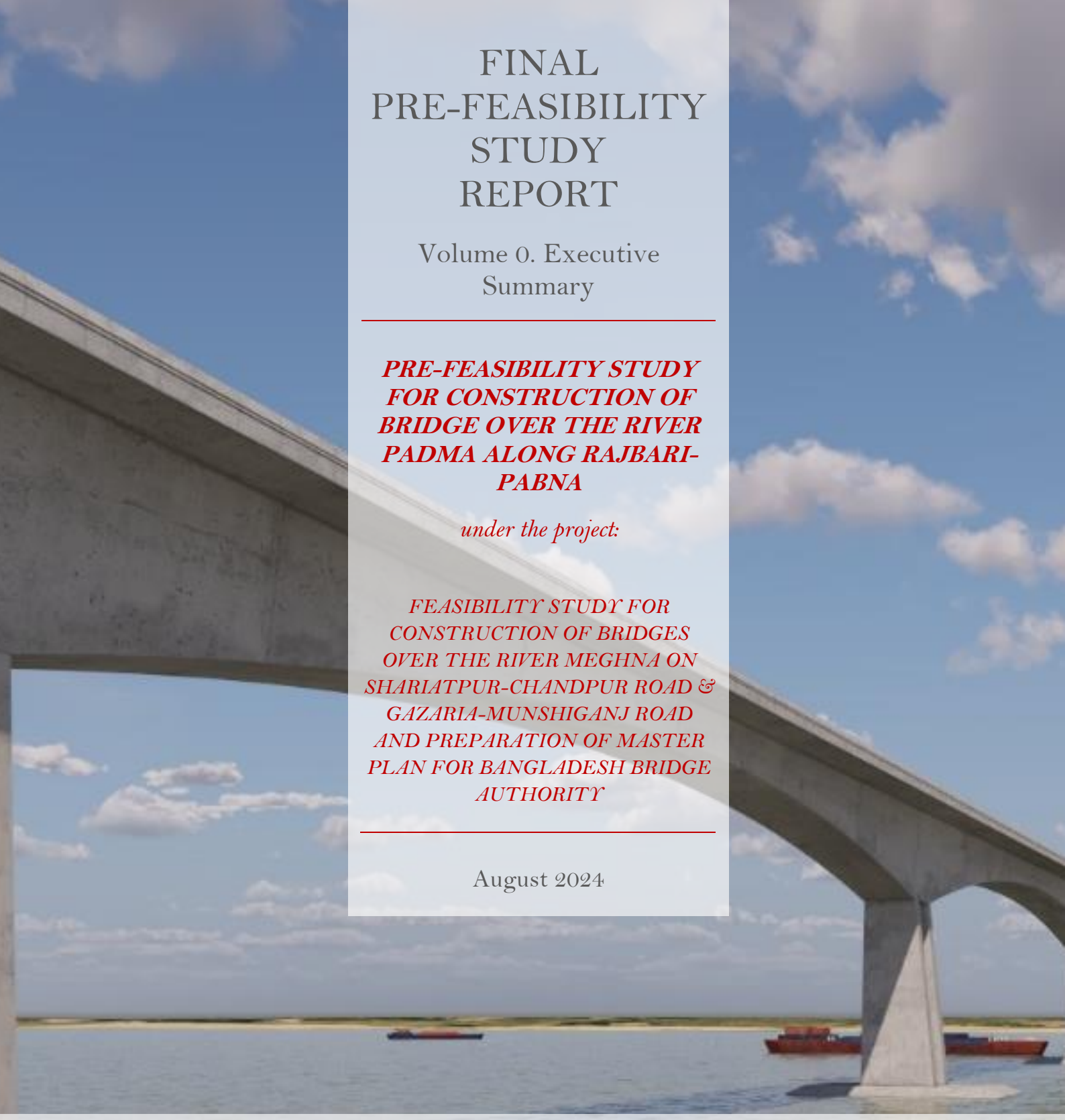

FINAL PRE-FEASIBILITY STUDY REPORT

Volume 0. Executive Summary

PRE-FEASIBILITY STUDY FOR CONSTRUCTION OF BRIDGE OVER THE RIVER PADMA ALONG RAJBARI-PABNA

under the project:

FEASIBILITY STUDY FOR CONSTRUCTION OF BRIDGES OVER THE RIVER MEGHNA ON SHARIATPUR-CHANDPUR ROAD & GAZARIA-MUNSHIGANJ ROAD AND PREPARATION OF MASTER PLAN FOR BANGLADESH BRIDGE AUTHORITY

August 2024

TYPSA

DOHWA NIPPON KOEI

ddc BCL DevCon

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার

BANGLADESH BRIDGE AUTHORITY বাংলাদেশ সেতু কর্তৃপক্ষ

Government of the People's Republic of Bangladesh
Ministry of Road Transport & Bridges
Bridges Division
Bangladesh Bridge Authority (BBA)

FINAL PRE-FEASIBILITY STUDY REPORT FOR CONSTRUCTION OF BRIDGE OVER THE RIVER PADMA ALONG RAJBARI-PABNA

VOLUME 0
EXECUTIVE SUMMARY

VOLUME 1
MAIN REPORT

VOLUME 2
ANNEX A. GEOTECHNICAL FACTUAL REPORT

VOLUME 3
ANNEX B. TOPOGRAPHICAL REPORT AND MAPS

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Quality Control sheet

DOCUMENT	**FINAL PRE-FEASIBILITY STUDY. CONSTRUCTION OF BRIDGE OVER THE RIVER PADMA ALONG RAJBARI-PABNA** **VOLUME 0. EXECUTIVE SUMMARY**		
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Control of Versions

VERSION	CONTROL OF CHANGES
1	First Submission
2	Second Submission

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Contents

List of Volumes

VOLUME 0: Executive Summary

VOLUME 1: Main Report (2 Books)

VOLUME 2: Annex A. Geotechnical Factual Report

VOLUME 3: Annex B. Topograhical Survey Report

List of Figures

List of Tables

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List of Abbreviations

1D	One Dimensional
2D	Two Dimensional
AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
ADT	Average Daily Traffic
AP	Affected Person
ARIPA	Acquisition and Requisition of Immovable Property Act
BAU	Business as Usual
BBA	Bangladesh Bridge Authority
BDT	Bangladesh Taka
BFRI	Bangladesh Fisheries Research Institute
BWDB	Bangladesh Water Development Board
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CC	Cement Concrete
CCB	Control Centre Building
CEGIS	Centre for Environmental and Geographic Information Services
CL	Lean Clay
CPR	Common Property Resources
DBFOT	Design-Build-Finance-Operate-Transfer
DC	Deputy Commissioner
DoE	Department of Environment
DSCR	Debt Service Coverage Ratio
EBITDA	Earnings before Interest, Taxes, Depreciation and Amortization,
EFP	Economic Financial Plan
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
ENPV	Economic Net Present Value
EPC	Engineering, Procurement and Construction
EZ	Economic Zone
FIDIC	The International Federation of Consulting Engineers
FIRR	Project Investment Cost
FNPV	Financial Net Present
FS	Feasibility Study
GDP	Gross Domestic Product
GoB	Government of Bangladesh
HH	Household
IEE	Initial Environmental Examination
IFC	International Finance Corporation
INGO	International Non-Governmental Organization
IoL	Inventory of Losses
IRC	Indian Road Congress

IRR	Inner Ring Road / Inner Circular Elevated Expressway (Dhaka)
IWM	Institute of Water Modelling
IWW	Inland Water Ways
JV	Joint Venture
Ke	Cost of equity
Km	Kilometre
LAP	Land Acquisition and Resettlement
LGED	Local Government Engineering Department
LRFD	Load Resistance Factor Design
m	Meter
MDB	Multilateral Development Banks
MSL	Mean Sea Level
MSS	Movable scaffolding system
MUSD	Million United States Dollar
N1	National One (Dhaka–Chattogram Highway)
NPV	Net Present Value
OPEX	Operating Expenses
PAPs	Project Affected Person
PCM	Public Consultation Meeting
PM	Prime Minister
PPP	Public and Private Partnership
PWD	Public Works Datum
PWD	Public Works Department
RAP	Resettlement Action Plan
RC	Replacement Cost
RHD	Roads and Highways Department
RoW	Right of Way
RTW	River Training Work
SCP	Sand Compaction Pile
SHWL	Standard High-Water Level
SIA	Social Impact Assessment
SM	Silty Sand
SP	Poorly Graded Sand
SRD	Social Rate of Discount
TAC	Technical Advisory Committee
ToR	Terms of Reference
USD	United States Dollar
VAT	Value Added Tax
VGF	Viability Gap Financing
WACC	Weighted Average Cost of Capital
WB	World Bank
WL	Water Level

Executive Summary

Summary of Key Findings and Recommendations of the Pre-feasibility Study

(Final Report – August 2024)

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1. PROJECT BASIC INFORMATION

Table 1. Basic Information

1.	Name of the Project	:	PRE-FEASIBILITY STUDY FOR CONSTRUCTION OF BRIDGE OVER THE RIVER PADMA ON RAJBARI-PABNA
2.	(a) Sponsoring Ministry/Division (b) Implementing Agency	:	(a) Government of the People's Republic of Bangladesh Ministry of Road Transport & Bridges (b) Bridges Division Bangladesh Bridge Authority (BBA)
3.	Project Objectives (Project to be taken based on the study)	:	To assess the pre-feasibility of a bridge and related infrastructures connecting Rajbari to Pabna crossing the Padma River Analysis shall include technical, socio-economic, financial, and environmental aspects
4.	Estimated project Cost. (Taka in Crore)	:	Estimated project Cost. 8,934.60 Cr BDT
5.	Sector & Sub-Sector	:	Transport Sector / Bridges Infrastructures
6.	Project Category	:	Project Red Category (Based on Environment Conservation Rules 1997)
7.	Project Geographic Location Countrywide Division District Upazila	:	 The People's Republic of Bangladesh Division: Dhaka / Rajshahi District: Rajbari / Pabna Upazila: Rajbari Sadar / Sujanagar
8.	Project Duration	:	Investment Period: 6 Y – 2026/2031 Operation Period: 30 Y – 2032/2061

2. INTRODUCTION

2.1. Assignment Background

With a view to boost up the economy of every region of Bangladesh, a roadmap and action plan (Master plan) of transport connectivity is being implemented by the Bangladesh Bridge Authority. In response to a long felt need for easy and quick communication among major cities of Bangladesh, the Master plan, prepared by BBA includes the implementation and construction of several bridge projects. Among these, one of the important infrastructures is the one over the river Padma on Rajbari-Pabna Road at Rajbari and Pabna Districts respectively.

A transport system contributes to the shaping of a country's foundation for economic growth and development. A bridge, as a major component of a transport system connects roads and turns inaccessible areas easily accessible, thus becoming these areas a pivot for development.

In April 2021, the BBA signed an agreement with the Consultant JV to conduct a series of studies, as part of the contract scope for the Consultancy Services for Feasibility Study for Construction of Bridges over the river Meghna on Shariatpur-Chandpur Road, Gazaria-Munshiganj road and preparation of Master Plan for Bangladesh Bridge Authority. The assignment included amongst other components, a series of four pre-feasibility studies to be carried out as part of the Phase I scope. This Phase I referred to the Transport Master Plan to be implemented, including a list of potential projects to be proposed to be carried out by the BBA within the period 2030-2050 and divided in three priority groups, short, mid and long terms.

The four selected projects, to carry out the pre-feasibility studies, were confirmed by the BBA, after the submission of the Master Plan Draft Report, that included the recommended list of potential projects based on multi-criteria analysis. The shortlist was communicated by the BBA via Memo No. 50.01.0000.671.99.004.21 (Part-2)-434 in August 2023.

1. Construction of Bridge over the river Meghna along Bhola-Lakshmipur.
2. Construction of bridge over Coxsbazar/Moheshkhali channel.
3. **Construction of Bridge over the River Padma along Rajbari-Pabna**.
4. Construction of an Elevated Expressway in haor Area along Sunamganj-Netrokona.

This report covers the Final Report of the **Pre-feasibility Study for Construction of Bridge over the River Padma along Rajbari-Pabna,** including the following contents for the pre-selected alternatives: preliminary field surveys, technical studies, preliminary design, cost estimating, environmental and social preliminary assessment, economic and traffic evaluations,

This pre-feasibility study consists of an Executive Summary and a Main Report along with two annexes containing information covering the field works undertaken: geotechnical campaign and topographical survey.

- Volume 0: Executive Summary
- Volume 1: Main report
- Volume 2: Annex A Geotechnical Factual Report
- Volume 3: Annex B Topographical Survey Report

2.2. Project Area

The proposed potential project, under study, is in Pabna and Rajbari districts, surrounded by Sujanagar and Rajbari Sadar Upazilas, and along the crossing of the Padma River. It will connect the southwestern region of the country, including Rajbari and Pabna districts, to the rest of the country, including the capital city Dhaka.

Rajbari and Pabna are two neighboring districts located in the southwestern region of Bangladesh. Rajbari district is bordered by the Padma River to the north, Faridpur district to the east, and Pabna district to the west. Pabna district is bordered by the Jamuna River to the north and Rajshahi district to the west.

- **Rajbari District:**

Rajbari District is in Dhaka Division, Bangladesh. The district has an area of 1,092 sq km. It is a part of the Greater Faridpur subregion of Bengal due to the historical and cultural identities of its inhabitants. It is bounded by Pabna district on the north, Faridpur and Magura districts on the south, Manikganj district on the east, Kushtia and Jhenaidah districts on the west. Most of the areas of the district are composed of the alluvial soil of the Padma River.

According to the 2022 Census of Bangladesh, Rajbari District had 295,219 households and a population of 1,189,821.

- **Rajbari Sadar Upazila**

Rajbari Sadar Upazila has an area of 322 sq km. It is bounded by Sujanagar and Bera upazilas and Padma (Ganges) river on the north, Faridpur Sadar and Madhukhali upazilas on the south, Goalanda and Faridpur Sadar upazilas on the east, Pangsha and Baliakandi upazilas on the west. Total population of Rajbari Sadar upazila is 331,631.

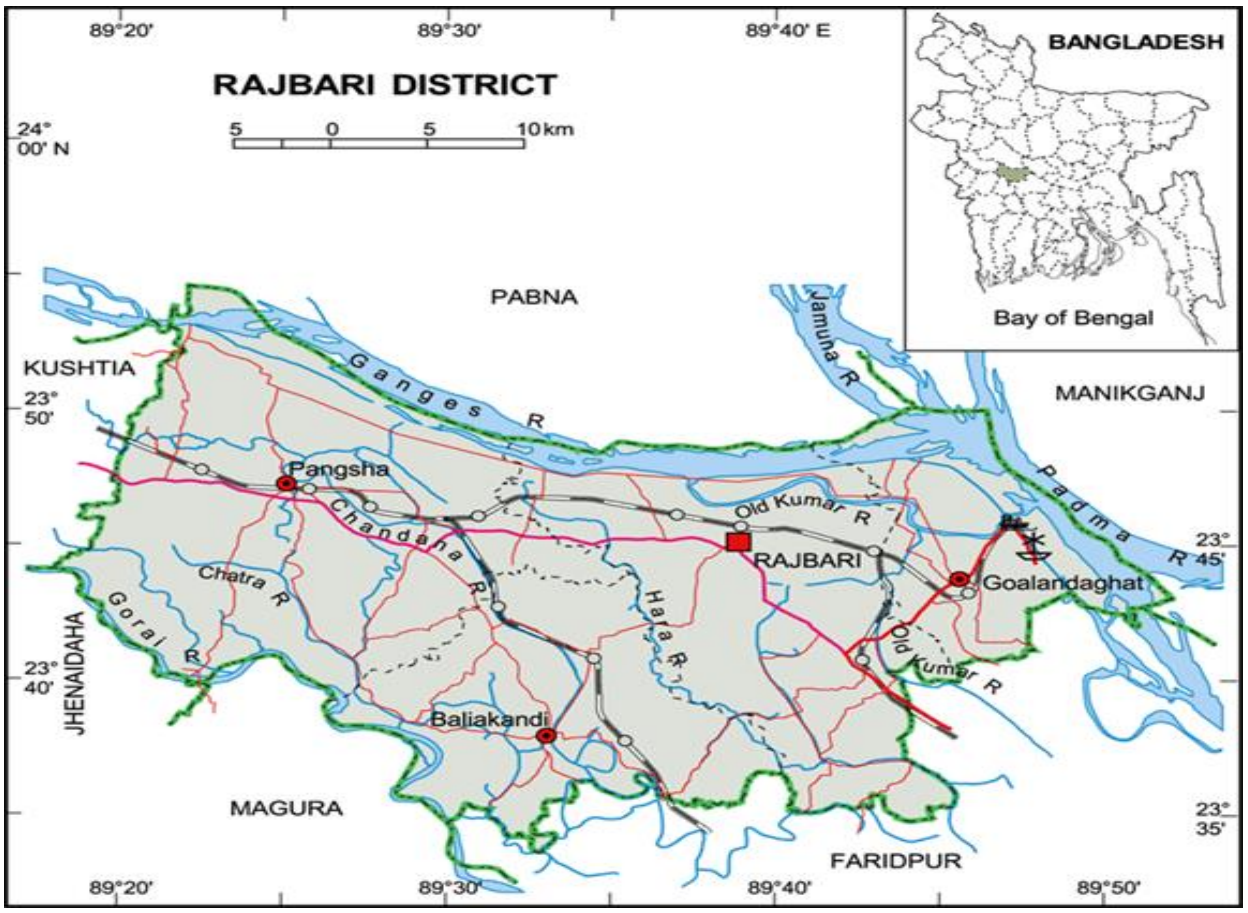


Figure 1. Rajbari zila map.

- **Pabna District**

Pabna District is located in Rajshahi Division, Bangladesh. The district has an area of 2,376 sq km. It is bounded by Natore and Sirajganj districts on the north, Padma river, Rajbari and Kushtia districts on the south, Manikganj and Sirajganj districts and Jamuna river on the east, Padma River, Natore and Kushtia districts on the south, Manikganj and Sirajgonj districts and Jamuna river on the east, Padma River, Natore and Kushtia west. According to the 2022 Census of Bangladesh, Pabna district had 743,557 households and a population of 2,909,622.

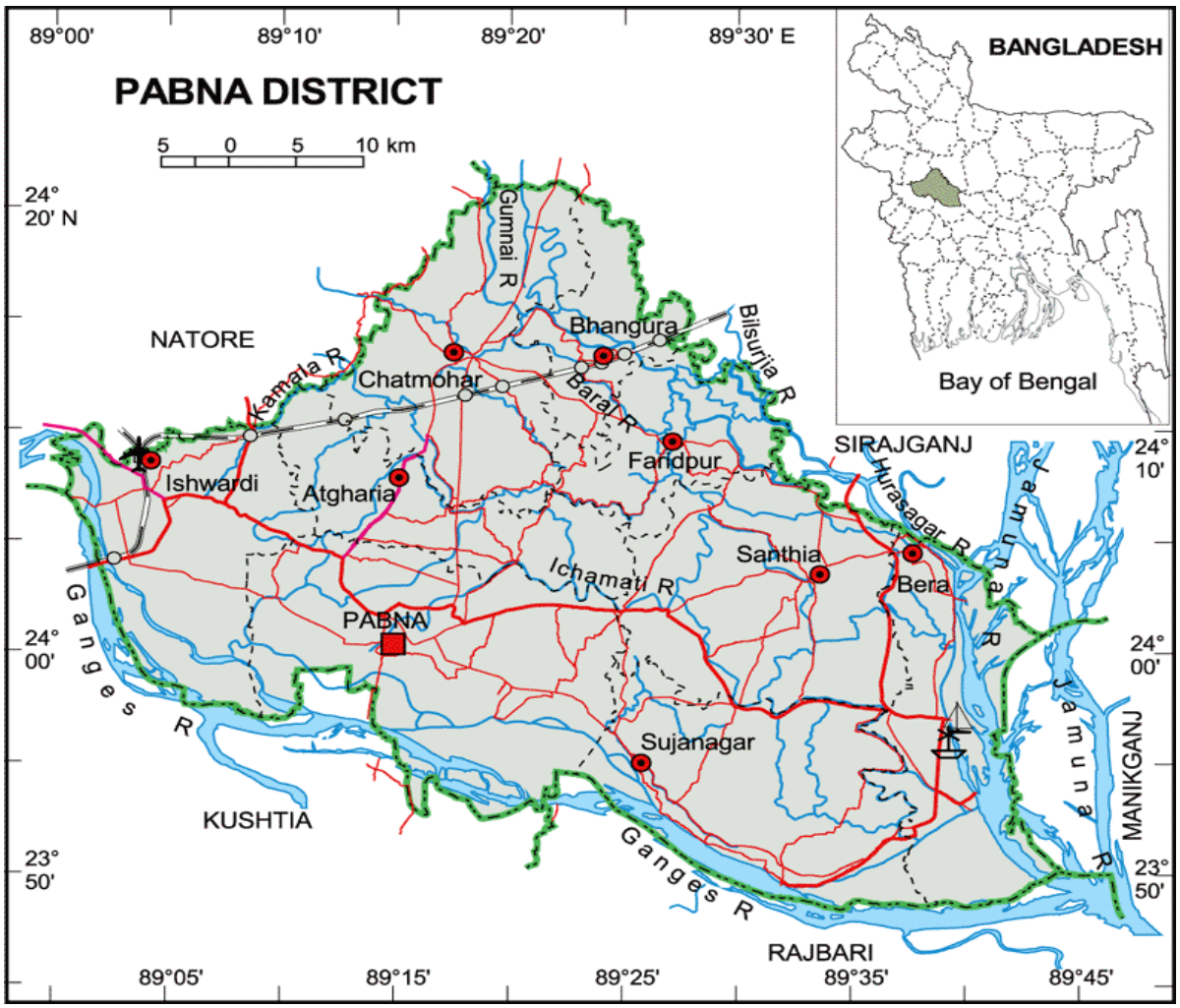


Figure 2. Pabna zila map.

- **Sujanagar Upazila**

Sujanagar Thana was formed in 1872 and it was turned into an Upazila in 1983 under the Pabna district. This upazila has an area of 339 sq km. It is bounded by Santhia Upazila on the north, Rajbari Sadar and Pangsha upazilas on the south, Bera Upazila on the east, Pangsha and Pabna Sadar Upazilas on the west. Total population of the Upazila is 278,096.

Upazila map is shown in the next figure.

