82.3	Freeboard= 0.8
B-2		3.6	50yrs	0.79	3,888	1.31	110.962	0.60	67.3	67.3	39.0	Freeboard= 0.6
B-3		11.1	50yrs	1.51	9,094	1.31	83.406	0.60	154.3	154.3	59.0	Freeboard= 0.6
B-4												
B-5												
B-6												
B-7												
B-8												
B-9		6.5	50yrs	0.81	4,004	1.31	110.158	0.60	120.1	120.1	52.1	Freeboard= 0.6
B-9a		0.4	20yrs	0.40	1,088	1.31	119.818	0.60	8.3	8.3	Ib	
B-10		0.3	20yrs	0.41	1,160	1.31	119.117	0.60	6.9	6.9	Ib	
B-11												
B-12		21.0	50yrs	1.55	9,383	1.31	82.270	0.60	287.4	287.4	80.5	Freeboard= 0.8
B-13		3.3	50yrs	0.65	2,900	1.31	118.353	0.60	65.4	65.4	38.4	Freeboard= 0.6
B-14		1.2	20yrs	0.44	1,350	1.31	117.298	0.60	24.4	24.4	II	
B-15		0.8	20yrs	0.48	1,639	1.31	114.627	0.60	16.1	16.1	Ic	
B-16		3.8	50yrs	0.71	3,306	1.31	115.202	0.60	72.7	72.7	40.5	Freeboard= 0.6
B-17		2.5	20yrs	0.47	1,591	1.31	115.069	0.60	47.3	47.3	III	
B-17a		1.3	20yrs	0.43	1,291	1.31	117.856	0.60	25.5	25.5	II	
B-18		3.5	50yrs	0.63	2,742	1.31	119.626	0.60	68.8	68.8	39.4	Freeboard= 0.6
B-19		2.1	20yrs	0.61	2,576	1.31	106.738	0.60	37.4	37.4	II	
B-20		0.5	20yrs	0.38	933	1.31	121.362	0.60	10.1	10.1	Ic	
B-21		7.5	50yrs	1.15	6,496	1.31	95.226	0.60	119.6	119.6	51.9	Freeboard= 0.6
B-22		0.4	20yrs	0.33	603	1.31	124.769	0.60	7.3	7.3	Ib	
B-23		1.4	20yrs	0.49	1,752	1.31	113.617	0.60	26.3	26.3	II	
B-24		0.8	20yrs	0.37	882	1.31	121.876	0.60	16.6	16.6	Ic	
B-25		18.5	50yrs	1.80	11,139	1.31	75.971	0.60	234.2	234.2	72.7	Freeboard= 0.8
B-26		24.5	50yrs	1.60	9,712	1.31	81.014	0.60	330.2	330.2	86.3	Freeboard= 0.8
<Section C>												
C-8		-	100yrs	-	-	-	-	-	-	-	-	Freeboard= 2.0
C-12		27.9	100yrs	2.12	13,449	1.67	77.723	0.60	361.7	361.7	90.3	Freeboard= 0.8
C-13	Sangu Bridge	2,440	100yrs	Specific Discharge by Probable Discharge			1666 m3/s	/ 2138 =	0.7792m3/s/km2	1,901	207.1	Freeboard= 1.0
C-26	Mathamuhuri Bridge	1,374	100yrs	Specific Discharge by Probable Discharge			2236 m3/s	/ 1010 =	2.2132m3/s/km2	3,041	261.9	Freeboard= 1.2

B4-B8 and B11 are not the drainage structures !

Note. Time of concentration is calculated by assumed velocity of Assumed V= 2.0 m/s.
Necessary Bridge Opening Width is calculated by Lacey's equation, in order to prevent contraction scour.

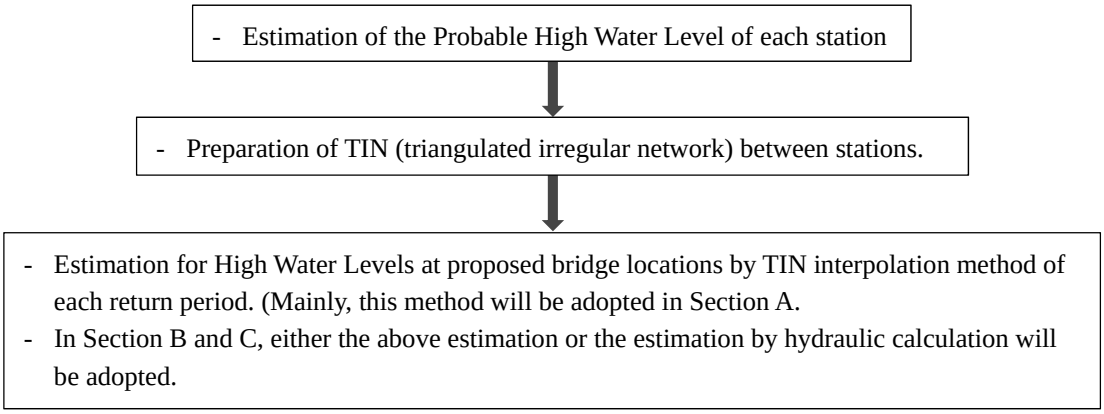
Culvert Type

Type	B (ϕ) (m)	H (ϕ) (m)	Cell No.	Slope (%)	Area (m2)	Wetted perimeter (m)	Velocity (m/s)	Discharge capacity (m3/s)	Remarks	BoQ
C90-1	0.90	0.90	1	0.50%	0.55	1.99	1.99	1.08	80% depth	0
C150-1	1.50	1.50	1	0.30%	1.52	3.32	2.16	3.28	80% depth	0
Ia	1.50	1.50	1	0.30%	1.80	3.90	2.18	3.93	80% depth	0
Ib	2.00	2.00	1	0.30%	3.20	5.20	2.64	8.45	80% depth	3
Ic	3.00	3.00	1	0.20%	7.20	7.80	2.83	20.35	80% depth	3
II	3.00	3.00	2	0.20%	7.20	7.80	2.83	40.70	80% depth	4
III	6.00	4.00	1	0.10%	19.20	12.40	2.82	54.17	80% depth	1

Source: JICA Survey Team

4) Design High Water Levels at Gauging Stations and Bridges: HFL

The design high water levels at proposed bridge sites are basically calculated by the following procedure.



As pointed out above in 5.4.1 (2), the hydrological characteristics in section A and other sections can be differentiated by the physiographic features. Therefore, high water levels of bridges for each section need to be examined carefully based on their characteristics. Furthermore, the probable high water levels of each bridge will be re-examined by checking the historical water levels as reported in the interview surveys, the topographical condition and the river situation, etc.

Regarding the water-level stations close to targeted bridges, the probability water-level of each station select the well fitted model from several distribution models, as same as the probability discharge. For the stations not close to targeted bridges, it will be calculated by the Gumbel's Extreme Value Type-1 distribution which is most commonly practiced in Bangladesh. (The Gumbel's distribution method is shown following.)

Computation for Probable Flood Level

$$K\_T=(\sqrt{6})/\pi\ [0.5772+ln\{ln(T/(T-1))\}]$$

And the Extreme Value (i.e. in our case, the 50 year flood level) within that distribution is given by:

$$X\_T=\bar{X}+K\_T\times\sigma\_(n-1)$$

where, $X\_T=Extreme\ Value$
$T=return\ period\ in\ years.$
$\bar{X}=Mean=(\sum x\_i)/n$
x_i=annual high flood level (HFL)
n=numbers pf years of records available
$\sigma\_(n-1)=Standard\ Deviation$

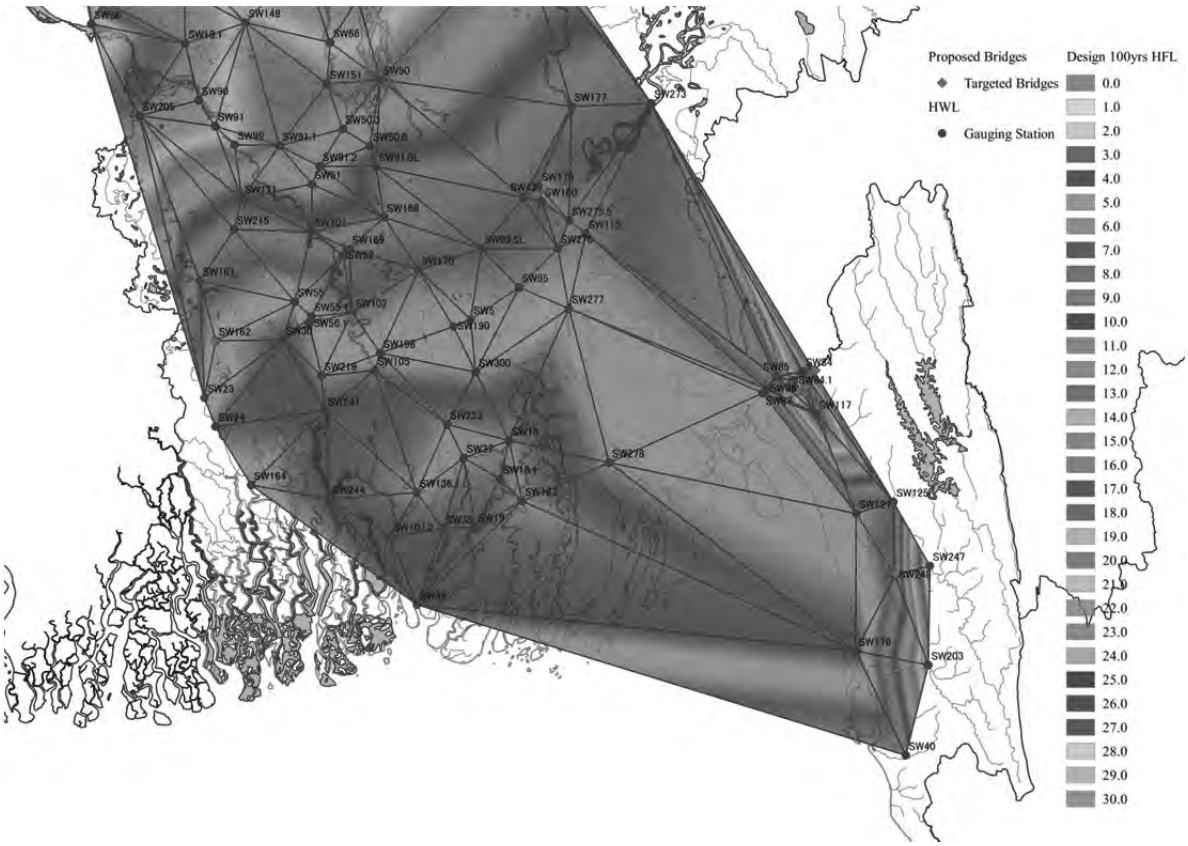
The criteria of HFL for each classification of the proposed bridges is "50 year flood" for Regional Roads and "100 year flood" for other high-standard roads, in reference to the RHD standards. (See 5.4.3 (1).) The freeboard of each bridge for the clearance beneath the bridge-girder will be 60cm-150cm. And, for the bridges except the proposed Kalna Bridge, the clearance of 1.5m for 1.1

year flood will be taken. Also, the designated clearance against SHWL will be secured on the official navigable waterway of the proposed Kalna Bridge. (See 5.4.3 (5).)

The results of calculations for probability high water levels at related gauging stations are shown in Table 5.4.10 to Table 5.4.13. As additional data, other station's results are added from the National Water Management Plan (1999) and other JICA studies.

The design water-level (HFL) is determined, based on the comprehensive judgement criterion (the probability water-level at the gauging-station, the distance from gauging-station to target-bridge, and the interview water-level at target-bridge). Especially, although bridges of Section B are close to each other, they have many catchment basins and different occurrence factors of floods. Therefore the HFL of Section-B is examined carefully.

The design high water-levels (HFL) for each bridge are shown in Table 5.4.13 and Figure 5.4.30.



