FINAL PRE-FEASIBILITY STUDY REPORT

Volume 0

Executive Summary

PRE-FEASIBILITY STUDY FOR CONSTRUCTION OF BRIDGE OVER COXSBAZAR-MOHESHKHALI CHANNEL

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

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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 COXSBAZAR-MOHESHKHALI CHANNEL

VOLUME 0
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Quality Control Sheet

DOCUMENT	**FINAL PRE-FEASIBILITY STUDY. CONSTRUCTION OF BRIDGE OVER COXSBAZAR-MOHESHKHALI CHANNEL** **VOLUME 0. EXECUTIVE SUMMARY**		
PROJECT	TR8138-MASTER PLAN BBA		
CODE	TR8138-JV-PF-G402-RP-000001-FPF_Vol0-D03		
AUTHORS:	Signed:	MCP	
	Date:	31/08/2024	
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	Date:	31/08/2024	31/08/2024
RECIPIENT	Bangladesh Bridge Authority (BBA)		
NOTES	Document created by the Joint Venture formed by TYPSA-DOHWA-NIPPON KOEI-DDC-BCL-DEVCON		

Control of Versions

VERSION	CONTROL OF CHANGES
1	First Submission
2	Second Submission
3	Third Submission

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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
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
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
MDP	Marine drive Project
MIDI	Matarbari Moheshkhali Integrated Initiative
ML	Silt
MSL	Mean Sea Level
MSS	Movable scaffolding system
MUSD	Million United States Dollar
N1	National One (Dhaka–Chattogram Highway)
NPV	Net Present Value
OLS	Obstacle Limitation Surface
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
SWOT	Strengths-Weaknesses-Opportunities-Threats
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. Project basic Information.

1.	Name of the Project	:	FINAL PRE-FEASIBILITY STUDY. CONSTRUCTION OF BRIDGE OVER COXSBAZAR-MOHESHKHALI CHANNEL
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 Coxsbazar and Moheshkhali. Analysis shall include technical, socio-economic, financial, and environmental aspects
4.	Estimated project Cost. (Taka in Crore)	:	Estimated project Cost. 7,974.72 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 Others (City Corporation/Pourashva)	:	 The People's Republic of Bangladesh Division: Chattogram District: Coxsbazar Upazila: Moheshkhali and Coxsbazar Sadar
8.	Project Duration	:	Investment Period: 6Y – 2027/2032 Operation Period: 30Y – 2033/2062

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 Moheshkhali Channel connecting Coxsbazar with Moheshkhali.

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 Coxsbazar-Moheshkhali channel,** 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. Objectives of the Study

The objective of this assignment is to prepare a pre-feasibility study-concept design for the construction of Bridge over Moheshkhali Channel to provide a safe and permanent connection between Coxsbazar and Moheshkhali.

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 study main objectives, including the evaluation of **three different alignment options,** were to:

- 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.

2.3. Approach and Methodology

This pre-feasibility study has been carried out by the Consultant following the scope as detailed by BBA in the Terms of Reference (ToR).

This includes the following activities:

- 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.

2.4. Project Area

The proposed potential project is located at Coxsbazar district surrounded by Moheshkhali and Coxsbazar Sadar Upazilas over the Moheskhali channel. It will develop connectivity between Zilla Road Z1004 and Zilla Road Z1132.

Moheskhali Island is aimed to be transformed into an industrial hub and economic zone, with a power hub that will produce 3,600 MW electricity from coal, gas, and other fuels at Matarbari. The Matarbari area is also selected for construction of a deep-sea port, the only one in the country. Therefore, the proposed bridge will connect these two important economic and touristic hubs into an integrated prosperous agglomeration.

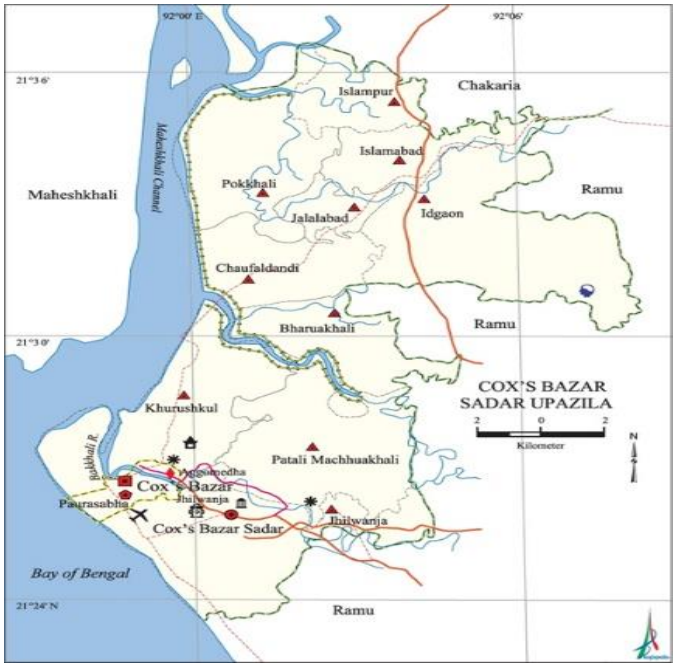

Figure 1. Map of Coxsbazar Sadar Upazila.

- **Coxsbazar District**

Coxsbazar District is in Chattogram Division, Bangladesh. The district has an area of 2,382.38 sq km, located in between 20°43' and 21°56' north latitudes and in between 91°50' and 92°23' east longitudes.

It is the seventh largest district of the 11 districts of Chattogram division. Almost half of the total area of the district represents the hilly region, and the other half is the coastal islands.

The longest sea beach in the world belongs to Coxsbazar.

Main offshore islands of the district are Moheshkhali, Kutubdia, Matarbari, Sonadia, Shah Pari and ST Martin's Island. Since it is a coastal district, the area of Coxsbazar changes due to erosion resulting in the formation of islands and char. The main Rivers are Matamuhuri, Bakkhali, Naf and water bodies are Moheshkhali channel and Kutubdia channel.

There are two Upazilas of the district related to this bridge project area. The **Coxsbazar Sadar Upazila** will be connected by this bridge with **Moheshkhali Upazila**. The total population of Coxsbazar Sadar upazila is 570,226.

Figure 2. Map of Moheskhali Upazila.

Moheshkhali Upazila occupies an area of 362.18 sq.km. Moheshkhali upazila is one of the potential developing upazila of Coxsbazar District. The government has undertaken an ambitious project to transform Moheshkhali Island in the Bay of Bengal into a thriving energy hub. The aim is to establish power plants and a liquefied natural gas (LNG) terminal by 2027. This endeavour is driven by the objective of strengthening the country's economy and achieving self-reliance in the power and fuel sector. As a result of this initiative, the country's energy crisis will improve significantly, and the socio-economic landscape of the region will become more sustainable.

For these reasons the road transport network needs to be improved.

Addressing social aspects is very important for any sort of development effort. National Land Zoning Project intends to ensure the best possible use of land resources; therefore, the socio-economic aspects of Moheshkhali Upazila have to be addressed to gain optimum economic benefits from agriculture, forestry, fisheries, tourism and industrial sector

The total population of this upazila is 391,768.

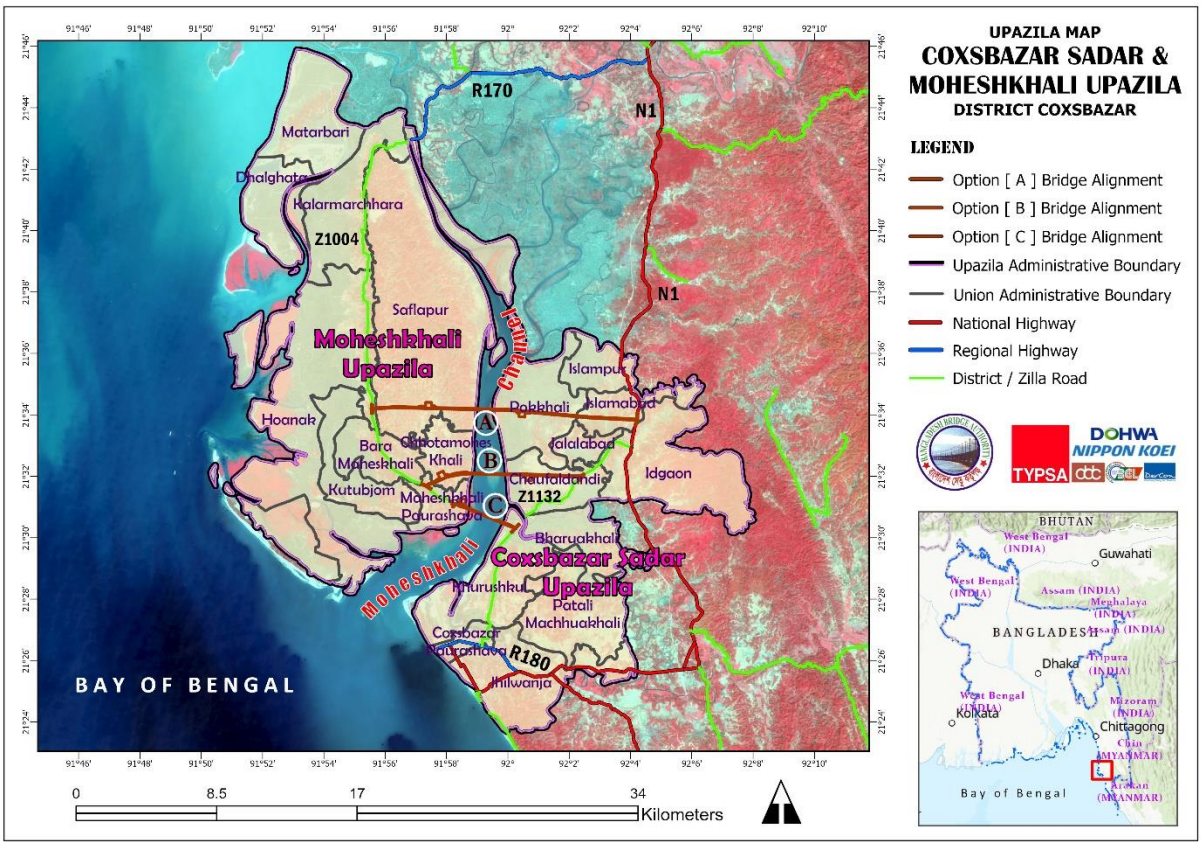

Figure 3. Coxsbazar and Moheshkhali Upazilas.

2.5. Key Findings - Salient Features

Table 2. Summary of Salient Features.

Salient Features of Coxsbazar-Moheshkhali Bridge				
		Option A	Option B SELECTED OPTION	Option C
Main alignment length	Road and bridge	14,950 m	8,795 m	3,834 m
Total bridge length		1,680 m	2,500 m	2,480 m
Balance Cantilever Bridge	Length		2,020 m	
	Main span		1,800 m (9x200)	
	Back spans		110+110=220 m	
	Width of the section		20.25 m	
Extradosed Bridge	Length	800 m		1,600 m
	Main span	600 m (3x200)		1,400 m (7x200)
	Back spans	100+100=200m		100+100=200m
	Width of the section	22.10 m		22.10 m
Accessing Spans (Precast +Girders)	Length	880 m	480 m	880 m
	Moheskhali Side	160 m (4x40)	160 m (4x40)	480 m (12x40)
	Coxsbazar Side	720 m (18x40 m)	320 m(8x40)	400 m(10x40)
	Width of the section	20.25 m	20.25 m	20.25 m
	Moheskhali Side	1,200 m (30x40)	640 m (16x40)	640 m (16x40)
	Coxsbazar 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 road	Total length	13,270 m	6,295 m	1,354 m
	Coxsbazar Side	7,630 m	3,825 m	515 m
	Moheshkhali Side	5,640 m	2,470 m	,839 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
Improvement roads				
	Coxsbazar Side	746 m	500 m	653 m
	Moheshkhali Side	575 m	620 m	396 m
Connection with the existing roads		Roundabouts	Roundabouts	Roundabouts

Salient Features of Coxsbazar-Moheshkhali Bridge				
		Option A	Option B SELECTED OPTION	Option C
	Coxsbazar Side	N1	Z1132	Z1132
	Moheshkhali Side	Z1004	Z1004	Z1004
Other features in approach road				
Culverts		10	5	2
	Coxsbazar Side	6 nos (2 Vent-5.00 x 3.50 m) at Ch 9+100,9+400,9+900,11+150,12+300 and 13+400 2 nos (4 Vent-5.00 x 3.50 m) at Ch 7+900 and 14+725	3 Nos (2 Vent-6.00 mx5.50 m) at Ch 5+420, Ch 7+200 and Ch 8+190	1 nos (1 Vent-3.00x3.50 m) at Ch 3+600
	Moheshkhali Side	2 nos (2Vent-6.00 mx5.50 m) at Ch 4+400 and 5+300	1 no (2 Vent-6.00 m x5.50 m) Ch 0+600 1 no (1V-6.00x5.50 m) at Ch 2+140	1 nos (1 Vent-3.00x3.50 m) at Ch 0+300
Minor Structures		4	1	0
	Coxsbazar Side	1 bridge 60 m long at Ch 10+300 1 bridge 200 m long at Ch 2+200	-	-
	Moheshkhali Side	1 bridge 40 m long at Ch 10+540 1 bridge 200 m long at Ch 2+200	1 bridge 40 m long at Ch 0+200	-
Toll Plaza		7 nos booth each side = Total 14 nos	7 nos booth each side = Total 14 nos	14 nos booth each side = Total 14 nos
	Coxsbazar Side	7 nos booth one direction	7 nos booth one direction	-
	Moheshkhali Side	7 nos booth one direction	7 nos booth one direction	14 nos booth both directions
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	-
	Coxsbazar Side	1 no	1 no	-
	Moheshkhali Side	1 no	1 no	-

Salient Features of Coxsbazar-Moheshkhali Bridge				
		Option A	Option B SELECTED OPTION	Option C
Engineer's Facilities and Service Area		1 no each side = Total 2 nos 2 x 22.50 = 45.00 acres	1 no each side = Total 2 nos 2 x 22.50 = 45.00 acres	1 no one side = Total 1 nos 1 x 22.50 = 22.50 acres
	Coxsbazar Side	1 no	1 no	-
	Moheshkhali Side	1 no	1 no	1 no
Construction Yard		50 Acres	50 Acres	50 Acres
River training works	Total length			
	LGB	1,372	1,406	1,595
	RGB	1,649	2,392	1,493.5
Land Acquisition				
	Width of right of way (ROW)	69.5 m	69.5 m	69.5 m
	Total land to be acquired	365.76	308.60	139.75
	Total number of projects affected units (business)	172	130	53
	Total number of persons affected	740	548	160
	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. Benefits and need and justification for the implementation of the infrastructure are analysed hereinafter:

3.1. Problem Statement

The existing problem, or potential improvement, to be addressed is mainly the lack of adequate infrastructure for efficient and convenient river crossings in this area of Bangladesh. The existing ferry service is not sufficient to meet the growing demands of transportation and connectivity in this area potentially growing in terms of industrial and tourism development. This results in longer travel times, limited accessibility, and hinders socio-economic development.