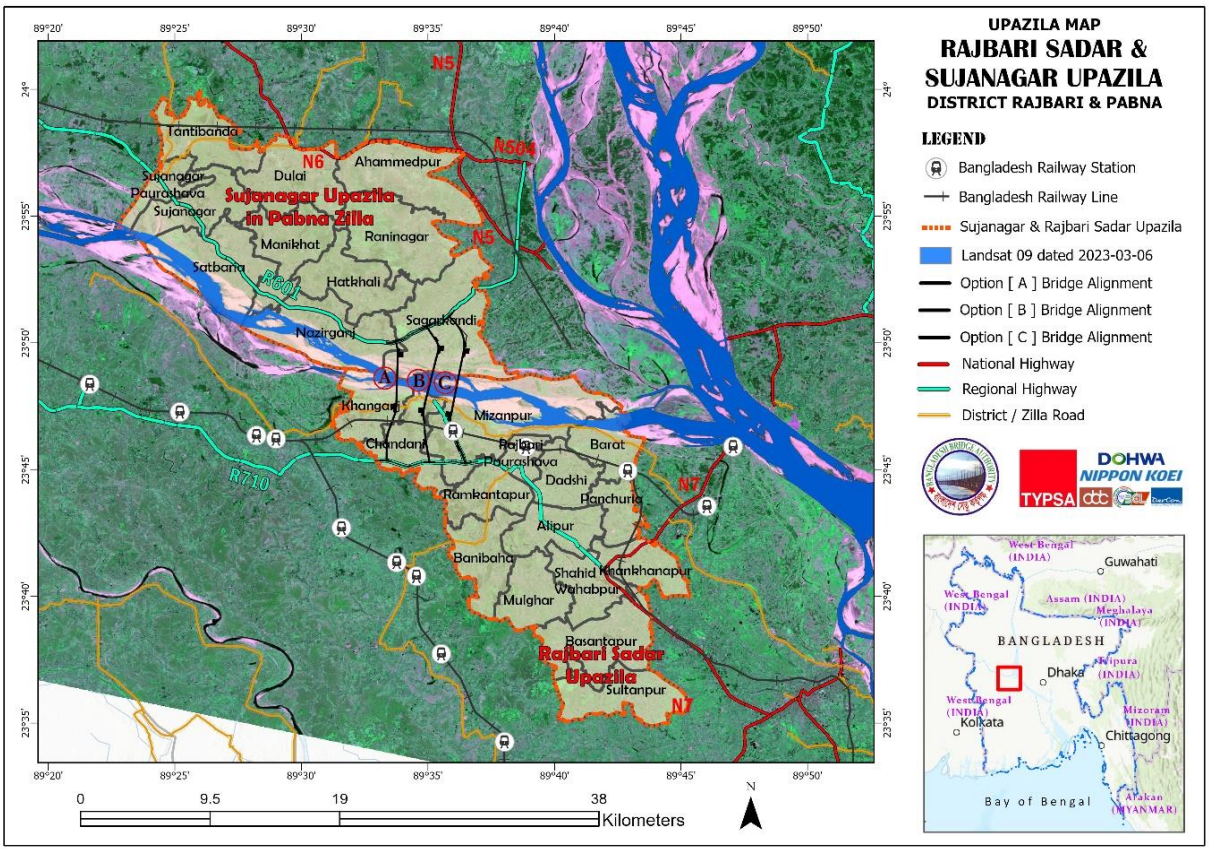


Figure 3. Rajbari Sadar and Sujanagar upazilas.

2.3. Objectives of the Assignment

The objective of this assignment is to prepare a Pre-FS-concept design for the construction of Bridge over Padma River to provide a safe and permanent connection between Rajbari and Pabna districts.

This study aims to be the precursor of a possible next phase of the project, namely feasibility study, at the BBA criteria and strategic decision. Due to this fact, it has been the purpose of the study, to assess three options and to present within the Main Report volume, the key outcomes from the technical, environmental social and cost standpoints, for the three options. The Consultant is presenting the conclusion of the economic and financial analysis for the pre-selected alignment option.

The main objectives of this study, including the evaluation of **three different alignment options**, are:

- Find three the suitable locations for the bridge and accessing roads.
- Carry out fieldworks (topography and geotechnical) campaigns at the initially preselected alignment (one out of three).
- Identify the types of bridge or tunnel suitable for the crossing for each option.
- Carry out preliminary design of the bridge, roads and associated facilities for each option.
- Evaluate a cost estimate for each option.
- Assess socio-economic status of the area.
- Evaluate technical, environmental and social viability of the project at each option.
- Evaluate the economic and financial viability for the pre-selected alignment option.

2.4. Approach and Methodology

This pre-feasibility study presents the outcome of the study that has been carried out by the Consultant JV. The assignment has been carried out following the scope as provided by BBA in the Terms of Reference (ToR).

This includes the following activities according to the ToR of the contract.

- Compilation, analysis and review of previous reports, studies, preliminary or detailed designs referred to the current feasibility study.
- Review available traffic count data and studies and carry out supplementary traffic counts.
- Detail traffic survey with O-D survey, traffic analysis and traffic forecast for a reasonable time horizon establishing traffic model.
- Preliminary Hydro-morphological study of the river flow characteristics.
- Determination of preliminary corridor/site selection (3 options)
- Determination of the pre-selected preferred location of the bridge, (optimization of Length, Location and Alignment of the Bridge).
- Optimization of the approach road. Routes Assessment, Project Road Corridor Alternatives, Geometric Design for the preferred alternative (Typical cross sections, Plan & Profile).
- Mapping, Land Use and Topographical Model for the preferred option.
- Geological and Geotechnical Investigation Campaign for the preferred solution (field studies and Reports) for: cuts and fills geometry, pavements, sources of materials, foundation design for viaducts, bridges, and other structures.
- Pavement Design.
- Structural Design. Comparative study for investment cost and O-M cost. Typological alternatives study.
- Economic and financial evaluation (30-year benefit stream period).
- Estimate the expected distribution of the project net benefits, based on the project economic analysis.
- Considering the economic evaluation, social benefits, and environmental impact, recommend the most suitable improvement option for each project road section.
- Initial Social impact Analysis.
- Meetings and dialogue with the community groups in the project areas.
- Initial environmental examinations (IEE) and Environmental Impact Assessment.
- Social Impact Assessment (SIA).
- Determination of appropriate construction method, configuration, and technology.

2.5. Key Findings - Salient Features

Table 2. Summary of salient features of the project.

Salient Features of Pabna-Rajbari Bridge				
		Option A	Option B SELECTED OPTION	Option C
Main alignment length	Road and bridge	8,750 m	10,200 m	11,250 m
Total bridge length		3,860 m	3,300 m	3,500 m
Balance Cantilever Bridge	Length	2,020 m	2,020 m	2,220 m
	Main span	1,800 m (9x200)	1,800 m (9x200)	2000 m (10x200)
	Back spans	110+110=220 m	110+110=220 m	110+110=220 m
	Width of the section	20.25 m	20.25 m	20.25 m
Approaching Spans (Precast +Girders)	Length	1,840 m	1,280 m	1,280 m
	Rajbari Side	1,200 m (30x40)	640 m (16x40)	640 m (16x40)
	Pabna Side	540 m (16x40 m)	640 m(16x40)	640 m(16x40)
	Width of the section	20.25 m	20.25 m	20.25 m
Approach Roads	Total length	4,890 m	6,900 m	7,750 m
	Rajbari Side	4,245 m	4,280 m	3,920 m
	Pabna Side	645 m	2,620 m	,3,830 m
	Total road width	39.5 m	39.5 m	39.5 m
	Main road (2+2-Lane Carriageway)	7.30 m = 2 x 3.65 m	7.30 m = 2 x 3.65 m	7.30 m = 2 x 3.65 m
	Service road (both sides)	5.50 m	5.50 m	5.50 m
Junctions	Rajbari Side (R710)	Trumpet Interchange	Trumpet Interchange	Trumpet Interchange
	Pabna Side (R601)	Trumpet Interchange	Trumpet Interchange	Trumpet Interchange
Other features in approach road				
Elevated Structure over the FFCC	Rajbari side	2x200 m (5x40)	2x200 m (5x40)	2x200 m (5x40)

Salient Features of Pabna-Rajbari Bridge				
		Option A	Option B SELECTED OPTION	Option C
Culverts		2	5	5
	Rajbari Side	2 nos (1 Vent-6.00 m x4 .50 m) (Ch 1+220, 3+000)	3 nos (1 Vent-6.00 m x4 .50 m) (Ch 0+800, 2+000, 3+200)	3 nos (1 Vent-6.00 m x4 .50 m) (Ch 0+800, 2+000, 3+100)
	Pabna Side	-	2 nos (1 Vent-6.00 m x4 .50 m) (Ch 8+250, 9+300)	2 nos (1 Vent-6.00 m x4 .50 m) (Ch 7+900, 10+000)
Toll Plaza		14 nos booth each side = Total 14 nos	7 nos booth each side = Total 14 nos	7 nos booth each side = Total 14 nos
	Rajbari Side	14 nos booth both directions	7 nos booth one direction	7 nos booth one direction
	Pabna Side	-	7 nos booth one direction	7 nos booth one direction
Weighing scale		1 no each side = Total 2 nos 4 nos Weigh bridge each side	1 no each side = Total 2 nos 4 nos Weigh bridge each side	1 no each side = Total 2 nos 4 nos Weigh bridge each side
Engineer's Facilities and Service Area		1 no each side = Total 2 nos 2 x 22.50 = 45.00 acres	1 no Rajbari 1 x 22.50 = 22.50 acres	1 no each side = Total 2 nos 2 x 22.50 = 45.00 acres
Construction Yard		Total land 5 acres	Total land 5 acres	Total land 5 acres
River training works	Total length			
	LGB	4,300 m	3,400 m	3,400 m
	RGB	4,600 m	1,400 m	3,400 m
Land Acquisition				
	Width of right of way (ROW)	69.5 m	69.5 m	69.5 m
	Total land to be acquired	188.95 acres	220.12 acres	234.79 acres

Salient Features of Pabna-Rajbari Bridge				
		Option A	Option B SELECTED OPTION	Option C
	Total number of projects affected units (business)	03	05	191
	Total number of persons affected	696	1,216	2,432
	Resettlement area	1 no each side = Total 2 nos 2 x 5 = 10 acre	1 no each side = Total 2 nos 2 x 5 = 10 acre	1 no each side = Total 2 nos 2 x 5 = 10 acre

3. MARKET/DEMAND ANALYSIS

This section assesses the need for public investments, as per the study of market and traffic demand that has been implemented. The project related benefits and need and justification for the implementation of the infrastructure are analyzed hereinafter:

3.1. Problem Statement

The study problem, or potential improvement, to be addressed is mainly the lack of adequate infrastructure for efficient and convenient river crossings in Bangladesh. The Bangabandhu Bridge, Padma Bridge and other existing bridges are not sufficient to meet the growing demands of transportation and connectivity in Bangladesh. This results in longer travel times, limited accessibility, hindering socio-economic development.

There are some direct causes:

- Insufficient number of bridges: currently, lack of bridges in operation for the main the rivers crossing, which is inadequate for the growing population and traffic demands.
- Limited investment in infrastructure: a lack of prioritization and allocation of resources for bridge construction in the region may have contributed to the current situation.

And some indirect causes:

- Population growth: an increasing population puts more pressure on existing infrastructure, aggravating the problem of inadequate river crossings.
- Economic development: as Bangladesh's economy continues to grow, the need for efficient transportation and connectivity becomes more critical for businesses and industries to thrive.
- Urbanization: rapid urbanization in cities like Dhaka has led to increased traffic congestion and greater demand for improved infrastructure, including bridges.

A good way to understand the need of the project is analyzing the situation in which the government would not carry out this investment in the bridge:

- The lack of efficient transportation and connectivity limits trade, investment, and overall economic growth in the region.
- Limited transportation infrastructure prevents residents from accessing essential services such as healthcare, education, or emergency services, ultimately impacting their quality of life.
- Without additional bridges, the existing crossings will become more congested, leading to longer travel times and increased transportation costs.
- Increased congestion can lead to higher emissions, air pollution, and negative impacts on local ecosystems.
- Limited access to opportunities and services can exacerbate social inequalities, with disadvantaged groups being disproportionately affected.

The essential purpose of any development is social investment. A planned project is an idea for an intended future condition regarding social and economic activities, their locations and linkages, and the development of essential land, structures, and mechanisms. Viewed from the implementation angle, however, a planned project is a program of action and pre-determined coordination of legislative, fiscal, and administrative measures designed to achieve the transition from the present situation to that represented by the model. It should be noted that the essential features of both of this situation are as follows:

- a commitment to improve the human condition through economic development and social change.
- a close integration of socio-economic and environmental development in harmony with accepted development strategies. And the complete interdependence between economic, social, and environmental planning on the one hand, and legislative, fiscal, administrative, and political action planning on the other, which together make a truly comprehensive plan.

3.2. Relevance of the Project Idea

Rajbari and Pabna are two neighboring districts located in the southwestern region of Bangladesh. Rajbari district is bordered by the Padma River to the north, Faridpur district to the east, and Pabna district to the west. Pabna district is bordered by the Jamuna River to the north and Rajshahi district to the west.

Rajbari district has a population of around 1.2 million and covers an area of 1,092 square kilometers. The district is known for its historical significance and is also home to a large number of garment factories, which are an important source of employment and income for the local population.

Pabna district has a population of around 2.9 million and covers an area of 2,376 square kilometers. The district is known for its rich cultural heritage, with several historical sites and landmarks. It is also an important agricultural region, with rice, wheat, jute, and vegetables being the main crops grown in the area.

The existing waterway is an easy way to travel between districts of South and North Bengal. Apart from Rajbari, buses and cargo trucks from surrounding districts including Faridpur, Madaripur, Pirojpur, Barishal, Gopalganj and other districts including Pabna, Sirajganj, Rajshahi, Rangpur, Natore travel daily through this waterway.

In addition, the area adjacent to the Lalon Shah Bridge (approximately 60 km east of the proposed bridge) is of great importance, due to the new Rooppur nuclear power plant and the Paksey industrial zone. The proposed bridge can provide an alternative route to the one using the Lalon Shah Bridge, which can be important considering the future traffic growth in the country.

To sum up, the proposed bridge would:

- Enhance transportation and communication: The bridge would provide a direct road link between the Rajbari district and the Pabna districts (connecting R601 with R711 and National Highway N6), improving access to essential services such as healthcare, education, and markets. It would also provide a reliable and efficient mode of transportation for people and goods between the districts.
- Improve economic growth: The improved connectivity and transportation infrastructure is expected to attract new businesses to the region, creating new job opportunities and promoting trade and commerce. This will contribute to the overall economic growth of the country.
- Promote environmental sustainability: Currently, transportation to the Rajbari-Pabna is primarily through ferries, which have a significant environmental impact. The construction of the bridge would reduce the environmental impact of transportation, promoting sustainable development in the region.
- Reduce travel distance: Establish a more direct route between Rajbari district and the Pabna district that were previously connected by ferry and Lalon Shah Bridge. So, this bridge would reduce travel distance around 67 km and reduce vehicular pressure upon Lalon Shah Bridge.
- Improve regional connectivity between different districts of South Bengal and different districts of North Bengal of Bangladesh.

3.3. Proposed Project Interventions

The Project implementation would need not only the address the construction of the main infrastructure, but also the construction of approach roads would be needed to connect with the existing network. Other interventions as engineers' facilities compound, toll plaza and service buildings would be needed to be implemented by the GoB.

In addition, the necessary river training works would need to be implemented, given the relevant riverbank erosion identified in this area of the Padma River.

Regarding an extended intervention including the alternative of a multimodal bridge (railway), it was discarded at this stage as the Consultant´s understanding is that the Bangladesh Railway Master Plan does not include any potential project that could justify a multimodal bridge in this location (in the image below, BR Network is shown in red, and the BR Master Plan related projects are shown in green).

Figure 4. BR existing network and Master Plan related projects.

3.4. Stakeholders Management

The list of involved stakeholders to be managed and coordinated for this project would be as follows:

- Ministry of Road Transport and Bridges: Responsible for overseeing the planning, implementation, and maintenance of transportation infrastructure projects in Bangladesh.
- Local Government authorities: Both districts' administrations would be involved in coordinating and facilitating the project at the local level.
- Bangladesh Water Development Board (BWDB): Responsible of overseeing and coordination of the river training works.
- Bangladesh Inland Water Transportation Authority (BIWTA): River navigational conditions and requirements to be coordinated for the project.
- Local Government Engineering Department (LGED): Local roads network authority.
- Roads and Highways Department (RHD): the agency of the Government of Bangladesh responsible for the construction and maintenance of highways, roads and bridges of length under 1,500 m across Bangladesh.

3.5. Demand Analysis

3.5.1. Definition of Scenarios

A transportation model was used along with data from various survey points to analyze the demand. Both the current demand and the projected demand were evaluated. To conduct a thorough economic and financial study, it is necessary to carefully analyze the traffic and compare the situation without the project to the situation with the project. The differences in costs between these two situations will be the benefits of constructing the bridge.

It is important to understand the different scenarios analyzed, with and without project. Both scenarios are compared in order to understand the benefits from the "with project" scenario compared with the "without project" scenario (case where the bridge is not built, in this case, there is no bridge but there will be some roads improvements, as well as an operating ferry service).

In the following images the difference between both scenarios is clearly shown:

Without Project (ferry service)

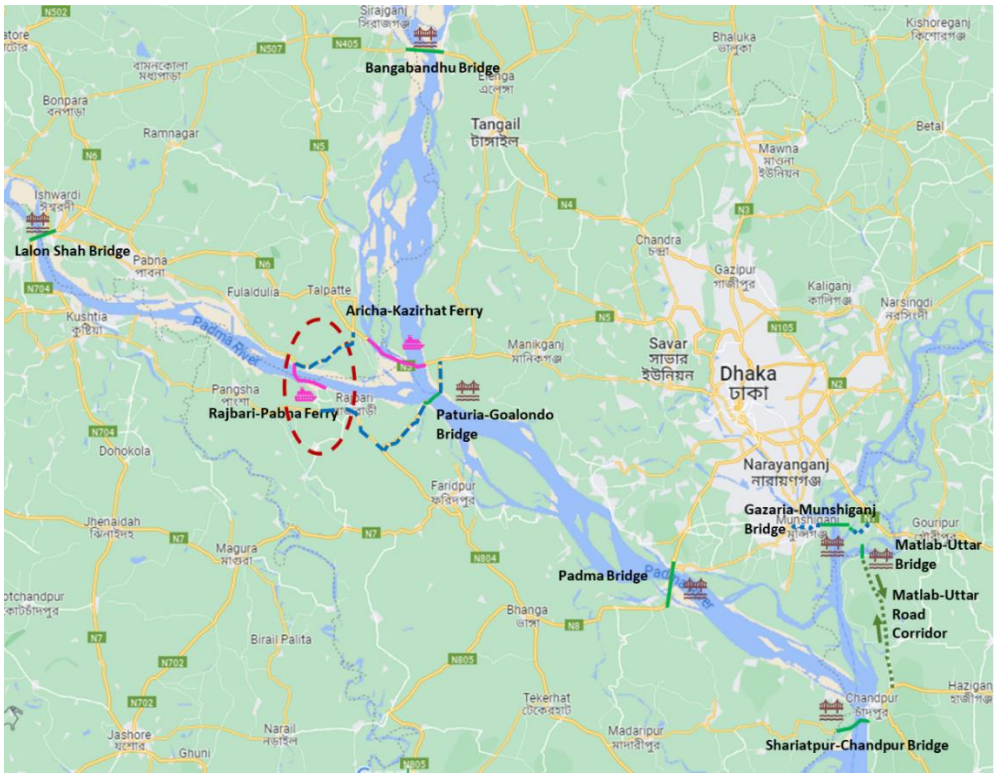


Figure 5. Scenario without project analysed.

It includes:

- Rajbari-Pabna Ferry Service.
- Road improvements (R601 and R710) on north-east & south-east side of Rajbari-Pabna Ferry.
- Aricha-Kazirhat Ferry Service.
- Paturia-Goalondo Bridge with road improvements on each side.
- Rasulpur Bridge.
- Matlab Uttar Bridge.
- Matlab Uttar Road Corridor.
- Gazaria-Munshiganj Bridge.
- Road improvements on either side of Gazaria-Munshiganj Bridge.
- Shariatpur-Chandpur Bridge.
- Improvement of R860.
- Shariatpur-Padma Road improvement.
- Padma Bridge.

With Project (new bridge)

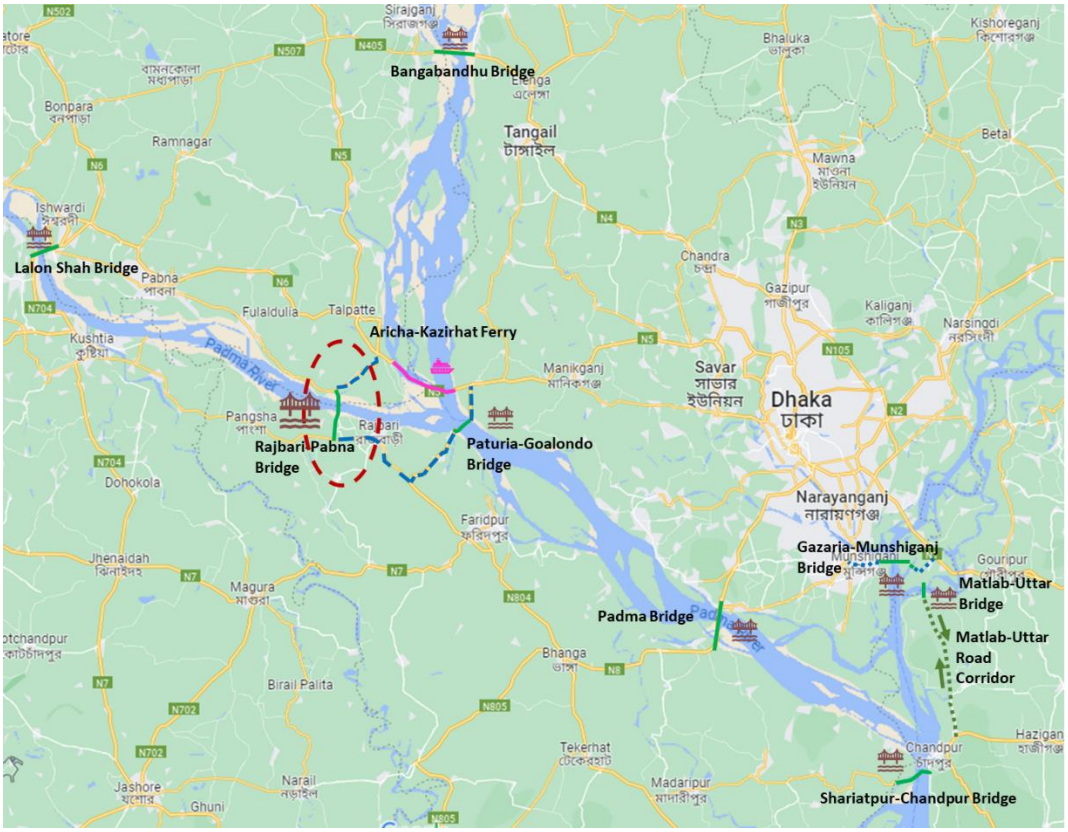


Figure 6. Scenario without project analysed.

It includes:

- Rajbari-Pabna Bridge.
- Road improvements (R601 and R710) on north-east & south-east side of Rajbari-Pabna Ferry.
- Aricha-Kazirhat Ferry Service.
- Paturia-Goalondo Bridge with road improvements on each side.
- Rasulpur Bridge.
- Matlab Uttar Bridge.
- Matlab Uttar Road Corridor.
- Gazaria-Munshiganj Bridge.
- Road improvements on either side of Gazaria-Munshiganj Bridge.
- Shariatpur-Chandpur Bridge.
- Improvement of R860.
- Shariatpur-Padma Road improvement.
- Padma Bridge.

3.5.2. Traffic Forecast

The forward traffic estimation was estimated based on the correlation between GDP and traffic growth, which was analyzed during a series of years in which traffic counts and historical data is available. There is a direct relation between GDP and AADT, since GDP relies on the movement of passengers and freight.

In order to set the most suitable toll fees, an analysis was undertaken to identify the values that would maximise the revenues. The current ferry fares, as well as the proposed toll fees are shown in the following table:

Table 3. Proposed toll fees.

	Ferry fare (veh/BDT)	Proposed toll fees (BDT/veh)
Motorcycles	197	**100**
Light vehicles	591	**900**
Buses	1,176	**1,800**
Trucks	917	**1,400**

The result of the traffic forecast study by type of traffic is shown below for the scenarios without project and with project (the main report includes the detailed information on the methodology and process of the traffic study).

Table 4. Daily traffic volumes by type of traffic.