Source: JICA Survey Team

Figure 5.4.31 Interpolation of HWL by TIN method

Table 5.4.10 Probability High Water-Level at 12 Stations Close to Target-Bridges

Station Name			Bhatiapara	Atharobanka	Jhikargacha	Dohazari	Lemsikhali	Lama	Chiringa	Sonapur	Dhumghat	Sobhapur	Kaliachari	Ramgarh	Remarks
River Name			Gorai-Madhumoti	Gorai-Madhumoti	Kobadak	Sangu	Kutubdia Channel	Mathamuhuri	Mathamuhuri	Feni	Feni	Feni	Feni	Feni	
Station ID			SW102	SW105	SW162	SW248	SW176	SW203	SW204	SW87	SW86	SW85	SW84.1	SW84	
Long. (X)			89.6958	89.7931	89.0994	92.0665	91.8958	92.2124	92.0800	91.4889	91.5025	91.5476	91.6263	91.6647	
Lat. (Y)			23.2150	22.9817	23.1011	22.1571	21.8496	21.7926	21.7727	22.8914	22.9091	22.9554	22.9418	22.9789	
Data No. of Extreme Value			37	32	34	34	34	34	33	29	26	7	34	33	
Probable Water Level (m, PWD)	(Year)	(%)													
	1.1	90.9%	4.50	2.65	2.95	5.76	2.45	10.95	5.88	4.47	5.00	4.97	8.95	14.88	
	2	50%	5.19	3.04	4.08	7.09	3.16	12.61	6.48	4.86	5.60	5.61	10.47	16.65	
	3	33.3%	5.49	3.22	4.44	7.44	3.38	13.20	6.67	5.03	5.82	5.97	11.05	17.20	
	5	20%	5.82	3.44	4.78	7.73	3.59	13.78	6.84	5.21	6.05	6.42	11.65	17.71	
	10	10%	6.23	3.73	5.13	7.99	3.80	14.44	7.03	5.45	6.31	7.06	12.36	18.20	
	20	5%	6.62	4.04	5.39	8.16	3.96	15.00	7.18	5.67	6.54	7.74	12.99	18.57	
	25	4%	6.74	4.15	5.47	8.20	4.01	15.17	7.23	5.74	6.61	7.97	13.18	18.67	
	30	3.33%	6.84	4.23	5.52	8.24	4.04	15.31	7.26	5.80	6.67	8.17	13.34	18.75	
	50	2%	7.12	4.49	5.66	8.32	4.13	15.67	7.35	5.96	6.82	8.73	13.76	18.93	
	80	1.25%	7.37	4.73	5.76	8.38	4.21	15.98	7.43	6.11	6.96	9.28	14.13	19.07	
	100	1%	7.50	4.85	5.81	8.40	4.24	16.12	7.47	6.18	7.02	9.55	14.31	19.13	
	150	0.667%	7.72	5.08	5.88	8.44	4.29	16.38	7.53	6.30	7.13	10.06	14.62	19.22	
	200	0.5%	7.87	5.24	5.93	8.47	4.33	16.56	7.57	6.39	7.21	10.44	14.84	19.28	
	300	0.333%	8.09	5.49	5.99	8.50	4.38	16.80	7.62	6.52	7.32	10.99	15.15	19.36	
	400	0.25%	8.25	5.67	6.03	8.52	4.41	16.97	7.66	6.61	7.39	11.40	15.37	19.40	
	500	0.2%	8.37	5.82	6.05	8.53	4.44	17.09	7.69	6.68	7.45	11.73	15.53	19.44	
Difference between PWD and MSL (m)			-0.76	-0.46	-0.46	-0.83	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-2.01	-1.46	
Probable Water Level (m, MSL)	(Year)	(%)													
	1.1	90.9%	3.74	2.19	2.49	4.93	1.99	10.49	5.42	4.01	4.54	4.51	6.94	13.42	
	2	50%	4.43	2.58	3.62	6.26	2.70	12.15	6.02	4.40	5.14	5.15	8.46	15.19	
	3	33.3%	4.73	2.76	3.98	6.61	2.92	12.74	6.21	4.57	5.36	5.51	9.04	15.74	
	5	20%	5.06	2.98	4.32	6.90	3.13	13.32	6.38	4.75	5.59	5.96	9.64	16.25	
	10	10%	5.47	3.27	4.67	7.16	3.34	13.98	6.57	4.99	5.85	6.60	10.35	16.74	
	20	5%	5.86	3.58	4.93	7.33	3.50	14.54	6.72	5.21	6.08	7.28	10.98	17.11	
	25	4%	5.98	3.69	5.01	7.37	3.55	14.71	6.77	5.28	6.15	7.51	11.17	17.21	
	30	3.33%	6.08	3.77	5.06	7.41	3.58	14.85	6.80	5.34	6.21	7.71	11.33	17.29	
	50	2%	6.36	4.03	5.20	7.49	3.67	15.21	6.89	5.50	6.36	8.27	11.75	17.47	
	80	1.25%	6.61	4.27	5.30	7.55	3.75	15.52	6.97	5.65	6.50	8.82	12.12	17.61	
	100	1%	6.74	4.39	5.35	7.57	3.78	15.66	7.01	5.72	6.56	9.09	12.30	17.67	
	150	0.667%	6.96	4.62	5.42	7.61	3.83	15.92	7.07	5.84	6.67	9.60	12.61	17.76	
	200	0.5%	7.11	4.78	5.47	7.64	3.87	16.10	7.11	5.93	6.75	9.98	12.83	17.82	
	300	0.333%	7.33	5.03	5.53	7.67	3.92	16.34	7.16	6.06	6.86	10.53	13.14	17.90	
	400	0.25%	7.49	5.21	5.57	7.69	3.95	16.51	7.20	6.15	6.93	10.94	13.36	17.94	
	500	0.2%	7.61	5.36	5.59	7.70	3.98	16.63	7.23	6.22	6.99	11.27	13.52	17.98	
X-COR(99%)			0.974	0.960	0.984	0.989	0.976	0.994	0.984	0.992	0.982	0.930	0.980	0.995	
P-COR(99%)			0.984	0.987	0.992	0.989	0.976	0.997	0.995	0.994	0.988	0.936	0.984	0.997	
SLSC(99%)			0.041	0.057	0.037	0.032	0.047	0.023	0.038	0.037	0.072	0.152	0.084	0.034	
Probabilistic Distributed model			3-parameter log-normal distribution (Quantile method)	Generalized extreme value distribution	Generalized extreme value distribution	Log Pearson type Ⅲ distribution (Real space method)	Log Pearson type Ⅲ distribution (Logarithmic space method)	2-parameter log-normal distribution（Slade I, L-moment method）	Log Pearson type Ⅲ distribution (Real space method)	Gumbel distribution	Log Pearson type Ⅲ distribution (Logarithmic space method)	3-parameter log-normal distribution (Quantile method)	Log Pearson type Ⅲ distribution (Logarithmic space method)	Generalized extreme value distribution	

Source: JICA Survey Team

Table 5.4.11 Probability High Water-Level at All Stations (1)

River / Station Name, Station No.			Longitude (X)	Latitude (Y)	No. in sample	Mean	Std. Deviation σ_{n-1}	Water Level each Return Period (year) (m, PWD)							Difference between PWD and MSL	Water Level each Return Period (year) (m, MSL)						
								1.1	5	10	20	25	50	100		1.1	5	10	20	25	50	100
								K_T								K_T						
								-1.132	0.719	1.305	1.866	2.044	2.592	3.137	-0.460	-1.132	0.719	1.305	1.866	2.044	2.592	3.137
< Water Level >																						
Arial Khan	Madaripur	SW5	90.2128	23.1868	30	4.491	0.506	3.919	4.855	5.151	5.435	5.525	5.802	6.077	-0.460	3.459	4.395	4.691	4.975	5.065	5.342	5.617
Bangali	Khanpur	SW11	89.4781	24.6197	30	13.472	1.292	12.009	14.402	15.158	15.883	16.113	16.822	17.525	-0.460	11.549	13.942	14.698	15.423	15.653	16.362	17.065
Barisal-Buriswar	Bakerganj	SW18.1	90.3418	22.5444	28	2.416	0.335	2.037	2.657	2.853	3.040	3.100	3.283	3.466	-0.460	1.577	2.197	2.393	2.580	2.640	2.823	3.006
Barisal-Buriswar	Barisal	SW18	90.3804	22.7002	30	2.463	0.204	2.231	2.610	2.729	2.844	2.880	2.993	3.104	-0.460	1.771	2.150	2.269	2.384	2.420	2.533	2.644
Barisal-Buriswar	Mirzaganj	SW19	90.2328	22.3517	21	2.892	0.356	2.490	3.148	3.356	3.556	3.619	3.814	4.008	-0.460	2.030	2.688	2.896	3.096	3.159	3.354	3.548
Betna-Kholpetua	Kalaroa	SW23	89.0499	22.8724	29	3.788	0.785	2.900	4.353	4.812	5.252	5.392	5.822	6.250	-0.460	2.440	3.893	4.352	4.792	4.932	5.362	5.790
Betna-Kholpetua	Benarpota	SW24	89.0979	22.7567	30	3.423	0.428	2.939	3.731	3.981	4.221	4.297	4.532	4.764	-0.460	2.479	3.271	3.521	3.761	3.837	4.072	4.304
Bishkhali	Jhalokati	SW37	90.1831	22.6300	29	2.298	0.235	2.032	2.467	2.604	2.736	2.778	2.906	3.034	-0.460	1.572	2.007	2.144	2.276	2.318	2.446	2.574
Bishkhali	Bamna	SW38	90.0926	22.3444	30	2.924	0.294	2.591	3.135	3.307	3.471	3.524	3.685	3.845	-0.460	2.131	2.675	2.847	3.011	3.064	3.225	3.385
Bishkhali	Patharghata	SW39	89.9783	22.0368	29	3.201	0.423	2.722	3.506	3.754	3.992	4.067	4.299	4.530	-0.460	2.262	3.046	3.294	3.532	3.607	3.839	4.070
Buriganga	Dhaka_Mill Barrack	SW42	90.4437	23.6758	30	5.619	0.713	4.812	6.132	6.549	6.949	7.076	7.467	7.855	-0.460	4.352	5.672	6.089	6.489	6.616	7.007	7.395
Burikhora Chiki	Nizbari Road Crossing	SW44.1	88.9581	25.7977	28	36.769	0.840	35.819	37.374	37.865	38.336	38.486	38.946	39.403	-0.460	35.359	36.914	37.405	37.876	38.026	38.486	38.943
Brahmaputra-Jamuna	Sirajganj	SW49	89.7211	24.4705	30	14.031	0.570	13.386	14.441	14.774	15.094	15.195	15.508	15.818	-0.460	12.926	13.981	14.314	14.634	14.735	15.048	15.358
Brahmaputra-Jamuna	Mathura	SW50.3	89.6540	23.9496	0	-	-	-	10.614	10.932	-	11.330	11.623	11.911	-0.460	-	10.154	10.472	-	10.870	11.163	11.451
Brahmaputra-Jamuna	Aricha	SW50.6	89.7728	23.8813	30	9.613	0.550	8.990	10.008	10.330	10.639	10.737	11.039	11.339	-0.460	8.530	9.548	9.870	10.179	10.277	10.579	10.879
Chitra	Khatur Magura	SW55	89.4447	23.2585	30	3.300	0.662	2.551	3.775	4.162	4.534	4.652	5.014	5.374	-0.460	2.091	3.315	3.702	4.074	4.192	4.554	4.914
Deonai_Charalkata_Jamuneswari_Karatoa	Boragari	SW61	88.8494	26.1063	30	51.989	0.645	51.259	52.453	52.830	53.192	53.307	53.660	54.011	-0.460	50.799	51.993	52.370	52.732	52.847	53.200	53.551
Deonai_Charalkata_Jamuneswari_Karatoa	Badarganj	SW62	89.0653	25.6749	28	31.835	0.907	30.809	32.488	33.018	33.527	33.689	34.186	34.680	-0.460	30.349	32.028	32.558	33.067	33.229	33.726	34.220
Deonai_Charalkata_Jamuneswari_Karatoa	Chak-Rahimpur	SW63	89.3805	25.1455	30	20.498	0.715	19.689	21.012	21.430	21.832	21.959	22.351	22.740	-0.460	19.229	20.552	20.970	21.372	21.499	21.891	22.280
Deonai_Charalkata_Jamuneswari_Karatoa	Bogra	SW65	89.3942	24.8307	30	15.312	0.885	14.310	15.949	16.467	16.964	17.122	17.607	18.089	-0.460	13.850	15.489	16.007	16.504	16.662	17.147	17.629
Deonai_Charalkata_Jamuneswari_Karatoa	Ullapara_Rly_ Crossing	SW66	89.5991	24.2943	30	11.774	0.953	10.695	12.460	13.018	13.553	13.723	14.246	14.765	-0.460	10.235	12.000	12.558	13.093	13.263	13.786	14.305
Fakirni Barnai	Naldanga_Rly. Crossing)	SW83.1	88.9628	24.5011	27	12.944	0.914	11.910	13.602	14.137	14.650	14.812	15.314	15.811	-0.460	11.450	13.142	13.677	14.190	14.352	14.854	15.351
Ganges-Padma	Rajshahi	SW88	88.5554	24.3682	30	18.267	0.756	17.412	18.811	19.253	19.677	19.812	20.227	20.638	-0.460	16.952	18.351	18.793	19.217	19.352	19.767	20.178
Ganges-Padma	Talbaria	SW91	89.0963	23.9610	29	12.957	0.638	12.236	13.416	13.789	14.147	14.261	14.610	14.958	-0.460	11.776	12.956	13.329	13.687	13.801	14.150	14.498
Ghagot	Gaibandha	SW97	89.5374	25.3520	30	21.975	1.134	20.691	22.791	23.454	24.091	24.292	24.914	25.532	-0.460	20.231	22.331	22.994	23.631	23.832	24.454	25.072
Gorai-Madhumati-Haringhata-Baleswar	Gorai Railway Bridge	SW99	89.1815	23.8864	40	12.563	0.581	11.905	12.981	13.321	13.647	13.750	14.069	14.385	-0.460	11.445	12.521	12.861	13.187	13.290	13.609	13.925
Gorai-Madhumati-Haringhata-Baleswar	KamarkhaliTransit	SW101	89.5177	23.5389	39	8.507	0.452	7.995	8.832	9.097	9.351	9.431	9.679	9.926	-0.460	7.535	8.372	8.637	8.891	8.971	9.219	9.466
Gorai-Madhumati-Haringhata-Baleswar	Rayenda	SW107.2	89.8622	22.3134	30	3.343	0.357	2.939	3.600	3.809	4.010	4.073	4.269	4.463	-0.460	2.479	3.140	3.349	3.550	3.613	3.809	4.003
Little Jamuna	Phulbari	SW132.2	88.9544	25.4997	16	29.293	0.946	28.222	29.973	30.526	31.057	31.225	31.744	32.259	-0.460	27.762	29.513	30.066	30.597	30.765	31.284	31.799
Little Jamuna	Joypurhat	SW132.5	89.0162	25.1441	29	20.008	1.088	18.777	20.791	21.427	22.038	22.232	22.828	23.420	-0.460	18.317	20.331	20.967	21.578	21.772	22.368	22.960
Little Jamuna	Manmathpur	SW132	88.8457	25.6593	29	36.110	0.958	35.025	36.799	37.360	37.898	38.068	38.594	39.116	-0.460	34.565	36.339	36.900	37.438	37.608	38.134	38.656
Little Jamuna	Naogaon	SW133	88.9347	24.8435	30	15.249	0.518	14.663	15.622	15.925	16.215	16.308	16.592	16.873	-0.460	14.203	15.162	15.465	15.755	15.848	16.132	16.413
Kocha	Umedpur	SW136.1	89.9782	22.4903	22	2.589	0.123	2.450	2.678	2.750	2.819	2.841	2.908	2.975	-0.460	1.990	2.218	2.290	2.359	2.381	2.448	2.515
Karatoa-Atrai-Gur-Gumani-Hurasagar	Bardeswari	SW139	88.4811	26.5417	29	85.990	1.025	84.830	86.727	87.326	87.902	88.084	88.646	89.204	-0.460	84.370	86.267	86.866	87.442	87.624	88.186	88.744
Karatoa-Atrai-Gur-Gumani-Hurasagar	Panchagarh	SW140	88.5470	26.3295	30	70.525	0.610	69.835	70.964	71.321	71.663	71.771	72.106	72.438	-0.460	69.375	70.504	70.861	71.203	71.311	71.646	71.978
Karatoa-Atrai-Gur-Gumani-Hurasagar	Bhushirbandar	SW142.1	88.7345	25.7670	30	39.893	0.578	39.238	40.309	40.647	40.972	41.075	41.392	41.707	-0.460	38.778	39.849	40.187	40.512	40.615	40.932	41.247