There are some direct causes:

- Insufficient number of bridges: currently, lack of bridges in operation, 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, exacerbating 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 of understanding the need of the project is analysing 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 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

3.2.1. Introduction

Coxsbazar-Moheshkhali is a proposed bridge project that aims to connect Coxsbazar District on the mainland with Moheshkhali Island in the Bay of Bengal. The total project length involves the construction of a 2,500 m long bridge across the Bay of Bengal.

The project is expected to have significant economic, social, and environmental benefits for the region. At present, Moheshkhali Island is connected with the mainland through Badarkhali (R172 + N1) by which the Moheskhali paurasava people have to travel more than 110 km (about 3h) to reach Coxsbazar.

Coxsbazar District is a popular tourist destination, known for its long sandy beaches and natural beauty. Moheshkhali is an Upazila of Coxsbazar District in the Division of Chattogram. Moheshkhali is an attractive island that is located 12 km apart from the main town of Coxsbazar.

This island is separated from the mainland by the Moheshkhali Channel. The offshore island is projected to be an important commercial and industrial area of the country. Several ongoing projects are coal-based power plants and PDB power plants, deep seaport, GTCL, BPC, economic zones, land-based LNG terminal, LPG terminal, single point mooring (SPM) project, etc. The development works of the world's largest coal-fired power plants cluster with the total capacity of 8,720 MW at Moheshkhali Island under Coxsbazar District have been progressing fast. According to the plan, SPL and SK Gas Korea will build petrochemical refinery, warehouse of petrochemical products and LPG terminal.

Modern jetty facilities would be also installed there for loading and unloading raw materials and products, etc. Therefore, it is essential to connect with the mainland. Currently, transportation between the two locations is primarily through ferry and motorized boat, which is unreliable, particularly during inclement weather.

Figure 4. Jetty and ghat in Coxsbazar.

Figure 5. Jetty at Bakkhali River channel.

3.2.2. Industrial Hub

In October 2022, Federation of Bangladesh Chambers of Commerce and Industry (FBCCI) president urged JICA to facilitate establishing a petrochemical industrial hub in Matarbari-Moheshkhali project area in Coxsbazar. According to FBCCI, despite having huge demand brought by the local industry, Bangladesh lacked a petrochemical industry. Therefore, a petrochemical complex is a much needed one to keep the country's industrial development and economic growth. In response to this, JICA assured the all-out cooperation for the private sector of Bangladesh to make the Matarbari-Moheshkhali Integrated Development Initiative (MIDI) successful, which is the core area for BIG-B Initiative. Once the above-mentioned infrastructure projects commence to operate, this area will be one of the biggest industrial areas in the country and traffic/freight volumes between Moheshkhali and Coxsbazar would significantly increase.

Figure 6. Overall site plan of Matarbari-Moheshkhali area.

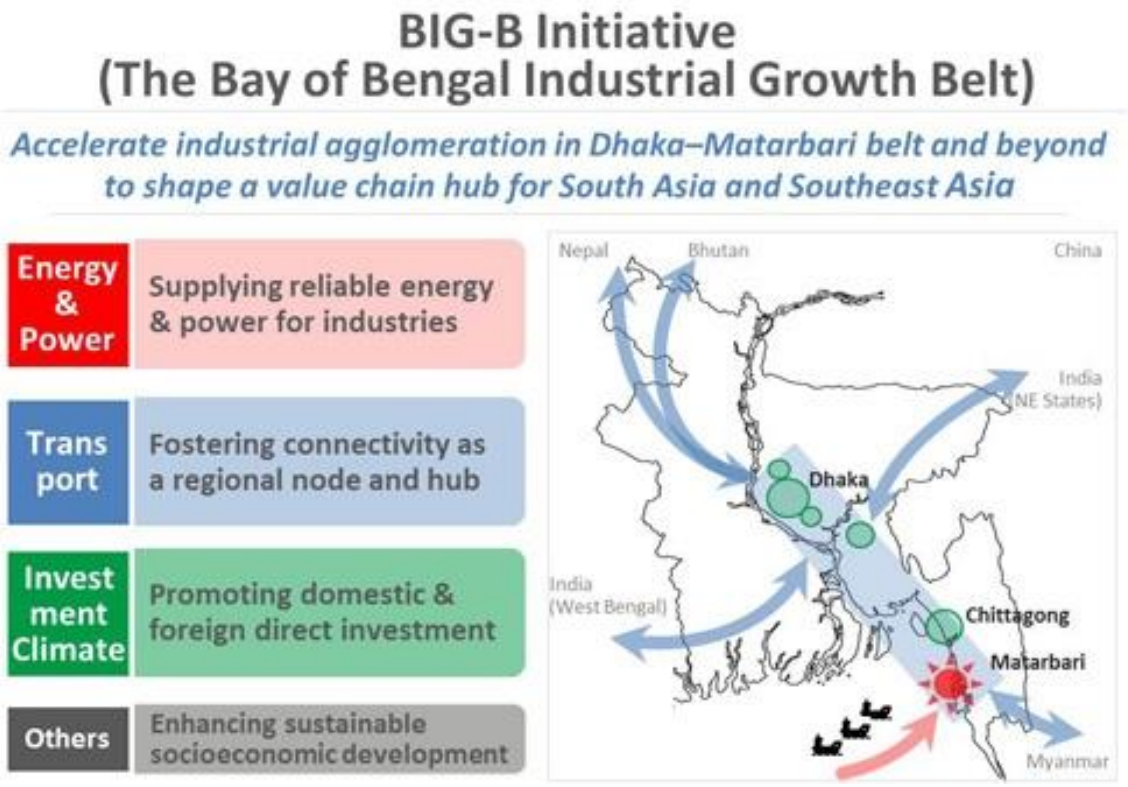

Figure 7. BIG-B Initiative.
Source: JICA Website. (https://www.jica.go.jp/bangladesh/english/office/activities/initiative.html)

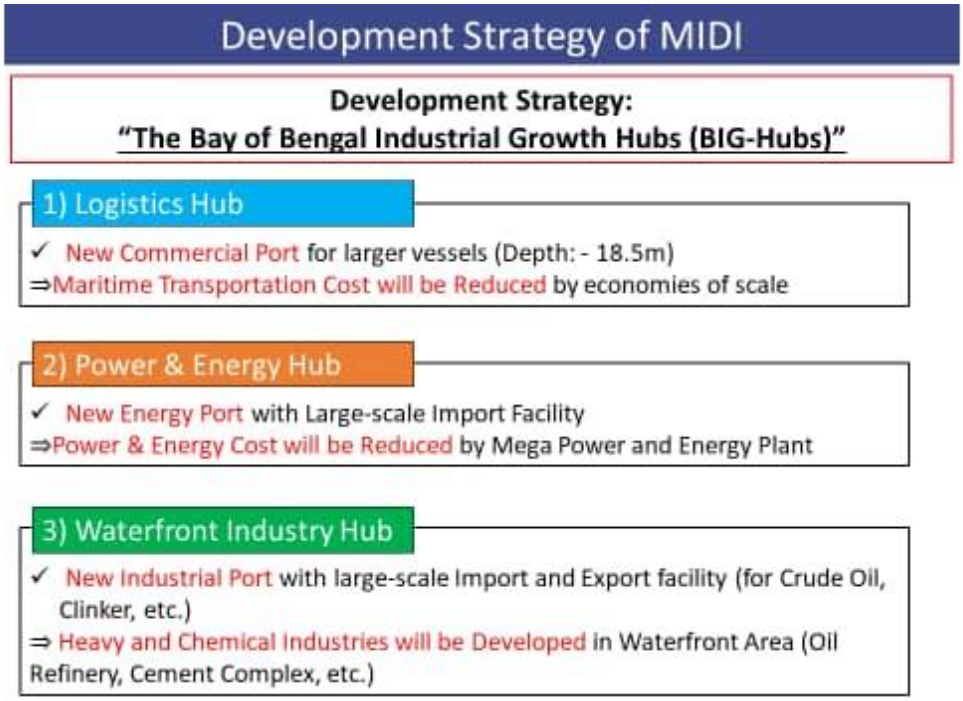

Figure 8. Development Strategy of MIDI.
Source: JICA Bangladesh Office

3.2.3. Tourism

The region of Coxsbazar and Moheshkhali shows a great growth potential for tourism. Coxsbazar coastal area is one of the main attractions, followed by Himchori and Inani beaches. There are also several natural parks and Buddhist temples to visit in the area. Many tourists also stop at Coxsbazar on their way to visit Saint Martin Island in Teknaf.

The maps and figures below illustrate the location and demand of some of the tourist places in Coxsbazar.

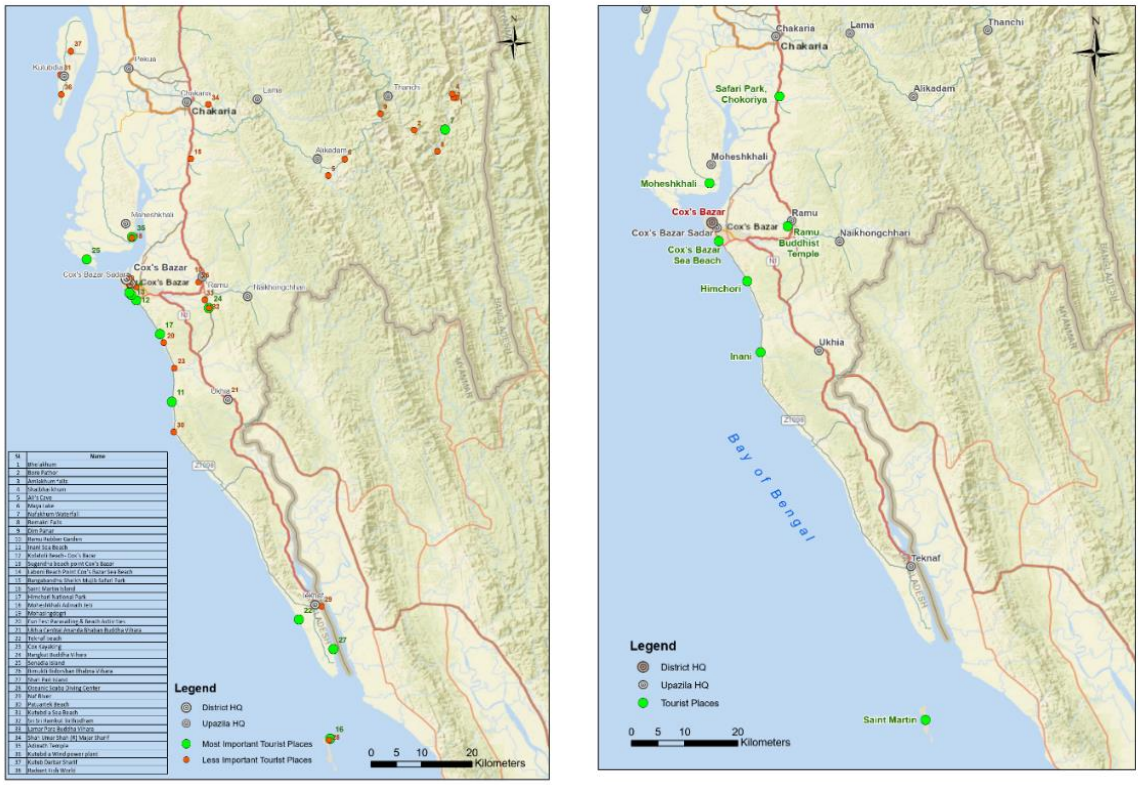

Figure 9. Maps of main tourist places in Coxsbazar region.

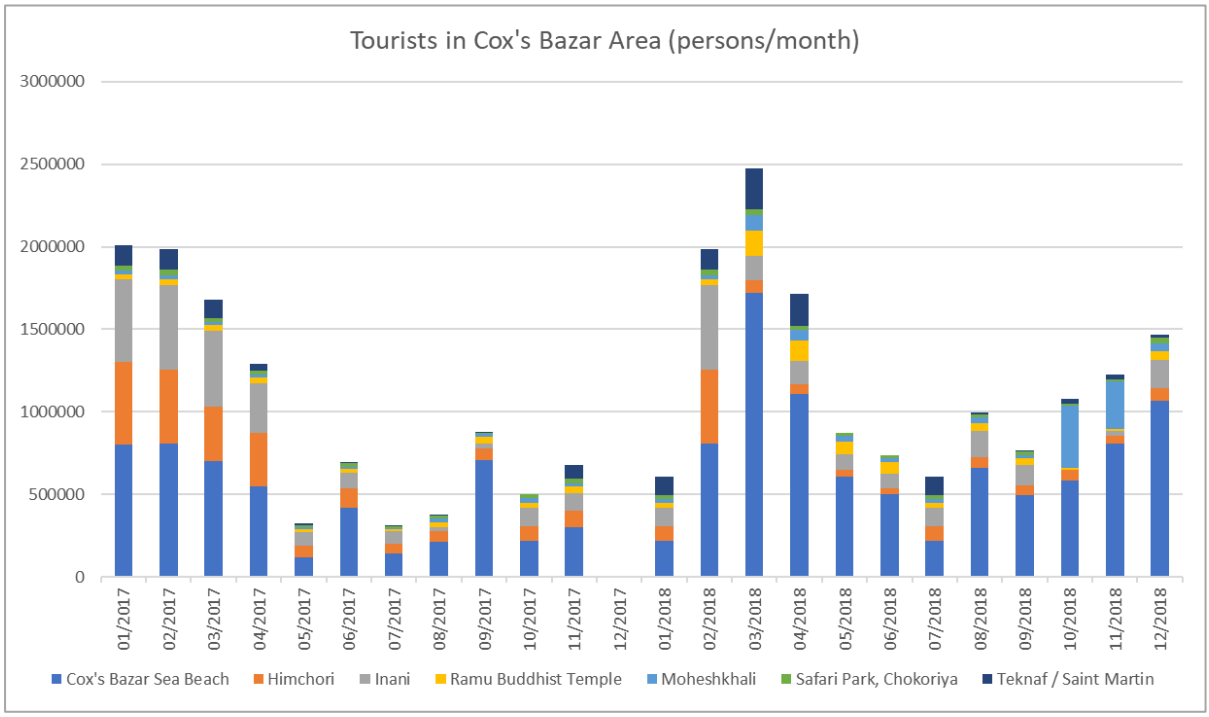

Figure 10. Number of tourists at Coxsbazar area (persons/month, 2017-2018).