Year	Normal traffic (without project)				Diverted			Generated		With project
	Road	IWW	EZ	Total Without Project (Normal traffic)	From road	From IWW	From EZ	Road – due to time reduction	Due to additional GDP increment	TOTAL
2025	356	0	0	356						
2032	589	0	120	708	2,496	425	65	276	3	3,974
2033	627	0	120	747	4,188	905	130	589	8	6,566
2034	666	0	120	786	5,082	1,443	195	939	16	8,461
2035	707	0	120	826	7,187	2,040	260	1,328	27	11,668
2036	748	0	120	868	7,607	2,159	260	1,405	34	12,334
2041	967	0	120	1,087	9,831	2,791	260	1,816	78	15,863

Year	Normal traffic (without project)				Diverted			Generated		With project
	Road	IWW	EZ	Total Without Project (Normal traffic)	From road	From IWW	From EZ	Road – due to time reduction	Due to additional GDP increment	TOTAL
2046	1,200	0	120	1,319	12,196	3,462	260	2,253	141	19,631
2051	1,438	0	120	1,557	14,615	4,149	260	2,700	203	23,484
2056	1,673	0	120	1,793	17,013	4,829	260	3,143	236	27,274
2057	1,720	0	120	1,839	17,484	4,963	260	3,230	243	28,019
2058	1,766	0	120	1,885	17,951	5,096	260	3,317	249	28,757
2059	1,811	0	120	1,931	18,413	5,227	260	3,402	255	29,489
2060	1,858	0	120	1,977	18,888	5,362	260	3,490	262	30,239
2061	1,906	0	120	2,025	19,375	5,500	260	3,580	269	31,009

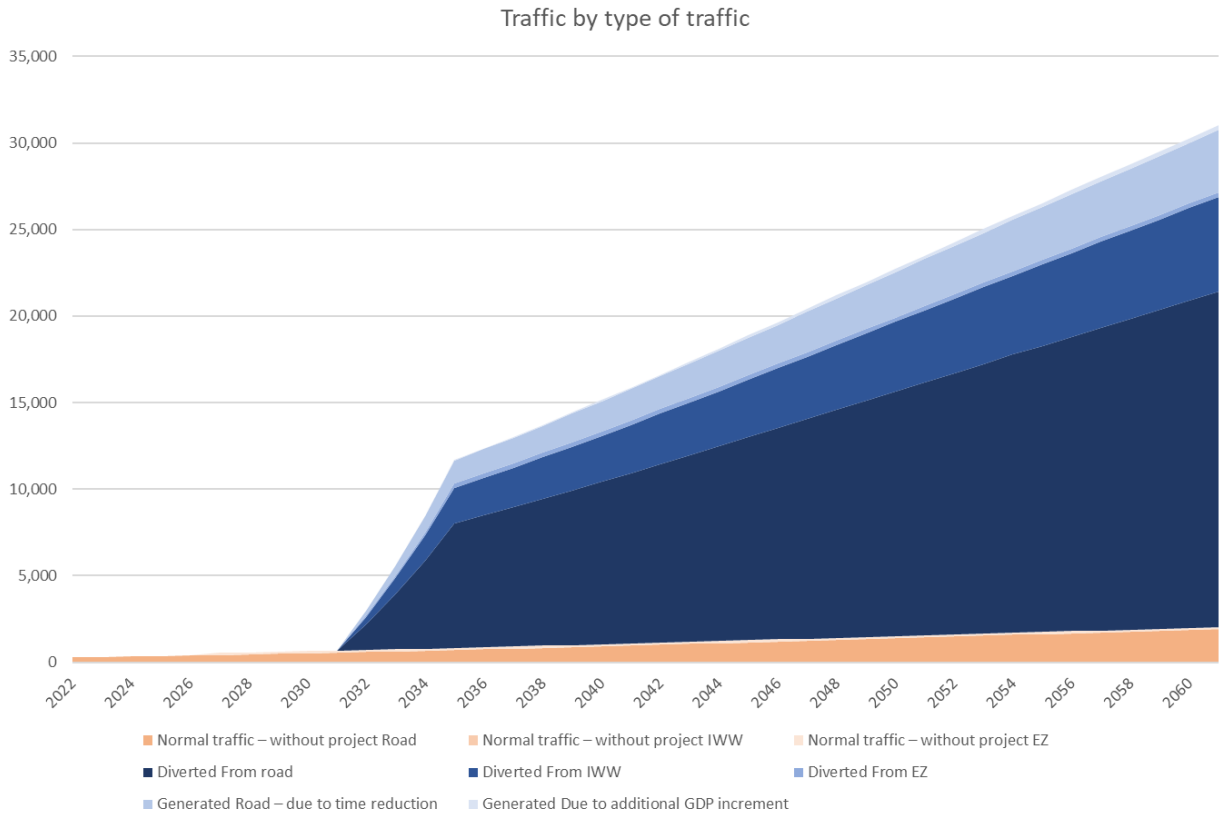
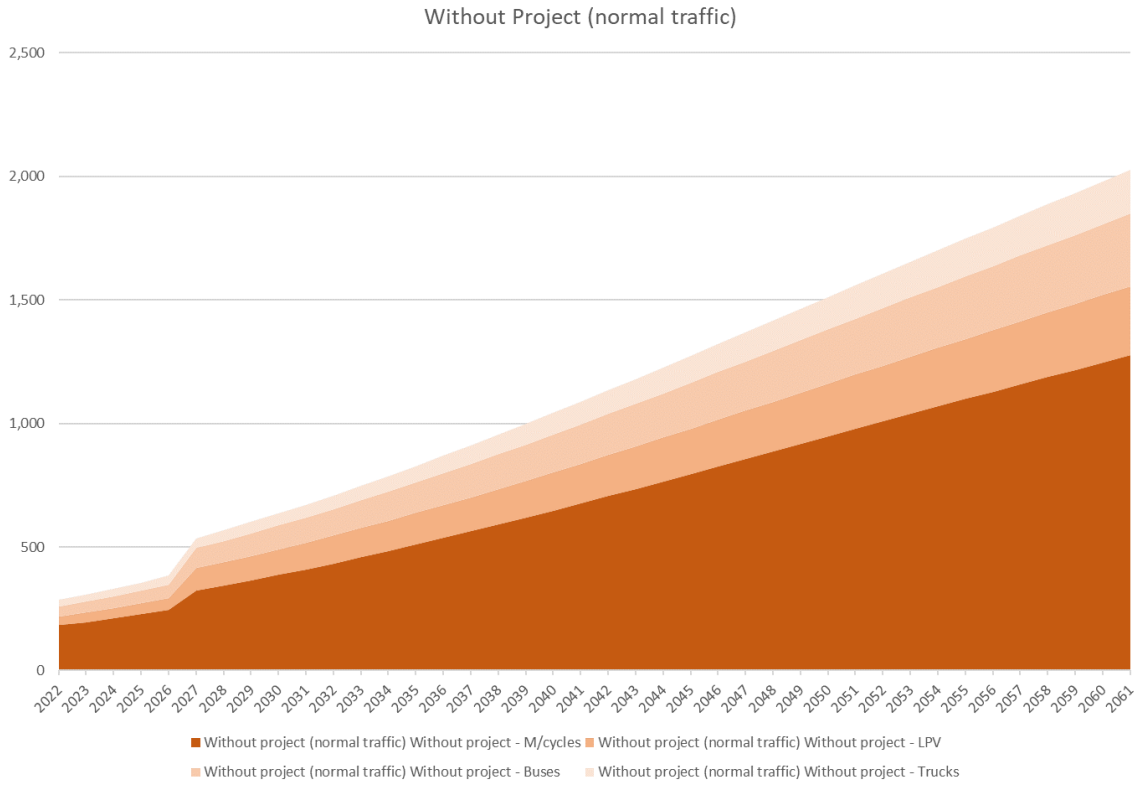


Figure 7. Daily traffic volumes by type of traffic.

The forecast of total motorized traffic (including motorcycles, light vehicles, buses, and trucks) for the Rajbari-Pabna Bridge project shows that an estimated **ADT of 31,009 veh/day in the year 2061.**

Table 5. Daily traffic volumes by type of vehicles.

	Without project (normal traffic)					With project				
	M/cycles	LPV	Buses	Trucks	Total without project	M/cycles	LPV	Buses	Trucks	Total With project
2030	387	104	96	48	635					
2031	410	109	101	51	671					
2032	434	113	106	55	708	2,064	636	1037	235	3,974
2033	458	118	112	58	747	3,248	795	2,080	443	6,566
2034	483	123	117	62	786	3,966	883	2,936	676	8,461
2035	509	128	123	66	826	5,424	1,203	4,108	934	11,668
2041	676	161	160	90	1,087	7,338	1,632	5,615	1,278	15,863
2046	825	190	193	112	1,319	9,056	2,017	6,971	1,587	19,631
2051	978	220	226	134	1,557	10,812	2,411	8,358	1,903	23,484
2056	1,129	249	259	156	1,793	12,544	2,798	9,717	2,215	27,274
2057	1,158	255	266	160	1,839	12,884	2,874	9,984	2,276	28,019
2058	1,188	261	272	164	1,885	13,222	2,950	10,249	2,337	28,757
2059	1,217	266	279	169	1,931	13,556	3,024	10,511	2,397	29,489
2060	1,247	272	285	173	1,977	13,899	3,101	10,780	2,459	30,239
2061	1,278	278	292	177	2,025	14,250	3,180	11,057	2,523	31,009



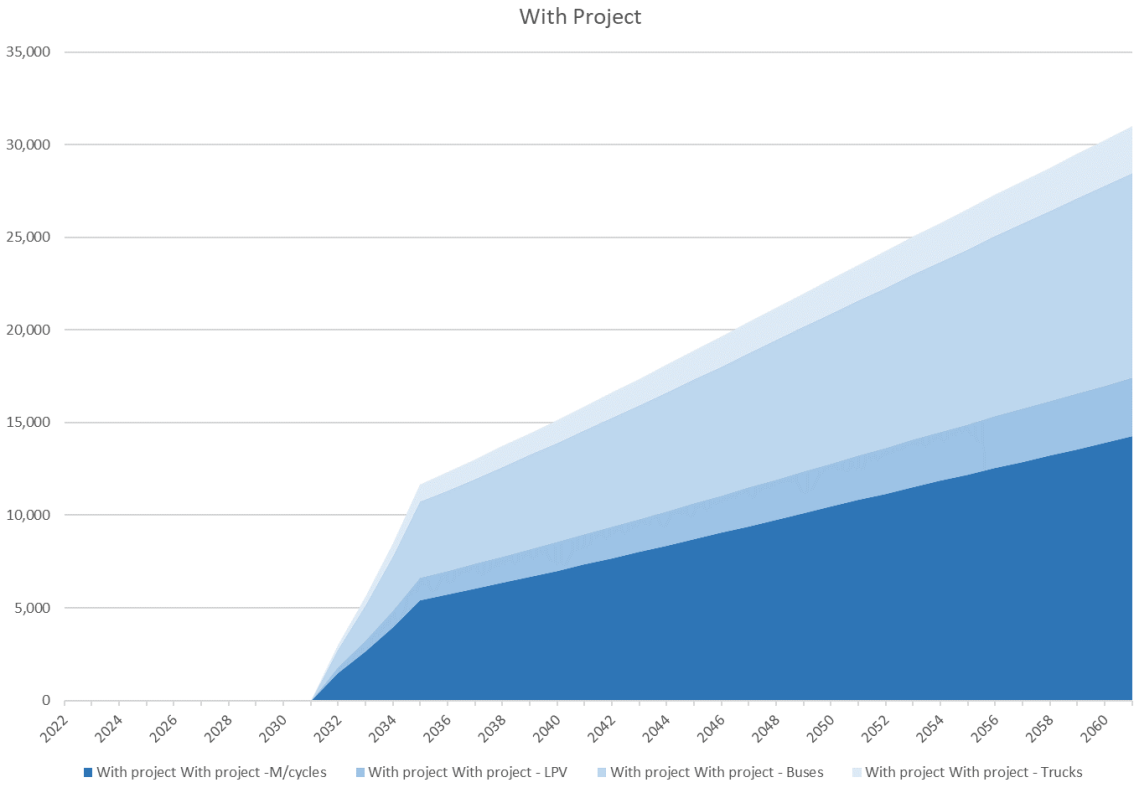


Figure 8. Daily traffic volumes by type of vehicles.

3.5.3. Economic Zones Study

One key initiative taken by the GoB during the last years, is the development of an Economic Zone (EZ) plan to implement across the country. Such zones clearly encourage rapid economic development in the areas where they are located, while at the same time contributing towards industry diversification, increase of production and exports and creation of employment.

To this specific study, special consideration was given to the planned Economic Zones of the area mainly due to the additional traffic that they will generate due to new created employment.

The Economic Zones are illustrated in the image below.

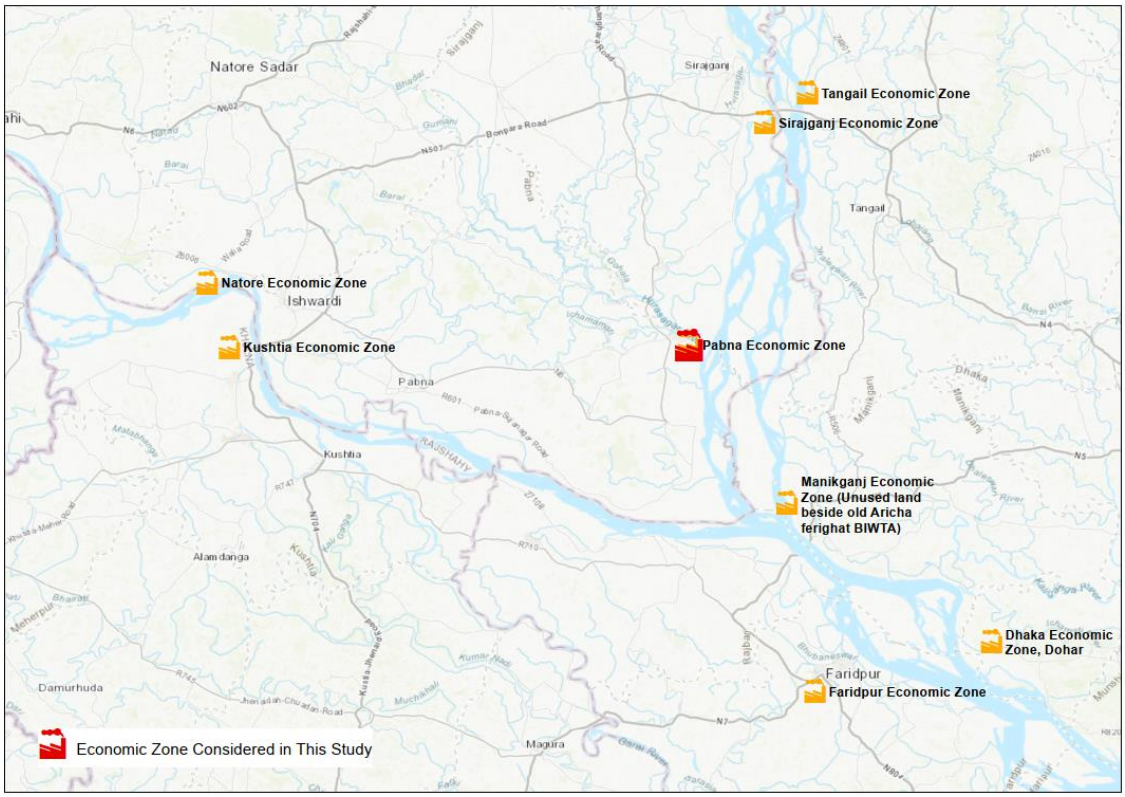


Figure 9. Location of planned Economic Zones in the area of influence.

According to the information collected from BEZA, Pabna Economic Zone is proposed to cover an area of 516 acres. Based on this area it has been assumed that the employment that this zone can generate will reach the 100,000 jobs. The economic zone in Pabna is anticipated to start operating by 2027. The trips that will be attracted by this economic zone will be home-based and it was assumed that will be distributed to all upazilas adjacent to the EZ. Around 200,000 daily trips have been considered for the EZ starting operation from 2027.

The distribution of these trips from/to each Upazila was estimated with the use of a gravity model, considering the population and the distance of each Upazila from the economic zones. The calculated number of trips (in number of passengers) to each of the adjacent Upazilas is presented below.

The passengers that will potentially use the bridge are highlighted in *blue* on the following table:

Table 6. Trip distribution to adjacent Upazilas (trips attracted by the considered Economic Zone).

Upazila	Number of additional trips per day (in number of passengers)
RAJBARI SADAR	*394*
GOALANDA	*77*
BALIAKANDI	*197*
KALUKHALI	*246*
PANGSHA	*243*
BELKUCHI	2,552
KAMARKHANDA	1,360
ULLAH PARA	6,789
BHANGURA	894
CHATMOHAR	1,932
ATGHARIA	388
FARIDPUR	65
SANTHIA	46,041
SHAHJADPUR	35,100
BERA	97,199
PABNA SADAR	4,014
SUJANAGAR	2,510
TOTAL	200,000

3.6. Need and Justification of the Project

3.6.1. SWOT Matrix

The identified key strengths and weaknesses of the project along with the opportunities and threats are presented in the following table.

Table 7. Project's SWOT matrix.

Strengths	Weaknesses
▪ The active participation, willingness, and support of the local gov't and citizens. ▪ The promoting agency BBA possesses previous expertise in similar projects like Padma and Jamuna Bridge, which adds to their capabilities and potential success in executing the current project. ▪ Availability of construction materials, as cement, stone from local market. ▪ Due to the river transport system, construction materials can be transported at low cost. ▪ The project is attracting interest from potential contractors and funding agencies,	▪ High-cost financing challenge. ▪ Supply of some materials source. ▪ Air and noise pollution may have some negative impacts on the environment. ▪ Disturbance to the movement of vehicles and pedestrians may occur during construction. ▪ Flooding, vessel impact and environmental aspects as Hilsa protection may pose risks during construction. ▪ In resettlement and rehabilitation, changes in economic activities, land-use, resource ownership, accessibility of natural resources and common property resources, loss of livelihoods, social disruption.

Opportunities	Threats
▪ To establish better connectivity with the national transport network, particularly in areas that are currently not connected due to the lack of proper road infrastructure. ▪ To facilitate smooth inter- and intra-town movement of people, goods, and services, thereby enhancing overall transportation efficiency and accessibility. ▪ To increase trade at both the local and regional levels, fostering economic growth and development in the area. ▪ To bring about improvements to the environment and public health, ensuring a sustainable and healthier living environment for the local communities. ▪ To foster sustainable decentralization, regional development, and resilient climate-adaptive practices, promoting long-term growth and resilience in the face of climate change challenges. ▪ To contribute significantly to local economic development, creating employment opportunities in the region. ▪ 2.81 Cr population living in 31 districts, in the Southwest and in the Northwest of Bangladesh would mostly be benefitted after completion of the proposed bridge. ▪ 41 lakhs in 14 upazilas would be benefited living in the two directly influenced districts Rajbari and Pabna.	▪ Influx of migrant people may have a negative impact on the quality of life. ▪ Occurrence of climate change-related and other natural hazards. ▪ The construction process could face hindrance in the event of a sudden natural disaster, impacting its continuity and progress. ▪ Excavation may result in sediments reaching watercourses. ▪ Land acquisition and rehabilitation processes can indeed be time-consuming. Furthermore, social and political obstacles can further complicate and prolong these procedures, potentially impacting the overall progress of the project. ▪ Achieving the target fund for a mega project is a formidable challenge. ▪ Due to various reasons, there is a possibility of not completing the work on time and increasing the cost of the project.

Source: Consultant Team

3.6.2. Project's Benefits

The main benefits generated by the project would be:

- Enhance transportation and communication: The bridge would provide a direct road link between the Rajbari district and the Pabna districts (connecting R601 with R711 and National Highway N6.
- Improve economic growth: The increase in connectivity and transportation infrastructure is expected to attract new businesses to the region, creating new job opportunities and promoting trade and commerce.
- Promote environmental sustainability: Currently, transportation to the Rajbari-Pabna is primarily through ferries, which have a significant environmental impact. The construction of the bridge will reduce the environmental impact of transportation, promoting sustainable development in the region.

- Improve regional connectivity between different districts of South Bengal and different districts of North Bengal of Bangladesh.
- Provide travel distance and time savings: Establish a more direct route between Rajbari district and the Pabna district that were previously connected by ferry and Lalon Shah Bridge. So, this bridge will reduce travel distance around 67 km and reduce vehicular pressure upon Lalon Shah Bridge.

The distance and time savings, due to the construction and operation of the bridge, are key elements obtained from the traffic study and cost benefit analysis (CBA). An estimation was done for each vehicle type, identifying the average yearly savings for the 30 years of the operation of the project.

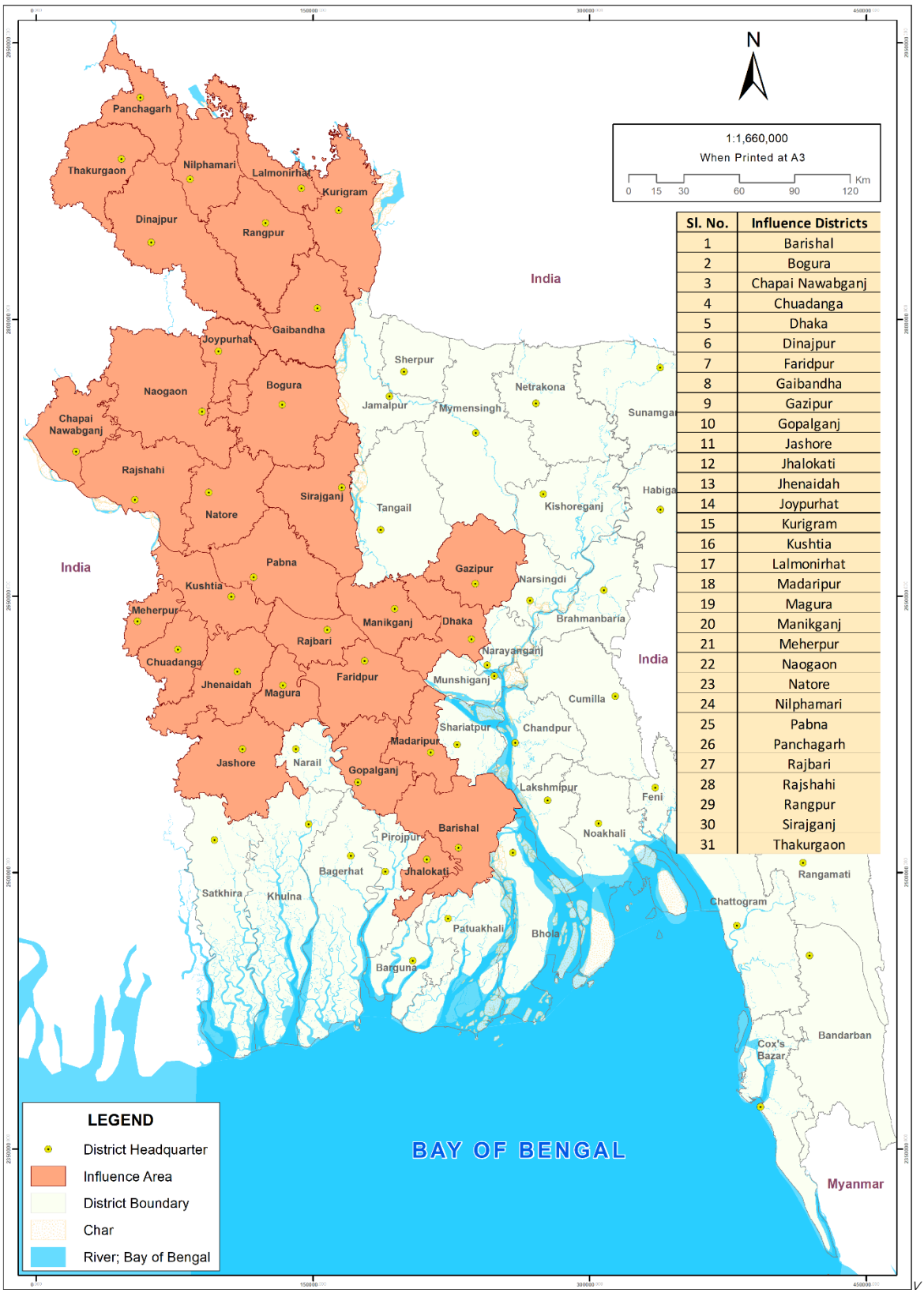
The results are illustrated in the tables below.

Table 8. Average annual time savings during the operation of the bridge.