Source: JICA Survey Team

Table 5.4.12 Probability High Water-Level at All Stations (2)

River / Station Name, Station No.			Longitude (X)	Latitude (Y)	No. in sample	Mean	Std. Deviation σ_{n-1}	Water Level each Return Period (year) (m, PWD)							Difference between PWD and MSL	Water Level each Return Period (year) (m, MSL)						
								1.1	5	10	20	25	50	100		1.1	5	10	20	25	50	100
								K_T								K_T						
								-1.132	0.719	1.305	1.866	2.044	2.592	3.137	-0.460	-1.132	0.719	1.305	1.866	2.044	2.592	3.137
< Water Level >																						
Karatoa-Atrai-Gur-Gumani-Hurasagar	Khansama	SW142	88.7241	25.9246	29	45.239	1.437	43.612	46.273	47.113	47.920	48.176	48.964	49.746	-0.460	43.152	45.813	46.653	47.460	47.716	48.504	49.286
Karatoa-Atrai-Gur-Gumani-Hurasagar	Shamjhiaghat	SW143	88.7628	25.5370	30	31.314	0.789	30.421	31.882	32.343	32.786	32.927	33.359	33.789	-0.460	29.961	31.422	31.883	32.326	32.467	32.899	33.329
Karatoa-Atrai-Gur-Gumani-Hurasagar	Atrai Rly. Bridge	SW147	88.9770	24.6110	30	13.603	0.517	13.018	13.975	14.277	14.567	14.659	14.942	15.224	-0.460	12.558	13.515	13.817	14.107	14.199	14.482	14.764
Karatoa-Atrai-Gur-Gumani-Hurasagar	Chanchkair	SW148	89.2288	24.3734	30	11.731	0.674	10.968	12.216	12.611	12.989	13.109	13.479	13.846	-0.460	10.508	11.756	12.151	12.529	12.649	13.019	13.386
Karatoa-Atrai-Gur-Gumani-Hurasagar	Baghabari	SW151	89.5852	24.1293	30	11.038	0.787	10.146	11.604	12.065	12.507	12.647	13.079	13.507	-0.460	9.686	11.144	11.605	12.047	12.187	12.619	13.047
Katakhal	Mohimaganj Railway Crossi	SW155	89.5079	25.1088	30	18.409	0.621	17.706	18.856	19.220	19.569	19.679	20.020	20.359	-0.460	17.246	18.396	18.760	19.109	19.219	19.560	19.899
Kharkhuria	Kundal	SW156A	88.8811	25.7710	28	39.161	0.726	38.340	39.683	40.108	40.515	40.644	41.042	41.437	-0.460	37.880	39.223	39.648	40.055	40.184	40.582	40.977
Kobadak	Tahirpur	SW161	89.0298	23.3421	29	5.327	0.882	4.329	5.962	6.477	6.972	7.129	7.613	8.093	-0.460	3.869	5.502	6.017	6.512	6.669	7.153	7.633
Kobadak	Jhikargacha	SW162	89.0994	23.1011	34	4.064	0.797	2.950	4.780	5.130	5.390	5.470	5.660	5.810	-0.460	2.490	4.320	4.670	4.930	5.010	5.200	5.350
Kumar_Faridpur	Faridpur	SW168	89.8344	23.5971	30	5.619	1.276	4.175	6.537	7.283	7.999	8.226	8.926	9.620	-0.460	3.715	6.077	6.823	7.539	7.766	8.466	9.160
Kumar_Faridpur	Mazurdia	SW169	89.6832	23.4694	28	4.351	1.289	2.892	5.279	6.033	6.756	6.986	7.693	8.394	-0.460	2.432	4.819	5.573	6.296	6.526	7.233	7.934
Kumar_Faridpur	Bhanga	SW170	89.9863	23.3858	29	4.638	0.814	3.717	5.224	5.700	6.157	6.302	6.749	7.192	-0.460	3.257	4.764	5.240	5.697	5.842	6.289	6.732
Kumar (Jessore)	Garaganj	SW171	89.2135	23.6714	30	6.499	1.220	5.118	7.376	8.090	8.774	8.991	9.660	10.324	-0.460	4.658	6.916	7.630	8.314	8.531	9.200	9.864
Madaripur Beel Route	Haridaspur	SW198	89.8183	23.0520	27	3.493	0.696	2.705	3.994	4.401	4.792	4.916	5.298	5.677	-0.460	2.245	3.534	3.941	4.332	4.456	4.838	5.217
Nabaganga	Jhenaidaha	SW215	89.1795	23.5478	28	6.413	0.829	5.475	7.009	7.494	7.959	8.107	8.562	9.013	-0.460	5.015	6.549	7.034	7.499	7.647	8.102	8.553
Rupsa-Pasur	Khulna	SW241	89.5764	22.8195	34	3.208	0.308	2.860	3.430	3.610	3.782	3.837	4.006	4.173	-0.460	2.400	2.970	3.150	3.322	3.377	3.546	3.713
Rupsa-Pasur	Mongla	SW244	89.5976	22.4642	24	2.948	0.396	2.499	3.233	3.465	3.688	3.758	3.976	4.191	-0.460	2.039	2.773	3.005	3.228	3.298	3.516	3.731
Sarupkati	Sarupkati	SW253	90.1106	22.7648	27	2.362	0.225	2.108	2.524	2.655	2.781	2.821	2.945	3.067	-0.460	1.648	2.064	2.195	2.321	2.361	2.485	2.607
Siva-Barnai-Gurnai	Nawhata	SW261	88.6152	24.4569	30	14.687	0.725	13.866	15.208	15.632	16.039	16.168	16.566	16.960	-0.460	13.406	14.748	15.172	15.579	15.708	16.106	16.500
Surma-Meghna	Chandpur	SW277	90.6423	23.2309	29	4.752	0.328	4.380	4.988	5.180	5.364	5.423	5.603	5.782	-0.460	3.920	4.528	4.720	4.904	4.963	5.143	5.322
Surma-Meghna	Daulatkhan	SW278	90.8183	22.6110	28	3.988	0.407	3.527	4.281	4.519	4.748	4.820	5.043	5.265	-0.460	3.067	3.821	4.059	4.288	4.360	4.583	4.805
Tangon	Thakurgaon	SW285	88.4636	26.0375	30	50.063	0.492	49.506	50.416	50.704	50.980	51.068	51.337	51.605	-0.460	49.046	49.956	50.244	50.520	50.608	50.877	51.145
Teesta	Kaliganj	SW293	89.1808	25.9579	29	40.556	0.473	40.021	40.896	41.172	41.438	41.522	41.781	42.038	-0.460	39.561	40.436	40.712	40.978	41.062	41.321	41.578
Teesta	Kaunia	SW294	89.4401	25.7873	30	29.711	0.465	29.184	30.046	30.318	30.579	30.662	30.917	31.171	-0.460	28.724	29.586	29.858	30.119	30.202	30.457	30.711
Torki	Gournadi	SW300	90.2351	22.9762	13	3.005	0.730	2.178	3.530	3.957	4.367	4.497	4.897	5.295	-0.460	1.718	3.070	3.497	3.907	4.037	4.437	4.835
Tulshiganga	Sonaimukhi	SW325	89.0633	25.0206	29	16.813	0.789	15.920	17.380	17.842	18.284	18.425	18.857	19.287	-0.460	15.460	16.920	17.382	17.824	17.965	18.397	18.827
Buri Teesta	Uttar Gomanati	SW331	88.9200	26.2195	25	58.691	0.273	58.382	58.888	59.047	59.201	59.249	59.399	59.548	-0.460	57.922	58.428	58.587	58.741	58.789	58.939	59.088
Kulik	Bhutdangi	SW335	88.2384	25.8243	25	38.752	0.979	37.644	39.457	40.029	40.579	40.753	41.290	41.823	-0.460	37.184	38.997	39.569	40.119	40.293	40.830	41.363
Meghna	Meghna Ferryghat	SW275.5	90.6419	23.5839	36	5.479	0.641	4.754	5.941	6.316	6.675	6.789	7.141	7.490	-1.131	3.623	4.810	5.185	5.544	5.658	6.010	6.359
Gumti	Daudkandi	SW115	90.7155	23.5309	36	5.564	0.600	4.885	5.996	6.347	6.684	6.791	7.120	7.447	-1.031	3.854	4.965	5.316	5.653	5.760	6.089	6.416
Lahkya	Demra	SW179	90.5101	23.7217	38	5.820	0.492	5.264	6.174	6.462	6.738	6.825	7.095	7.363	-1.159	4.105	5.015	5.303	5.579	5.666	5.936	6.204
Chandana Arkandikhal	Ramdia	SW51	89.5193	23.7292	27	9.066	0.884	8.066	9.702	10.219	10.715	10.873	11.357	11.838	-0.460	7.606	9.242	9.759	10.255	10.413	10.897	11.378
Chitra	Ratandanga	SW55.1	89.5168	23.1992	29	3.708	0.743	2.867	4.242	4.676	5.093	5.225	5.632	6.037	-0.460	2.407	3.782	4.216	4.633	4.765	5.172	5.577
DCJ Karatoa	Shibganj	SW64	89.3239	25.0025	32	17.754	0.720	16.939	18.272	18.694	19.098	19.226	19.621	20.013	-0.460	16.479	17.812	18.234	18.638	18.766	19.161	19.553
Fakirni Barnai	Jote Bazar (Off take	SW82	88.7304	24.6840	31	16.434	0.531	15.833	16.816	17.127	17.425	17.520	17.811	18.100	-0.460	15.373	16.356	16.667	16.965	17.060	17.351	17.640
Ganges	Sureswar	SW95	90.4240	23.3156	30	4.850	0.597	4.174	5.280	5.630	5.965	6.071	6.399	6.724	-0.460	3.714	4.820	5.170	5.505	5.611	5.939	6.264
Kobadak	Chandkhali	SW164	89.2536	22.5206	21	3.331	0.810	2.414	3.914	4.387	4.842	4.986	5.430	5.871	-0.460	1.954	3.454	3.927	4.382	4.526	4.970	5.411
Lohalia	Kaitpara	SW183	90.4372	22.4564	9	2.684	0.101	2.570	2.757	2.816	2.873	2.891	2.946	3.001	-0.460	2.110	2.297	2.356	2.413	2.431	2.486	2.541
Lower Kumar	Mostafapur	SW190	90.1369	23.1591	30	4.015	0.557	3.384	4.416	4.742	5.055	5.154	5.460	5.763	-0.460	2.924	3.956	4.282	4.595	4.694	5.000	5.303

Source: JICA Survey Team

Table 5.4.13 Probability High Water-Level at All Stations (3)