In addition to the Master Plan for Coxsbazar (under development by UDD) which has great focus on improving the entire beach promenade (corniche), there are several touristic development projects nearby, such as Sonadia Eco-Tourism Park in Moheshkhali, or Sabrang Tourism Park in Teknaf, etc.

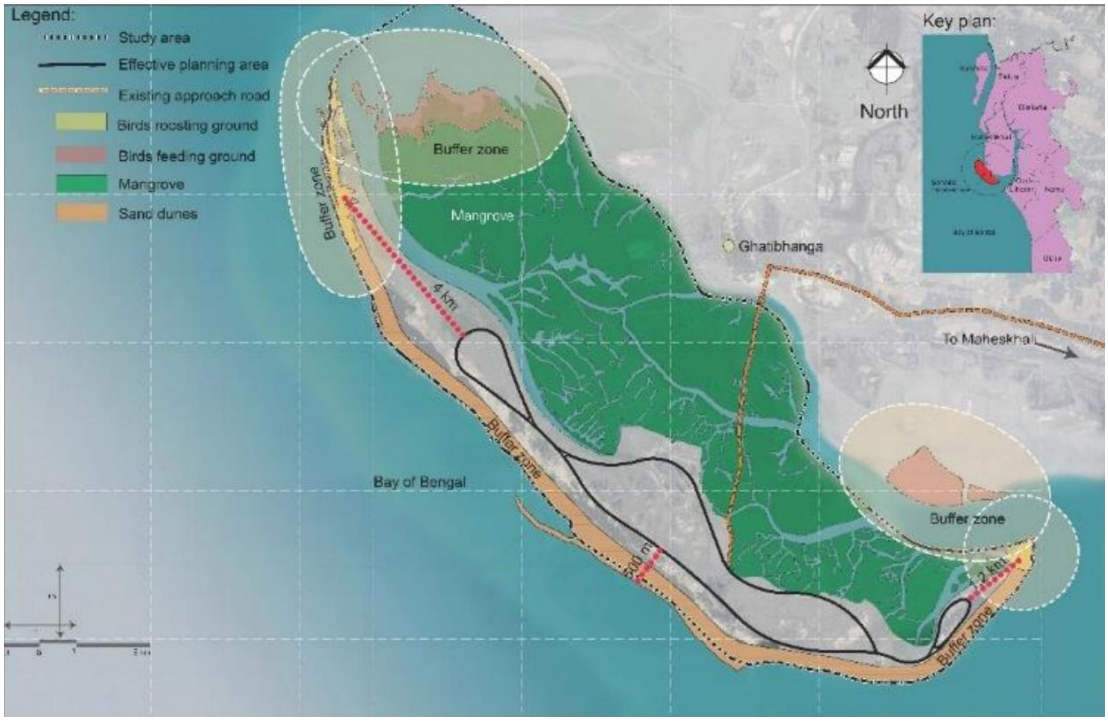

Figure 11. Location and zoning plan of Sonadia Eco-Tourism Park (SE-TP), Moheshkhali

Source: Feasibility Study Sonadia Eco-Tourism Park, BEZA 2021.

3.2.4. Project Objectives

Overall, the Coxsbazar-Moheshkhali Bridge would be a significant infrastructure project that is expected to bring significant economic, social, and environmental benefits to the region, making it an important development project for the country.

The bridge is expected to achieve the following objectives:

- **To enhance transportation and communication**: The bridge would provide a direct road link between the Coxsbazar District and the Moheshkhali Island (connecting Z1132 with Z1004), 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 by reducing transportation costs and travel time.
- **To boost 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 would contribute to the overall economic growth of the country.
- **To facilitate tourism development:** The improved transportation infrastructure would make it easier for tourists to access Moheshkhali Island, promoting tourism development in the region. This would create new job opportunities and contribute to the overall economic growth of the country.

- **To promote environmental sustainability:** Currently, transportation to Moheshkhali Island 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.
- **To enhance social and cultural exchange:** The improved transportation infrastructure would make it easier for people to travel between the Coxsbazar district and the Moheshkhali Island, promoting social and cultural exchange between communities.
- **To connect national highway N1 with 7 Economic Zones** such as Coxsbazar Special Economic Zone, Moheshkhali, Moheshkhali Economic Zone–1, Coxsbazar, Moheshkhali Special Economic Zone, Ghativanga-Sonadia, Moheshkhali Special Economic Zone Coxsbazar, Moheshkhali Economic Zone, Kalarmarchara, Moheshkhali Economic Zone–3, Dhalghata, Coxsbazar, Moheshkhali Economic Zone–2, Kalarmarchara, Coxsbazar.

3.3. Marine Drive Project (RHD)

Today, the Dhaka Chittagong Highway (N1) is the only connecting road providing access to several important projects that are being developed in the coastal region south of Chittagong.

N1, R170 and R172 are the main roads connecting to Coxsbazar. N1 is now not sufficient to respond to the traffic demand, and additionally it is estimated a high upcoming demand from future planned projects as Deep-Sea Port, and others. To mitigate these issues, the GoB decided to construct a completely new road with an approximate 170 km alignment of Mirsharai (Jorarganj)-Sitakunda-Chattogram-Coxsbazar 4-Lane Marine Drive Expressway Project.

During the TAC meeting of the Draft Report, a discussion was opened regarding the mentioned project and the need of carrying out optimum coordination amongst both initiatives under the same Ministry.

This project feasibility study and preliminary design have been carried out by the Consultant SMEC International Pty LTD in JV with ACE Consultants Ltd. As per the information obtained, the proposed corridor lies within the district boundaries of Chittagong and Coxsbazar it will connect Jorarganj (N1)-Mirsharai-Sitakunda- Chattogram-Coxsbazar as shown in the image below.

The Marine Drive Expressway project, by RHD, has completed the preliminary design stage. The project was duly analysed aiming to assess and to ensure the appropriate coordination between both infrastructures being planned.

This Pre-FS stage proposed bridge, at alignment B, has been assessed not to entail any conflict with the mentioned project. However, the roads connectivity solution shall be duly coordinated, and responsibility to be taken by RHD agency under its mandate in the case of any additional intervention needed. It has been observed that the extent of the necessary road link to the Marine Drive project near the Coxsbazar airport might need to be revised at the moment of the implementation of the project.

The Consultant position and appraisal regarding the Marine Drive project selected location, near to Option C of this Pre-FS, for the crossing has been fully exposed in the alignment selection section of the report with a sound and grounded justification. After the assessment of this project, the proposed

alignment B for the bridge remains as the preferred one due to several relevant technical reasons that reinforce its justification (full detailed justification is included in Section 4.2).

Figure 12. Image of Marine Drive Expressway and Coxsbazar Bridge.

As explained in the site selection section 4.2 of this report, the Consultant has selected option B as the preferred location for the bridge after carrying out a thorough multi-criteria analysis. The proximity to Coxsbazar Airport and its restrictions (OLS) and to the 60 MW Wind Power Plant in the East side are key factors for the conclusion regarding the alignment and site selection.

Figure 13. Proposed roads improvement to connect Alignment B with MDP.

3.4. Proposed Project Interventions

The Project implementation would need not only the address the construction of the main infrastructure, but as it is explained within the technical features section, the construction of approach roads would be needed to connect with the existing road 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 and critical river training works would be needed, given the relevant riverbank erosion identified in this area of the Meghna River.

Additionally, but not included within this estimated CAPEX, the project would certainly require some roads interventions, related to the improvement of existing roads with the aim of connecting the brdge to the existing RHD network and to the future project to be implemented, Marine Drive Project. This aspect is detailed in Section 4.6 "Approach Roads" of this report.

3.5. 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): Agency of the Government of Bangladesh responsible for the construction and maintenance of highways and roads across Bangladesh.
- Civil Aviation Authority Bangladesh (CAAB): Agency responsible for all civil aviation and airport related matters.

3.6. Demand Analysis

A transportation model was used along with data from various survey points to analyse the demand. Both the current demand and projected demand (i.e., demand that would use the bridge if it existed) were evaluated.

To conduct a thorough economic and financial study, it is necessary to carefully analyse 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.

3.6.1. Definition of Scenarios

It is important to understand the different scenarios analysed, with and without project. Both scenarios will be compared 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).

The following images show the two scenarios that were analysed:

Without Project (ferry service) | With Project (new bridge)

Figure 14. Analysed scenarios for the traffic study.

It includes:

- Coxsbazar-Moheshkhali ferry service
- Road improv. on Z1132 connecting to N1.
- RHD Marine Drive Road project
- Bangabandhu Tunnel (Karnaphuli River)
- Bridge over Sangu River on Marine Drive
- Matlab Uttar Bridge
- Matlab Uttar Road Corridor to Chandpur
- Cumilla-Chandpur Road improvement
- Shariatpur-Chandpur Bridge
- Gazaria-Munshiganj Bridge
- Padma Bridge
- N1 improvement between Dhaka and Chattogram

It includes:

- Coxsbazar-Moheshkhali Bridge
- Road improv. on Z1132 connecting to N1.
- RHD Marine Drive Road project
- Bangabandhu Tunnel (Karnaphuli River)
- Bridge over Sangu River on Marine Drive
- Matlab Uttar Bridge
- Matlab Uttar Road Corridor to Chandpur
- Cumilla-Chandpur Road improvement
- Shariatpur-Chandpur Bridge
- Gazaria-Munshiganj Bridge
- Padma Bridge
- N1 improvement between Dhaka and Chattogram

For both the traffic with and without the project the Transport Model is applied in its latest update when this estimation is carried out. It is assumed in both scenarios that some roads improvements will also be executed.

3.6.2. Traffic Forecast

The forward traffic estimation comes from the relation between GDP and traffic growth observed during a series of years in different traffic counts where historical data is available. There is a clear relation between GDP and AADT, since GDP is in line with the movement of passenger and freight.

The results of the traffic forecast study by type of traffic are shown below for the scenarios without project and with project (please refer to the main report for more information on the methodology and calculation process for the traffic study).

Table 3. 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	EZ	Road – due to time reduction	Due to additional GDP increment	TOTAL
2024	409	1,193	0	1,602						
2033	782	2,284	1,251	4,317	1,784	457	563	540	9	7,671
2034	832	2,429	1,251	4,512	3,795	972	1,127	1,149	39	11,594
2035	883	2,578	1,251	4,712	6,041	1,547	1,690	1,829	94	15,914
2040	1,155	3,372	1,251	5,778	10,535	2,698	2,253	3,190	454	24,907
2045	1,447	4,225	1,251	6,923	13,200	3,380	2,253	3,997	955	30,708
2050	1,749	5,106	1,251	8,106	15,953	4,085	2,253	4,831	1,549	36,777
2055	2,050	5,986	1,251	9,287	18,703	4,789	2,253	5,663	1,816	42,512
2060	2,345	6,847	1,251	10,443	21,391	5,477	2,253	6,477	2,077	48,118
2061	2,406	7,025	1,251	10,682	21,948	5,620	2,253	6,646	2,131	49,281
2062	2,469	7,208	1,251	10,928	22,520	5,767	2,253	6,819	2,187	50,474

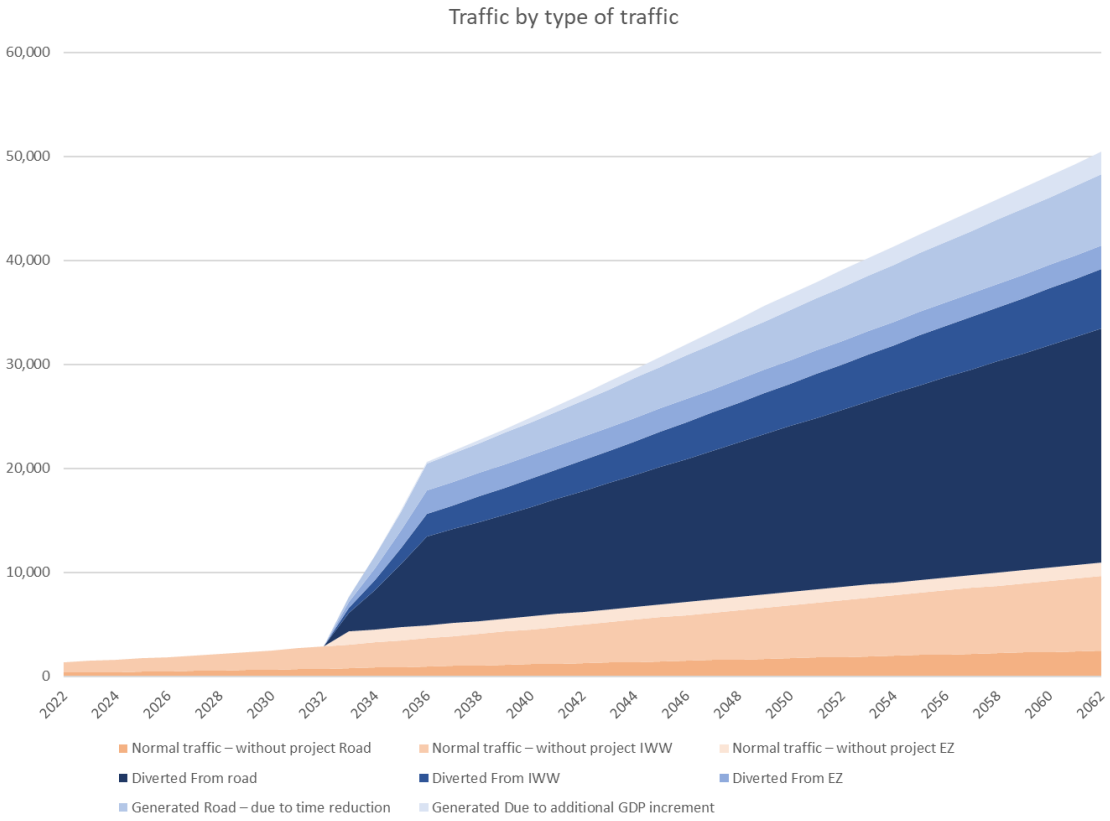

Figure 15. Daily traffic volumes by type of traffic.