	Motorcycles (M pass-hour per year of operation)	LPV (M pass-hour per year of operation)	Bus (M pass-hour per year of operation)	Trucks (M Ton-hour per year of operation)
Without project	27.86	13.70	491.42	71.78
With project	17.43	7.80	401.16	39.74
Time Savings	**10.43**	**5.91**	**90.26**	**32.04**

Table 9. Average annual distance savings during the operation of the bridge.

	Motorcycles (M veh-km per year of operation)	LPV (M veh-km per year of operation)	Bus (M veh-km per year of operation)	Trucks (M veh-km per year of operation)	Total (M veh-km per year of operation)
Without project	467.42	91.73	460.81	108.65	**1,128.61**
With project	423.43	80.44	448.70	105.13	**1,057.7**
Distance Savings	**43.99**	**11.29**	**12.11**	**3.52**	**70.91**



Sl. No.	Influence Districts
1	Barishal
2	Bogura
3	Chapai Nawabganj
4	Chuadanga
5	Dhaka
6	Dinajpur
7	Faridpur
8	Gaibandha
9	Gazipur
10	Gopalganj
11	Jashore
12	Jhalokati
13	Jhenaidah
14	Joypurhat
15	Kurigram
16	Kushtia
17	Lalmonirhat
18	Madaripur
19	Magura
20	Manikganj
21	Meherpur
22	Naogaon
23	Natore
24	Nilphamari
25	Pabna
26	Panchagarh
27	Rajbari
28	Rajshahi
29	Rangpur
30	Sirajganj
31	Thakurgaon

Figure 10. Influence area map.
(Source: Consultant Team based on the Traffic Survey Data)

4. TECHNICAL AND ENGINEERING ANALYSIS

4.1. Design Standards

- The Eurocode has been adopted in the design of the structures: EN 1990, EN 1991-1, EN 1991-2, EN 1993, EN 1994 and EN 1998 along with EN 1337, EN 10080, EN 10138 and EN206.
- Despite being related to building structures, the Bangladesh National Building Code (BNBC) is followed in the determination of wind loads and the earthquake design spectrum.
- AASHTO LRFD 2017 specifications for Highway Bridges, with interim revisions 2020, 2022 and 2023, is considered appropriate to be used in the determination of stream pressure on piers.
- Geometric Design Standard for Bridges and Approaches and Bridge Design Standard by RHD
- Geometric Design Standards Manual (Revised) 2005 (GDSM 2005). Roads and Highways Division.
- A policy on "Geometric Design of Highway and Streets" 2018, AASHTO
- Manual of Specifications and Standards for Expressways, IRC: SP: 99-2013
- Manual of Specifications and Standards for Four Laning of Highways, IRC: SP: 84-2019
- Pavement Design Guide for Roads and Highways Department 2005 for pavement design works along with "AASHTO Guide for Design of Pavement Structures 1993".

4.2. Hydro-morphological Study

4.2.1. Hydro-morphological Analysis of the Sites

The hydro-morphological study was carried out by the Consultant with the expert collaboration of the local nominated subconsultant IWM. The results from different analyses based on historical data, present data, field observation and previous model results have been summarized in the following table to show the relative advantages and disadvantages of the selected bridge locations in terms of different hydraulic, morphological, and other factors, which lead to the selection of bridge site. For each factor a ranking has been done from 1 to 3. The maximum number of top positions among the three alternatives will be the most appropriate site for the bridge location.

The results of different analyses based on historical data, present data, field observation and previous model results have been summarized in the following table to show the relative advantages and disadvantages of the selected bridge locations in terms of different hydraulic, morphological and other factors, which lead to the selection of bridge site. Each factor has been ranked from 1 to 3.

Table 10. Minimum width of the river (satellite images).

Options	River Width (m)	Bank full Width (m)
Option A	1,134	3,258
Option B	1,880	2,148
Option C	2,055	2,480

Summary findings of the study on selection of suitable bridge location on the Padma River along with estimation of the hydraulic design parameters of bridge are described in the following sections.

- Analyzing the three options, Option B shows better results in respect of hydro-morphological viewpoint among all other options. However, constructing a bridge along Option B may require the demolition of all existing establishments at the right bank. Besides, the bridge length is also higher for Option B than that for Option A. Thus, construction of a bridge at Option B has been discouraged in respect of social viewpoint and Option A has been suggested as the most suitable site for the pre-feasibility stage of proposed Rajbari-Pabna bridge.
- The proposed bridge site is fallen under Class I navigational route (as per BIWTA 2018 Gazette)
- The Minimum Vertical Clearance from SHWL is 18.3 m (as per BIWTA 2018 Gazette)
- The soffit level of the bridge = 11.53 + 18.3 = 29.83 mPWD
- Using Lacey's regime scour depth formula, scour has been calculated and the computed scour depth is found to be 23 m. Hence, the maximum scoured depth in river is about 1.75 times of computed scour depth, which is 40.25 m, and the scour level is -28.25 mPWD.
- The simulated scour depth near Rajbari is found to be -33.12 mPWD from past study conducted by BUET during 2023.
- The local scour has been calculated using different empirical formulas, such as FHWA method, Laursen method, Breusers method etc. The maximum scour is found 36.97m using FHWA method.
- Riverbank protection work for each alternative has been studied based on planform change of river, historical bankline shifting, the present field condition and previously developed simulated model results.

Table 11. Hydraulic parameters.

Hydraulic Parameters	Unit	Value	Remarks
Design Discharge	m^3/s	79059	Observed data
Design High water Level	mPWD	12.00	For 1 in 100 flood event
Low water Level	mPWD	1.76	slope interpolation from observed data
Standard High Water Level	mPWD	11.53	slope interpolation from observed data
Standard Low Water Level	mPWD	1.92	slope interpolation from observed data
Maximum velocity	m/s	3.85	extracted from model
Average Bank Level	mPWD	9.5	from DEM
Minimum Bed Level	mPWD	-13	BWDB observed data at RMG 2
Design Maximum Scour Level	mPWD	-33.12	extracted from model
Bed material size, d_{50}	mm	0.15	Observed data
Water Depth	m	25	HFL-min bed level

4.2.2. River Protection Works

To avoid the outflanking of channel and guide the flow towards the bridge opening, two bank protection works or guide bunds have been suggested at both banks for all options. Considering no loss of land along the entire protected length, no damage due to oblique flow, flow diversion from

riverbank, navigation, minimum maintenance, partial damage does not create non – functional, easy construction and use of dredged material for land reclamation etc.; Bank Protection work with revetment and dredging in the channel appeared to be the most feasible option and hence adopted.

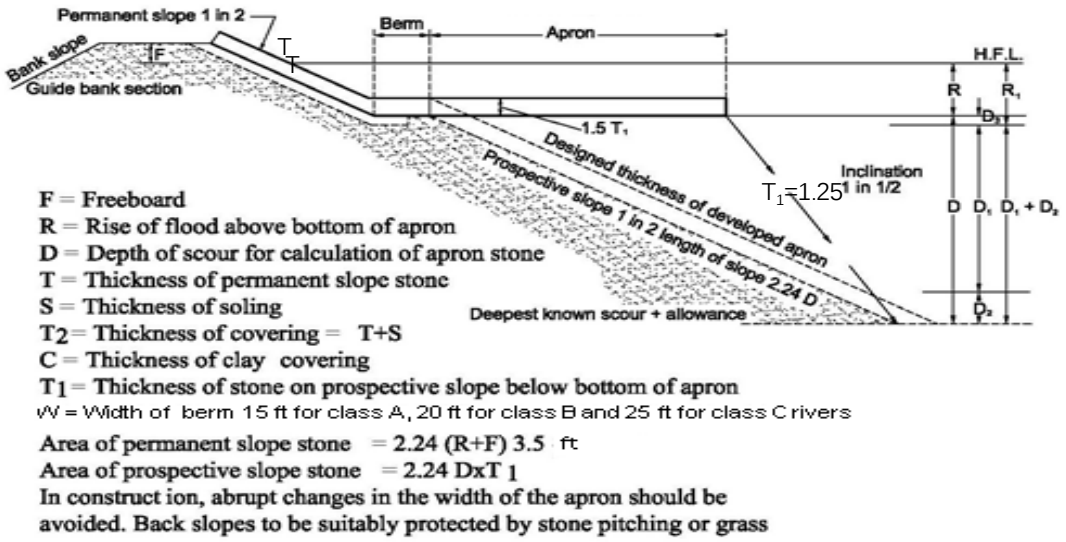


Figure 11. Proposed solution for the river training works

Table 12. Length of the proposed bank protection works.

Options	Length of LGB (m)	Length of RGB (m)	Total Length (m)
Option A	4,300	4,600	8,900
Option B	3,400	3,400	6,800
Option C	3,400	3,400	6,800

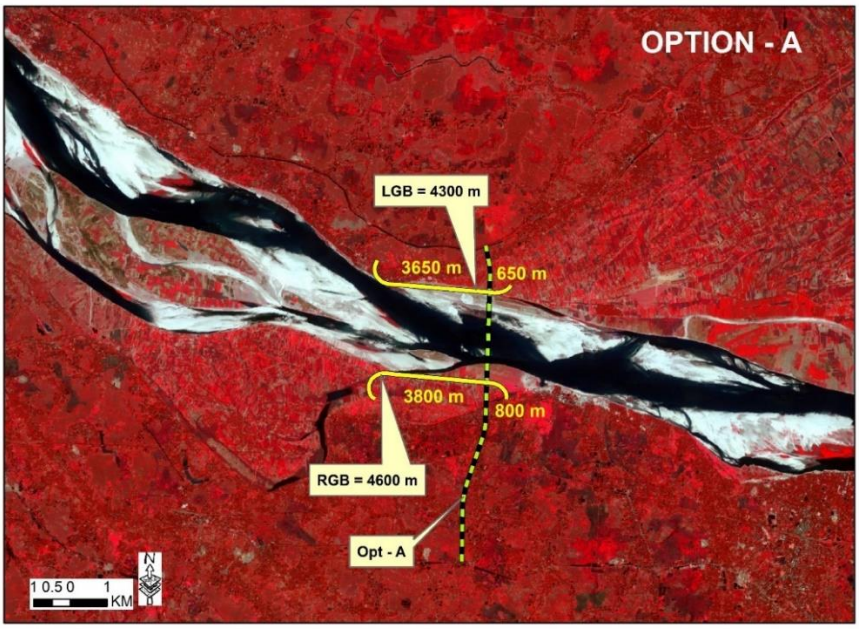


Figure 12. Bank Protection Works (Guide Bund) for Option A

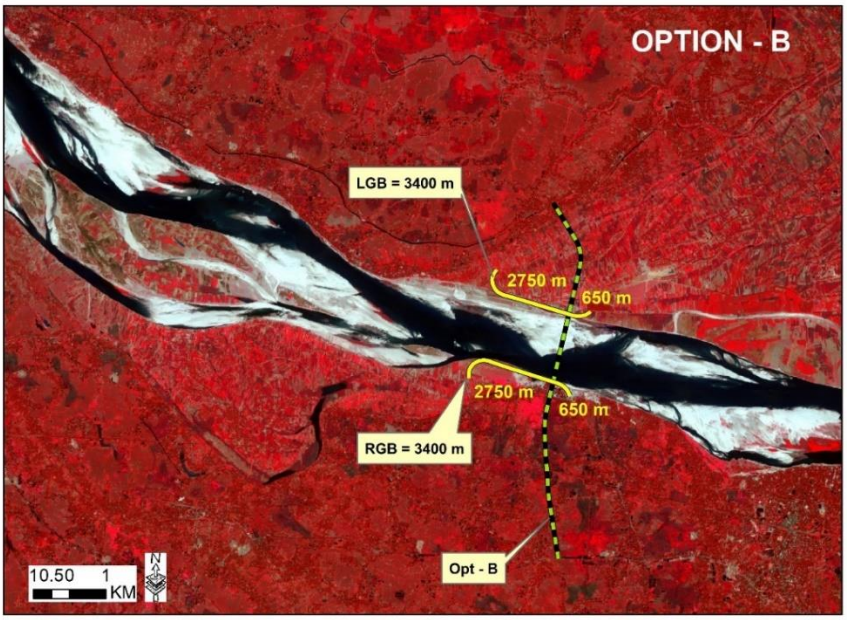


Figure 13. Bank protection works proposed for Option B.

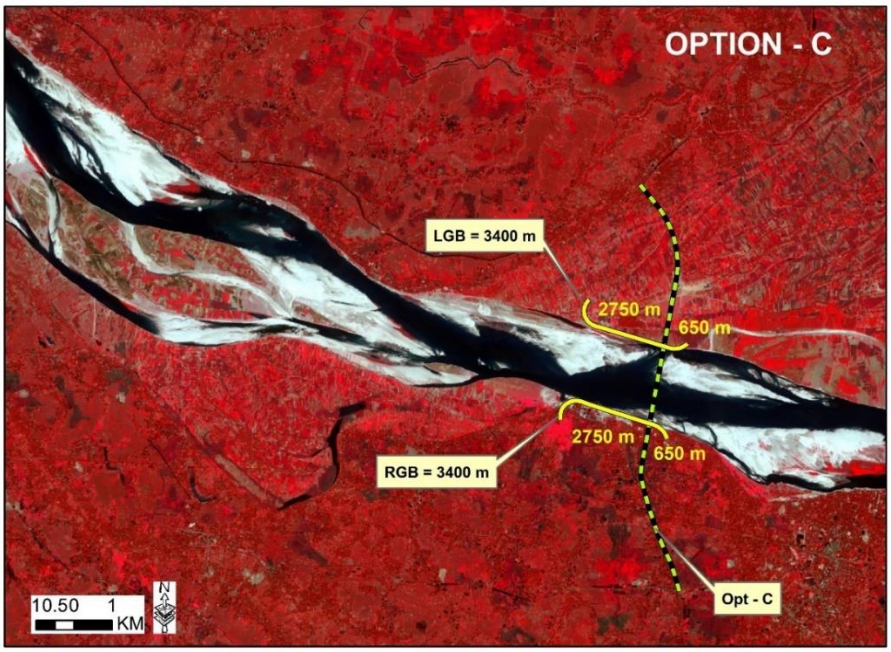


Figure 14. Bank protection works proposed for Option C.

Option B selected is located next to land acquired for the construction of a solar plant. Currently, the project is ongoing, but it is expected that the project includes the proper measures of the protection of the riverbank of the adjacent river. Based on that, the preliminary length considered for the proposed right guide bund in the Option B has been reduced over 2,000 m being the final lengths considered in the cost estimate for the river protection works of this pre-feasibility study (Figure 15), as follows:

- Length of RGB = (2,750 m - 2,000 m) +650 m = 1,400 m
- Length of LGB = 2,750 m + 650 m = 3,400 m

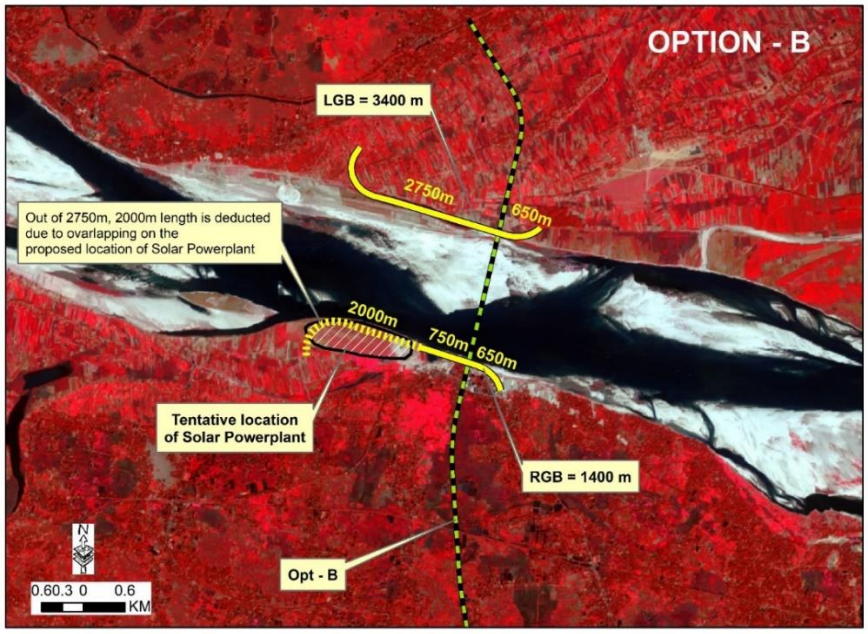


Figure 15. Selected Option B proposed protection works.

4.3. Selection of Bridge Location

A preliminary analysis carried out from hydro-morphological, structural and road connectivity points of view, was undertaken to pre-select the location of the project in which the field works were carried out. The Consultant engaged to Institute of Water Modelling (IWM), according to the ToR, which presented the primary selection of suitable site for proposed Rajbari-Pabna bridge based on the analysis of observed hydro-morphological characteristics of the Padma River as discussed hereinafter.

As stated earlier, three probable sites on the Padma River near Rajbari-Pabna were selected preliminarily based on the connectivity with the existing road network, rail network, historical available cross-section data and observed bank erosion. In general terms, the following are the factors that were conveniently considered:

- The river reach should be straight; the bridge axis & river flow direction should be at a right angle, steady and uniform river flow without cross currents.
- The width of the river channel should be minimum, narrow channel with stable banks, suitable high banks above high flood level on each side.
- There should be no excessive scouring & silting at the bridge site, rock or other hard in erodible strata close to the riverbed level. There should be the availability of hard strata or non-erodible foundations for the bridge.
- The site should be sufficiently away from the confluence point.
- Economical approaches, the approaches should be free from obstacles such as hills, frequent drainage crossings, scared places, graveyards, built-up areas or troublesome land acquisition, absence of sharp curves in the approaches with minimum obstruction to natural waterways.
- There should not be the necessity for extensive river training works.

- The bridge axis should align with the centreline of the approach road, the bridge should be absolutely at level. If it must be in gradient, it should comply with that of the roadways.
- There should be sufficient clearance for high flood level (HFL).
- Absence of excessive underwater construction works.
- There should be the availability of construction materials.

Based on these factors, the locations for the probable bridge site were selected as shown in Figure 16.

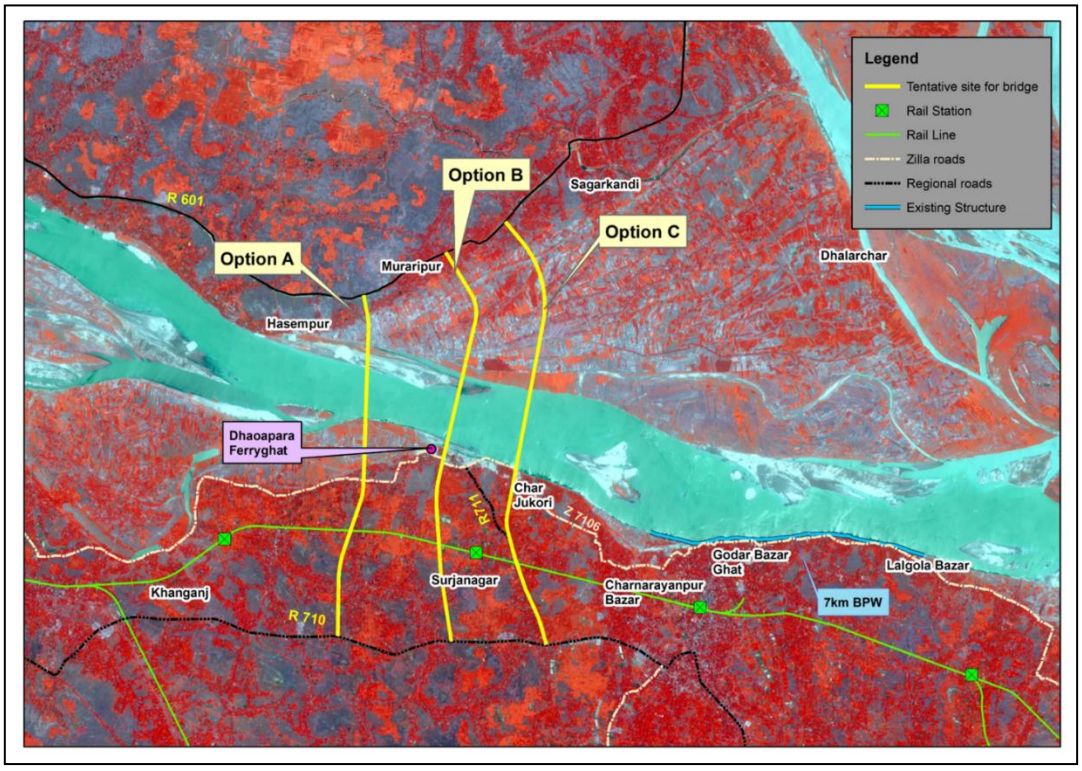


Figure 16. Selected three sites for the proposed Rajbari-Pabna Bridge over Padma River

Table 13. Selecting criteria for choosing different options

Tentative options	Location or Position	Selecting Criteria
Option A	Located at Hasampur on the left bank. (1.2km d/s from Mohendrapur WL station).	Close to the road network (R601) on left side.
Option B	Located near Dhaoapara ferryghat at Right Bank (3.3km d/s from Mohendrapur WL station).	Close to the Rail, road and ferry ghat and right bank seems stable.
Option C	Located near Charjukori at Right Bank (5.1km d/s from Mohendrapur WL station).	Close to the Rail and road network (R711) on right side and right bank seems stable.

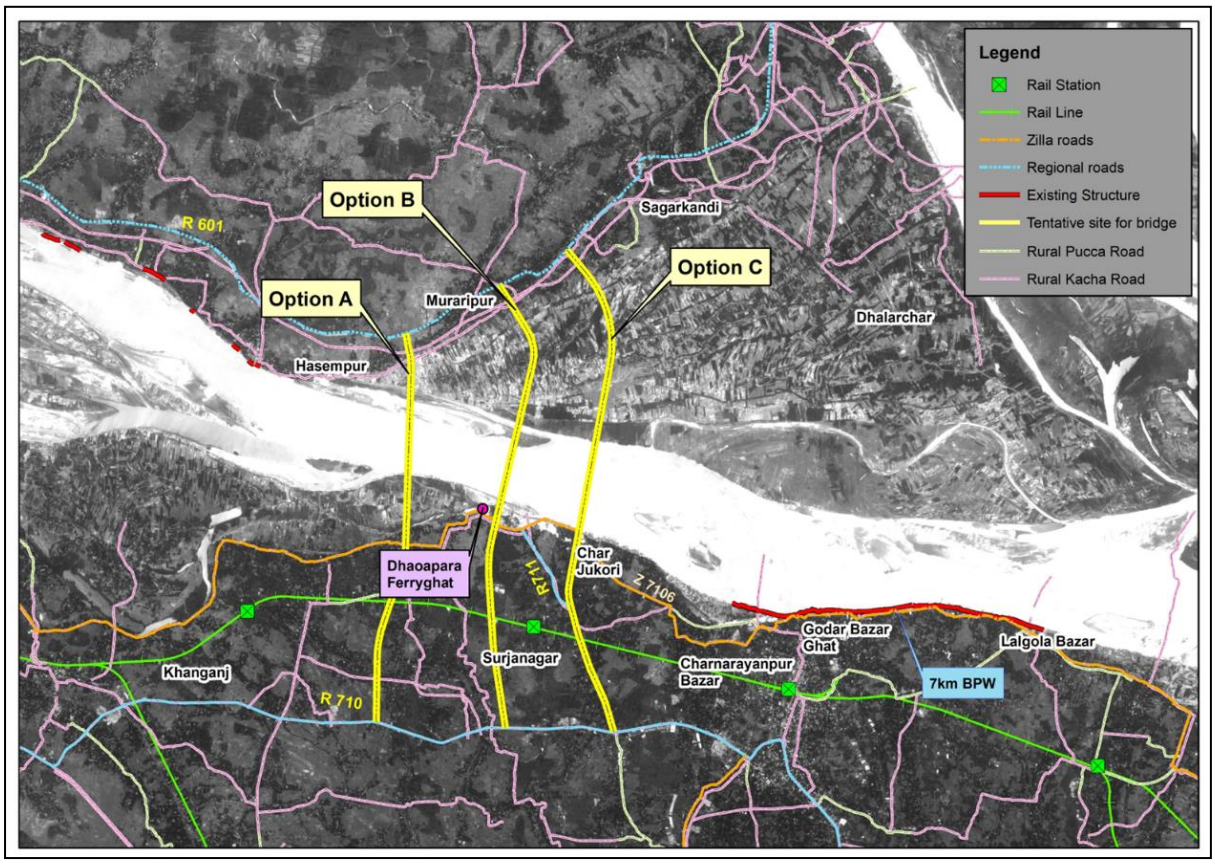


Figure 17. Road network near Rajbari- Pabna.