River / Station Name, Station No.			Longitude (X)	Latitude (Y)	No. in sample	Mean	Std. Deviation σ_{n-1}	Water Level each Return Period (year) (m, PWD)							Difference between PWD and MSL	Water Level each Return Period (year) (m, MSL)						
								1.1	5	10	20	25	50	100		1.1	5	10	20	25	50	100
								K_T								K_T						
								-1.132	0.719	1.305	1.866	2.044	2.592	3.137	-0.460	-1.132	0.719	1.305	1.866	2.044	2.592	3.137
< Water Level >																						
Punarbhaba	Pulhat	SW236	88.6218	25.6204	17	33.211	0.587	32.547	33.633	33.977	34.306	34.411	34.733	35.052	-0.460	32.087	33.173	33.517	33.846	33.951	34.273	34.592
Tangon	Raniganj	SW284	88.4791	26.2269	39	61.284	3.049	57.833	63.478	65.262	66.973	67.516	69.188	70.848	-0.460	57.373	63.018	64.802	66.513	67.056	68.728	70.388
Bangali	Sharia Kandi	SW11A	89.5701	24.8963	32	16.384	0.595	15.710	16.812	17.160	17.494	17.600	17.927	18.251	-0.460	15.250	16.352	16.700	17.034	17.140	17.467	17.791
Baral	Malanchi	SW16.1	88.9665	24.2905	32	13.196	1.129	11.918	14.008	14.668	15.302	15.503	16.122	16.736	-0.460	11.458	13.548	14.208	14.842	15.043	15.662	16.276
Ghagot	Jafarganj Rd.Crossin	SW96A	89.1882	25.8002	32	34.021	0.786	33.131	34.586	35.047	35.488	35.628	36.059	36.487	-0.460	32.671	34.126	34.587	35.028	35.168	35.599	36.027
Lahkya	Narayanganj	SW180	90.5240	23.6602	19	5.749	0.548	5.129	6.143	6.464	6.771	6.868	7.169	7.467	-0.460	4.669	5.683	6.004	6.311	6.408	6.709	7.007
Tangon	Kodalkatigaon	SW287	88.4337	25.6843	32	34.376	1.289	32.916	35.303	36.058	36.782	37.011	37.718	38.420	-0.460	32.456	34.843	35.598	36.322	36.551	37.258	37.960
Surma-Meghna	Satnal	SW276	90.5936	23.4721	32	5.136	0.577	4.483	5.551	5.888	6.212	6.315	6.631	6.945	-0.460	4.023	5.091	5.428	5.752	5.855	6.171	6.485
Lahkya	Lakhpur	SW177	90.6534	24.0397	34	6.523	0.636	5.803	6.981	7.353	7.710	7.824	8.173	8.519	-0.460	5.343	6.521	6.893	7.250	7.364	7.713	8.059
Brahmaputra-Jamuna	Chilmari	SW45.5	89.7044	25.5438	0	-	-	-	24.371	24.583	-	24.805	24.942	25.080	-0.460	-	23.911	24.123	-	24.345	24.482	24.620
Brahmaputra-Jamuna	Bahadurabad	SW47	89.6802	25.1106	0	-	-	-	20.135	20.281	-	20.413	20.484	20.538	-0.460	-	19.675	19.821	-	19.953	20.024	20.078
Mathabhanga	Kazipur	SW205	88.7667	24.0026	0	-	-	-	16.023	16.258	-	16.517	16.685	16.834	-0.460	-	15.563	15.798	-	16.057	16.225	16.374
Jamuna	Serajganj	SWunknown52	89.7184	24.4710	0	-	-	-	14.249	14.742	-	15.134	15.424	15.710	-0.460	-	13.789	14.282	-	14.674	14.964	15.250
Brahmaputra-Jamuna	Porabari	SW50	89.8181	24.1468	0	-	-	-	12.648	12.867	-	13.082	13.206	13.305	-0.460	-	12.188	12.407	-	12.622	12.746	12.845
Ganges	Hardinge Bridge	SW90	89.0255	24.0640	0	-	-	-	14.668	14.858	-	15.037	15.135	15.211	-0.460	-	14.208	14.398	-	14.577	14.675	14.751
Ganges	Sengram	SW91.1	89.3783	23.8828	0	-	-	-	12.155	12.425	-	12.716	12.902	13.063	-0.460	-	11.695	11.965	-	12.256	12.442	12.603
Ganges	Mahendrapur	SW91.2	89.5539	23.8006	0	-	-	-	11.102	11.383	-	11.699	11.909	12.098	-0.460	-	10.642	10.923	-	11.239	11.449	11.638
Ganges	Baruria	SW91.9L	89.7994	23.8001	0	-	-	-	8.565	8.842	-	9.215	9.509	9.817	-0.460	-	8.105	8.382	-	8.755	9.049	9.357
Ganges	Mawa	SW93.5L	90.2605	23.4704	0	-	-	-	6.291	6.548	-	6.913	7.215	7.545	-0.460	-	5.831	6.088	-	6.453	6.755	7.085
Surma-Meghna	Bhairab Bazar	SW273	91.0019	24.0527	0	-	-	-	6.982	7.218	-	7.462	7.612	7.739	-0.460	-	6.522	6.758	-	7.002	7.152	7.279
Old Brahmaputra	Jamalpur	SW225	89.9607	24.9358	0	-	-	-	17.408	17.519	-	17.590	17.617	17.633	-0.460	-	16.948	17.059	-	17.130	17.157	17.173
Old Brahmaputra	Mymensingh	SW228	90.4339	24.7366	0	-	-	-	12.843	13.078	-	13.267	13.356	13.417	-0.460	-	12.383	12.618	-	12.807	12.896	12.957
Bhairab	Afraghat	SW30	89.3930	23.1050	32	3.255	0.298	2.917	3.470	3.644	3.812	3.865	4.028	4.191	-0.460	2.457	3.010	3.184	3.352	3.405	3.568	3.731
Chitra	Narail	SW56.1	89.5070	23.1701	31	3.759	0.516	3.175	4.130	4.432	4.722	4.814	5.097	5.378	-0.460	2.715	3.670	3.972	4.262	4.354	4.637	4.918
Nabaganga	Gazirhat	SW219	89.5614	22.9611	28	3.699	0.490	3.144	4.051	4.337	4.612	4.699	4.968	5.234	-0.460	2.684	3.591	3.877	4.152	4.239	4.508	4.774
Nil Jinjiram	Boalmari	SW327	89.8150	25.6644	32	24.885	1.093	23.648	25.671	26.310	26.923	27.118	27.717	28.312	-0.460	23.188	25.211	25.850	26.463	26.658	27.257	27.852
Gorai-Madhumoti	Bhatiapara	SW102	89.6958	23.2150	40	5.390	0.733	4.500	5.820	6.230	6.620	6.740	7.120	7.500	-0.760	3.740	5.060	5.470	5.860	5.980	6.360	6.740
Gorai-Madhumoti	Atharobanka	SW105	89.7931	22.9817	32	3.141	0.491	2.650	3.440	3.730	4.040	4.150	4.490	4.850	-0.460	2.190	2.980	3.270	3.580	3.690	4.030	4.390
Bogkhali	Ramu	SW40	92.1141	21.4258	31	6.826	0.811	5.909	7.409	7.884	8.339	8.483	8.927	9.369	-0.460	5.449	6.949	7.424	7.879	8.023	8.467	8.909
Mathamuhuri	Lama	SW203	92.2124	21.7926	34	12.673	1.307	10.950	13.780	14.440	15.000	15.170	15.670	16.120	-0.460	10.490	13.320	13.980	14.540	14.710	15.210	15.660
Mathamuhuri	Chiringa	SW204	92.0800	21.7727	34	12.673	1.307	5.880	6.840	7.030	7.180	7.230	7.350	7.470	-0.460	5.420	6.380	6.570	6.720	6.770	6.890	7.010
Kutubdia Channel	Lemsikhali	SW176	91.8958	21.8496	33	3.161	0.511	2.450	3.590	3.800	3.960	4.010	4.130	4.240	-0.460	1.990	3.130	3.340	3.500	3.550	3.670	3.780
Sangu	Bandarban	SW247	92.2192	22.1941	32	14.532	2.295	11.934	16.183	17.526	18.814	19.223	20.481	21.731	-0.460	11.474	15.723	17.066	18.354	18.763	20.021	21.271
Sangu	Dohazari	SW248	92.0665	22.1571	34	6.980	0.858	5.760	7.730	7.990	8.160	8.200	8.320	8.400	-0.832	4.928	6.898	7.158	7.328	7.368	7.488	7.568
Halda	Enayethat	SW121	91.8970	22.4058	30	4.178	0.692	3.394	4.676	5.081	5.469	5.593	5.972	6.349	-0.460	2.934	4.216	4.621	5.009	5.133	5.512	5.889
Ichamati (Tributary to Karnafuli)	Outfall Karnaful	SW125	92.0598	22.4526	30	4.588	0.884	3.586	5.224	5.741	6.238	6.395	6.880	7.362	-0.460	3.126	4.764	5.281	5.778	5.935	6.420	6.902
Halda	Narayanhat	SW117	91.7227	22.8069	34	16.289	0.917	15.251	16.949	17.486	18.001	18.164	18.667	19.167	-0.460	14.791	16.489	17.026	17.541	17.704	18.207	18.707
Feni	Ramgarh	SW84	91.6647	22.9789	33	16.603	1.213	8.950	11.650	12.360	12.990	13.180	13.760	14.310	-1.460	7.490	10.190	10.900	11.530	11.720	12.300	12.850
Feni	Kaliachari	SW84.1	91.6263	22.9418	34	10.598	1.325	4.970	6.420	7.060	7.740	7.970	8.730	9.550	-2.010	2.960	4.410	5.050	5.730	5.960	6.720	7.540
Feni	Sobhapur	SW85	91.5476	22.9554	7	5.883	1.080	5.000	6.050	6.310	6.540	6.610	6.820	7.020	-0.460	4.540	5.590	5.850	6.080	6.150	6.360	6.560
Feni	Dhumghat	SW86	91.5025	22.9091	26	5.640	0.509	4.470	5.210	5.450	5.670	5.740	5.960	6.180	-0.460	4.010	4.750	4.990	5.210	5.280	5.500	5.720
Feni	Sonapur	SW87	91.4889	22.8914	29	4.926	0.382	5.880	6.840	7.030	7.180	7.230	7.350	7.470	-0.460	5.420	6.380	6.570	6.720	6.770	6.890	7.010
Chandana Arakandikhal	Ghosepur	SW52	89.6568	23.4429	21	6.257	0.708	5.456	6.766	7.180	7.577	7.703	8.091	8.476	-0.460	4.996	6.306	6.720	7.117	7.243	7.631	8.016