Table 4. 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
2024	1,060	358	136	49	1,602					
2033	2,587	1,157	480	93	4,317	4,342	1,717	1,475	137	7,671
2034	2,716	1,201	496	99	4,512	6,429	2,370	2,603	193	11,594
2035	2,848	1,245	513	105	4,712	8,731	3,076	3,851	256	15,914
2040	3,554	1,483	603	137	5,778	13,664	4,499	6,329	415	24,907
2045	4,312	1,739	700	172	6,923	16,930	5,422	7,816	540	30,708
2050	5,095	2,003	800	208	8,106	20,340	6,402	9,363	672	36,777
2055	5,877	2,267	900	244	9,287	23,589	7,270	10,865	788	42,512
2060	6,641	2,524	998	279	10,443	26,766	8,119	12,333	901	48,118
2061	6,800	2,578	1,018	286	10,682	27,424	8,295	12,637	925	49,281
2062	6,963	2,633	1,039	294	10,928	28,100	8,475	12,950	949	50,474

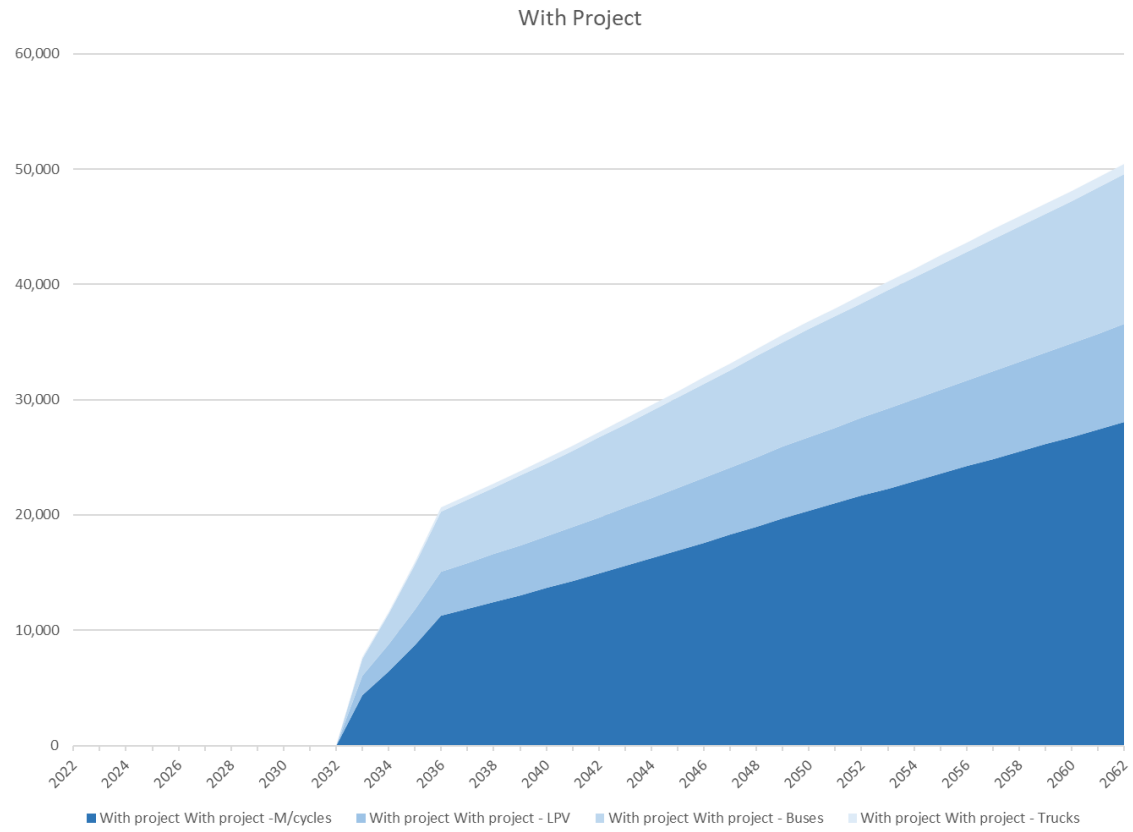

Figure 16. Daily traffic volumes by type of vehicles.

Table 5. Total daily traffic summary (veh/day).

Year	Total Without Project	With Project
2033	4,317	7,671
2034	4,512	11,594
2035	4,712	15,914
2040	5,778	24,907
2045	6,923	30,708
2050	8,106	36,777
2055	9,287	42,512
2060	10,443	48,118
2062	10,928	50,474

The traffic values obtained are based on the actual demand observed in the field campaign for the bridge. The field campaign has not only considered the vehicles that currently cross the ferry at the point where the bridge will be built, but also the traffic that is using other routes.

The transport model allows to obtain the assignment of all these trips once calibrated with their travel times and travel distance in the scenarios where the roads are upgraded, and the bridge is included.

The new traffic generated by the reduction in travel times is quite considerable. Undoubtedly the lack of trips at present is due to the lack of connectivity that will be solved with this bridge.

The forecast of total motorized traffic (including motorcycles, light vehicles, buses, and trucks) for the scenario with Coxsbazar-Moheshkhali Bridge project shows that the estimated ADT in the year 2062 could reach around 50,500 vehicles per day.

From the traffic survey, forecast and projection it may be deduced, at this stage, that for the Coxsbazar-Moheshkhali bridge **a 4-lane carriageway is required to meet volume and capacity requirements**.

3.6.3. 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.

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

The Economic Zones are illustrated in the image below.

The Consultant identified seven planned Economic Zones in Moheshkhali (area of influence). These Economic Zones are illustrated in the image below.

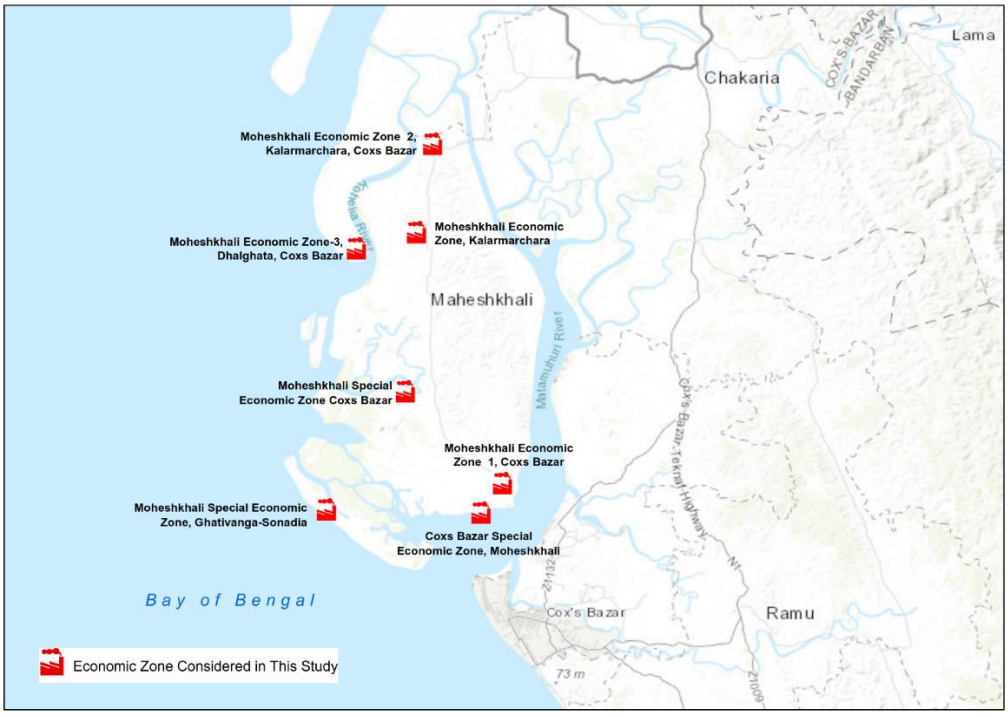

Figure 17. Location of planned Economic Zones in the area of influence.

A conservative approach was taken by assuming that the employment that these zones could generate might reach 75,000 jobs. The economic zones in Moheshkhali are anticipated to start

operating by 2033. The trips that would be attracted by these economic zones were estimated to be home-based and were assumed to be distributed to all Upazilas adjacent to the EZ. A gravity model was applied, 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 where the passengers that is estimated that would potentially use the bridge are the ones that are shown in ***blue***.

Table 6. Trip distribution to adjacent Upazilas (trips attracted by EZs).

Upazila	Number of additional trips per day (in number of passengers)
RAMU	*4,204*
NAIKHONGCHHARI	*809*
COXS BAZAR SADAR	*4,719*
MAHESHKHALI	**93,918**
PEKUA	**10,195**
BANSHKHALI	**17,623**
LOHAGARA (CHATTOGRAM)	**5,068**
TOTAL	150,000

The final estimation, for the year 2033, of additional local traffic due to the development of the Economic Zones in the Moheshkhali area is presented in the table below.

Table 7. Additional trips in the "with project" scenario (S2) due to EZs.

Vehicle type	Additional trips in "With Project" scenario (veh/day)
Motorcycles	932
Light vehicles	892
Buses	429
Total	**2,253**

3.7. Need and Justification of the Project

3.7.1. SWOT Matrix

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

Table 8. 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 directly 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 to local economic development, creating employment opportunities for the people in the region. ▪ 1.31 Cr population living in 11 districts, in the Chattogram Division would be benefitted by the proposed bridge.	▪ 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.

3.7.2. 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 Coxsbazar District and the Moheshkhali Island (connecting Z1132 with Z1004), improving access to essential services such as healthcare, education, and markets.
- To connect national highway N1 with 7 Economic Zones such as Coxsbazar Special Economic Zone, Moheshkhali, Moheshkhali Economic Zone–1, Coxsbazar, Moheshkhali Special Economic Zone, Ghativanga-Sonadia, Moheshkhali Special Economic Zone Coxsbazar, Moheshkhali Economic Zone, Kalarmarchara, Moheshkhali Economic Zone–3, Dhalghata, Coxsbazar, Moheshkhali Economic Zone–2, Kalarmarchara, Coxsbazar.
- To facilitate tourism development: The improved transportation infrastructure would make it easier for tourists to access Moheshkhali Island, promoting tourism development in the region. This would create new job opportunities and contribute to the overall economic growth of the country.
- 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 this zone of the country.
- Provide travel distance and time savings: Establish a more direct route reducing distance and time savings, due to the construction and operation of the bridge.

Time and distance savings 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.

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 9: 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	32.23	22.28	377.10	10.65
With project	21.84	10.49	318.62	4.29
Time Savings	**10.39**	**11.80**	**58.48**	**6.36**

Table 10: 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	815.23	162.84	559.23	15.61	**1,552.91**
With project	802.10	155.97	559.34	16.05	**1,533.46**
Distance Savings	**13.13**	**6.87**	**-0.12**	**-0.45**	**19.43**

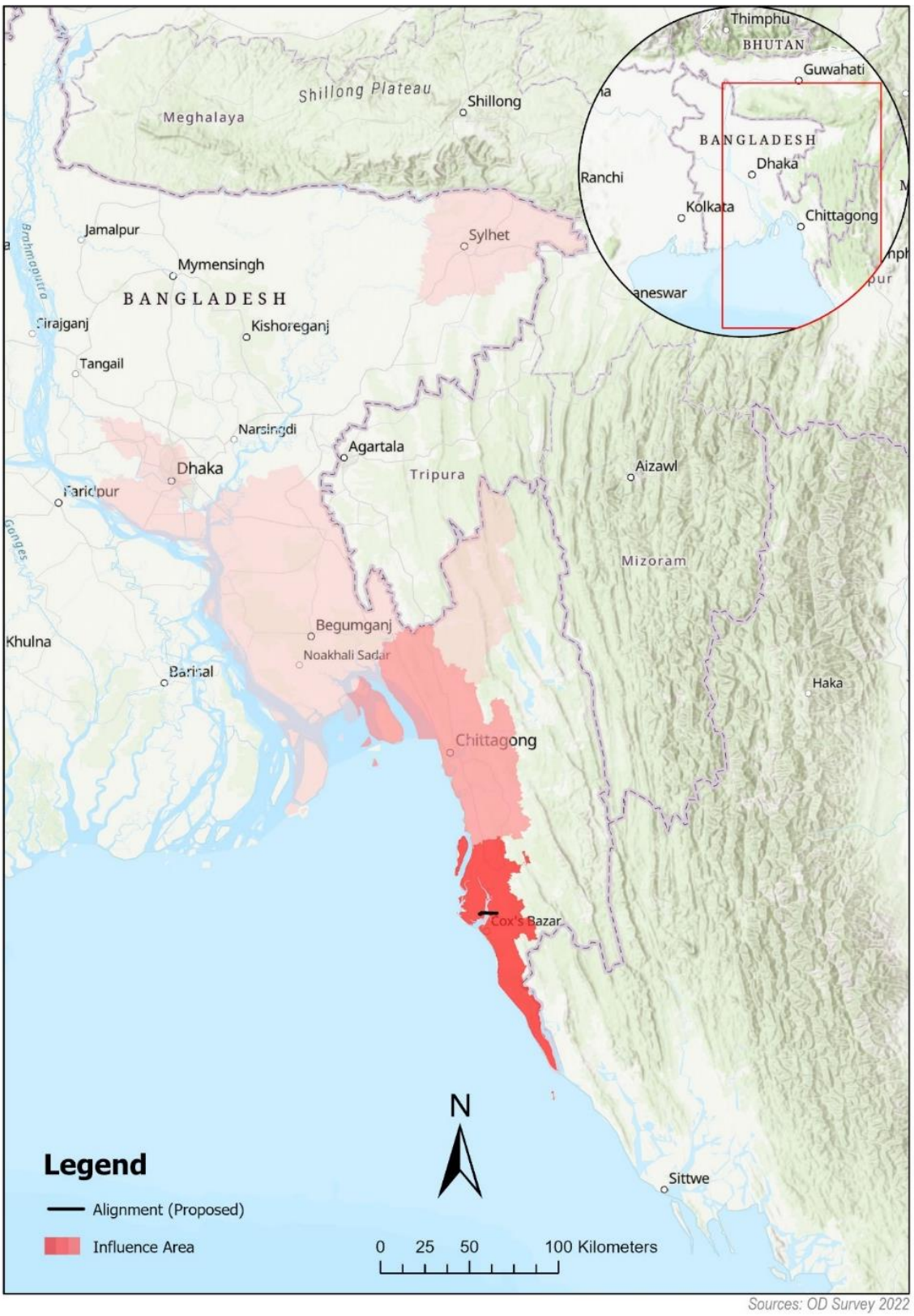

Figure 18. Influence area map.
(Source: Consultant Team based on Survey Data).

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 specs for Highway Bridges, with revisions 2020, 2022 and 2023, is considered appropriate to be used in the determination of stream pressure on piers.
- Geometric Design Standard Bridges and Approaches and Bridge Design Standard by RHD.
- Geometric Design Standards Manual (Rev2005 (GDSM 2005). RHD.
- 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. Selection of Bridge Location

4.2.1. General Considerations and Multi-criteria Analysis

A thorough preliminary analysis, from hydro-morphological, structural and road connectivity points of view, was undertaken to select the location of the project in which the field works were carried out.