Table 14. Aerial distance to connect the bridge on both sides.

Options	Aerial Distance to connect with Regional Road (m)		Aerial Distance to connect with Zilla Road (m)	
	Left side	Right side	Left side	Right side
Option A	1,278	5,545	-	1,490
Option B	3,089	4,830	-	423
Option C	6,450	1,630	-	310

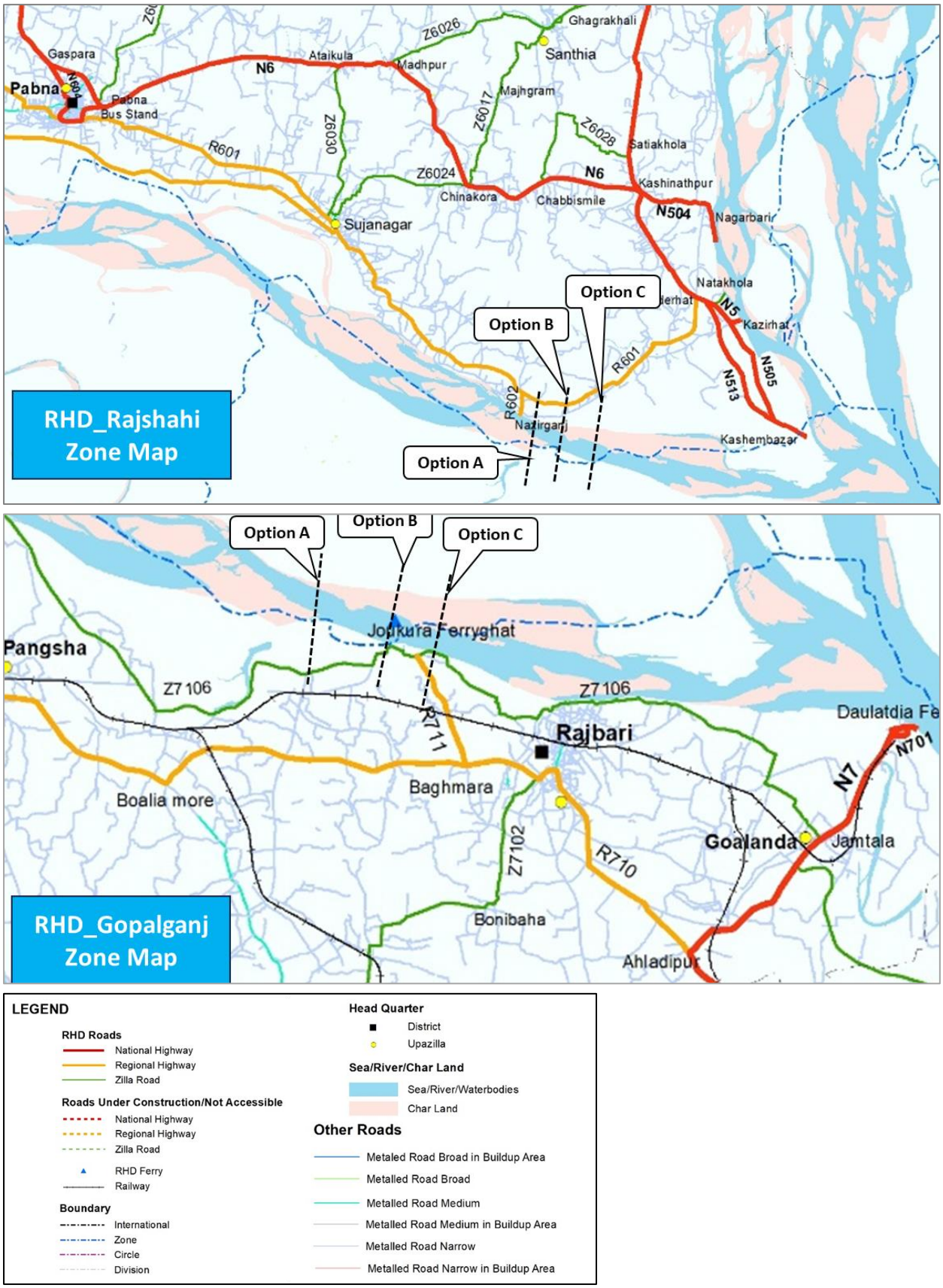


Figure 18. Road network near Rajbari- Pabna (Source: RHD website).

Table 15. Multi-Criteria Analysis for selecting potential bridge location.

Sl. No	Hydraulic Condition	Option A	Option B	Option C
1	Road Connectivity at Left Bank	1	2	3
2	Road Connectivity at Right Bank	3	2	1
3	Width of River (bank to bank)	3	1	2
4	Uniformity in section	3	1	2
5	Bed Scour	2	3	1
6	Uniformity from skewness viewpoint (angle)	3	1	2
7	Obliquity of flow	3	1	2
8	Bank erosion (Left Bank), 1990 to 2023	2	1	1
9	Bank erosion (Right Bank), 1990 to 2023	1	1	2
10	Bank erosion (Left Bank), 2002 to 2023	3	1	2
11	Bank erosion (Right Bank), 2002 to 2023	1	2	3
12	Channel incidence	2	1	2
13	Presence of Thalweg	1	2	3
14	Field Condition	1	2	3
15	Required Length of Bank Protection Works	2	1	1
16	Cost Estimation	3	1	2
	Frequency of top position	***5***	***10***	***4***

From the above table and all the aspects that were assessed in the study, it could be concluded that Option B followed by Option A appeared to be the most suitable site from a hydro-morphological point of view.

It must be remarked that an important issue affecting to the option A, was identified at the late stage of the Draft Final Report implementation process, after receiving updated information regarding the acquisition of part of the land for the construction of a 100 MW (AC) future solar power plant by Theis Power (Singapore) PTE. Limited. This fact poses an unavoidable impact on option A, reinforcing the selection in favor of option B as the preferred alignment.

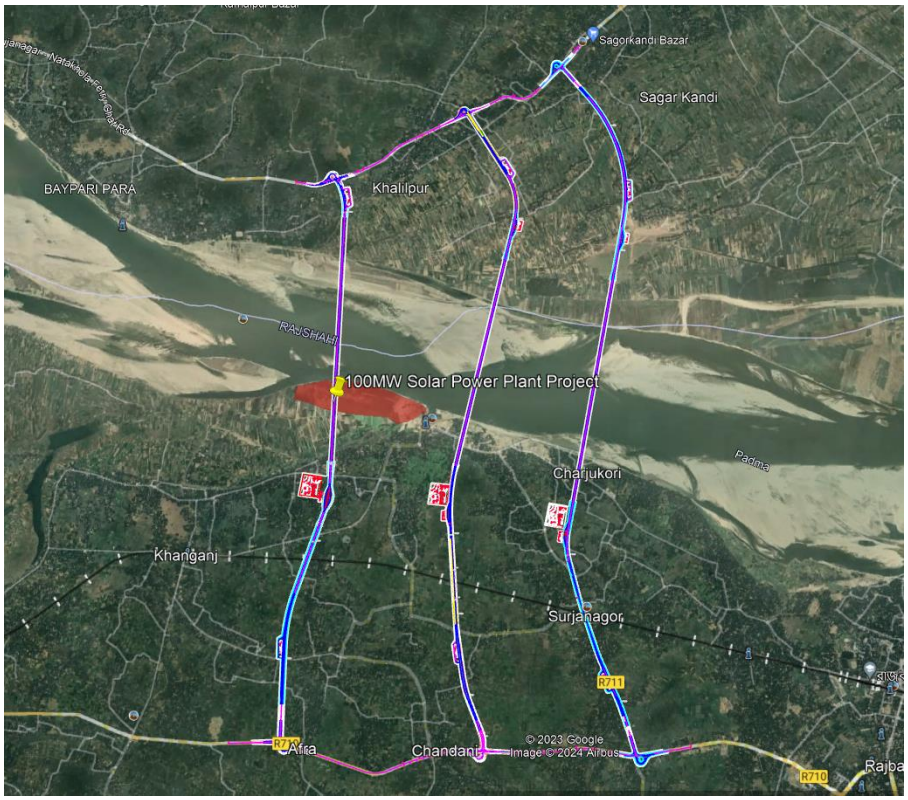


Figure 19. Alignments under assessment and the Impact of the Solar Plant.

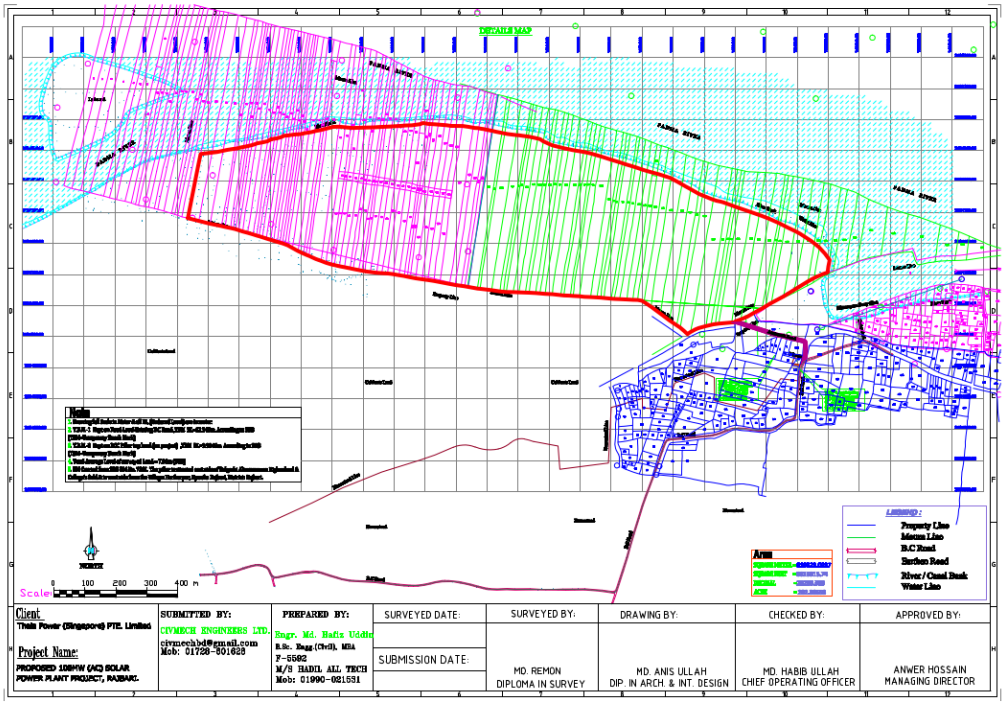


Figure 20. Detailed plan and location of the 100 MW Solar Plant

4.4. Fieldworks

The existing field conditions were assessed also after various site visits paid by the Consultant's team. The visits main objectives were to carry out terrain reconnaissance and to meet with the local communities and key stakeholders. In other cases, special supervision of diverse works as geotechnical or topographical works, or utilities coordination supervision was undertaken. All visits were duly reported and in some cases the visits were organized with the attendance of BBA officials.

Table 16. Site visits record.

No	Location Visited	Start Date	Finish Date	Purpose of the Trip or Site Visit	Consultant JV Participants
1	Rajbari	14 09 2023	14 09 2023	To supervise Field Works	BBA PD, geotechnical Lead Expert and Team
2	Rajbari and Pabna	18 09 2023	21 09 2023	To meet with company coordination issues regarding utilities interface with the bridge project	Utilities Interface coordination team
3	Rajbari and Pabna	26 09 2023	28 09 2023	To supervise topographical works at both projects for pre-FS purposes,	Topographical Intl. Expert and GIS Expert
4	Rajbari and Pabna	01 10 2023	04 10 2023	To supervise topographical works at both projects for pre-FS purposes,	Topographical Intl. Expert and GIS Expert
5	Rajbari and Sujanagar	17.11.2023	18.11.2023	Reconnaissance of the project area and Public Consultation Local People	Environmental Team

4.4.1. Topographical Surveys

A detailed topographical survey was carried out, at the two pre-selected options (A and B) along the proposed alignments using GPS (Static Method) and Total Station. The other option C was analysed using aerial images for a preliminary alignment study.

The preliminary alignment for the proposed new approach roads, on both sides of the bridge, was designed as per the findings of the surveys undertaken by BSO Associates Ltd. (BSO). The topographical surveys were carried out during the months of October of 2023 and May 2024.

The scope of works of the topographical surveys was follows:

- Collection of information of reference Benchmark.
- Reconnaissance Survey.

- Selection of Reference BM.
- Establishment of control points.
- Fly Levelling.
- Traverse Survey.
- Detail Topographical survey.
- Cross Section Survey.
- Preparation of the report and maps.

The topographical report and maps are attached in the Volume 3. Annex B of the Main Report.

4.4.2. Geotechnical Investigation

To carry out a comprehensive study, it is essential to get a detailed and thorough understanding of the ground conditions, soil behaviour and interaction between the ground and the proposed foundations and structures.

The main objectives of the GI works are to determine:

- To identify the presence of soft silts and clays on the riverbank.
- To determine the geological stratification along the bridge alignment
- To derive and determine the engineering properties of each soil type for the purpose of designing the main bridge of the project and other components.

The preliminary ground investigation was conducted by Ground Instrumentation & Engineering Pte Ltd (GIE). The campaign included the drilling of two boreholes (PBBH-1 and PBBH-02) during the period between September 9th to October 3rd, 2023. The maximum depth reached was 150 m.

The geotechnical factual report is attached in the Annex A of the Main Report.

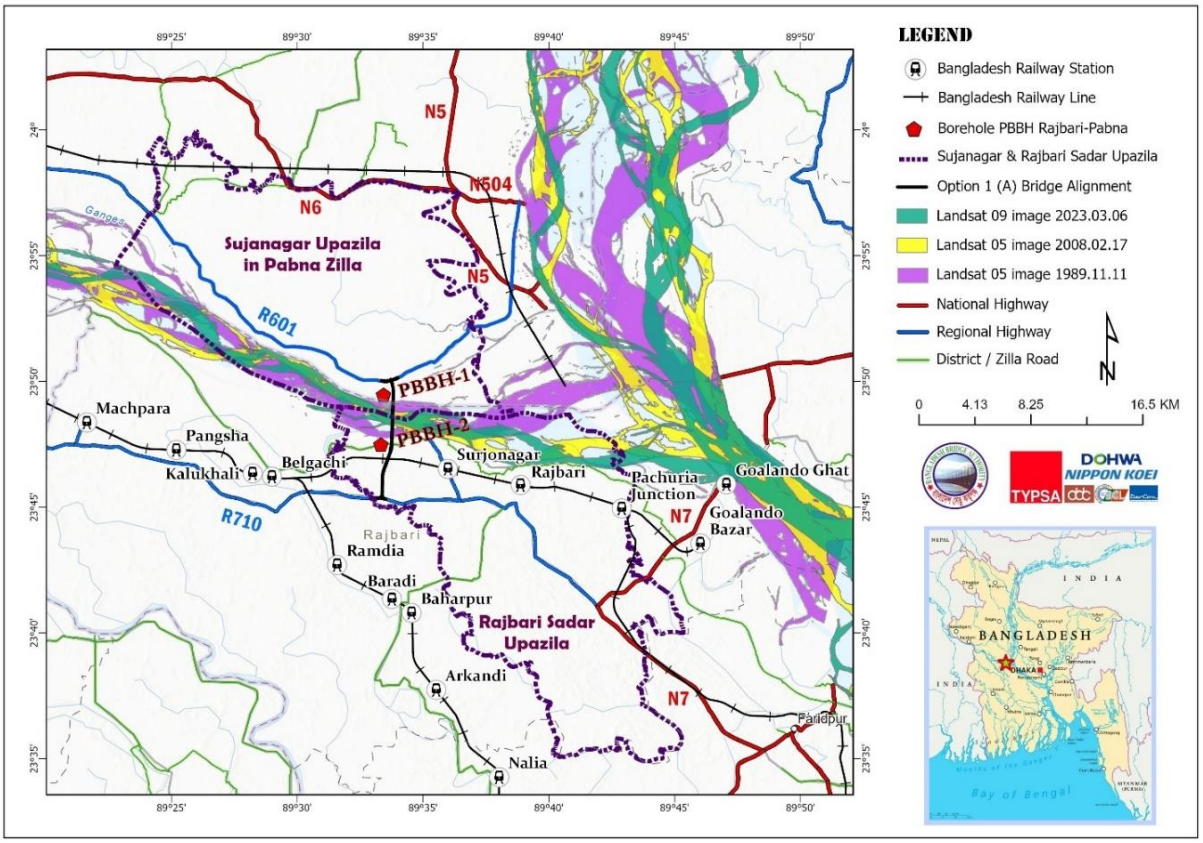


Figure 21. Location of boreholes.

4.4.3. Existing Utilities

For identifying the conflicts with the existing public utilities within the project area, some field visits were carried out in coordination with representatives of the utilities' companies. The aim of these inspections was to collect all necessary information related to the interference of the existing electric line of Palli Bidyuit Samity (PBS), and overhead transmission lines of PGCB & West Zone Power Distribution, Rajshahi (WZPWR).

After the site visit and the data collection, it may be concluded that the project would have some impact on some existing PBS electricity lines, PGCB transmission lines, and transmission lines of West Zone Power Distribution Company Ltd. (WZPDCL). It should be also remarked that other public utilities such as gas, underground water pipeline, and optical fiber cable were not identified in the project area.

4.5. Proposed Engineering Solution

The proposed solution for the bridge over the Padma River is based on **Balanced Cantilever Bridge with span arrangement of 110 + 9 x 200 + 110 m over the class I navigation area and accessing spans of precast I-beams of 40 m span.** The total length of the bridge including access spans is **3.30 km**.

Table 17. Bridge length distribution for Rajbari-Pabna bridge.

Stretch	Lengths in m
South Ramp	640
Class I Main Bridge	**2,020**
East Ramp	640
Total ramp/connecting spans length	1,280
Total Class I spans length	2,020
Total Bridge Length	**3,300**

Figure 22. Balanced cantilever bridge proposed for Rajbari-Pabna.

Figure 23. Image of access spans proposed for Rajbari Pabna.

The foundation of the piers for the central section, which were planned to be executed in wet conditions, have been estimated to require 12 steel driven piles Φ3.0 m of 120 m in length. Further development of the current calculation during detailed design may allow for the use of a different diameter for the steel driven piles. For the approach spans with I girders, the foundation has been estimated to require 4 reinforced concrete bored piles Φ1.80m of 70 m in length.

Two toll plazas (one per direction) have been located before the crossing of the bridge as well as two axle load stations and two engineering facilities as BBA required.

Amongst the study of structural alternatives that was carried out, the steel truss with a span configuration of nx200m was considered and thoroughly assessed. The detailed analysis in terms of typology, alignment level required, construction period and cost comparison can be found in section 6.3 of Volume 1. Taking everything into account, truss bridge alternative was found less suitable than balanced cantilever bridge.

Three alignment options were studied and compared for the Rajbari-Pabna crossing. For each alignment, three bridge typologies were proposed.

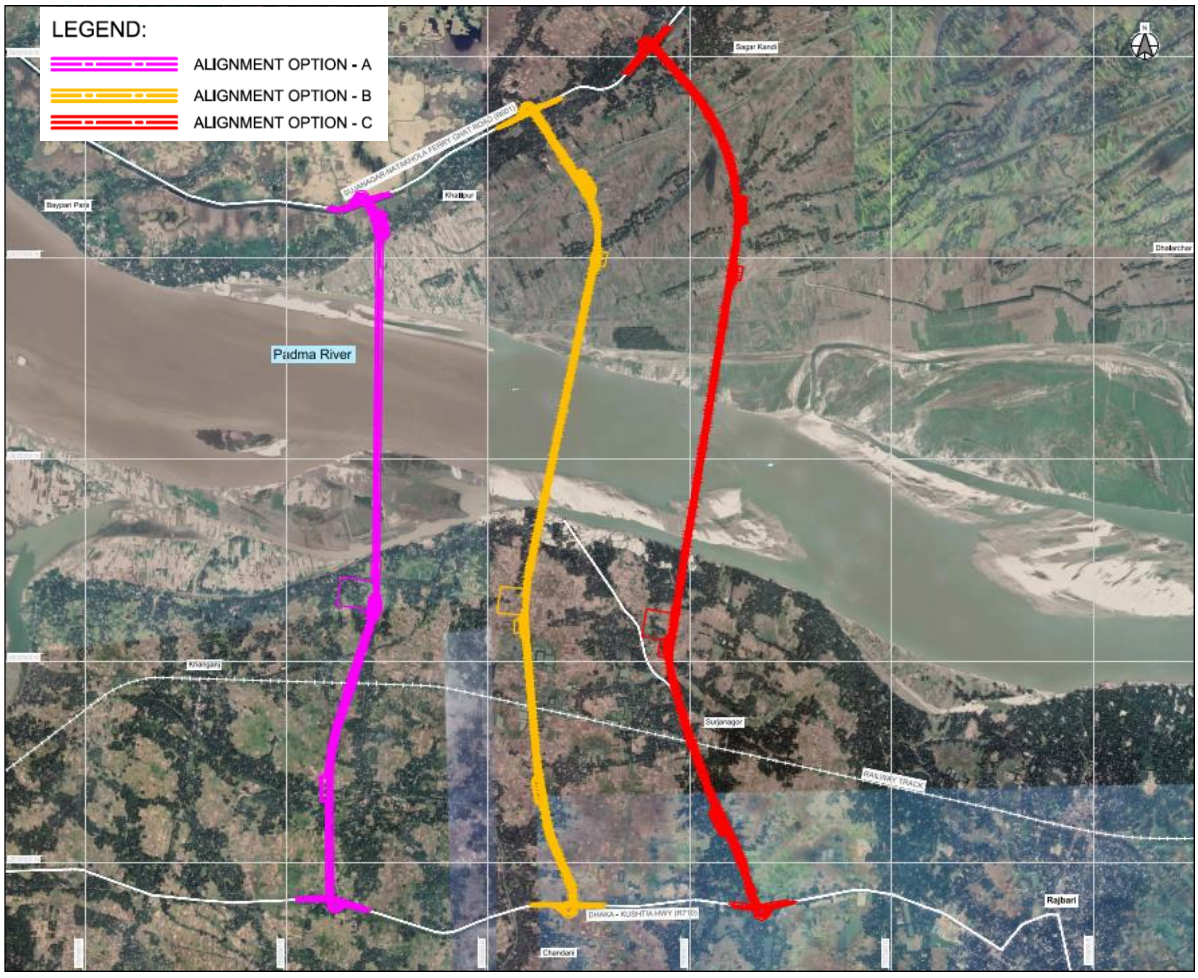


Figure 24. Alignment options studied.

Figure 25. Balanced cantilever spans proposed.

Figure 26. Image of balanced cantilever spans proposed.