Source: JICA Survey Team

Table 5.4.14 Design High Water-Level (HFL) at Target Bridges

Sl. no.	Bridge ID	Bridge Name	Existing Bridge			New Bridge			Probable Water Level (m, MSL)										Vertical Clearance (m, MSL)							Difference between Existing and New bridge's Girder (m)	Remarks
			Damage Category	Total Brd. Length (m)	Brd. Width (m)	Type	Total Brd. Length (m)	Brd. Width (m)	1.1 yr (NHWL)	10 yr	20 yr	25 yr	50 yr (Design HWL)	100 yr (Design HWL)	Applied Calculation High WaterLevel		Historical WL (by Interview) (m, MSL)		**Applied Design High Water Level**		Bottom of Existing Brd. Girder, Elev.		Necessary Freeboard, Elev.		Design Bottom Level	Free-board		
A1	N-706_14b	Jhikorgacha Bridge	C	118.7	6.9	PC-I	125.0	2x14.2	2.49	4.67	4.93	5.01	5.20	5.35	5.35	**100yr**	3.769	2000	5.35	**100yr**	4.790	F	6.15	3	6.15	0.80	1.36	SW162
A2	R-750_25a	Tularampur Bridge	D	91.5	8.2	PC-I	100.0	2x10.4	2.36	3.61	3.90	3.99	4.27	4.55	4.55	**100yr**	3.387	1971	4.55	**100yr**	5.704	-	5.35	3	5.70	1.15	-	
A3	Z-7503_5a	Hawai khali Bridge	C	26.1	7.9	PC-I	35.0	2x11.3	3.00	4.39	4.71	4.81	5.12	5.43	5.43	**100yr**	6.033	1971	6.03	Interview	5.761	F	6.63	-	6.63	0.60	0.87	
A4	N-806	Kalna	-	-	-	PC-I + Steel	690.0	21.9	3.74	5.47	5.86	5.98	6.36	6.74	6.74	**100yr**	5.650	1988/ 1989	6.74	**100yr**	New	-	13.96	8	13.96	7.22	-	SW102 SHWL: **6.34**
A5	N-805_24a	Garakola Bridge	C	105.1	10.0	PC-I	110.0	2x10.4	3.52	5.38	5.81	5.94	6.36	6.77	6.77	**100yr**	5.734	1988	6.77	**100yr**	8.691	-	7.57	3	8.69	1.92	-	
B1	R-151_3a	Purbo Hinguli Bridge	B	18.5	7.8	0	0.0	0.0	4.54	6.43	7.01	7.20	7.84	8.52	7.84	**50yr**	6.985	1988	7.84	**50yr**	7.942	-	8.64	3	8.64	0.80	0.70	
B2	R-151_4a	Telipool Bridge	D	15.2	4.2	PC-I	25.0	13.4	4.54	6.47	7.08	7.28	7.95	8.67	7.95	**50yr**	7.913	1988	7.95	**50yr**	6.259	F	8.55	-	8.55	0.60	2.29	
B3	R-151_4c	Lakshmi chara Bridge	C	15.4	4.2	PC-I	40.0	13.4	4.54	6.52	7.15	7.36	8.06	8.81	8.06	**50yr**	8.001	1988	8.06	**50yr**	6.748	F	8.66	-	8.66	0.60	1.91	
B4	R-151_11a	Tulatuli Lohar Bridge	D	24.5	5.0	0	0.0	0.0							-	-	N/A	-	-	-	55.931	-	-	-	-	-	-	
B5	R-151_11c	tulatuli Bridge	C	24.3	7.2	0	0.0	0.0							-	-	N/A	-	-	-	51.410	-	-	-	-	-	-	
B6	R-151_12a	Buro Camp Bridge	B	24.2	7.2	0	0.0	0.0							-	-	N/A	-	-	-	43.781	-	-	-	-	-	-	
B7	R-151_12c	Bangra Tabor Bridge	C	24.3	7.2	0	0.0	0.0							-	-	N/A	-	-	-	43.995	-	-	-	-	-	-	
B8	R-151_12e	Kalapani Bridge-1	C	24.4	7.2	0	0.0	0.0							-	-	N/A	-	-	-	39.851	-	-	-	-	-	-	
B9	R-151_14a	Kalapani Bridge-2	D	24.8	4.1	PC-I	35.0	13.4	9.04	13.59	14.18	14.34	14.76	15.08	14.76	**50yr**	13.650	-	14.76	**50yr**	13.519	F	15.36	-	15.36	0.60	1.84	
B10	R-151_14c	Niharkanti Das Bridge	B	42.0	8.6	0	0.0	0.0	9.18	13.81	14.40	14.55	14.96	15.26	14.96	**50yr**	N/A	-	14.96	**50yr**	18.108	-	15.56	-	18.11	3.15	-	
B11	R-151_15a	Koilapara Bridge	C	24.4	7.1	0	0.0	0.0							-	-	N/A	-	-	-	41.801	-	-	-	-	-	-	
B12	R-151_16a	Koilabazar Bridge	A	36.8	4.9	PC-I	55.0	13.4	9.39	14.13	14.71	14.86	15.26	15.54	15.26	**50yr**	15.510	UNK	15.51	Interview	15.822	-	16.31	3	16.31	0.80	0.49	
B13	R-151_16c	Balutila Bridge	C	21.4	4.0	PC-I	30.0	13.4	9.55	14.37	14.95	15.10	15.48	15.74	15.48	**50yr**	15.990	1988	15.99	Interview	15.735	F	16.59	-	16.59	0.60	0.86	
B14	R-151_18a	Fulchari Bridge	C	15.3	4.1	Box Culvert	-	-	9.90	14.92	15.49	15.63	15.99	16.21	15.99	**50yr**	20.511	UNK	20.51	Interview	21.122	-	21.11	-	21.12	0.61	-	
B15	R-151_22a	Heaku Bazar B ridge	C	12.5	4.1	Box Culvert	-	-							0.00	**50yr**	23.299	1988	23.30	Interview	23.719	-	23.90	-	23.90	0.60	0.18	
B16	R-152_Sa	Heako Bridge	C	12.4	4.1	PC-I	25.0	-							0.00	**50yr**	23.229	1963	23.23	Interview	23.065	F	23.83	-	23.83	0.60	0.76	
B17	R-152_3a	Amtali Bridge	B	19.8	7.2	0	0.0	0.0							0.00	**50yr**	26.474	UNK	26.47	Interview	28.468	-	27.07	-	28.47	1.99	-	
B18	R-152_7a	Chikon Chara Bridge	C	24.2	7.3	PC-I	30.0	13.4	13.83	17.16	17.51	17.60	17.84	18.02	17.84	**50yr**	19.996	1988	20.00	Interview	20.173	-	20.60	-	20.60	0.60	0.42	
B19	R-152_8a	Chikon Chara Bridge	D	12.5	4.2	Box Culvert	-	-	13.80	17.13	17.48	17.58	17.82	18.00	17.82	**50yr**	17.331	1988	17.82	**50yr**	18.513	-	18.42	-	18.51	0.69	-	
B20	R-152_8c	Banglabazar bridge	D	12.7	4.3	Box Culvert	-	-	13.75	17.07	17.43	17.52	17.77	17.95	17.77	**50yr**	17.245	1988	17.77	**50yr**	17.415	F	18.37	-	18.37	0.60	0.95	
B21	R-152_10a	Borobil Bridge	B	30.6	7.2	0	0.0	0.0	13.76	17.09	17.44	17.54	17.78	17.96	17.78	**50yr**	14.830	1988	17.78	**50yr**	15.034	F	18.38	-	18.38	0.60	3.35	
B22	R-152_10c	Borobil Bridge	C	15.2	4.1	Box Culvert	-	-	13.82	17.15	17.51	17.60	17.84	18.02	17.84	**50yr**	17.374	1963	17.84	**50yr**	15.706	F	18.44	-	18.44	0.60	2.73	
B23	R-152_11b	Gadar dokan Bridge	D	13.2	4.2	Box Culvert	-	-	13.88	17.21	17.56	17.65	17.89	18.06	17.89	**50yr**	17.448	1963	17.89	**50yr**	16.095	F	18.49	-	18.49	0.60	2.39	
B24	R-152_13a	Bagan Bazar Bridge	C	18.4	4.2	Box Culvert	-	-	13.63	17.02	17.38	17.48	17.73	17.91	17.73	**50yr**	16.483	1963	17.73	**50yr**	19.180	-	18.33	-	19.18	1.45	-	
B25	R-152_14a	East baganbazar Bridge	C	36.8	4.2	PC-I	50.0	13.4	13.55	16.95	17.31	17.41	17.66	17.85	17.66	**50yr**	16.407	1963	17.66	**50yr**	16.741	F	18.46	3	18.46	0.80	1.72	
B26	R-152_15a	Sonaipool Bridge	C	36.9	4.1	0	0.0	13.4	13.72	17.11	17.47	17.56	17.80	17.98	17.80	**50yr**	16.377	1963	17.80	**50yr**	17.231	F	18.60	3	18.60	0.80	1.37	
C8	N-1_257a	Patiya Bridge	C	50.3	8.4	PC-I	55.0	2x11.3	3.73	5.64	5.94	6.03	6.30	6.56	6.56	**100yr**	6.235	1997	6.56	**100yr**	7.538	-	7.36	3	7.54	0.98	-	
C12	N-1_272a	Mazar Point Bridge	D	50.8	7.2	PC-I	60.0	2x11.3	4.51	6.64	6.86	6.92	7.10	7.24	7.24	**100yr**	8.374	1988	8.37	Interview	10.218	-	9.17	3	10.22	1.84	-	
C13	N-1_279a	Sangu Bridge	C	211.0	7.2	PC-I	215.0	2x10.4	4.93	7.16	7.33	7.37	7.49	7.57	7.57	**100yr**	8.835	1988	8.84	Interview	10.114	-	9.84	4	10.11	1.28	-	SW248
C26	N-1_328a	Mathamuhuri Bridge	D	294.2	7.2	PC-I	310.0	2x10.4	5.42	6.57	6.72	6.77	6.89	7.01	7.01	**100yr**	6.717	2015	7.01	**100yr**	6.073	F	8.21	5	8.21	1.20	2.14	SW204

B4-B8 and B11 are not the drainage structures !

Refer to Interview WL !

Note.

1. Asian Highways and N roads are adopted **100yr** return period.
2. R roads are adopted **50yr** return period.
3. Z roads are adopted **25yr** return period.
4. In case of "Interviewed WL>Calculated WL", it is adopted "Interviewed WL" with 0.6m freeboard.

Vertcal Clearance

	1	0.60 + Intervewed HWL
	2	0.60 + Design HWL
	3	0.80 + Design HWL
	4	1.00 + Design HWL
	5	1.20 + Design HWL
	6	1.50 + Design HWL
Navigation	7	1.80 + 1.1yr HWL or Design HWL+freeboard, except
Navigation	8	7.62 + SHWL (Class-III) for Kalna Bridge

Source: JICA Survey Team

5) Standard High Water Level: SHWL for Navigation

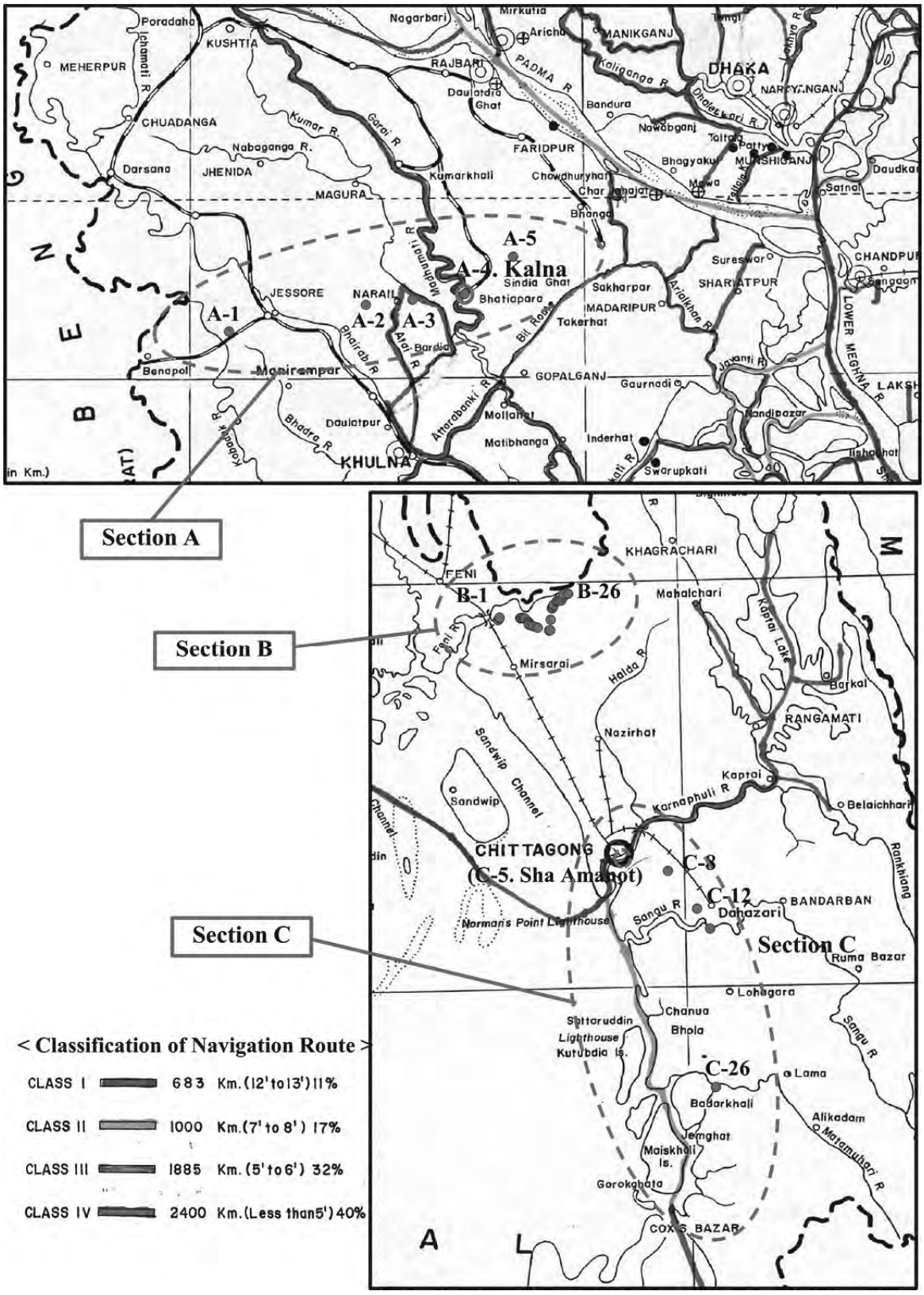
The Standard High Water Level (SHWL) is known as the overhead clearance datum which will seldom be exceeded. SHWL have been determined by BIWTA (Inland Waterways of Bangladesh, 1991), and the inland waterway for ship navigation has been classified officially, as shown in Figure 5.4.32. A bridge over inland waterways in the proposed bridges at Section-A is only the Kalna Bridge, and it is classified as "Class-III" by BIWTA. (Of the others in the listed bridges for this study, the Sha-Amanot Bridge in Chittagong is over a BIWTA inland waterway.) The SHWL at the gauge stations near the target bridges, are shown in Table 5.4.15.

Table 5.4.15 Standard High Water Level at Gauging Stations near Target Bridges

Station Name	River Name	Station ID	SLWL		SHWL		Remarks (Positional relation with the Bridge)
			m, PWD	m, MSL	m, PWD	m, MSL	
Bhatiapara	Modhumati	SW102	0.59	-0.17	7.10	6.34	2.67 km upstream from the Kalna bridge
Sadarghat (Chittagong)	Karnaphuli	1330	-1.93	-2.39	3.49	3.03	2.5 km downstream from the Sha Amanot bridge

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 and PWD datum is 46cm officially.

Source: BIWTA



Source: BIWTA

Figure 5.4.32 (Official) Navigation Channel in Bangladesh

(5) Navigation Clearance

BIWTA has specified the minimum vertical and horizontal clearance for free navigation considering the type of navigational routes, which are classified as Class I through Class IV as given in the following Table. According to the Classifications of BIWTA, rivers of target Bridges are classified in Class III and IV, on their classified map. However, by result of meeting with BIWTA, the Kalna Bridge on the Madhumati River was recommended as "Class-III" for the navigational maintenance (=passage of a dredging ship).

Table 5.4.16 Fairway Limitation in Bangladesh

Classification of Waerways	Minimum Vertical Clearance	Minimum Horizontal Clearance	Remarks
Class-I	18.30m (60ft)	76.22m (250ft)	
Class-II	12.20m (40ft)	76.22m (250ft)	
Class-III	7.62m (25ft)	30.48m (100ft)	(new) Kalna Bridge, Chittagong Bridge
Class-IV Including seasonal rivers	5.00m (16.5ft)	20.00m (66ft)	Official classification of (new) Kalna Bridge

Source: BIWTA, 1991

(6) Hydraulic Calculations

1) General

In the tidal river, the hydraulic phenomena (rising tide, falling tide, etc., in addition to the river's own flood) at the tidal compartment of the river are needed to simulate all of the tidal reaches. However, as presented in 5.4.3 (2), the tidal range at the proposed bridge during flooding is small. Hence, the effect of the tidal component of the river is ignored on the hydraulic calculation in this study.

The 1-dimensional hydraulic analyses are performed at 3 main bridges of the Kalna (A-4), Sangu (C-13) and Mathamuhuri (C-26) for confirming of the average flow condition and the bridge scour. Furthermore, at the Kalna Bridge only, the 2-dimensional hydraulic calculation is performed in order to compute a spatial distribution of the flow parameters (e.g. velocity, water-level, vorticity, limit of movement diameter) in the river reach.