As stated earlier, three probable sites on the Moheshkhali Channel 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 factors were conveniently:

- 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 should be free from obstacles such as hills, frequent drainage crossings, scared places, graveyards or built-up areas or troublesome land acquisition, absence of sharp curves in the approaches with minimum obstruction to natural waterways.
- To be avoided extensive river training works.
- The bridge axis should align with the centreline of the approach road.
- There should be sufficient clearance for high flood level (HFL).
- Absence of excessive underwater construction works.
- There should be the availability of construction materials.

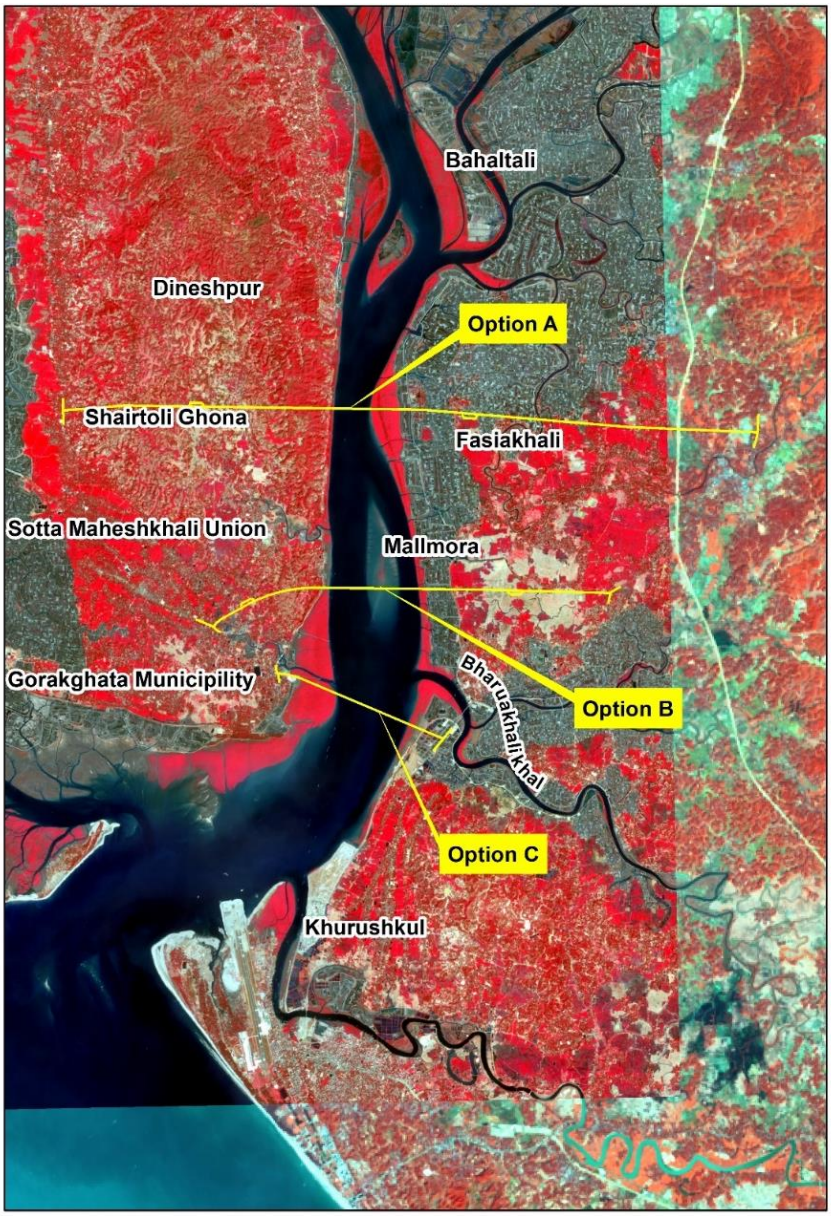

Figure 19. Preliminary selected three sites for the bridge over Maheshkhali Channel.

Table 11. Preliminary selection criteria for the site.

Options	Location or Position	Selecting Criteria
Option A	Located near Shairtoli Ghona at Right Bank (9.5km d/s from Saflapur WL station)	River width is minimum
Option B	Located immediate u/s of mangrove plants at Right Bank and 1.8 km u/s of Bharuakhali khal at Left bank (13 km d/s from Saflapur WL station)	Both banks are stable for a longer period
Option C	Located near main locality (15.7 km d/s from Saflapur WL station)	Close to the Zilla road Z 1004 on right bank and Z1132 on left bank

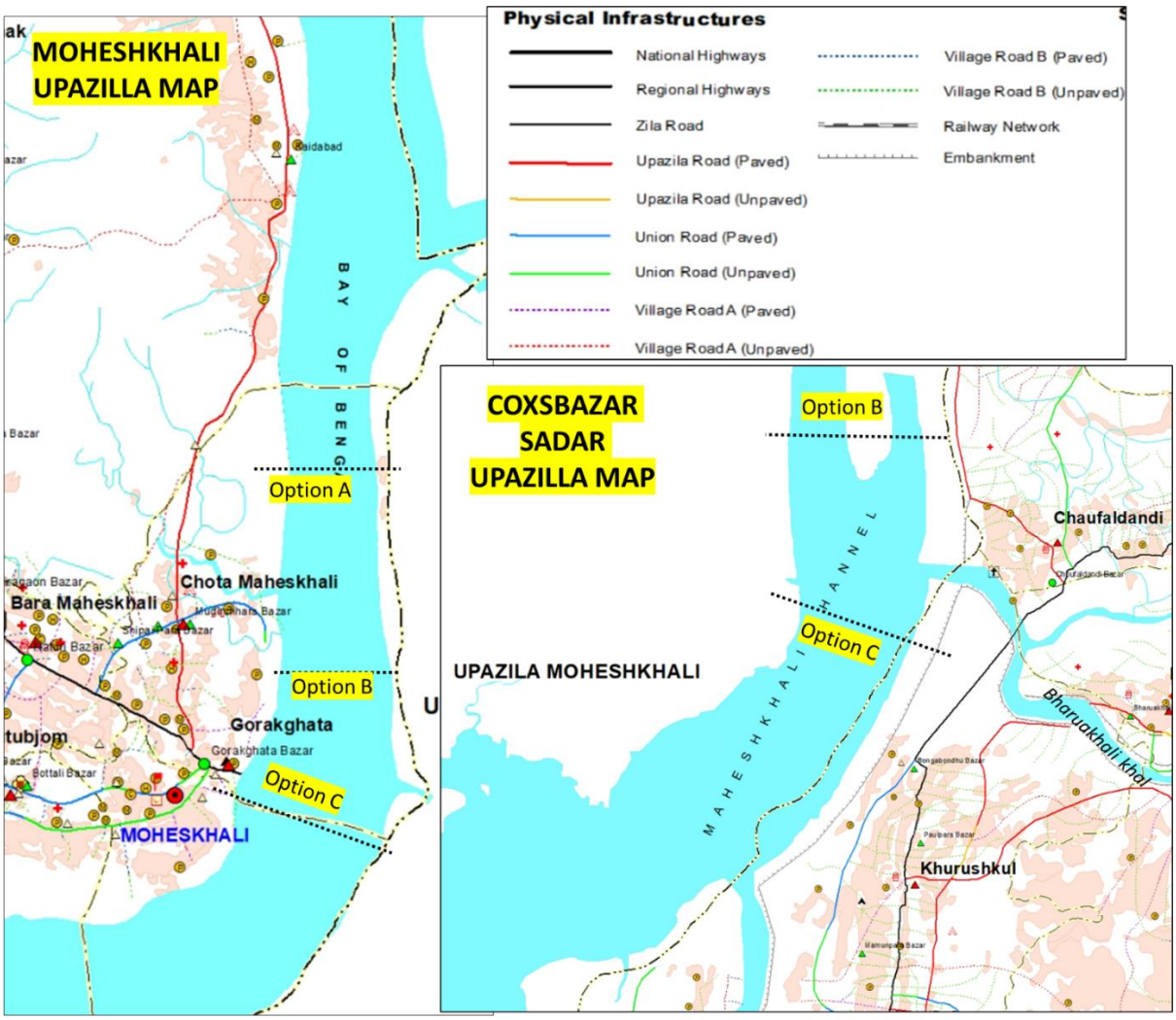

Figure 20. Road network in the project area.

Table 12. The minimum width of the river measured from recent satellite images.

Options	River Width (m) *(Ebb flow)*	River Width (m) (Flood flow)
Option A	822	1,407
Option B	1,936	1,936
Option C	1,740	2,617

Table 13. Summary table showing pros and cons of three options.

	Pros	Cons
Option A	1. River width is minimum.	1. Presence of small hills forest at RB. 2. Travelling time will be higher. 3. Length of approach road very high.
Option B	1. River is straight. 2. Each bank is highly stable. 3. Presence of locality along the RB. 4. Rural Road connection is close with LB.	1. Right channel deeper, left channel is in aggradation mode. 2. Presence of hilly forest at the right bank of channel.

	Pros	Cons
	5. Completely out of the OLS CAAB funnel height restriction area (7.5 km from the airport)	
Option C	1. Road connectivity (Zilla road) is very good at both banks. 2. Presence of locality. 3. Local people's demand (in between Option B and C).	1. Located in a bend. 2. Length of the bridge will be higher (approx. 3 km) including viaduct. 3. Proximity to the airport of Coxsbazar (OLS CAAB funnel height restriction area) – construction phase risk. 4. Proximity to 60 MW Wind Power Plant. 5. Proximity to open sea and Bharuakhali Khal.

Table 14. Multi-Criteria analysis for selecting bridge location.

Sl. No		Option A	Option B	Option C
1	Road Connectivity at Left Bank	3	2	1
2	Road Connectivity at Right Bank	3	2	1
3	Width of River (water edge to edge)	2	1	3
4	Width of River (bank to bank)	2	1	3
5	Uniformity in section	3	1	2
6	Bed Scour	3	2	1
7	Uniformity from skewness viewpoint (angle)	3	1	2
8	Presence of Thalweg	3	2	1
9	Bank erosion (Left Bank), 1989 to 2023	2	1	3
10	Bank erosion (Right Bank), 1989 to 2023	2	1	3
11	Channel incidence	2	1	3
12	Field Condition	3	1	2
13	Required Length of Bank Protection Works	2	3	1
14	Cost Estimation	3	2	1
	Frequency of top position	0	8	6

The multi-criteria analysis suggested **Option B as the most suitable site for the proposed bridge** location. From hydro-morphological point of view all the options are almost similar as bank erosion is found negligible overtime due to the cohesive property at coastal region. Thus hydro-morphological criteria will not be a governing factor to choose the suitable location of the proposed bridge.

Among the three options, Option A posed a key problem which is the forest in a hilly region on the right side of Moheshkhali channel. The available Zila road Z1004 is located far away (5.8 km) from this option. In addition, construction of the bridge at this site will be threatening to the forest area and it will also increase the cost of the construction. Furthermore, the traveling time for the people of Moheshkhali island to visit Coxsbazar would also be higher.

Option B would avoid this hilly forest area and would reduce the length of the approach road.

Option C is relatively close to the locality and the road connectivity is favourable. However, C is near to the open sea and to the confluence of the Bharuakhali khal downstream.

A relevant factor (driver) to consider in this assessment is the proximity to Coxsbazar Airport and to the 60 MW Wind Power Plant. OLS height restriction due to the proximity to the airport, has been thoroughly assessed. Option C, located 5 km from the airport, would fall within the funnel (conical surface) restricted area. This fact could pose issues during the construction of the bridge phase (use of high cranes). Options A and B fall totally outside of the funnel restriction area.

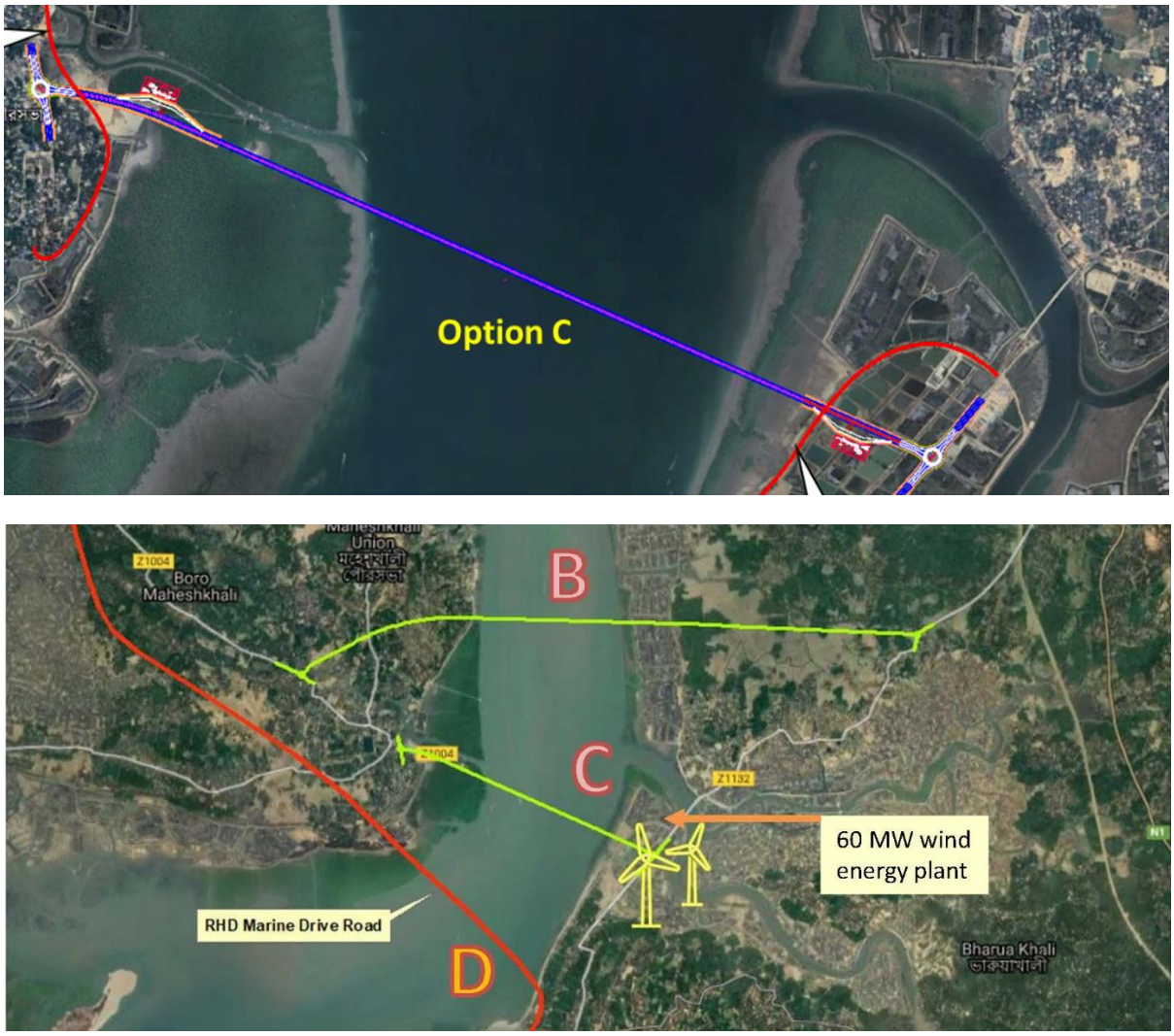

Figure 21. Option C alignment considered downsides.