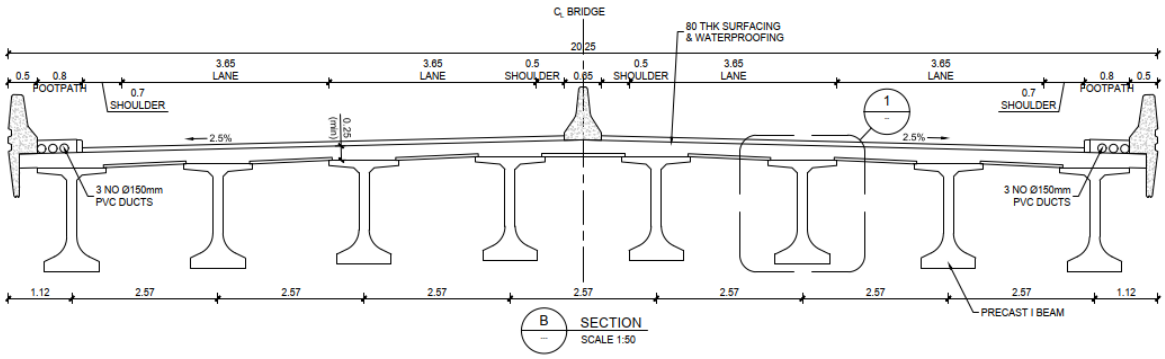


Figure 27. Typical cross section (Precast I-beams) for accessing spans.

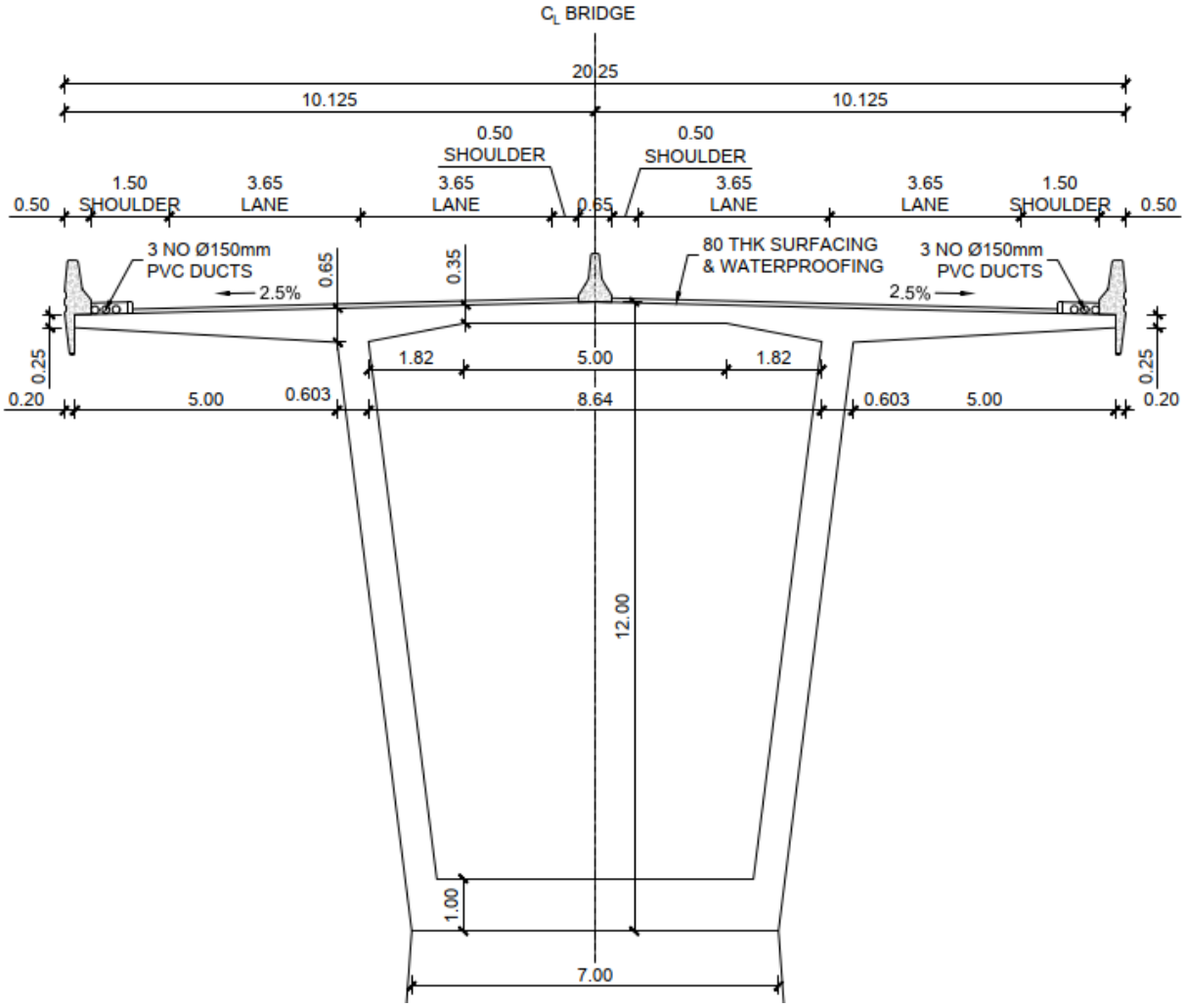


Figure 28. Typical cross section over pier (Main span).

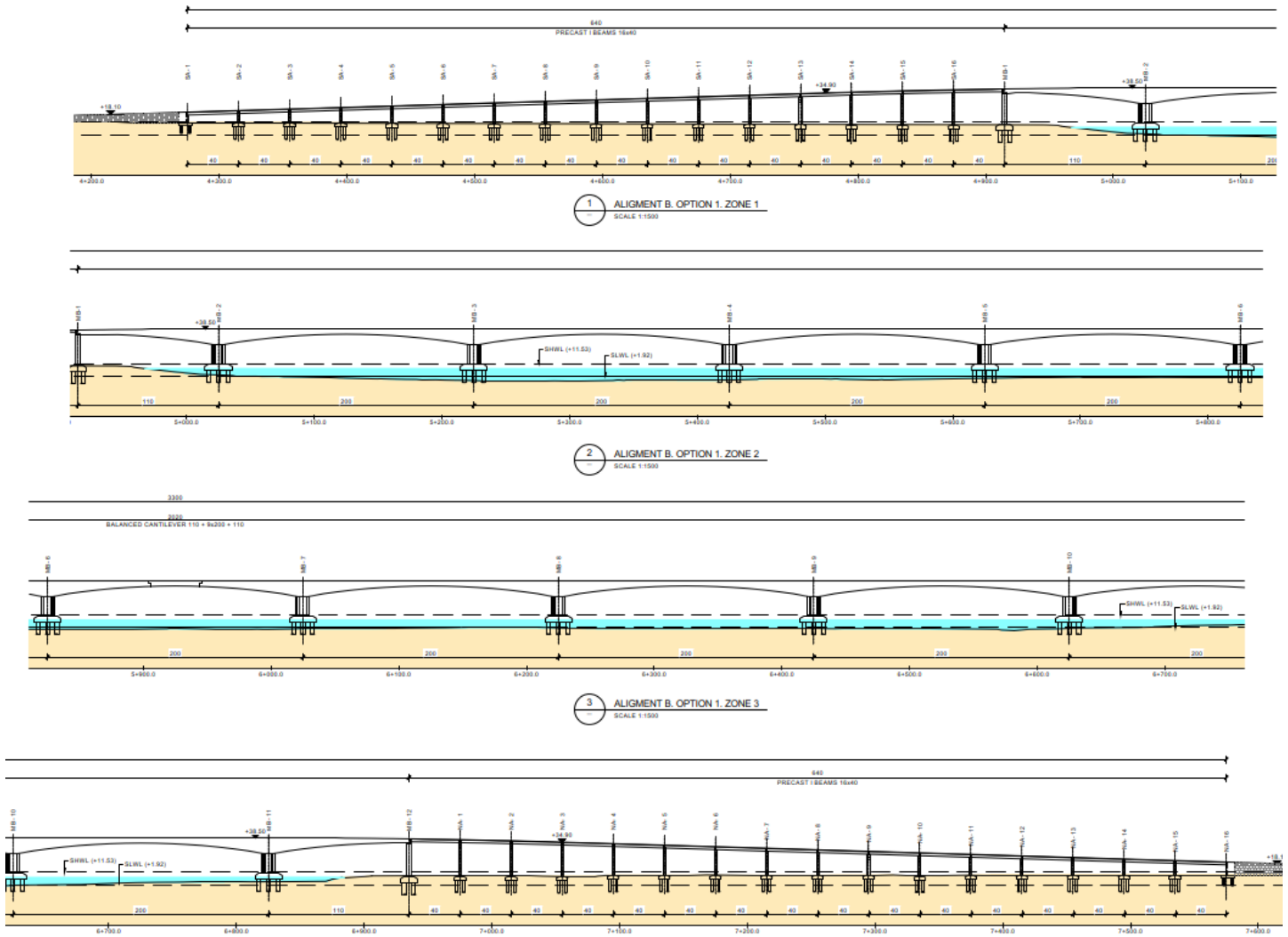


Figure 29. Elevation of the whole bridge.

4.6. Approach Roads

The bridge crossing the River Padma at Rajbari-Pabna would provide the missing link in the RHD road network solving the connectivity between the Regional Highway R601 and the Regional Highway R711.Three alignments were examined connecting the R610 and the R710 (A, B and C) as shown in the image below.

The bridge approach roads at the selected option B, comprising a total of 6.90 km of accessing roads to link to the Regional Highway R711 (4.28 km) and to the Regional Highway R601 (2.62 km).

Figure 30. Rajbari-Pabna bridge alignment options.

The four-lane approach road has been designed primarily as per RHD standard supplemented by AASHTO specifications where needed.

The design envisages a four-lane dual carriageway with an unpaved median of 3.5 m. The geometric design of the project has been developed for a speed of 80 km/h. The design of curves is compatible with the adopted design speeds and Geometric Standards as laid by the American Association of States Highway and Transportation Officials (AASHTO) 2018 have been incorporated.

The proposed alignments would cross over an existing railway track at the chainage Ch 2+715, Ch 2+500 and Ch 2+200 for the option A, B and C respectively. The crossing was solved through a 200 m long elevated structure with two separate platforms and 8.5 m of vertical clearance over the rail line.

The approach roads to the bridge would connect with the regional Road R601 at the North and R711 at the South. The initial proposal of a roundabout to connect the proposed bridge with the existing road network was evaluated and it was concluded that they would reach capacity in the short term. For this reason, the trumpet junctions were included to solve the intersections with the existing roads

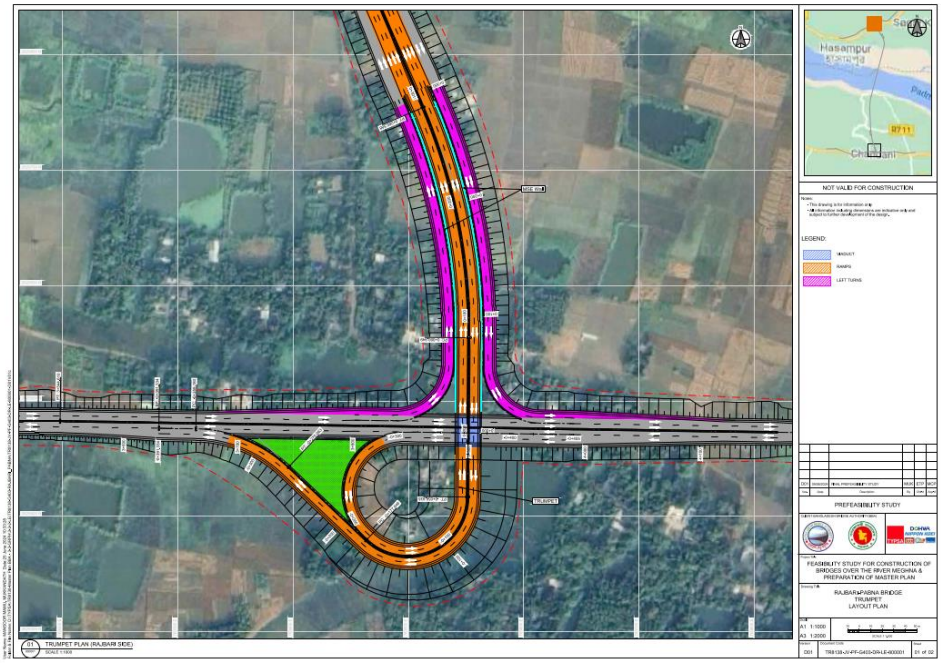


Figure 31. Trumpet intersection with R710.

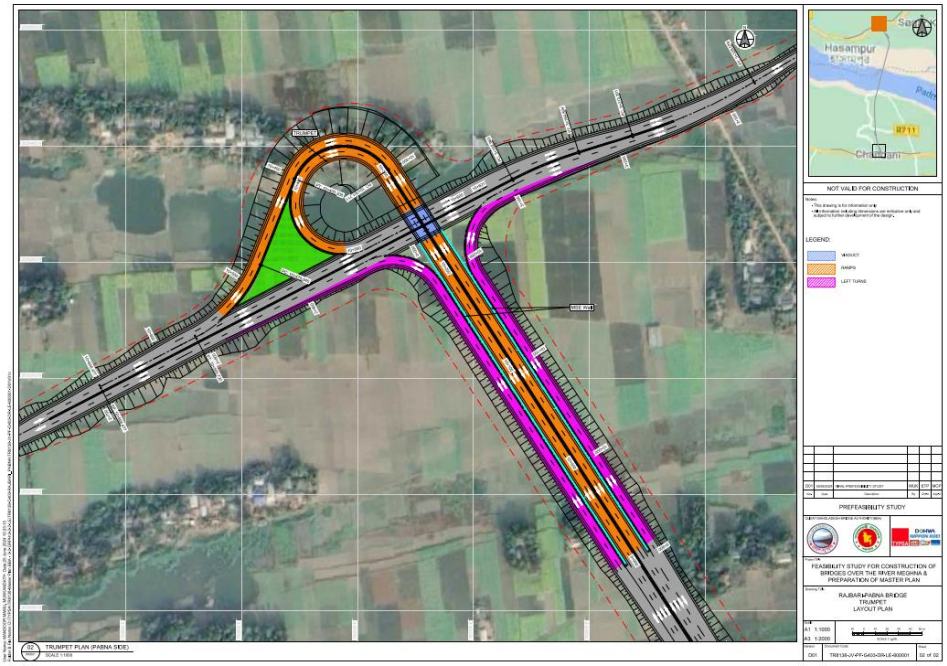


Figure 32. Trumpet intersection with R601.

Table 18. Roads design criteria.

DESIGN STANDARDS			
Design Elements	Unit	Design Parameters	Source
Road Standard		Type 2	Figure 4.1, RHD Standard, Page 12
Design Speed	Km/h	80	RHD, Table 2.2, Page-5
Stopping Sight Distance (SSD)	m	120	RHD, Table 2.3, Page-5
Intermediate Sight Distance (ISD)	m	250	RHD, Table 2.3, Page-6
Cross-Sectional Elements			
Carriageway Width	m	7.30	In each direction
Lane Width	m	3.65	RHD, Table 2.1, Page-4
Service Road/NMT	m	3.0-6.0	RHD, Table 4.1, Page-20
Outer Shoulder Width	m	1.5	RHD, Table 2.1, Page-4
Minimum Inner Shoulder Width	m	0.5	RHD, Table 4.13, Page-72
Central Median	m	1.2	AASHTO
Minimum Median Width with Barrier	m	3.5	RHD, Table 4.12, Page-70
Normal Cross fall	%	3	RHD, Table 4.7, Page-17
Cross fall of Shoulder soft	%	5	RHD, Table 4.7, Page-17
Embankment Slope (Absolute Min)	H:V	2:1	RHD, Table 4.9, Page-18
Horizontal Alignment			
Minimum Radius	m	500	RHD Table 5.1, Page-75
Maximum Super Elevation	%	3 to 5	RHD, Table 5.2, Page-76
Min. Transition Length	m	25 to 65	RHD, Table 5.3, Page-75
Vertical Alignment			
Maximum Grade	%	3 to 6	3 % as per Asian Highway Standard, 6 % maximum on the approach to structures
Minimum K Value			
Crest Vertical curve		35	RHD, Table 6.1, Page-82
Sag Vertical curve		26	AASHTO

4.7. Cost estimate

Table 19. Summary of preliminary estimated cost.

No.	Item	Alignment Option A	Alignment Option B SELECTED	Alignment Option C
		(Cr BDT)	(Cr BDT)	(Cr BDT)
1	General and Site Facilities	185.33	190.74	205.84
2	Main Span (Balance Cantilever)	3,105.37	3,105.37	3,395.49
3	Accessing Spans	802.60	558.33	558.33
4	Approach Road including small structures	1,252.73	1,285.97	1,604.68
5	Toll Plaza and Engineering Facilities	365.52	392.98	392.98
6	Bank Protection Work	3,828.99	2,052.48	3,007.88
(A)	**Subtotal**	**9,540.55**	**7,585.88**	**9,165.20**
(B)	Provisional Sum for Physical Contingency = 3 % of (A)	286.22	227.58	274.96
(C)	**Sub Total (A+B)**	**9,826.76**	**7,813.45**	**9,440.16**
(D)	Provisional Sum for Price Contingency = 6 % of (C)	589.61	468.81	566.41
(E)	Engineer's Estimate = (C+D)	10,416.37	8,282.26	10,006.57
(F)	**Land Acquisition and Resettlement Costs**	**82.92**	**121.33**	**159.25**
(G)	Design Cost = 2 % of (A)	190.81	151.72	183.30
(H)	Construction Supervision = 5 % of (A)	477.03	379.29	458.26
(I)	**Project Estimate = (E+F+G+H)**	**11,167.12**	**8,934.60**	**10,807.38**

4.8. Implementation Timeline

The estimated implementation timeline, in accordance with conversations held with BBA officials has been proposed as follows:

PRE-INVESTMENT PERIOD

- After the approval of the Pre-FS, in September 2024, a Feasibility Study process has been assumed to last from the last quarter of 2024 to September 2025, this is **12 months.**
- Y0 from October 2025 to December 2026 - DPP implementation - Procurement process for Detailed Design and RAP+LAP implementation / **15 months.**

TOTAL ROJECT INVESTMENT PERIOD BEFORE OPERATION: 6Y

- Project Detailed Design Phase, including RAP and LAP implementation phase and Main Contractor Tender Process / **18 months** - from July 2026 to December 2027.
- Construction period including Testing and commissioning / **54 months** - from July 2027 to December 2031.
- Defects Notification Period (DNP 1 year) January 2032 to December 2032

Total PROJECT OPERATION PERIOD: 30Y = January 2032 to December 2061

TOTAL PROJECT PERIOD: 30 + 6 = 36Y

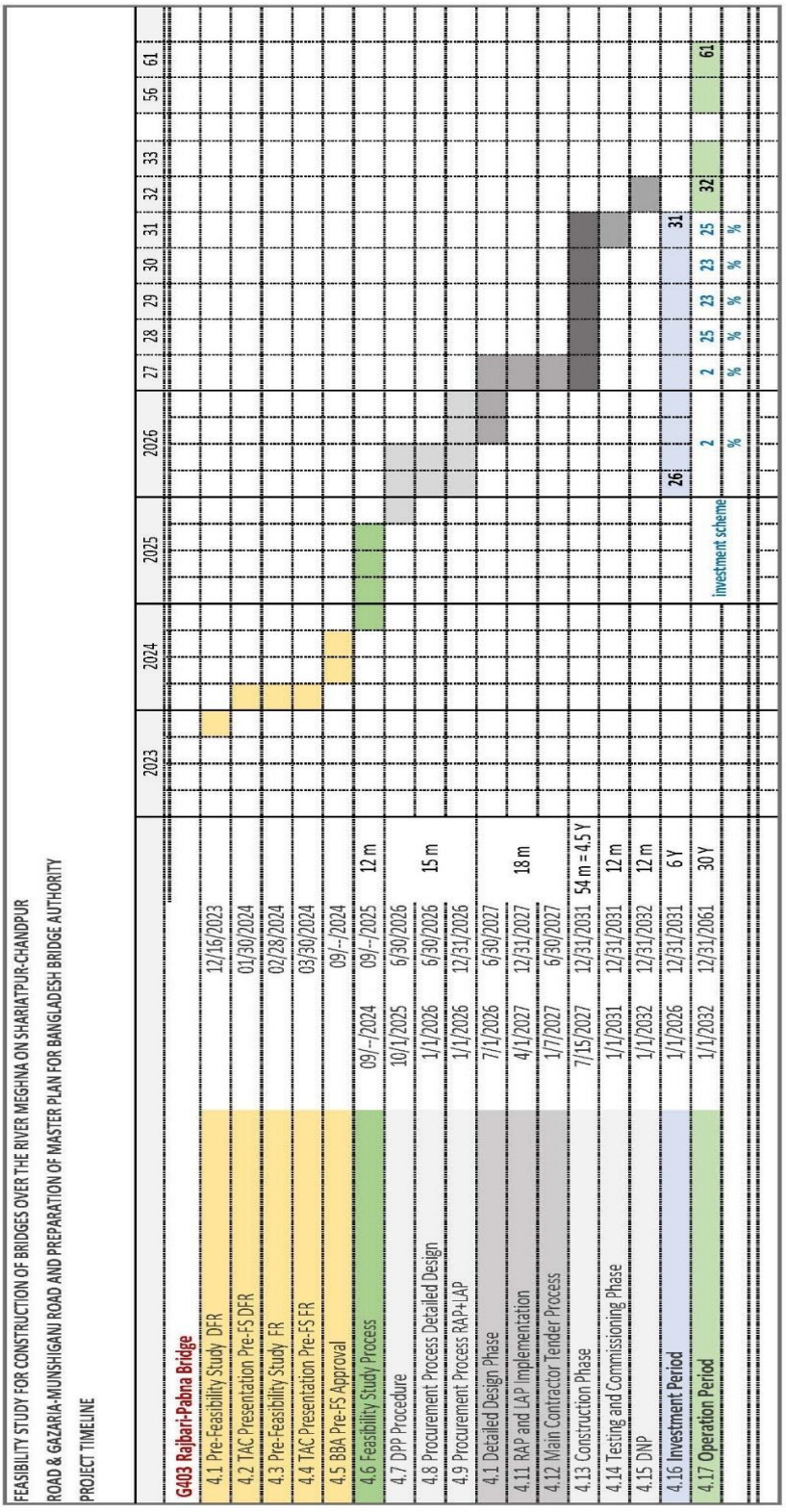


Figure 33. Project implementation proposed timeline.