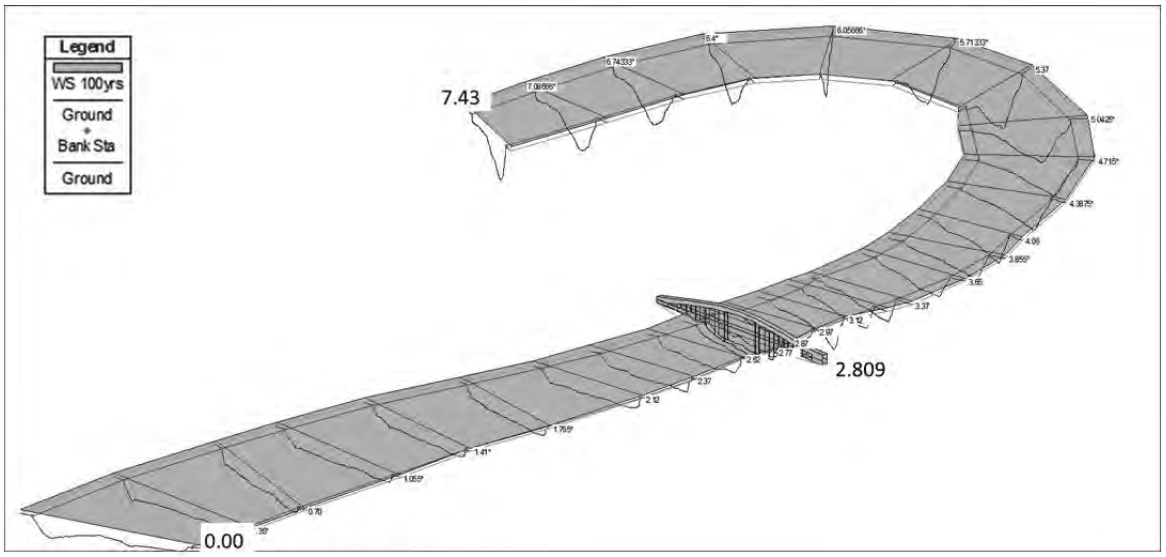
The 1-dimensional hydraulic analyses are used the HEC-RAS model (Hydrologic Engineering Center - River Analysis System) developed by US Army Corps of Engineers, USA. And the iRIC (International River Interface Cooperative - River flow and River bed fluctuation Analysis System) developed by U.S. Geological Survey and Hokkaido University of Japan is used for the 2-dimensional analysis.

2) 1-Dimensional Hydraulic Analysis of the Proposed Kalna Bridge (A-4)

The hydraulic calculation model at the proposed Kalna Bridge is shown in Figure 5.4.33. The cross-sections for hydraulic calculation are given by using the bathymetry survey results.

Hydraulic analysis is performed under the following conditions and its result is shown in Table 5.4.17 and Figure 5.4.34. And the results of scour estimation are as shown in and Figure 5.4.35.

- Calculation Case - 2 case of 'With Bridge' and 'Without Bridge'
- Discharge - 1.1, 10, 25, 50, 100 (design scale) and 500 years
- Water-level at downstream end on calculation - To set up to fit with a probability water-level at the location of SW102 station



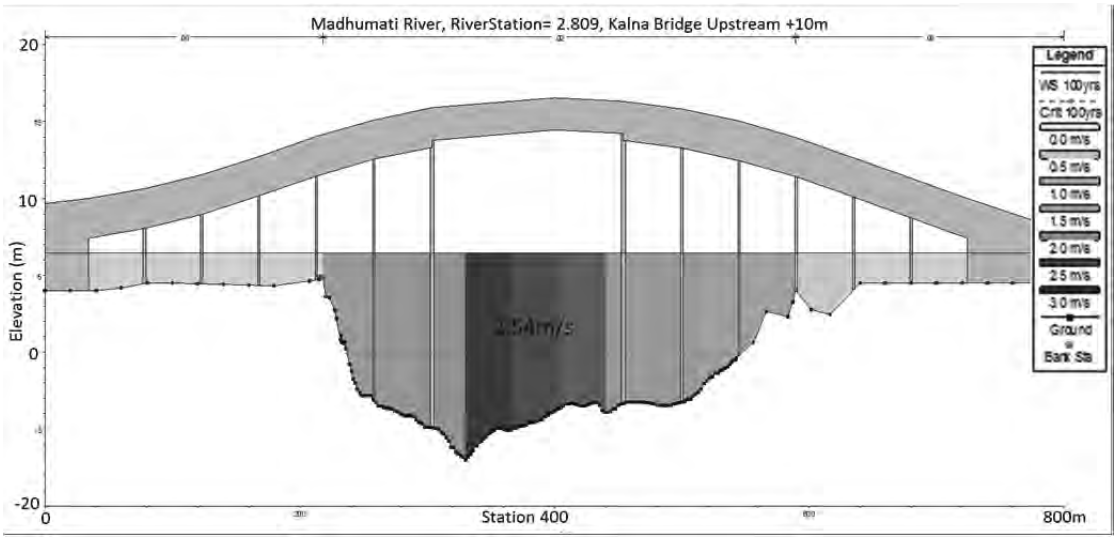
Source: JICA Survey Team

Figure 5.4.33 1-D Hydraulic Analysis Model at Proposed Kalna Bridge

Table 5.4.17 Results of Hydraulic Analysis at Proposed Kalna Bridge

Plan: F.Plan2 Madhumati Main RS: 2.809 Profile: 100yrs				
E.G. US. (m)	6.66	Element	Inside BR US	Inside BR DS
W.S. US. (m)	6.49	E.G. Elev (m)	6.66	6.65
Q Total (m3/s)	6561	W.S. Elev (m)	6.48	6.47
Q Bridge (m3/s)	6561	Crit W.S. (m)	-0.11	-0.21
Q Weir (m3/s)		Max Chl Dpth (m)	13.46	12.6
Weir Sta Lft (m)		Vel Total (m/s)	1.63	1.62
Weir Sta Rgt (m)		Flow Area (m2)	4013.72	4039.57
Weir Submerg		Froude # Chl	0.16	0.17
Weir Max Depth (m)		Specif Force (m3)	18663.95	19000.15
Min El Weir Flow (m)	7.89	Hydr Depth (m)	6.04	6.08
Min El Prs (m)	14.44	W.P. Total (m)	790.8	793.66
Delta EG (m)	0.01	Conv. Total (m3/s)	642827.8	649740.8
Delta WS (m)	0.01	Top Width (m)	664	664
BR Open Area (m2)	7319.78	Frctn Loss (m)	0	0
BR Open Vel (m/s)	1.63	C & E Loss (m)	0	0
Coef of Q		Shear Total (N/m2)	5.18	5.09
Br Sel Method	Energy only	Power Total (N/m s)	0	0

Source: JICA Survey Team



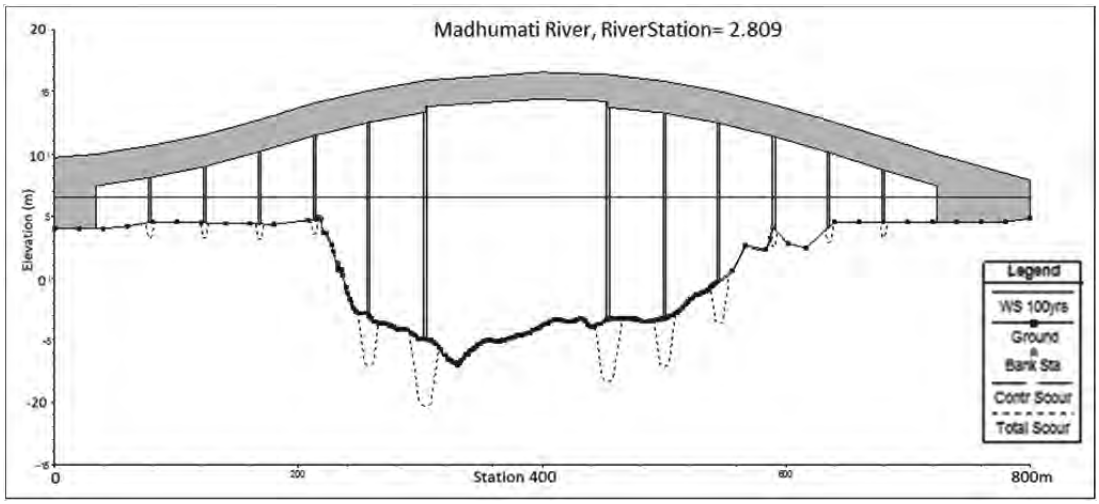
Source: JICA Survey Team

Figure 5.4.34 Hydraulic Cross-sectional Profile of Proposed Kalna Bridge

Table 5.4.18 Results of Scouring Computation at Proposed Kalna Bridge

Pier No.	Calculated Scour Depth (m)		
	Local Scour	Contraction Scour	Total Scour
Pier 1	1.19	-	1.19
Pier 2	1.24	-	1.24
Pier 3	1.44	-	1.44
Pier 4	3.28	0.14	3.42
Pier 5	3.72	0.14	3.86
Pier 6	4.88	0.14	5.02
Pier 7	5.25	0.14	5.40
Pier 8	3.77	0.14	3.92
Pier 9	1.19	-	1.19
Pier 10	1.24	-	1.24
Pier 11	1.22	-	1.22
Pier 12	1.25	-	1.25

Source: JICA Survey Team



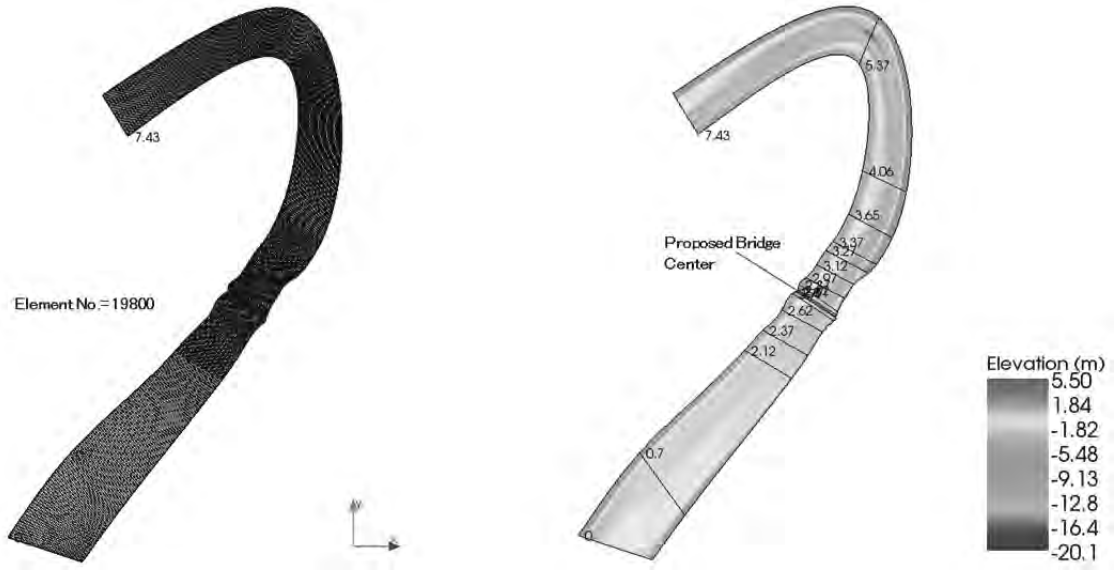
Source: JICA Survey Team

Figure 5.4.35 Scouring Computation Result at Proposed Kalna Bridge

3) 2-Dimensional Hydraulic Analysis of Proposed Kalna Bridge (A-4)

As a pre-condition of 2-dimensional hydraulic analysis, the following conditions were adopted in the modelling;

- The river profile was set up in the hydraulic model using the river cross-sections measured at upstream and downstream,
- The calculation elements are divided in 19800 and it is densely divided around the bridge,
- The upstream boundary condition at the river inputs the probable flood discharge for the 100-year return period discharge, and
- The downstream boundary condition inputs the water level from the result of HEC-RAS



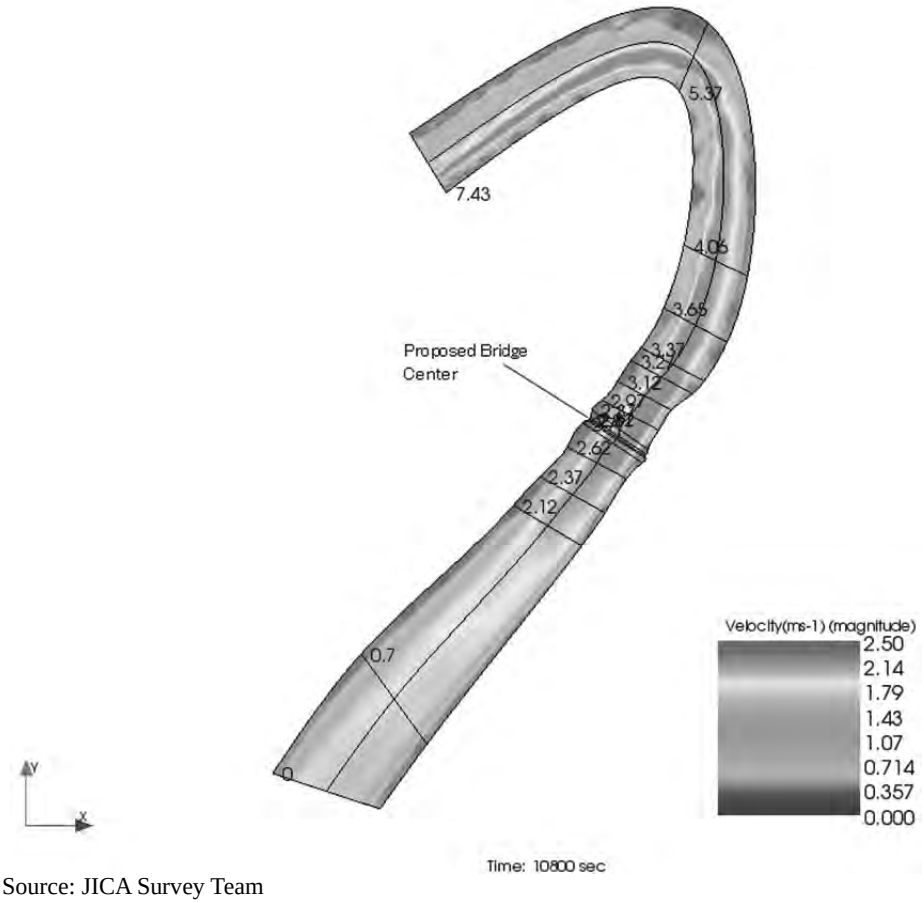
Source: JICA Survey Team

Figure 5.4.36 2-D Hydraulic Analysis Model at Proposed Kalna Bridge

The spatial distribution of the flow velocity in 100 year flood is shown in Figure 5.4.37 and Figure 5.4.38. Although these velocities are the instantaneous velocity, the extraordinary flow velocity is not particularly occurred depending on the location. Also, it does not have any formation of harmful vortex around the proposed bridge in this modeling. (The basic mechanism causing local scour at piers or abutment is formation of vortices at their base as shown in Figure 5.4.41.) However, in the river bend portion of proposed-bridge upstream, the generation of vortex is recognized as shown in Figure 5.4.39.