4.2.2. Coxsbazar Airport Limitation (OLS)

As Coxsbazar Airport is situated at the d/s of Moheshkhali Channel, there is height restriction requirements to importantly consider. The next figure shows an Obstacle Limitation Surface (OLS) map by Civil Aviation Authority of Bangladesh. This map displays the height restrictions within the territory subject to its distance. Within the 4 km boundary line (at Inner Horizontal Surface) the maximum height of an obstacle should be 150 feet or 45 m. Similarly, the boundary line for the Outer Horizontal Surface is 15 km. There is a sloping zone in between inner horizontal surface and outer horizontal surface named as Conical Surface, which maintains a slope 1:20.

To assess the possible impact on the height limitation, the tentative deck level needs to be calculated. To estimate the deck level of the bridge, the Bridge Height itself, Height of the Light Post, Standard High-Water Level (SHWL), Vertical Navigational Clearence (VNC), Sea Level Rise (SLR) for future Climate Change scenario, and surge height is required. The total summation of all these factors should be less than the height restriction given by CAAB.

Deck level of the Bridge = Bridge height + SHWL + VNC + SLR + Height of Light Pole.

The estimated maximum elevation of the bridge might approximately be 48.1 mPWD. The elevation at the runway of airport is around 4.5 mPWD, so adding 45 m more to this elevation would mean 49.5 mPWD at the inner side of the conical surface, which would very close to the maximum level of bridge height (including light poles).

However, whilst the proposed three options will have a certain margin of safety, given by the slope 1:20 in the case of Option C, it has been assessed that this alignment could pose some risk during the temporary construction phase of the bridge, mainly due to the use of high cranes. To be in the safe side of this fact, option C was precluded as the recommended alignment.

Options A and B both fall out of the conical surface restricted area, where the height restriction is 150 m, hence 154.5 mPWD which entails a high level of safety for both, even during the temporary construction phase.

4.2.3. Alignment Selection Conclusion

After assessing the OLS restrictions considerations and rest of facts explained above, option B would be the optimum recommended alignment, whilst option C could be the second option viable. The latter might pose some risk during construction phase, and it is very close to the energy plant located on the Coxsbazar side of the bridge.

Another 4th option, related to the Marine Drive Project proposed bridge has been analysed with the next section 4.2.4.

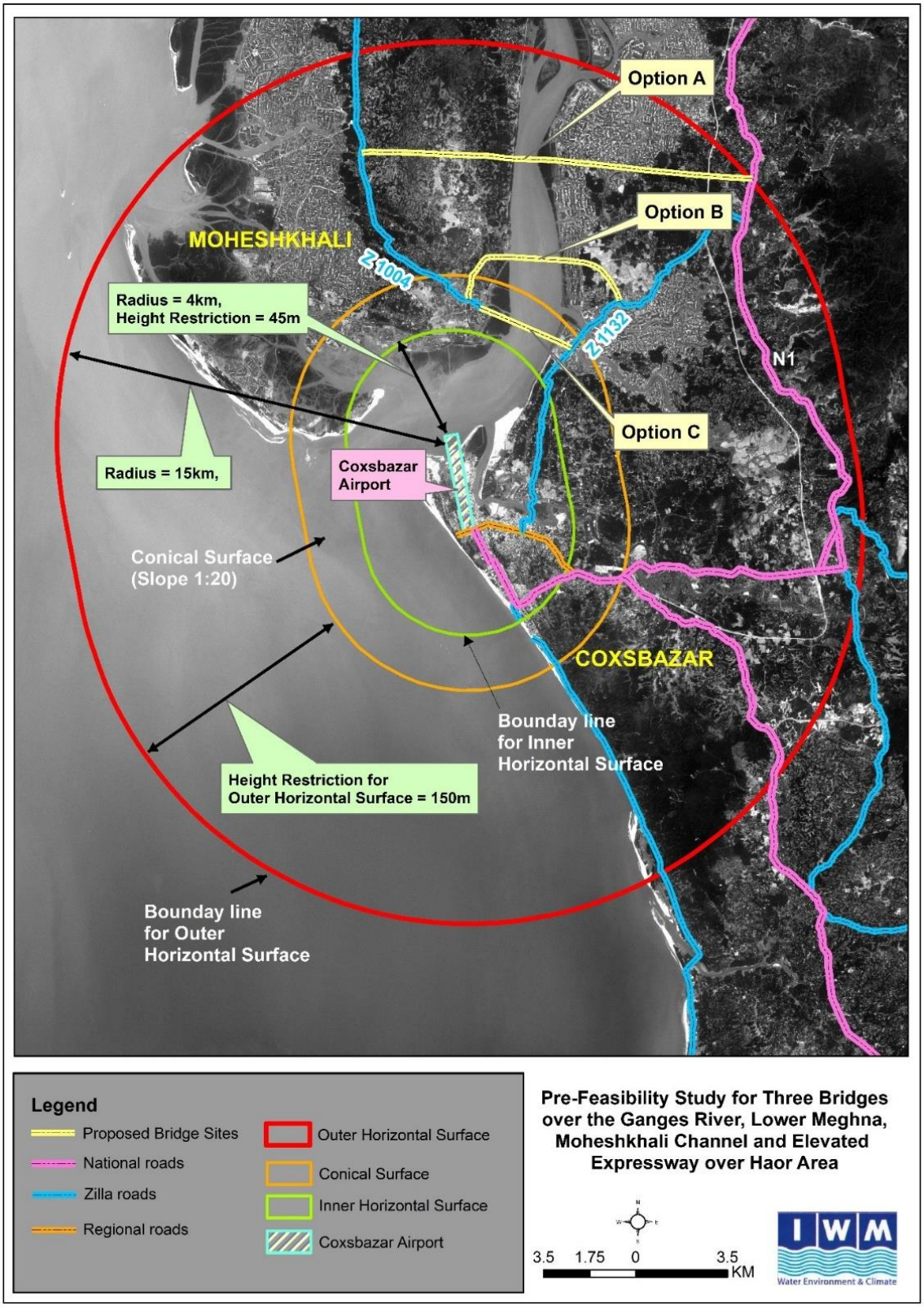

Figure 22. Coxsbazar Airport OLS (CAAB) height restriction surface.

4.2.4. Analysis of a 4th alignment (Option D) – RHD Marine Drive project:

The distance between riverbanks is around 1,500 m. Considering this, the length of the bridge shall be around 2,500 m including ramps. This is roughly the same as option B and option C bridge locations.

The bridge deck would need to be at level +26.0 (PWD) assuming Class I navigation requirements and +2.67 SHWL.

Coxsbazar Airport is located close to this option, around 3.00 km away from the location of option D, 1.5 km nearer than option C. This implies that option D location falls within the height restriction area, where the maximum allowed height is 45 m above the runaway platform, assumed at level lower than +4.50 m. Therefore, the construction of the option D bridge will be very limited for cranes and height construction equipment. The permitted height over the deck will be around 20 m, while the advised vertical clearance for heavy construction cranes should be around 50 m.

Once the bridge is operation, there would be restrictions to the type and condition of the lighting, to avoid any interference with the signalling of the runaway. Also, the risks involved in case of an accident of a landing or taking off plane are very high because of the potential consequences of the event. Aviation authorities need to be consulted, as the new infrastructure would be built within the 4 km area around the airport runaway.

Because of the height limitation of 20 m, neither cable stayed bridge typology, nor extradosed bridge with span over 150 m are feasible. The bridge type at this option D location shall be considered as balanced cantilever concrete box bridge, or steel truss bridge. Because of the proximity of the sea and the corrosion aggressiveness of the area, it is recommendable to consider the concrete material.

The bridge at option D location is crossing the deeper area of the section of the river under analysis, what involves extra cost and type for the foundations. While option B and C are crossing where the bathymetry depth is around 5 m and with an 8 m deep at the maximum depth, the option D finds most of the cross section around 8 m, and with a section of 400 m with water-depth up to 16 m (20 m deep with SHWL), close to the easter (left) riverbank. This deep area with much more depth than the surrounding area is a sign that the currents and scouring proneness are much higher. Therefore, option D involves higher hydro-morphology risks than the other proposed locations, with lower water velocity and lower scouring risks. The cost of the foundation in this area would be very high. Considering this, it is advised to design a long span over this area, around 400 m of span, that would require a cable stayed bridge; but this solution is not feasible because of the restrictions due to the proximity of the airport.

Other considerations about option D refer to its closeness to the sea (around 5 km), and therefore it is more exposed to strong winds and to corrosion aggressiveness.

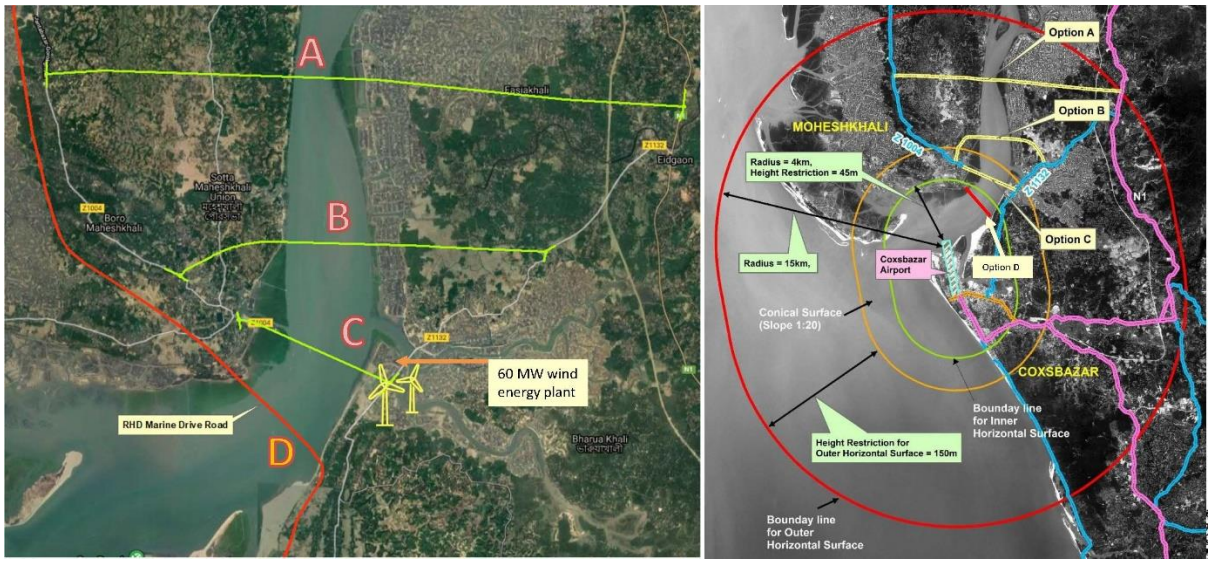

Figure 23. Image of Marine Drive Expressway and Coxsbazar Bridge.

Compatibility of proposed solutions B – C with the Marine Drive project.

Both solution B-C bridges are proposed connecting to Z1004 road at the west bank. Option C is close to the existing Moheshkhali Ghat, while option B is in a more open land. So, both are connected to existing connectivity infrastructures. Both solutions are feasible, while option B, considered as an isolated project, shows as more recommendable because it avoids the affection to the existing wind power plant, and it gives better connectivity to the N1 road.

The Marine Drive Road project runs parallel to the existing Z1004. With a little shift to the north at the edge close to the western riverbank, it could connect to the preferred location for the bridge, for option C (less than 1 km away) or B (less than 3 km away). The alignment of the Marine Drive could connect with the city area following the eastern riverbank in the same way as it was initially planned. For option B it would enjoy the additional benefit of the improved connectivity to the N1.

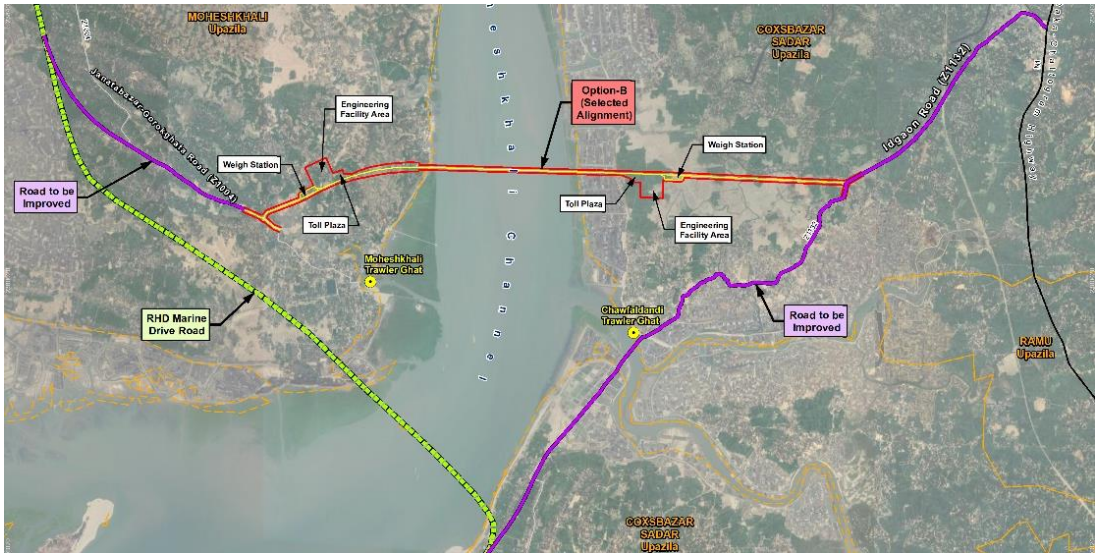

Figure 24. Image of Marine Drive Project and the roads connecting Alignment Option B.

Due to all the above considerations, option D bridge location was assessed to be a more costly option and entails a key downside related to its relevant interaction with the operation of the airport OLS implying important height restrictions.

Besides, this option would entail higher hydro-morphological disadvantages.

Option D therefore shall not be recommended as the optimum alignment option for the planned bridge.

4.3. Hydro-morphological Study

The hydro-morphological study was carried out by the Consultant team of experts with the collaboration of the local nominated subconsultant IWM.

The full report is included within the Main Report of this pre-feasibility study. Following is a summary of the hydrological study findings:

Table 15. Key hydraulic parameters.