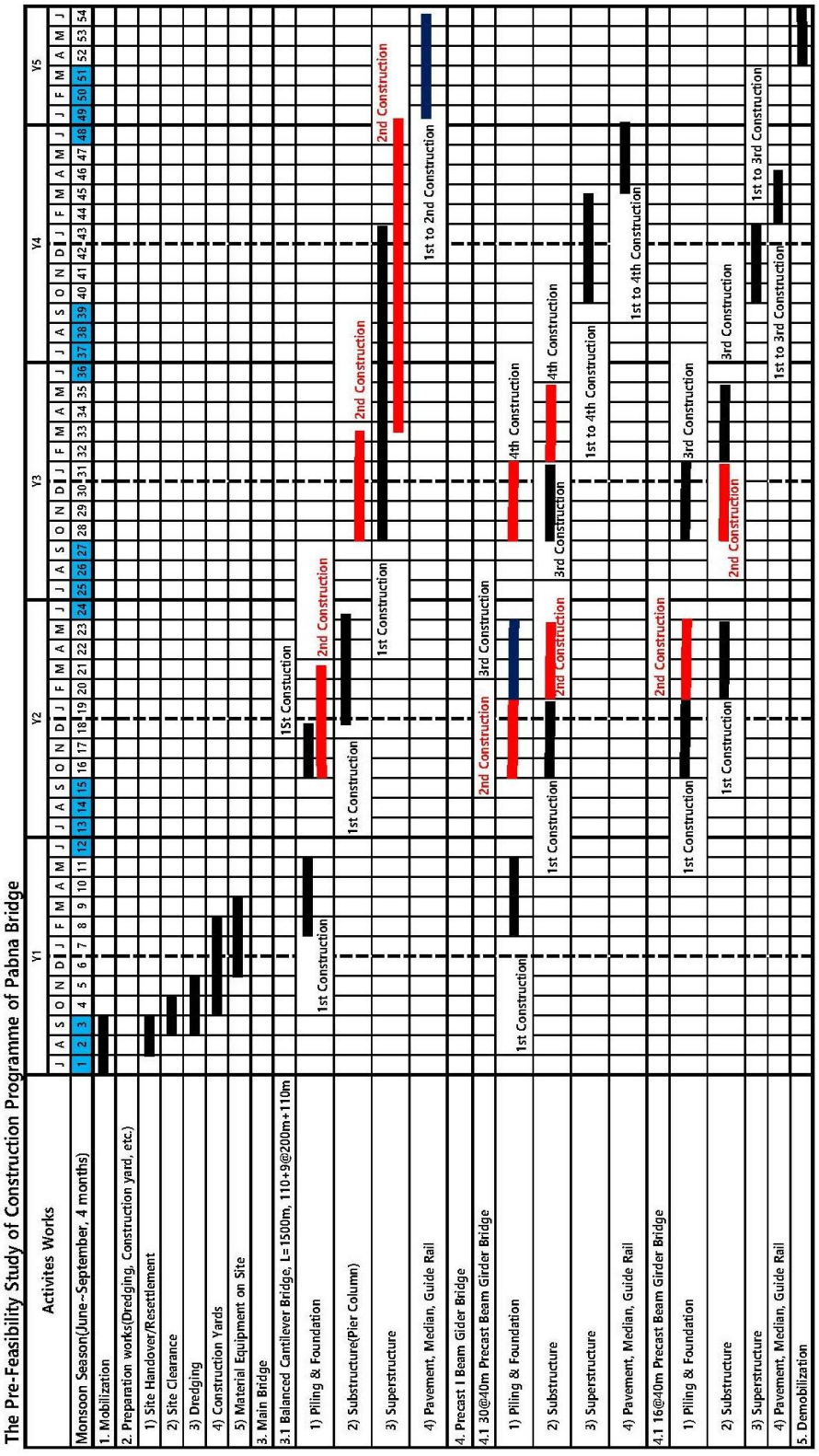


Figure 34. Project construction work programme.

5. ENVIRONMENTAL SUSTAINABILITY, CLIMATE RESILIENCE AND DISASTER RISK ANALYSIS

5.1. Environmental, Climate Change and Disaster Risk Analysis

The Rajbari-Pabna Bridge project is assessed to pose some environmental risks. Some of these are only anticipated in the construction phase while the others are anticipated mainly in the operation phase. However, these risks can be mitigated by implementing some counter measures. Anticipated environmental impacts include during construction stages are - loss of trees, impact on fauna and impact on aquatic ecosystem, water pollution, soil pollution, noise pollution, air pollution, vibration, drainage congestion, soil erosion and deterioration of public health. To reduce these impacts, the necessary mitigation measures would be tree plantation, avoiding dumping of wastes, cement, bentonite and other chemicals in water and soil, use of noise barriers and roadside greenbelt, provision of ample drainage, culverts and river protection. To protect public health including workers, necessary steps would be to provide safe water, good food and sanitation facilities for workers in construction camps. Using simulation models, it has been found during operation of the bridge beyond 20 m air and Noise quality will not exceed the National standards of Government of Bangladesh for residential areas.

It should be mentioned that as per Environment Conservation Rules (ECR), 2023 of DoE, GoB, construction / reconstruction / extension of bridges with length of 500 m or more is included (under item 39) in the list of Red Category of projects. As per Environment Conservation Rules (ECR), 2023 of DoE, GoB, the proposed bridge (3.860 Km) is in the red category and requires environmental Clearance from DoE.

The project is not within notified Hilsa sanctuary but it has been included in EMP that Department of Fisheries Protection and Conservation of Fish Act, 1950 (E.B Act No. XVIII of 1950) Protection and Conservation of Fish Rules 1985, amended in 2014, Rule 13, will be followed during construction and other measures suggested in EMP for protection of the aquatic system, hence impact aquatic animals will be of low in nature.

Environmental & Social Risk Assessments have been undertaken through a series of consultations and review sessions. The principal in AS/NZS ISO 31000:2009, as well as the proponent's internal risk assessment documentation, guided the risk assessment.1

[1] AS/NZS ISO 31000:2009. This Joint Australian/New Zealand Standard was prepared by Joint Technical. Committee OB-007, Risk Management. ISO 31000:2009 **provides principles and generic guidelines on risk management**. ISO 31000:2009 can be used by any public, private or community enterprise, association, group or individual. Therefore, ISO 31000:2009 is not specific to any industry or sector

5.2. The Induced Environmental Impacts at Regional Level

The Induced Environmental Impacts at Regional Level due to the project has been presented in the following table:

Table 20. Induced social impact.

Impact/ Consequences	Degree of Impact/Consequences	Period/Interval	Risk Hedge
Land acquisition and resettlement	Medium negative impact	Long term impact	Partly mitigable
Air and Noise Pollution	Low negative Impact	Short term impact	Fully mitigable
Waste Generation	Low negative impact	short term impact	Fully mitigable
Health Impacts	Low negative impact	Short term impact	Fully mitigable
Business Development	High positive impact	Long term impact	Enhancement
Industrialization	High positive impact	Long term impact	Enhancement
Tourism	High positive impact	Long term impact	Enhancement
Employment opportunities	High positive impact	Long term impact	Enhancement

It is expected that the connectivity of the region with the other part of country will provide increased accessibility to markets, land ports, and growth centres. This will lead to development of business (including agriculture and fisheries), industry, communication, tourism, and urbanization. The induced development has both negative and positive impacts. The positive impacts are increased in the socio-economic conditions of the region through employment generation and poverty reduction. There are also negative impacts like air and noise pollution due to construction activities, increase in traffic levels and industrial development, generation of wastes due to increased living standards, consequent health impacts due to pollution and waste generation, loss of biodiversity, and land acquisition and resettlement which are moderate to low in nature and can be mitigated through EMP implementation.

5.3. Assessment of Disaster Resilient of the Project

Bangladesh is one of the country's most vulnerable to climate change, as well as one of the most disaster prone. Bangladesh's flat topography, low-lying and climatic features, combined with its population density and socio-economic environment, make it highly susceptible to many natural hazards, including floods, droughts, cyclones, and earthquakes. To combat such a situation a contingency plan has been prepared.

Contingency plan

Contingency plan involves anticipating a specific hazard based on specific events or known risks at local, national, regional or even global levels (e.g., earthquakes, floods or disease outbreaks), and establishing operational procedures for response, based on expected resource requirements and capacity. It also means rehearsing our procedures and working out where the gaps are, so that we can be ready when we are needed most. Plans need to be regularly updated and tested through

simulations. Steps considered for the disaster management cycle are – Prevention, Preparedness, Response and Recovery

Disaster Management Plan for the project

The disaster management plan of the project will include the preventive measures which will include the following -

- Formulation and strict implementation of safety codes and measures.
- Periodic inspection of safety measures recommended and equipment.
- Preventive Maintenance.
- Aware the workers about electric shock, equipment related accidents and activity related accidents.
- Declaring the project area, a "no smoking zone".
- Mock drill on Emergency plan.
- Mock drills by the firefighting cells/ groups.
- Provision and inspection of firefighting equipment and fire hydrant system in all the sections.
- Proper training of the employees in the importance of codes.
- Training the employees and the residents of the surrounding villages about the actions to be taken during an accident, disaster etc.

It has been recommended to develop the entire facility environment policy and display necessary documentation for ease of accessing information. Some of these documents include Emergency contacts and Emergency response procedures for fires and any other accident. The facilities operations and monitoring will be carried out under the management and help from both the employees and relevant government leading agencies.

5.4. Emergency Response for Typical Emergencies Identified

For this project an emergency response procedure that needs to be implemented during typical emergency situations has been included in the emergency response plan. Steps considered in preparation of Emergency Response plan are-

Step-1: Determine the potential hazards associated with the incident, substance or circumstances and take appropriate action identify the type and qualities of dangerous goods involved and any known associated hazards.

Determine potential hazards stemming from local conditions such as inclement weather, water bodies etc. and ensure that the initial response team is aware of these conditions.

Step-2: Determine the source/cause of the event resulting to the emergency and prevent further losses.

Step-3: Assess the incident site for any further information on hazards or remedies.

Step-4: Initiate redress procedures.

Step-5: Report the incidence its nature cause impact applied redress procedures and any further assistance required etc. to the appropriate company, government and/or landowner.

Step-6: Take appropriate steps with respect to hazards to wildlife, other resources and addressing public and media concerns and issues, as applicable. Response priorities are to protect human lives, property and the environment.

5.5. Public communication during Emergency

The following safety precautions will be taken with respect to the emergency which demand protection to public:

- Immediately block the public road and allow the emergency vehicle only.
- Continuously announce by mike in the nearest community for evacuation if necessary due to the severity of the emergency
- Call external govt. authority (Fire service & Civil defense, Union perished, Police etc.) to take control of the community according to govt. protocol.

5.6. Environmental Studies Conclusion

Environmental issues pertaining to the project should be incorporated properly in the design and assessed to incur benefits from the project by enhancing the environmental positive impacts and offsetting the negative impacts.

At this pre-feasibility stage, it has been proposed a balanced cantilever bridge, over the river, to minimize the impact on the aquatic ecosystem. Proper navigational clearance has been adopted for movement of ships and to avoid water transport hazards. Piles with improved soil stabilization chemicals adopted in the design will generate minimum noise and vibrations which will create minimum disturbance to the aquatic animals.

This preliminary Initial Environment Examination / assessment for the proposed project has been carried out through the following methodologies: screening of the significant environmental impacts, assessing them, enhancing the positive impacts and recommending the mitigation measures for the negative impacts. These have been done based on available secondary data, field data and discussion with the PAPs. Based on the impact assessment, it is observed that the project has positive impacts mainly on road transportation, commercial facilities, industrial activities, job opportunities, landscape and biological diversity. Some negative impacts mainly on noise, erosion and siltation, housing and commercial structures loss as well as community split has been anticipated. EMP has been proposed to minimize the negative impacts and achieve sustainable bridge project.

No highly significant negative environmental impacts are expected during the construction period of 54 months except the normal construction hazards. However, during construction close monitoring is required over the following issues: interruption of traffic, contamination of surface and ground water, disruption of drainage, pollution of air, noise and soil, disturbance of wildlife mainly birds, reptiles, aquatic life, health and sanitation hazards and social disruption including split of communities.

It should be remark that the impacts associated with the change in landscape after the construction of the project can be negative unless proper landscape plan is formulated by the government and adhered to.

It is estimated that around 220.12 acres of land will require acquisition for the project. Apart from the primary structures a significant quantity of secondary structures will also be affected. A total of 25 waterbodies/ponds will be affected by the approach roads. All these impacts are compensated as per ARIPA, 2017.

A total of 16,300 nos. of trees including new plantation as saplings are going to be affected due to the project. This loss can be mitigated by plantation of 48,900 tree seedlings and 110,400 vetiver roots on embankment slopes and other vacant lands which will enhance the environmental condition of the area.

It should be mentioned that as per Environment Conservation Rules, 2023 of Department of Environment, Government of Bangladesh, construction / reconstruction / extension of bridges with length of 500 m or more is included in the list of Red Category of projects. The proposed bridge falls within red category as per DoE, GoB and require environmental clearance from DoE, GoB.

The impacts during construction can easily be mitigated by taking advance adequate precautions and some additional measures appropriate to the construction. A detailed EMP shall be formulated in the next stages to control/ mitigate the negative impacts arising from construction related activities which shall be followed by the contractors.

A comprehensive Environmental Management Plan (EMP) has been developed to reduce and mitigate the impacts of the project. Estimated EMP cost of the project has been estimated as 3.92 Cr BDT. To have a sustainable bridge project all the mitigation measures suggested in the EMP to be drafted at the next stages shall be followed. In this preliminary IEE, mitigation measures have been detailed as a reference for the later phases. Close monitoring is required at every stage and steps of the project for implementation of the EMP of the project.

The impacts after construction of the project, unless regulatory measures are taken in time, will be uncontrolled settlement, environmental pollution from industries and innumerable places of possible access to the road leading to traffic congestion and hazard. It will, therefore, be desirable to institutionalize some form of effective control on the growth of settlements on the ROW land. One of the measures could be to have an exclusion zone up to a certain distance, say 100 m on each side of the road where no structure would be allowed to be erected and no access from any individual property will be allowed directly on the land considering future expansion of roads.

It can, therefore, arguably be concluded that the proposed Rajbari-Pabna Bridge Project would be environmentally sound and sustainable. Short term negative impacts identified during project preparation could be managed by the positive impacts through the recommended mitigation measures. The positive impacts will offset the negative impacts.

Finally, it should be mentioned that the project needs further environmental assessment as Environmental Impact Assessment (EIA) according to ECR 2023. A detailed ToR for EIA should be provided at that next stage of the design.

6. SOCIAL SAFEGUARD ASSESSMENT

6.1. Project Area and Socio-Economic Profile

A Social Impact Assessment (SIA) was carried out for the proposed Pabna-Rajbari Bridge, considering three options: Option A, Option B, and Option C, each with a different alignment and affection to the community.

In summary, the project would have an impact on 2,909,622 population in Pabna and 1,189,821 in Rajbari. The average household size in Rajbari District is reported to be 4.03, while in Pabna District, it is slightly lower at 3.91.

In Option A, a total of 696 individuals would be affected, constituting 356 males and 340 females. Option B impact would affect 1,216 individuals, with 601 males and 615 females. The most substantial impact is observed in Option C, where 2,432 individuals, including 1,210 males and 1,222 females, would be affected. The education level in Pabna is about 70.38 %, and Rajbari is 69.37%. Involving different business and professions. It was estimated the land in acres, to be acquired to be:

188.95 for Option A, 220.12 for Option B and 234.79 for Option C.

6.2. Objectives of the Social Impact Assessment

The primary goal of the **Social Impact Assessment (SIA)** is to evaluate the potential social consequences and implications of a proposed alternatives systematically and comprehensively. The overarching aim is to inform decision-makers, stakeholders, and the public about the anticipated impacts on communities, cultures, and individuals, facilitating the development of strategies to enhance positive outcomes and mitigate adverse effects. The specific objectives are:

- Evaluate and analyse the social impact of the Rajbari-Pabna Bridge construction project.
- Examine the potential effects of three alternative alignments on local communities.
- Assess the impact on socio-economic structures in the project area.
- Evaluate the potential impact on cultural heritage and local traditions.
- Analyse the overall well-being of the communities in the vicinity of the proposed bridge.
- Provide insights and recommendations to minimize adverse social impacts.
- Offer guidance for maximizing positive outcomes during the planning, construction, and operation phases of the bridge project.

6.3. Social Safeguard Assessment Cost

Table 21. Budget land acquisition for Option B.

Compensation for land					
District	Type of land	Area (decimal)	Average Mouza Rate (BDT/decimal)	200% Premium (BDT/decimal)	Cost Estimate (BDT)
Rajbari	River	885.50		-	-
	vita	1,000.00	6,457	19,371	19,371,375
	Home	1,950.00	6,641	19,922	38,847,656
	Nul	6,712.50	5,941	17,822	119,631,853
	Pond	300.00	2,036	6,107	1,832,063
	Bil	-	2,088	6,263	-
	Khal	25.00	2,088	6,263	156,563
	Subtotal	**10,873.00**			**179,839,509**
Pabna	River	-		-	-
	vita	600.00	5,070	15,209	9,125,400
	Home	750.00	40,705	122,115	91,586,250
	Nul	6,346.65	22,684	68,052	431,902,226
	Pond	-		-	-
	Bil	-		-	-
	Khal	30.00	8,967	26,900	806,985
	Subtotal	**7,726.65**			**533,420,861**
Total		18,599.65			713,260,370

Table 22. Budget structures for Option B.

Compensation for structures				
Category	Unit	Quantity	Rate (BDT/Sft.)	Cost Estimate (BDT)
Rajbari				
Pucca	Sft.	5,770	2,548	14,701,960
Semi-Pucca	Sft.	10,156	915	9,292,740
Tin-Made	Sft.	49,088	332	16,297,216
Thatched	Sft.	1,786	129	230,394
Subtotal		**66,800**		**40,522,310**
Pabna				
Pucca	Sft.	8,484	2,548	21,617,232

Compensation for structures				
Category	Unit	Quantity	Rate (BDT/Sft.)	Cost Estimate (BDT)
Semi-Pucca	Sft.	2,831	915	2,590,365
Tin-Made	Sft.	14,076	332	4,673,232
Thatched	Sft.	1,173	129	151,317
Subtotal		**26,564**		**29,032,146**
Total Estimate for structures		93,364		69,554,456

Table 23. Budget Trees for Option B.

Compensation for trees				
Category	Unit	Quantity (uts)	Rate (BDT/ut)	Cost Estimate (BDT)
Rajbari				
Large	No.	721	8,300	5,984,300
Medium	No.	2,865	4,500	12,892,500
Small	No.	2,749	1,800	4,948,200
Sapling	No.	2,169	60	130,140
Banana	No.	1,801	100	180,100
Papaya	No.	214	50	10,700
Bamboo	No.	2,734	100	273,400
Subtotal		**13,253**		**24,419,340**
Pabna				
Large	No.	101	8,300	838,300
Medium	No.	515	4,500	2,317,500
Small	No.	887	1,800	1,596,600
Sapling	No.	525	60	31,500
Banana	No.	357	100	35,700
Papaya	No.	102	50	5,100
Bamboo	No.	877	100	87,700
Subtotal		**3,364**		**4,912,400**
Total Estimate for tress				29,331,740

Table 24. Compensation for businesses and utilities for option B.

Compensation for businesses and utilities				
Category	Unit	Quantity	Rate (BDT/ut)	Cost Estimate (BDT)
Benefits for Rajbari				
Cash compensation equivalent to 3 month- net income @BDT15000/ Month for small and medium scale business	No.	2	15,000	**30,000**
Utility (electric poles Replace labour Cost)	No.	92	10,000	**920,000**
Subtotal				**950,000**
Benefits				
Cash compensation equivalent to 3 month- net income @BDT15000/ Month for small and medium scale business	No.	3	15,000	**45,000**
Utility (electric poles Replace labour Cost)	No.	50	10,000	**500,000**
Subtotal				**545,000**
Total Compensation				**14,95,000**
Total Estimate for businesses and utilities			813,641,566	

Table 25. Overall land acquisition and resettlement budget.

Breakdown of cost estimate (BDT)	Alignment A	Alignment B	Alignment C
Total Land Budget	343,087,180	713,260,370	838,391,863
Total Structure Budget	107,782,470	69,554,456	228,813,015
Total Tree Budget	14,448,930	29,331,740	44,350,130
Business Loss and Utility	845,000	1,495,000	5,190,000
Sub-total	**466,163,580**	**813,641,566**	**1,116,745,008**
Land for construction yard (Requisition)	675,000	675,000	675,000
Land Cost for River Training	66,258,720	35,739,552	50,607,105
Land for Toll Plaza	35,157,278	35,157,278	35,157,278
Land for Engineering Facility	25,098,000	25,098,000	25,098,000
Land for Weigh Station	25,098,000	25,098,000	25,098,000
Land Cost for Resettlement	50,196,000	50,196,000	50,196,000
Provision for construction of Resettlement area	10,000,000	10,000,000	10,000,000
Other Resettlement Benefits	56,271,698	98,337,540	134,717,105
Operation cost for RAP Implementing Agency /INGO	30,000,000	30,000,000	30,000,000

Breakdown of cost estimate (BDT)	Alignment A	Alignment B	Alignment C
Operation cost of External Monitoring Agency	10,000,000	10,000,000	10,000,000
Sub-total	308,754,696	320,301,370.54	371,548,488.50
Total	774,918,276	1,133,942,936.72	1,488,293,496.50
Administrative and Contengency cost @% 7%	54,244,279.35	79,376,006	104,180,545
Grand Total (BDT)	829,162,556	1,213,318,942	1,592,474,041

7. ECONOMIC AND FINANCIAL ANALYSIS

7.1. Socio-Economic Analysis

7.1.1. Introduction

In this section, the Consultant presents **the economic evaluation of the Rajbari-Pabna bridge project, at the pre-selected alignment option (B).** Economic analysis is a **method used to calculate the profitability of a project from a social point of view, by quantifying the costs and benefits of an investment project in monetary terms to allocate society resources in an efficient way**[2].

7.1.2. Methodology

7.1.2.1. Incremental Scenarios Appraisal

Prior to any step in the process, it needs to be identified which are the **incremental scenarios to be considered:** estimating the effects when carrying out the project with respect to a reference scenario ("without project" scenario):

- ***"Without project" scenario***: no bridge project is implemented in the area. Instead, existing traffic structures and travel times to be projected will follow current conditions. In other words, existing transport operating features will be maintained.
- ***"With project" scenario***: the bridge program is implemented. Traffic projections considered will prevail and new infrastructure section (bridge) will add transport capacity to the system.

7.1.2.2. Key Economic Impacts

Evaluating economic impacts, requires measuring the change in total social surplus created by the project, which is the sum of the changes in producer surplus, consumer surplus and external effects. The following illustration framework of the calculation process shows the **generic economic impacts**:

Overall Economic Impact	=	**Change in transport user benefits (Consumer Surplus)**	+	**Change in system operating costs and revenues (Producer Surplus and Government impacts)**	+	**Change in costs of externalities (Environmental costs, accidents, etc.)**	-	**Investment costs (including mitigation measures)**

Figure 35. Economic analysis by categories of impacts.

[2] Economic appraisal differs from financial analysis since many of the social/ economic impacts are public goods (health, security, time) or goods without a clear market, and some technical corrections need to be made conversion factors, shadow prices, etc.

7.1.3. Project Capital Expenses

Required project capital expenses are composed of the main components of the crossing and its access roads at both sides. The table below summarizes the capital expenses. These costs are indicated without VAT and based (capitalized accordingly) on year 2026:

Table 26. Basic elements that compose the total project Capex (2026 monetary units).

Number	Item	Cr BDT
1	General and Site Facilities	193.39
2	Main Bridge (Balance Cantilever)	3,148.47
3	Approach Bridges	566.08
4	Approach Road including small structures	1,303.82
5	Toll Plaza & Engineering Facilities	398.44
6	Bank Protection Work	2,080.96
7	Provisional Sum for Physical Contingency	230.73
8	Provisional Sum for Price Contingency	475.31
9	Land Acquisition and Resettlement Costs	132.24
10	Design Cost	143.79
11	Construction Supervision)	359.48
	TOTAL	9,032.72

For purposes of economic modelling, the consultant has assumed a specific time frame for the deployment of capital expenses, which is presented below.

Table 27. Capital expenses deployment with project.

	2026	2027	2028	2029	2030	2031
Split by year of the CAPEX	2 %	2 %	25 %	23 %	23 %	25 %

7.1.4. Other Assumptions

7.1.4.1. Period of analysis

Base year for study projections has been set in 2026 (1st January) and the horizon year in 2061 (31st December)

- Total Investments period: 6 years (2026 – 2031).
- Total operations period: 30 years (2032 – 2061).

7.1.4.2. Value of Time (VoT)

Value of time is one of the most determining inputs that are related to the project CBA appraisal. Since the bridge project would offer significant time savings, the value of time provides an important part of the potential benefits assessment of the project from the user point of view.

Table 28. Values for VoT.

Mode	VoT BDT/pass-h (2022)	VoT BDT/pass-h (2026)
Motorcycles	94.35 BDT/pass-h	107.71 BDT/pass-h
Light vehicles	105.45 BDT/pass-h	120.39 BDT/pass-h
Buses	83.25 BDT/pass-h	95.04 BDT/pass-h
Trucks	3.89 BDT/ton-h	4.44 BDT/ton-h

7.1.4.3. Vehicle Operating Costs

Vehicle Operating costs (VOC's) adopted were obtained on a case- by- case modal basis. It has been adopted a conservative approach when selecting VOC values. The figures adopted are:

Table 29. Vehicle operating costs by mode.