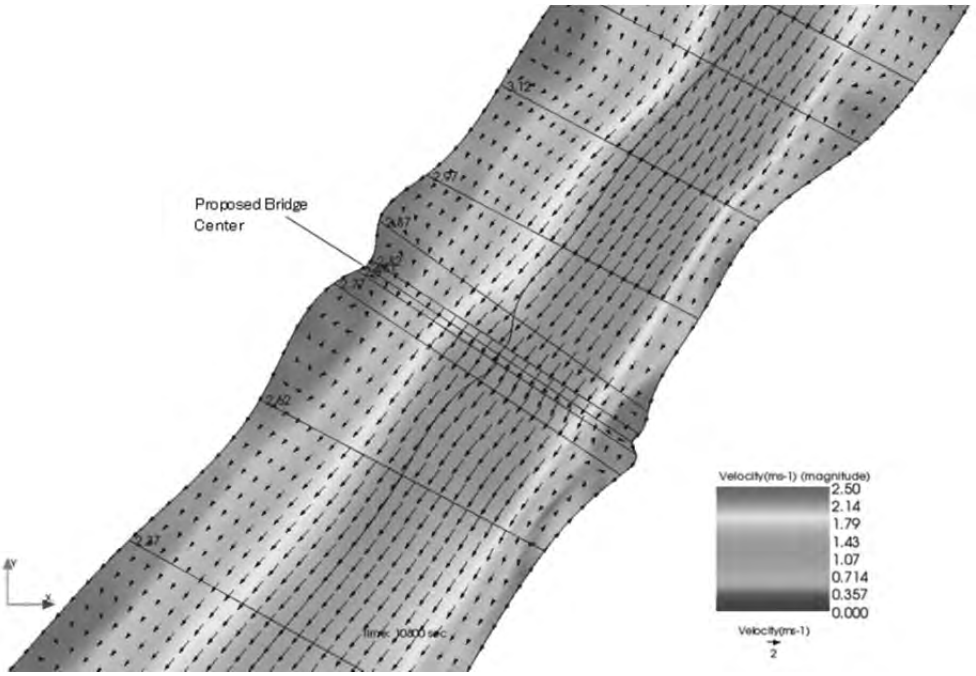
According to the geological survey result, the mean diameter (D50) of the river-bed material at the Madhimati River is 0.17mm of microsand. As an indicator of scour-prone river-bed materials (D50), the critical velocity for movement of bed material is calculated from the velocity and water depth. The calculation result for the limit of movement diameter of river-bed material is shown in Figure 5.4.40. This Figure shows that all of river-bed materials will be washed out, under 100 year flood

condition. (In reality, against the natural dynamic flow conditions, the scouring and sedimentation of riverbed has been repeated.)



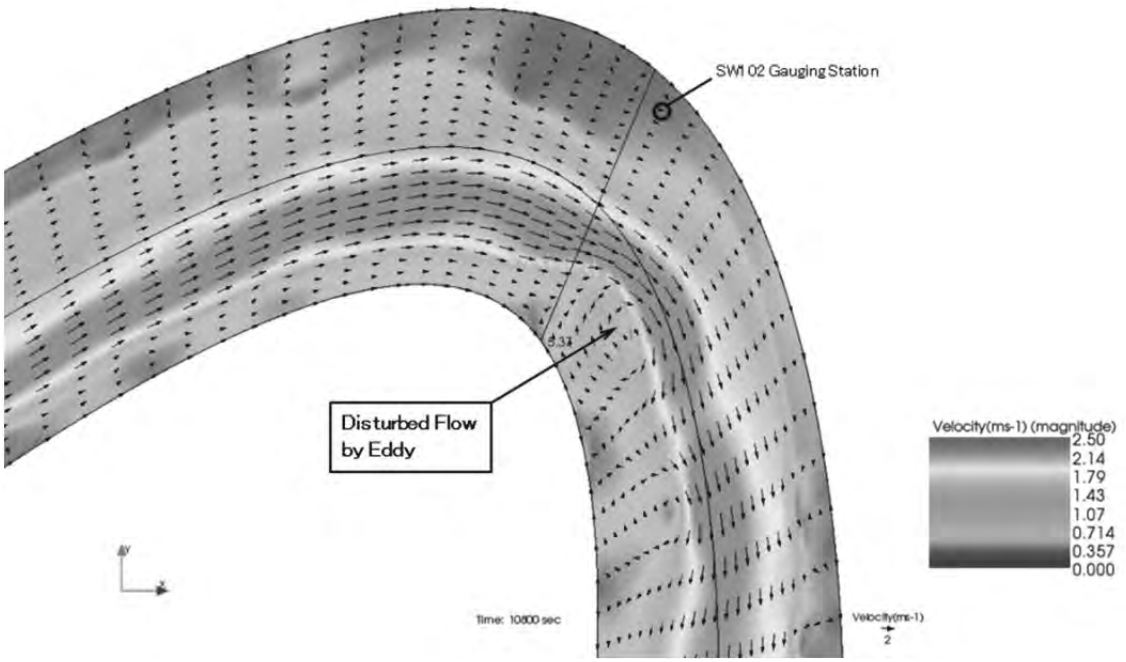
Source: JICA Survey Team

Figure 5.4.37 Spatial Distribution of Flow Velocity at Proposed Kalna Bridge



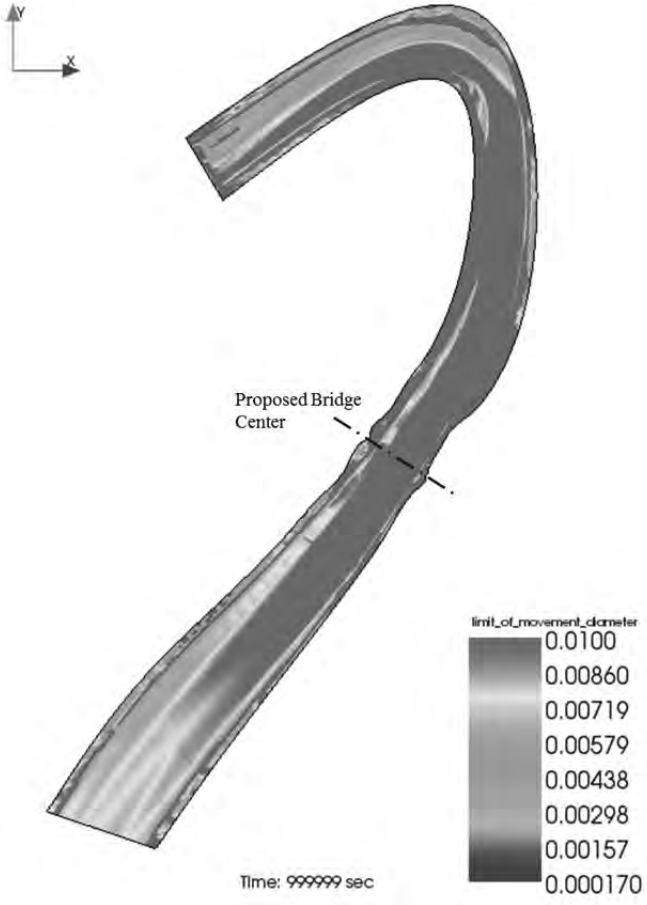
Source: JICA Survey Team

Figure 5.4.38 Zoomed View of Velocity Distribution and Velocity Vector around the Proposed Kalna Bridge



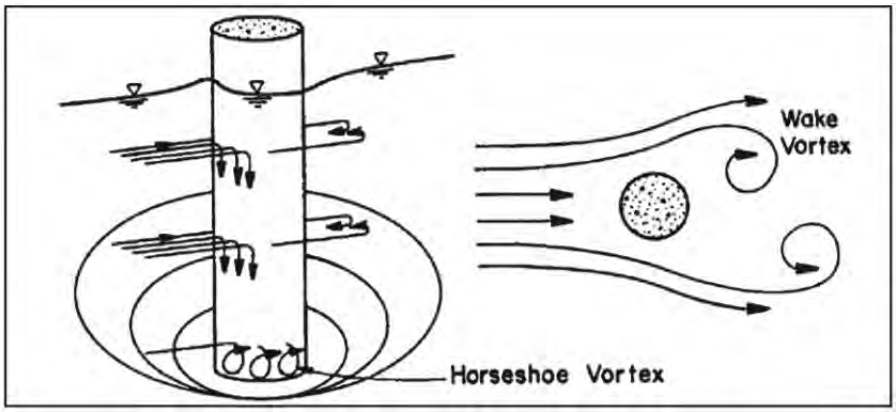
Source: JICA Survey Team

Figure 5.4.39 Zoomed View of Velocity Distribution and Velocity Vector around the River Bend of Upstream



Source: JICA Survey Team

Figure 5.4.40 Spatial Distribution of the Limit of Movement Diameter of the River-Bed Material



Source: Evaluating Scour at Bridges (2012 Fifth edition), Hydraulic Engineering Circular No. 18 (HEC 18), FHWA, USA

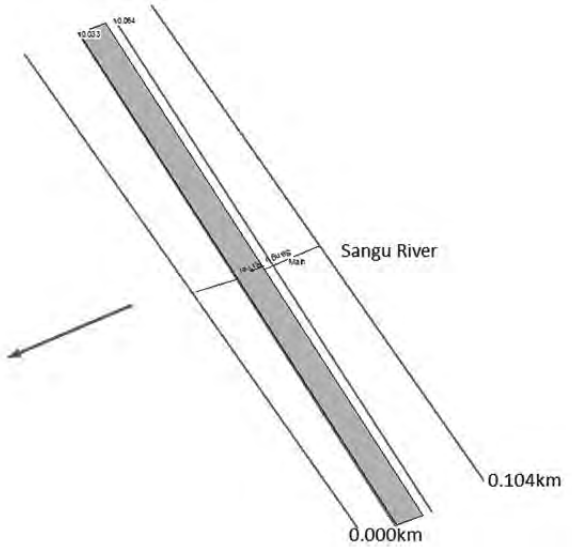
Figure 5.4.41 Simple Schematic Representation of Scour at a Cylindrical Pier

4) 1-Dimesional Hydraulic Analyses of the Sangu (C-13) and Mathamuhuri (C-26) Bridges

The hydraulic calculation models at the Sangu and Mathamuhuri Bridges are shown in Figure 5.4.42 and Figure 5.4.45. The cross-sections for hydraulic calculation are given by using the bathymetry survey results.

Hydraulic analysis is performed under the following conditions and its result is shown in Table 5.4.19 / Table 5.4.21 and Figure 5.4.43 / Figure 5.4.46. And the results of scour estimation are as shown in Table 5.4.20 / Table 5.4.22 and Figure 5.4.44 / Figure 5.4.47.

- Calculation Case - 2 case of 'With Bridge' and 'Without Bridge'
- Discharge - 1.1, 10, 25, 50, 100 (design scale) and 500 years
- Water-level at downstream end on calculation - A probability water-level at SW248 (Sangu, C-13) and SW204 (Mathamuhuri, C-26) stations



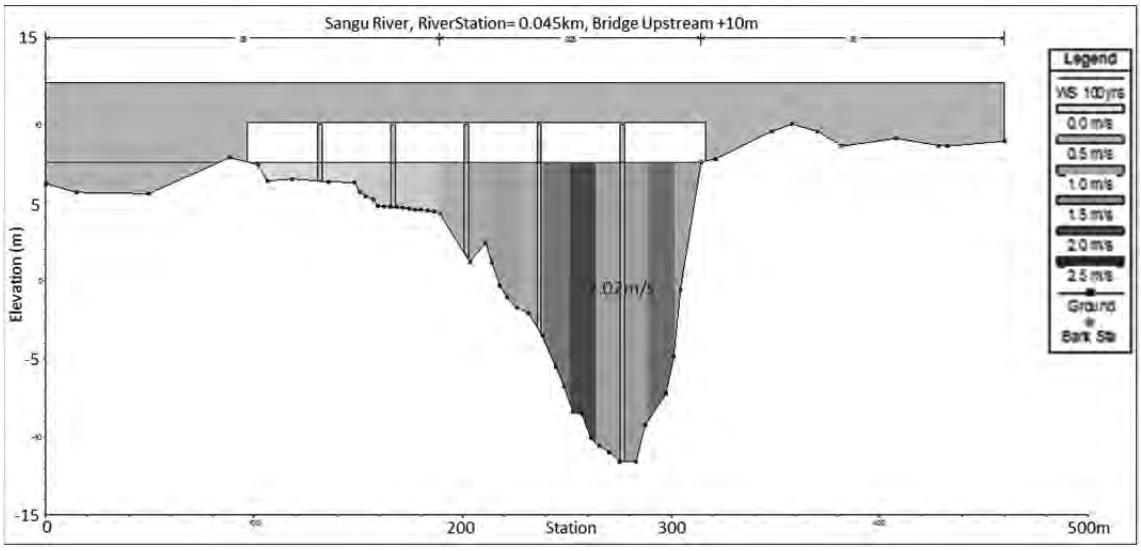
Source: JICA Survey Team

Figure 5.4.42 1-D Hydraulic Analysis Model at Sangu Bridge

Table 5.4.19 Results of Hydraulic Analysis at Sangu Bridge

Plan: Future mod Sangu River Main RS: 0.045 Profile: 100yrs				
E.G. US. (m)	7.66	Element	Inside BR US	Inside BR DS
W.S. US. (m)	7.58	E.G. Elev (m)	7.66	7.65
Q Total (m3/s)	1901	W.S. Elev (m)	7.57	7.55
Q Bridge (m3/s)	1901	Crit W.S. (m)	-4.12	-2.53
Q Weir (m3/s)		Max Chl Dpth (m)	19.18	17.56
Weir Sta Lft (m)		Vel Total (m/s)	1.23	1.33
Weir Sta Rgt (m)		Flow Area (m2)	1543.52	1429.02
Weir Submerg		Froude # Chl	0.13	0.14
Weir Max Depth (m)		Specif Force (m3)	10180.07	8817.03
Min El Weir Flow (m)	8.89	Hydr Depth (m)	7.43	7.13
Min El Prs (m)	10.11	W.P. Total (m)	296.75	279.73
Delta EG (m)	0.01	Conv. Total (m3/s)	205310.1	190204.7
Delta WS (m)	0.03	Top Width (m)	207.68	200.3
BR Open Area (m2)	1964.15	Frctn Loss (m)	0	0
BR Open Vel (m/s)	1.33	C & E Loss (m)	0	0
Coef of Q		Shear Total (N/m2)	4.37	5
Br Sel Method	Energy only	Power Total (N/m s)	0	0