Hydraulic Parameters	Unit	Values	Remarks
Design Discharge	m^3/s	10,815	For 1in100 flood event
Design High water Level	mPWD	3.086	For 1in100 flood event
Low water Level	mPWD	-3.71	Slope interpolation from observed data
Standard High Water Level	mPWD	2.73	Slope interpolation from calculation
Maximum velocity	m/s	1.95	Extracted from model and Calculation from Mannings eq^n (whichever is higher)
Average Bank Level	mPWD	1.75	from DEM and cross-section
Minimum Bed Level	mPWD	-8.41	Surveyed data during 2021
Bed material size, d_{50}	mm	0.05	Surveyed data
Water Depth	m	11.49	HFL-min bed level
Angle of attack	(degree)	86.5	Extracted from retrieved model
Fetch Length	m	2,253	Calculated
Wind Speed	m/s	80	Collected from BNBC 2020 map
Wave Height	m	1.84	Calculated from equation
Wave Period	s	3.4	Calculated from equation

- The proposed bridge site falls under Class II navigational route (as per BIWTA 2018 Gazette). However, considering the movement of heavier vessels in future (as there will be few mega Projects like Matarbari Deep Sea Port, Matarbari Coal Powerplant etc.), this route might be considered as Class I. It is mentioned worthy that the Navigational Clearance should be decided by the main authority (BIWTA).
- The Minimum Vertical Clearance from SHWL is 18.5 m (as per BIWTA 2024 Gazette)

- Using Lacey's regime scour depth formula, scour has been calculated and the computed scour depth is found to be 14.2 m. Hence, the maximum scoured depth in river is about 1.27 times of computed scour depth, which is 18 m, and the scour level is -14.9 mPWD.
- The local scour has been calculated using different empirical formulas, such as FHWA method, Laursen method, Breusers method etc. The maximum scour at the proposed site (Option B) is found to be 21.26 m using Laursen's method.
- Riverbank protection work for each alternative has been suggested based on planform change of river, historical bankline shifting, the present field condition and previously developed simulated model results. The length of the LGB is 1406m and RGB is 2392m.

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.

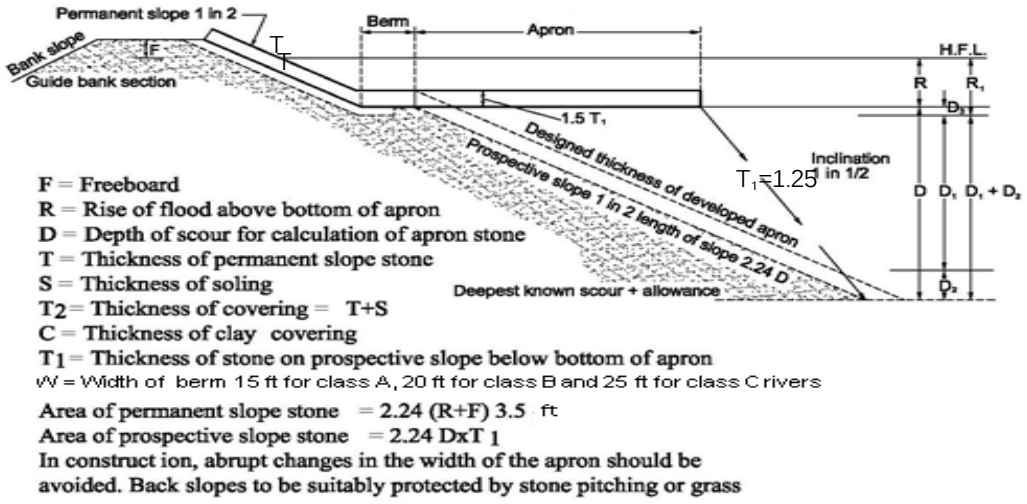

Figure 25. Proposed solution for the river training works.

Table 16. Length of bank protection works.

	Length of LGB (m)	Length of RGB (m)
Option A	1,372	1,649
Option B	1,406	2,392
Option C	1,595	1,493

Figure 26. Bank Protection Works for Option A.

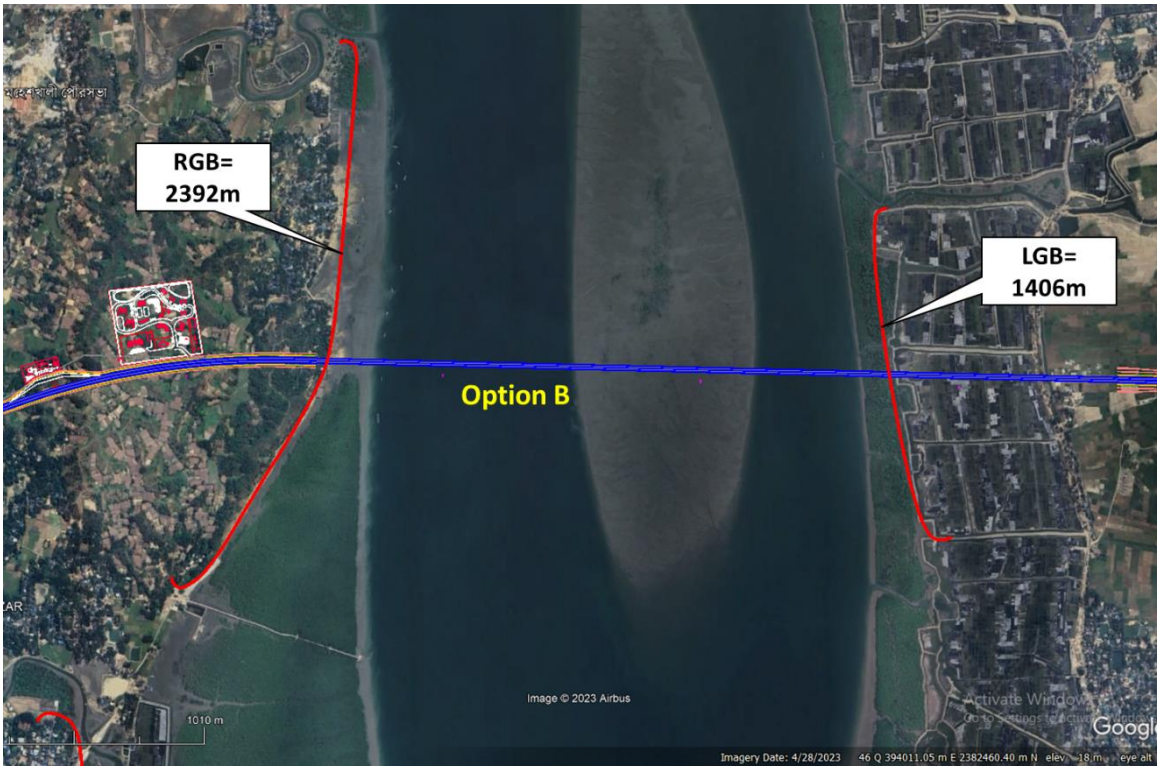

Figure 27. Bank Protection Works for Option B.

Figure 28. Bank Protection Works for Option C.

4.4. Fieldworks

The existing field conditions were assessed after the various site visits paid by the Consultant's team. These visits correspond to reconnaissance of the terrain, site and communities, to joint visits arranged with the BBA officials, special supervision of diverse works as geotechnical or topographical works, or regular supervision works done recurrently by the teams in charge or other that relevantly were carried out for this Pre-feasibility Study and reported accordingly.

Table 17. Site Visits Record.

No	Location Visited	Start Date	Finish Date	Purpose of the Trip or Site Visit	Consultant JV Participants
1	Coxsbazar and Moheshkhali	15 10 2023	17 10 2023	To visit the projects site in the concerned area to undertake a full environmental and social assessment and a complete reconnaissance task	A team composed by Environmental Lead expert, Social Safeguard lead expert, Resettlement Specialist, socio-ecological Expert and Survey Expert
2	Coxsbazar and Moheshkhali	22 10 2023	26 10 2023	To meet with company coordination issues regarding utilities interface with the bridge project.	Utilities Interface coordination team

4.4.1. Topographical Survey

At the preferred pre-selected option, a topographical survey was carried out along the proposed alignment using GPS (Static Method) and Total Station. The other two options have been analysed by the use of aerial images for a preliminary alignment study.

The preliminary alignment for the proposed new approach roads, on either side of the bridge, was designed as per the findings of the surveys undertaken by BSO Associates Ltd. (BSO) during the months of September and October of 2023.

The scope of work 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.
- Cross Section Survey.
- Preparation of the report and maps.

4.4.2. Geotechnical Investigation

In order 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 Geotechnical Investigation of this pre-feasibility study comprised of drilling of two boreholes (CMBH-1 and CMBH-02) during the period between October 14th 2023 to October 26th 2023.

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

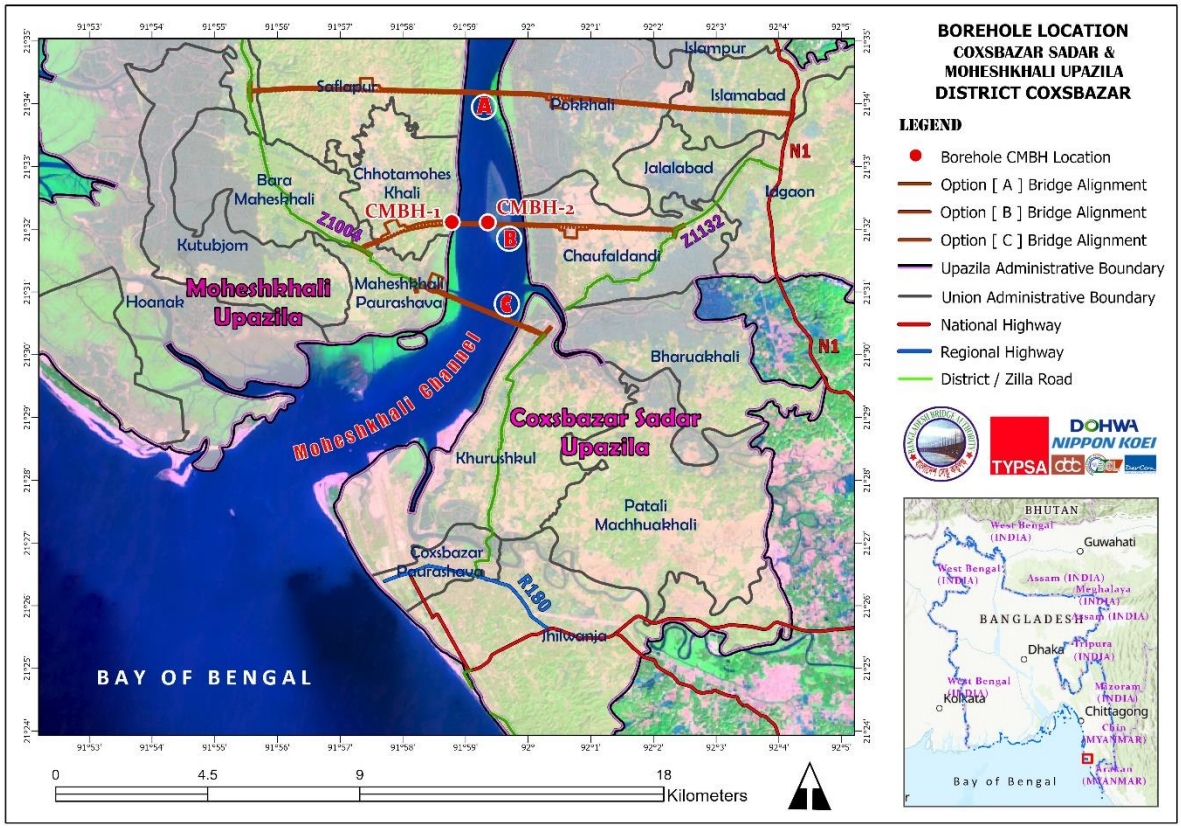

Figure 29. Location of the geotechnical survey boreholes.

4.4.3. Existing Utilities

Aiming to identify 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 Bidyut Samity (PBS) Coxs bazar, US-DK Green Energy (BD) Lted. 60 MW Wind Energy Project, and cell phone towers network.After the site visit and the data collection, it may be concluded that the project would have some impact on some existing utilities that will need further coordination and budget allocation.

4.5. Proposed Engineering Solution

The final proposed solution for the bridge over the Moheshkhali Channel is based on **Balanced Cantilever Bridge with span arrangement of 110 + 9 x 200 + 110 m over the class I navigation area.** The total length of the bridge including access spans is **2.50 km**.

Figure 30. Image of the proposed balanced cantilever bridge.

The foundation of the piers for the central section, most of which are planned to be executed in wet conditions, have been estimated to require 12 reinforced concrete bored piles Φ3.0 m of 105m in length. Further development of the current calculation during detailed design may allow for the use of a different diameter for the reinforced concrete bored piles. For the approach spans with I girders, the foundation has been estimated to require 4 reinforced concrete bored piles Φ1.80m of 70m 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.

Three alignment options were studied and compared for the Coxsbazar-Moheshkhali crossing. For each alignment, three bridge typologies were assesed.

Amongst the study of structural alternatives that was carried out, the steel truss with a span configuration of nx200m was considered and thoroughly assessed. A detailed analysis was carried out, analyzing the bridge typology, alignment level required, construction period and cost comparison. Taking these aspects into account, truss bridge alternative was found to be less suitable than balanced cantilever bridge. The proximity to the sea must be considered also a negative factor in the case of the steel truss option.

A third option was studied, consisting in an extradosed bridge structural option, which was the recommended option for the alignment C.

The following sections define the standards, conditioning factors and main characteristics of each typology considered in the design of the bridge and the different areas of study involved in the determination of the most suitable solution.

Table 18. Bridge length distribution for Coxsbazar-Moheshkhali project.

Stretch	Length (m)
West Ramp	160
Class I Main Bridge	**2,020**
East Ramp	320
Total ramp/connecting spans length	480
Total Class I spans length	2,020
Total Bridge Length	**2,500**

Figure 31. Image of accessing spans proposed for Coxsbazar-Moheshkhali.