Mode	BDT / veh – km (2022)	BDT / veh – km (2026)
Motorcycles	11.10	13.7
Light vehicles	15.54	19.18
Buses	33.30	41.11
Trucks	44.40	54.81

7.1.4.4. Externalities

Costing estimation for externalities was undertaken using data extracted from "*Update of the Handbook on External Costs of Transport" – European Commission – 2019*[3]. This Handbook summarizes the external costs, providing a cost expressed in economic units for each vehicle or passenger per km:

[3] https://ec.europa.eu/transport/themes/sustainable/studies/sustainable_en

Table 30. Unitary average costs for externalities applied.

	Accidents [BDT/pass-km]	Air Pollution [BDT/veh-km]	Climate Change [BDT/veh-km]	Well o tank [BDT/veh-km]
Motorcycles	4.84	0.45	0.36	0.20
Light vehicles	1.70	0.43	0.72	0.24
Buses	0.37	5.47	3.30	1.09
Trucks	0.48	3.58	2.47	0.95

7.1.4.5. Average Annual Time Savings During the Operation of the Bridge

The distance and time savings, due to the construction and operation of the bridge, are key elements used in the cost benefit analysis. An estimation has been done for each vehicle type, identifying the average yearly savings for the 30 years of the operation of the project.

The results are illustrated in the tables below.

Table 31. Average annual time savings during the operation of the bridge.

	Motorcycles (M pass-hour per year of operation)	LPV (M pass-hour per year of operation)	Bus (M pass-hour per year of operation)	Trucks (M Ton-hour per year of operation)
Without project	27.86	13.70	491.42	71.78
With project	17.43	7.80	401.16	39.74
Time Savings	**10.43**	**5.91**	**90.26**	**32.04**

Table 32. Average annual distance savings during the operation of the bridge.

	Motorcycles (M veh-km per year of operation)	LPV (M veh-km per year of operation)	Bus (M veh-km per year of operation)	Trucks (M veh-km per year of operation)	Total (M veh-km per year of operation)
Without project	467.42	91.73	460.81	108.65	**1,128.61**
With project	423.43	80.44	448.70	105.13	**1,057.7**
Distance Savings	**43.99**	**11.29**	**12.11**	**3.52**	**70.91**

7.1.5. Socio-economic Analysis Results

7.1.5.1. Projection of Economic Flows

The projection of economic flows for the considered period has been estimated and rendered in the following graph.

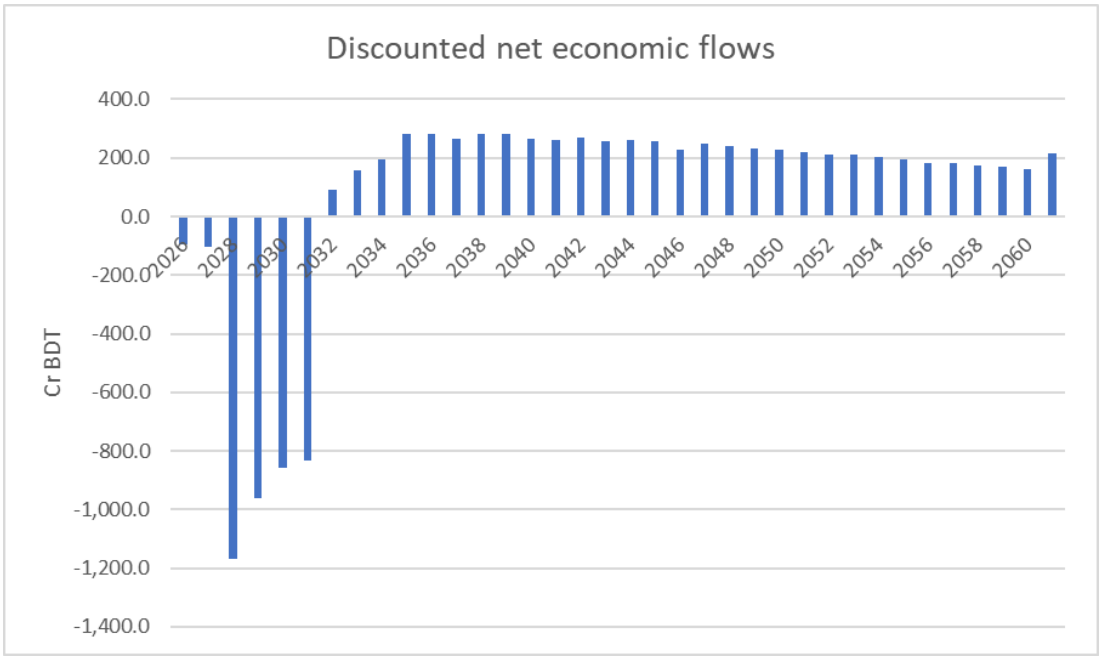


Figure 36. Discounted economic flows (Cr BDT).

The main net costs arise during construction period (2026 - 2031) and after this initial phase and during the first years of operation, flows become positive growing yearly[4]. When cumulative discounted flows are analyzed, it is observed that after some construction outflows, the cumulative flow reaches a minimum peak financing (in 2031) and then with the increase of operation growth, the cumulative flows also increase. The cumulative discounted net economic flows reach zero between 2047 and 2048 and turn into positive values from 2048 onwards.

In terms of distribution of impacts, the following figures show the split of the main positive NPV flows, showing that change in Consumer Surplus for transport users is by very far the element with the highest impact: around 81 % (more precisely, passenger time savings represents 80 % of positive impacts).

[4] *It must be noted that operational economic flows have a* ***certain declining timeframe due to the application of a social rate of discount***

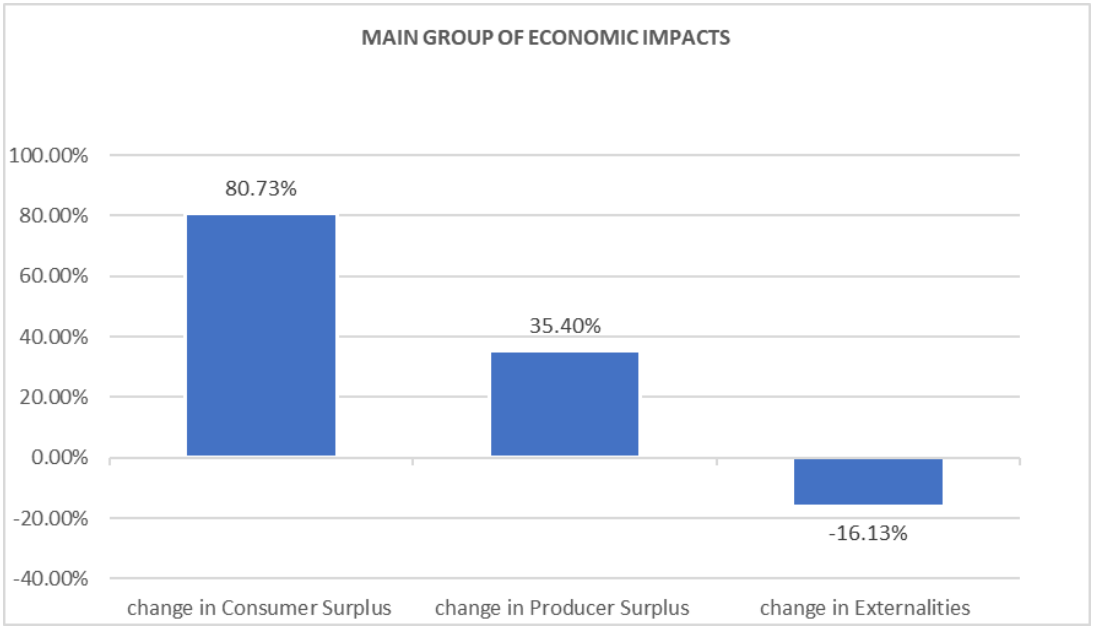


Figure 37. Main group of economic impacts.

7.1.5.2. Socio-Economic Analysis Conclusion

Based on the assumptions taken and the after analyzing the computed results from the CBA model, it can be concluded that the Rajbari-Pabna bridge would be, a feasible project from a socio-economic point of view. The project is essentially intended to save time for road and ferry users since that is the main positive impact derived from project implementation[5].

Table 33. Economic indicators.

Economic Net Present Value (Cr BDT):	2,688.62
Economic Internal Rate of Return (E-IRR):	15.72 %
Benefit / Cost ratio	1.78
Pay back (year)	2048

[5] Although newly generated economic activities (among them traffic) could bring some diseconomies in terms of incremental external effects.

7.2. Financial Analysis

7.2.1. Introduction

In this section, the Consultant presents **the financial evaluation of the Rajbari-Pabna bridge project, at the pre-selected alignment option (B).**

As part of the pre-feasibility study of the Rajbari-Pabna bridge project, a financial analysis was carried out to check whether the Project is capable to generate operating revenues enough to cover the operating expenses and to amortize the initial investments during the period of analysis. This unlevered analysis refers to the operating and investment cash flows of the Project itself: operating revenues, operating expenses, initial investments and overhaul investments. Therefore, it does not include the financial cash flows: capital contributions, financial debt, dividends distribution, etc.

In the event the Project requires non-refundable Capital Grant to make it feasible, even as a payment during the investment phase and/or as periodic payments during the operation phase, the amount of these grants, known as "Viability Gap Financing" ("VGF"), should not be higher than 40 % of total Project costs.

The final objective of the study is to estimate the financial feasibility and profitability of the Project based on the following indicators:

- Financial Net Present Value (FNPV). This is the value resulting from adding the discounted values of the Project inflows or positive cash flows (income) and the Project outflows or negative cash flows (investments and expenses) of the Project. For the discount of the flows, a 12.00 % Financial Discount Rate (FDR) is used.
- Financial Internal Rate of Return (FIRR). This value represents the rate at which the investments made are remunerated by the Project during its term. This rate would be the one that, applied as a discount rate of the cash flows, would result in a net present value equal to zero.

The Project can be implemented and operated through diverse contract structures, such as traditional procurement, where the Project is implemented and operated by the Government (i.e., Public Project), or as Public Private Partnership (i.e., PPP Contract). If VGF needed to make the Project viable is higher than 40 %, the PPP contract is not viable and so, the Project will be implemented as a Traditional procurement or Public Project structure.

7.2.2. Project Cash Flows

The implementation period considers the total investment budget, which amounts 8,934.60 Cr BDT, VAT included, while total budget increased with expected inflation up to early 2026 (first year of implementation) and VAT not included is 9,067.83 Cr BDT. The initial investments during the 6 years of implementation are shown in the following chart.:

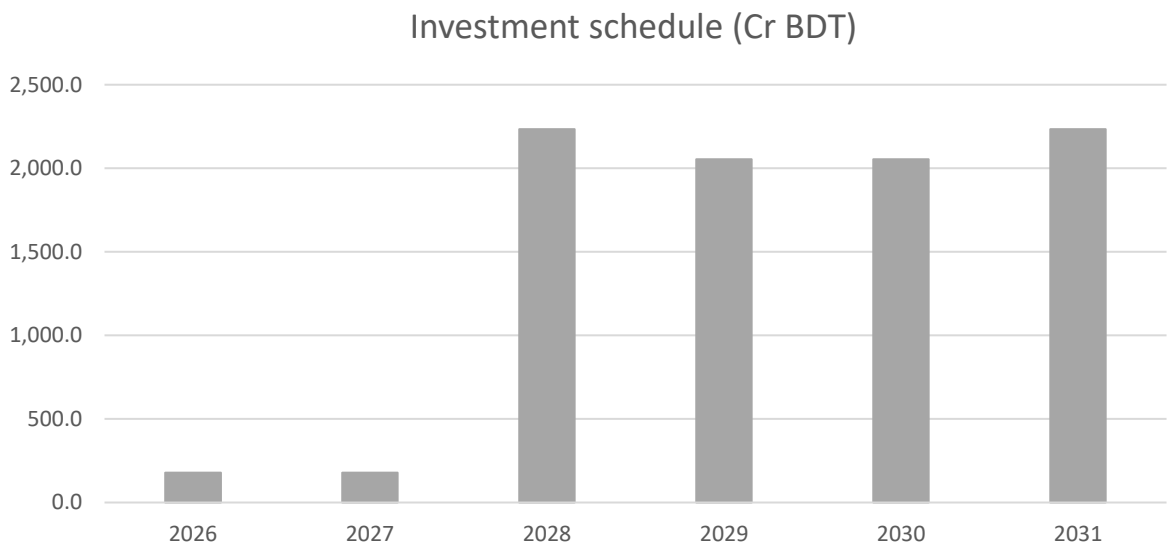


Figure 38. Implementation schedule.

During the 30 years of operation period, the Project would generate operating revenues, mainly from toll fares, and operating expenses, from ordinary and extraordinary maintenance. Toll revenues are expected mainly from buses (over 70 %). Additional commercial revenues will be produced from the lease of the infrastructure to cross service telecommunication lines and other services. As conservative approach, no commercial revenues have been considered in the financial analysis.

Table 34. Maintenance expenses.

Maintenance (Cr BDT. VAT not included)	Investment	Mainten. / year
Main span (Balance Cantilever)	3,148	44.1
Approaching viaducts	566	7.9
Approaching roads	1,304	20.9
Bank protection and river training	2,081	83.2
Toll Plaza	398	10.1
Total		166.20

As a result of the explained above cash inflows and outflows, and regardless of the financing or contract structure, the following table shows the Project cash flows projected during the 36 years of period of analysis valid for both procurement alternatives above explained:

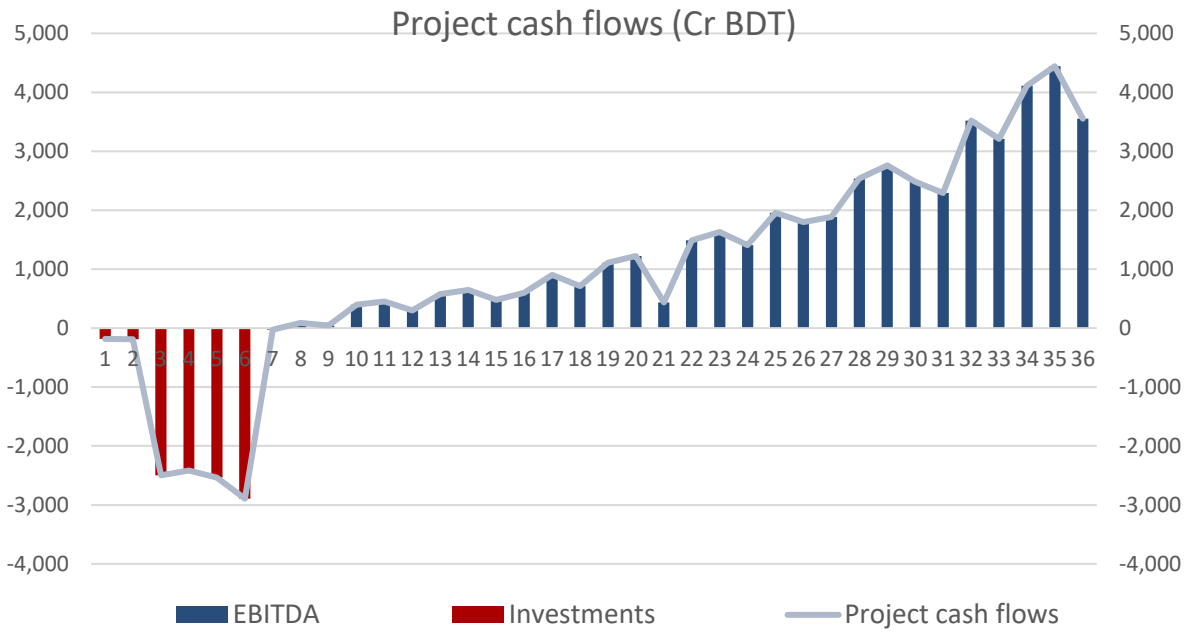


Figure 39. Project cash flows.

Toll revenues generate a growing trend of EBITDA during the operation period due to both the increasing annual traffic and the growing toll fares with inflation. Operating expenses are substantially lower than revenues, except in years 7, 9, due to the starting of operation, and year 21 because of the high extraordinary maintenance costs, although generating positive cash flow.

7.2.3. Financial Analysis Results

The financial indicators of the Project resulting from the projected cash flows are as follows:

Table 35. Financial indicators. PPP contract structure.

FINANCIAL RESULTS	Bf Grants	After Grants
F-IRR Project (unlevered)	5.41 %	12.00 %
NPV (@ 12.0 %). Cr BDT	-4,684.55	0.0
GoB Grants required. Cr BDT		7,616.20
VGF required (% over total Project costs)		34.62 %

As shown in the above table, results for the PPP Contract structure before and after grants have different values because of the capital grants. Both FIRR and FNPV for the project after capital grants are positive and they show that the feasibility of the Project is reached with 7,616.20 Cr BDT of GoB grants with a VGF estimated in 34.62 % (< 40 %), which means that the Project could be implemented with a PPP contract structure involving private investors.

The alternative procurement option (Public Project) would generate the following financial indicators:

Table 36. Financial indicators. Public Project contract structure.

FINANCIAL RESULTS	After Grants
F-IRR Project (unlevered)	6.62 %
NPV (@ 12.0 %). Cr BDT	-4,781.50
Total GoB net contributions (@ 12.0 %). Cr BDT	-881.17

The Project cash flows generate a positive FIRR (unlevered) of 6.62 %, not reaching the FDR of 12.00 %, and so, generating a negative FNPV of -4,781.50 Cr BDT. Total net contributions from the GoB during the whole period of analysis are estimated in 881.17 Cr BDT. As a conclusion, the Project is not feasible from the financial point of view considering the FDR of 12.00 %, although it generates a F-IRR (unlevered) close to 7 %.

7.2.4. Financial Analysis Conclusion

The conclusions arisen from this unleveraged approach of the financial assessment for the Option B are the following ones:

- Operating result (EBITDA) is expected to be positive and growing during the period of analysis, with several years of very low EBITDA (years 7, 9) due to starting of operation, and year 21 due to the high extraordinary maintenance costs.
- The financial analysis with the PPP Contract structure, including the GoB grant, shows positive 12.00 % FIRR of the project. However, the Project, despite the positive EBITDA, requires capital grants (VGF) amounting 7,616.20 Cr BDT, which represents 34.62 % of total project costs, lower than the legal limit of 40 %, which means that the Project could be implemented as a PPP Contract.
- Financial indicators, with the Public Project contract structure, show a Project with a positive FIRR of 6.62 % (unlevered), which is lower the FDR (12.0 %), so generating a negative FNPV of -4,781.50 Cr BDT. Total net contributions from the GoB during the whole period of analysis are estimated in 881.17 Cr BDT.

8. CONCLUSION

The essential purpose of any investment is the socio-economic development and contribution to the growth of the country. In this regard, a pre-feasibility study assesses a preliminary plan at its first stage of the study. After being previously identified as a project of potential interest for the country, the study analyses a proposal for an intended future condition considering social and economic activities, their locations and linkages, and the development of an infrastructure within the existing and prospected conditions.

The bridge project that would connect Rajbari and Pabna districts over Padma River, was shortlisted within the Master Plan potential projects recommended to be implemented by the BBA in the short-term. The Consultant after evaluating the key features of this project, has presented the main conclusions of the pre-feasibility study within this Executive Summary report.

This study aims to be the precursor of its next phase, namely feasibility study, subject to the BBA criteria and strategic approach. Based on this, it has been the purpose of the study, to assess three options and to present within this report, the key outcomes from the technical, environmental social and cost standpoints, for the three of them. The Consultant is presenting the conclusion from the economic and financial analysis for the pre-selected alignment option.

The proposed solution, **a bridge 3.30 km long**, crossing the Padma River at the selected **alignment B**, through the designed **balanced cantilever bridge (110m x1 + 200m x9 + 110m x1)** and **6.90 km of approach roads,** was selected amongst several options, covering three different alignments. The selected option B was assessed as the optimum one considering all the multi-criteria factors and after evaluating possible interfaces with other existing projects (case of options A and C).

Additionally, and as a preliminary approach assessment, the tunnel solution was discarded due to the high complexity and increase in cost (considering both, the investment stage and the operation and maintenance stage expenses).

The Consultant arguably recommends this project, with the proposed bridge solution, to be implemented by the BBA, as it would provide sound social and economic progress and benefits to the population living in the directly related areas. It would also promote and enhance potential connectivity corridors in this part of the country.

The regional connectivity improved by the bridge would function as a key linkage between the south-western and north-western regions of the country. If the proposed bridge is built, a population of near 2.81 Cr, living in 31 districts belonging to Dhaka, Rajshahi, Rangpur and Khulna divisions would benefit from this major transportation improvement. The population belonging to the two directly connected districts, Rajbari and Pabna, that would be benefited from the project is estimated to be 41 lakhs from 14 upazilas.

The project and its implementation should be approached with careful planning, considering various aspects such as environmental impact, infrastructure investment, and social implications. Engaging with local communities and stakeholders during the planning and implementation stages is essential for the success of such a project.

An Initial Environmental Examination (IEE) was carried out accordingly with the current DOE guidelines and recommendations, falling the project under red category. The identified risks would be duly mitigated through the implementation of the proper Environmental Impact Assessment (EIA) and Environmental management Plan (EMP) during the construction phase.

Social safeguard aspects have been assessed through a Social Impact Assessment (SIA), following the current legislation and guidelines. The project impact would require resettlement of part of the affected areas and would be mitigated by the implementation of a Social Impact Assessment Action Plan. Consultation to the community of the affected area was carried out with a positive response.

The completion of this project construction has been estimated in 54 months. It has been assumed that, after 6 years of investment phase (2026 to 2031), the operation phase would start in 2032 and would end in 2061 (30 years).

The investment **cost for the selected option (B)** has been estimated to be **8,934.60 Cr BDT**. Values of project estimated cost for other options, A and C, were assessed as 11,167.12 Cr BDT and 10,807.38 BDT respectively.

Traffic surveys were undertaken covering the area of influence of the project, and a traffic model was implemented by the Consultant, enabling to generate the necessary traffic estimations at various scenarios. As a summarized output, the traffic forecast for the final year of operation (2061) was estimated as **31,009 vehicles** (the use 3 wheelers were precluded from the study).

Economic Cost-Benefit Analysis (CBA), was carried out at the selected option (B), considering two scenarios.[6] The results obtained from the economic model are clearly positive from the socio-economic standpoint: **EIRR 15.72 %, ENPV 2,688.62 Cr BDT, C/B ratio 1.78** and **pay-back year 2048.**

The Financial indicators, in the case of Public Project contract structure, showed a Project with a positive **FIRR of 9.56 %** (levered) and 6.62 % (unlevered). Despite it is positive, this value is lower than the targeted FDR of 12.00 %; the estimated **FNPV** would be **-4,781.50 Cr BDT**.

The Project shows **financial feasibility under a PPP structure** as it would require a grant of 7,616.20 Cr BDT, which represents 34.62 % of total project costs (VGF). not reaching the limit of 40 % set up by law for PPP contract structures and therefore the PPP Contract structure could be implemented according to VGF regulation.

[6] Two scenarios were considered in the socio-economic and financial assessment, "with project" case and "without project" case (ferry-ghat). For both scenarios, the ongoing, future and potential transport infrastructure developments were considered (road improvements (R601 and R710) on north-east & south-east side of Rajbari-Pabna Ferry, Paturia-Goalondo Bridge with road improvements on each side, an improved corridor along Gazaria-Lakshmipur corridor, Matlab Uttar Bridge, Cumilla-Chandpur road improvement, Shariatpur-Chandpur Bridge, Shariatpur-Padma road improvement, R860 road improvement, N809 access road between Gazaria-Munshiganj improvement, and N1 improvement).

Figure 40. Image of balanced cantilever proposed bridge.

Viewed from the implementation standpoint and as a summarizing outcome derived from this pre-feasibility study, considering all technical, social, and environmental standpoints, it may be concluded that the project, located at Rajbari and Pabna districts, consisting of the 3.30 km long bridge, crossing the Padma River at the selected alignment B, through the designed balanced cantilever bridge and a series of other needed associated components would be feasible.