Source: JICA Survey Team



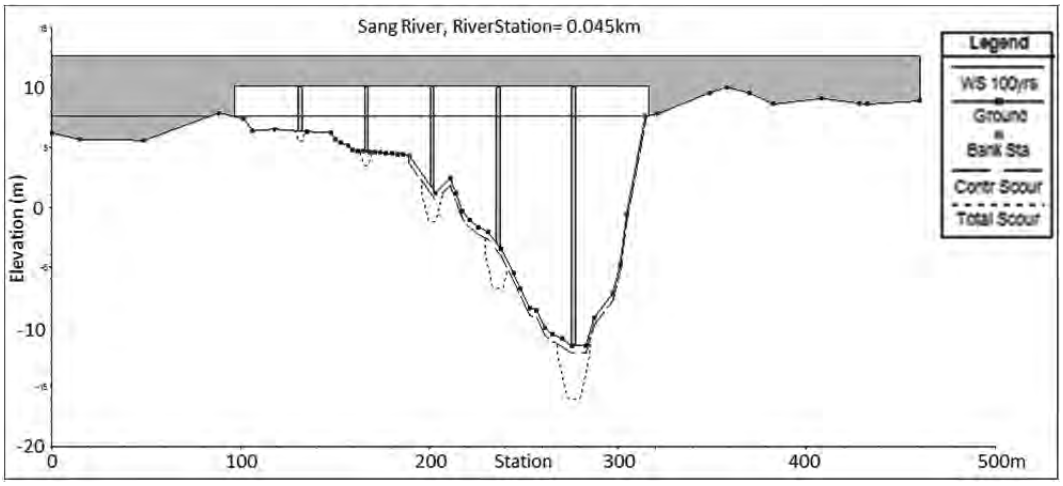
Source: JICA Survey Team

Figure 5.4.43 Hydraulic Cross-sectional Profile of Sangu Bridge

Table 5.4.20 Results of Scouring Computation at Sangu Bridge

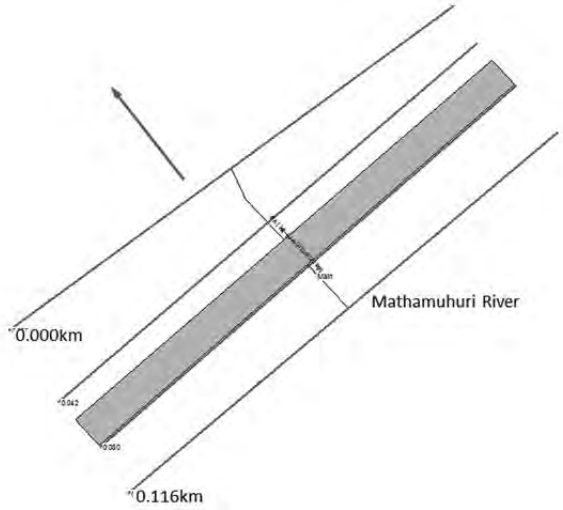
Pier No.	Calculated Scour Depth (m)		
	Local Scour	Contraction Scour	Total Scour
Pier 1	3.86	0.61	4.47
Pier 2	2.99	0.61	3.60
Pier 3	2.20	0.61	2.81
Pier 4	1.22	-	1.22
Pier 5	0.85	-	0.85
Left Abutment (A2)	0.02	-	0.02

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.44 Scouring Computation Result at Sangu Bridge



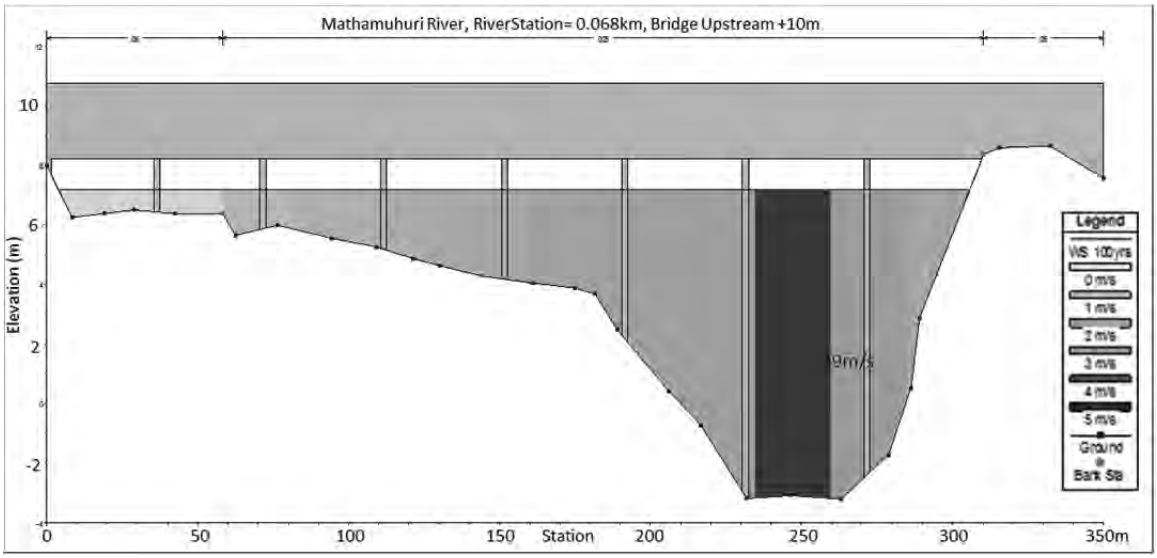
Source: JICA Survey Team

Figure 5.4.45 1-D Hydraulic Analysis Model at Mathamuhuri Bridge

Table 5.4.21 Results of Hydraulic Analysis at Mathamuhuri Bridge

Plan: C26_plan1 Mathamuhuri Rive	Main RS: 0.068	Profile: 100yrs		
E.G. US. (m)	7.54	Element	Inside BR US	Inside BR DS
W.S. US. (m)	7.23	E.G. Elev (m)	7.54	7.52
Q Total (m3/s)	3041	W.S. Elev (m)	7.18	7.16
Q Bridge (m3/s)	3041	Crit W.S. (m)	3.39	3.1
Q Weir (m3/s)		Max Chl Dpth (m)	10.38	10.83
Weir Sta Lft (m)		Vel Total (m/s)	2.57	2.59
Weir Sta Rgt (m)		Flow Area (m2)	1183.08	1172.71
Weir Submerg		Froude # Chl	0.38	0.26
Weir Max Depth (m)		Specif Force (m3)	4923.57	5066.34
Min El Weir Flow (m)	10.76	Hydr Depth (m)	4.11	3.99
Min El Prs (m)	8.21	W.P. Total (m)	353.93	354.61
Delta EG (m)	0.04	Conv. Total (m3/s)	112117.3	110044.1
Delta WS (m)	0.05	Top Width (m)	287.71	293.85
BR Open Area (m2)	1483.4	Frctn Loss (m)	0.02	0.01
BR Open Vel (m/s)	2.59	C & E Loss (m)	0	0.01
Coef of Q		Shear Total (N/m2)	24.12	24.77
Br Sel Method	Energy only	Power Total (N/m s)	0	0

Source: JICA Survey Team



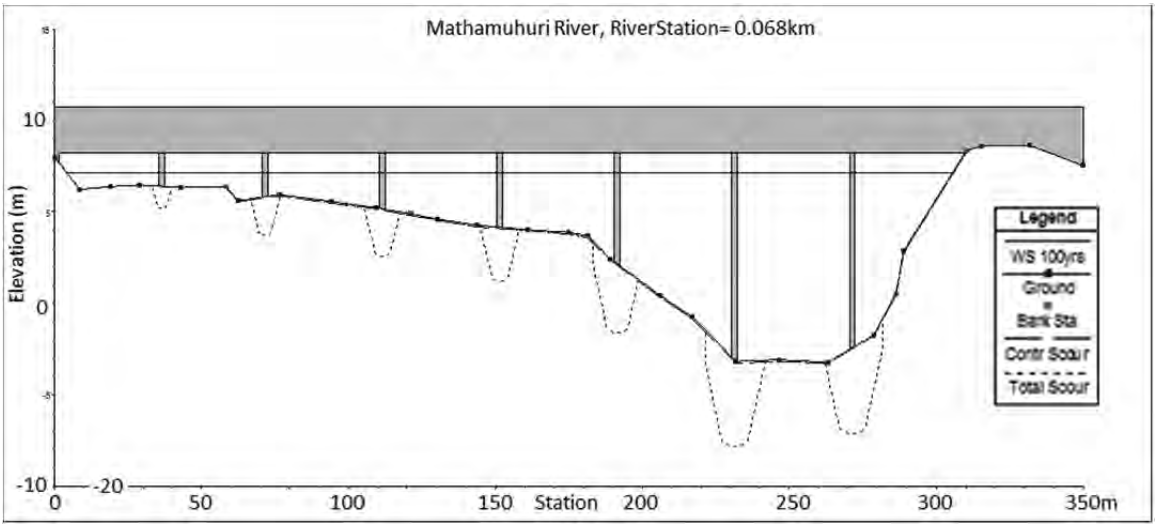
Source: JICA Survey Team

Figure 5.4.46 Hydraulic Cross-sectional Profile of Mathamuhuri Bridge

Table 5.4.22 Results of Scouring Computation at Mathamuhuri Bridge

Pier No.	Calculated Scour Depth (m)		
	Local Scour	Contraction Scour	Total Scour
Pier 1	4.65	0.08	4.72
Pier 2	4.62	0.08	4.70
Pier 3	3.70	0.08	3.77
Pier 4	2.87	0.08	2.94
Pier 5	2.54	0.08	2.62
Pier 6	2.06	0.08	2.13
Pier 7	1.25	-	1.25

Source: JICA Survey Team



Source: JICA Survey Team

Figure 5.4.47 Scouring Computation Result at Mathamuhuri Bridge

5.4.4 Hydrological Assessment

(1) Hydrological Survey Results

The results of above-described hydrological statistical analyses, bridge-scour and hydraulic computations can summarize as follows;

- ✓ In the topographic survey, the elevation differences of 'PWD datum of BWDB stations' and 'topographic survey datum (MSL)' were measured at 4 locations which is relatively close the distance of BWDB stations and bridges. The differences for real were 0.55-2.01m, although its official difference is 0.46m. This means that the observed BWDB water-level data of other stations except 4 stations includes the error. Namely, in the calculated water-level, it includes some errors.
- ✓ Under conditions of 'With Bridge' and 'Without Bridge' in case of the Kalna (A-4), Sangu (C-13) and Mathamuhuri (C-26) Bridges, both changes of water-level around bridges are negligible amounts.
- ✓ The contraction scour occurs 0.14m for the Kalna, 0.61m for the Sangu and 0.08m for the Mathamuhuri. This means that the river section flow area is small. However, the value of the contraction scour is not so big, and it might be no problem.
- ✓ The river-bed materials around the Kalna Bridge are very fine. In 2D-modeling of this time, all of materials will be washed out, if the amount of 100-year flood continues.
- ✓ As the computation results in the local scouring, it occurs in most of piers each bridge. Therefore, the riverbed around piers which are occurred the scouring, have taken costs for the appropriate bed protection work into account.

(2) Hydrological Recommendations

As for hydraulic issues of the proposed bridge from above results, the following points are left as future challenges;

- ✓ In order to secure the accuracy of the elevation and design water-level, the checking of the difference between 'PWD datum of BWDB stations' and 'topographic survey datum' shall be performed in the D/D (detailed design) stage.
- ✓ The hydraulic calculation including the scouring is conducted for only 3 bridges. In the D/D stage, the detailed study of the bridge-hydraulics shall be performed for all bridges furthermore. Especially, regarding the proposed Kalna Bridge, the further detailed hydrological study will be required for verifications of the dynamic river-bed fluctuation, the proper design discharge and the turbulent flow field around piers, etc..
- ✓ There are many kinds of bed protection and revetment works. Therefore several construction methods or comparison for them shall be conducted at the D/D stage. In addition, estimation of scouring is necessary to study further other prediction formulas including the HEC formula.