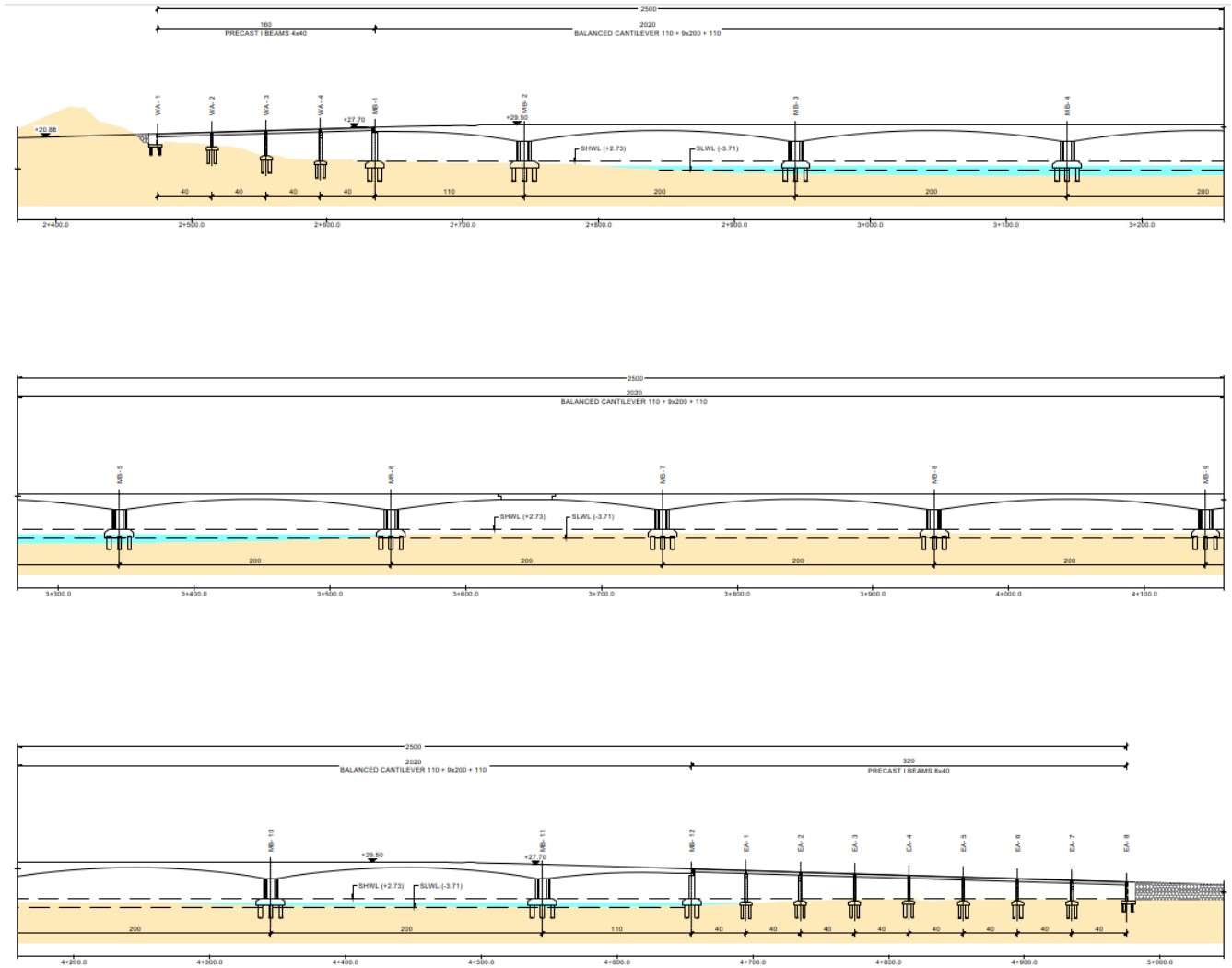

Figure 32. Elevation of main section of the bridge.

4.6. Approach Roads

The provision of a bridge over Moheshkhali Channel will improve the communication between the East part (Coxsbazar Sadar of Coxsbazar District) and the West part (Moheshkhali Upazila of Coxsbazar District) of the river connecting the Zilla Road Z1004 and Zilla Road Z1132.

Three alignments have been examined connecting the existing roads (A, B and C) as shown in the image below.

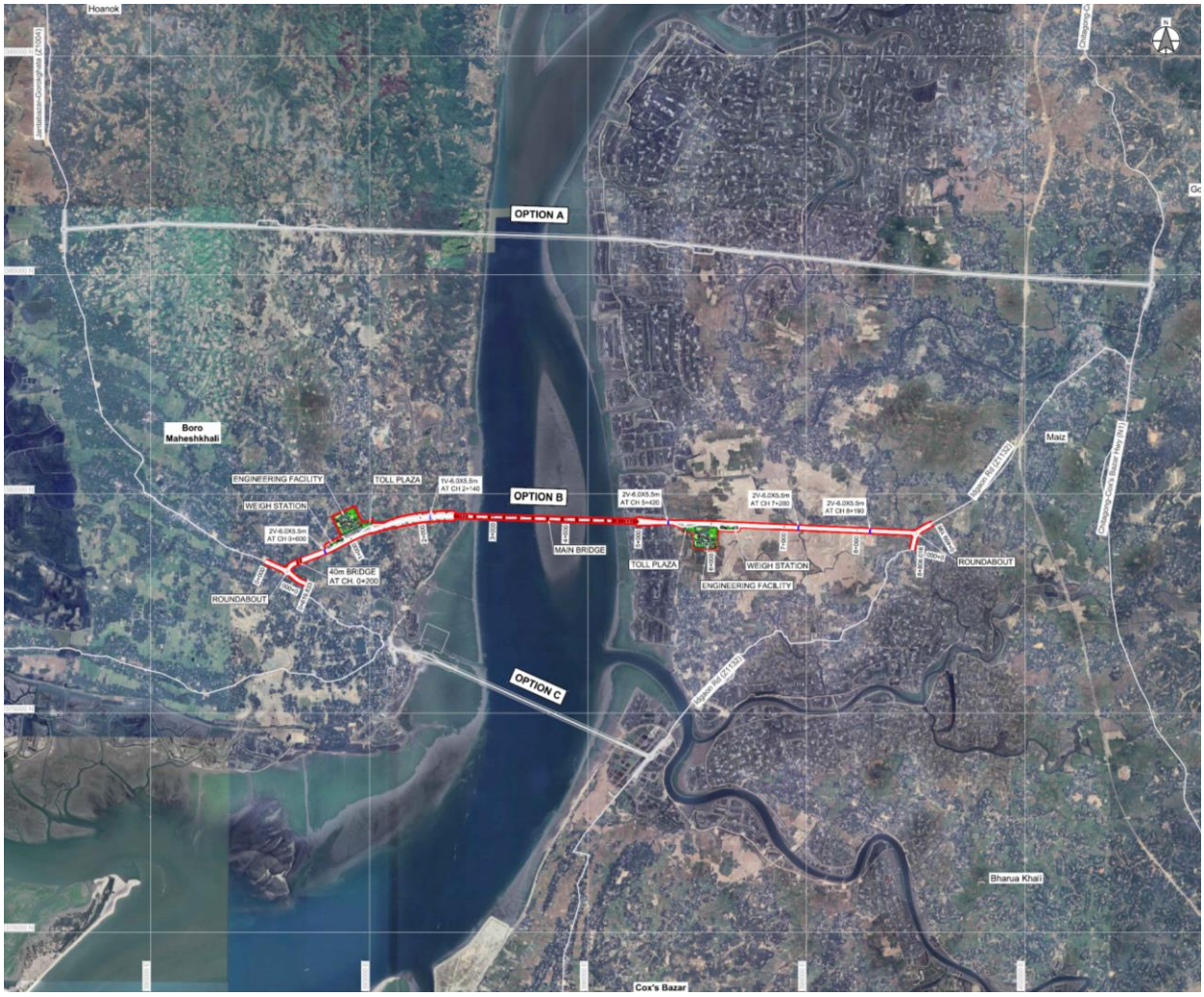

Figure 33. Proposed alignment Option B.

Figure 34. Proposed roads improvement to connect Alignment B with the MDP.

A preliminary analysis of these three alternatives was carried out to select the preferred location for undertaking the fieldworks being the Option B, the selected alignment. The bridge approaches comprise some 6.295 km of road to link the bridge to the Z1004 and Z1132.

Short Description for Proposed Roads to be Improved

There are two existing roads which need to be improved to connect with the proposed Marine Drive Road. One road is situated on the Moheshkhali side, and another one is on the Coxsbazar side. The proposed improved road on the Moheshkhali side is the existing RHD district road (Z1004) which starts from Janatabazar and ends to Gorokghata. The existing road is now a single lane which needs to be improved to 4 lanes preferably but at least standard 2 lanes (crest width 13 m). The proposed road needs to be diverted and connected with Marine Drive Road to ensure better communication.

The other existing road is also RHD district road (Z1132) which starts from Chattogram-Coxsbazar Highway Eidgaon bus stand and ends to Romalirchara main road (R180). It is now a single land road which needs to be improved to 4 lanes preferably but at least standard 2 lanes (crest width 13 m). The road needs to divert from Rastar Para, Khurushkul to connect with Marine Drive Road.

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.

Table 19. Road 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

The cost estimate for the three studied alignment options is shown in the following table:

Table 20. Summary of preliminary cost estimation.

No.	Item	Alignment Option A	Alignment Option B PRE-SELECTED	Alignment Option C
		Amount (Cr BDT)	Amount (Cr BDT)	Amount (Cr BDT)
1	General and Site Facilities	326.76	341.53	367.33
2	Main Span (Balance Cantilever)	1,381.00	2,537.36	2,587.00
3	Approach Bridges	381.00	207.80	381.00
4	Approach Road including small structures	1,864.83	1,085.88	647.66
5	Toll Plaza & Engineering Facilities (*)	564.21	564.21	364.78
6	Bank Protection Work	1,607.72	1,450.51	1,631.35
(A)	**Subtotal**	**6,125.52**	**6,187.29**	**5,979.11**
(B)	Provisional Sum for Physical Contingency = 3% of (A)	183.77	185.62	179.37
(C)	**Sub Total (A+B)**	**6,309.29**	**6,372.91**	**6,158.49**
(D)	Provisional Sum for Price Contingency = 6% of (C)	378.56	382.37	369.51
(E)	Engineer's Estimate = (C+D)	6,687.84	6,755.29	6,528.00
(F)	**Land Acquisition and Resettlement Costs**	**1,182.84**	**786.32**	**462.59**
(G)	Design Cost = 2% of (A)	122.51	123.75	119.58
(H)	Construction Supervision = 5% of (A)	306.28	309.36	298.96
(I)	**Project Estimate = (E+F+G+H)**	**8,299.47**	**7,974.72**	**7,409.12**

4.8. Implementation Timeline

The estimated implementation timeline, in accordance with conversations held with BBA officials is:

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 m.**
- Y0 from October 2025 to December 2026 - DPP implementation - Procurement process for Detailed Design and RAP+LAP implementation / **15 m.**

TOTAL ROJECT INVESTMENT PERIOD BEFORE OPERATION: 6Y

- Project Detailed Design Phase, including RAP and LAP implementation phase and Main Contractor Tender Process / **18 m** - from January 2027 to July 2028.
- Construction period incl. Testing+commissioning / **54 m** - from July 2028 to December 2032.
- Defects Notification Period (DNP 1 year) January 2033 to December 2033

Total PROJECT OPERATION PERIOD: 30 Y = January 2033 to December 2062

TOTAL PROJECT PERIOD: 30 + 6 = 36 Y

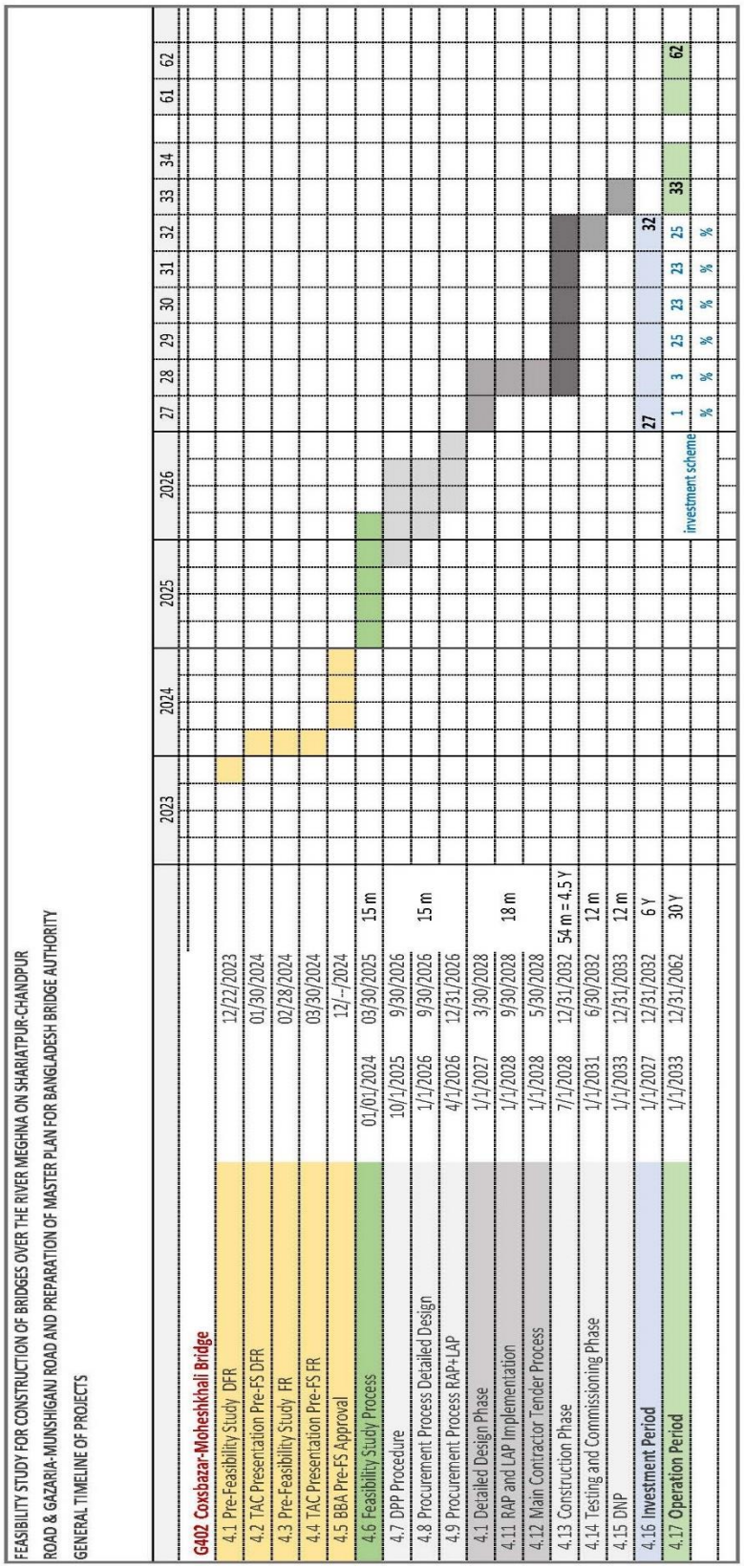

Figure 35. Project implementation proposed timeline.

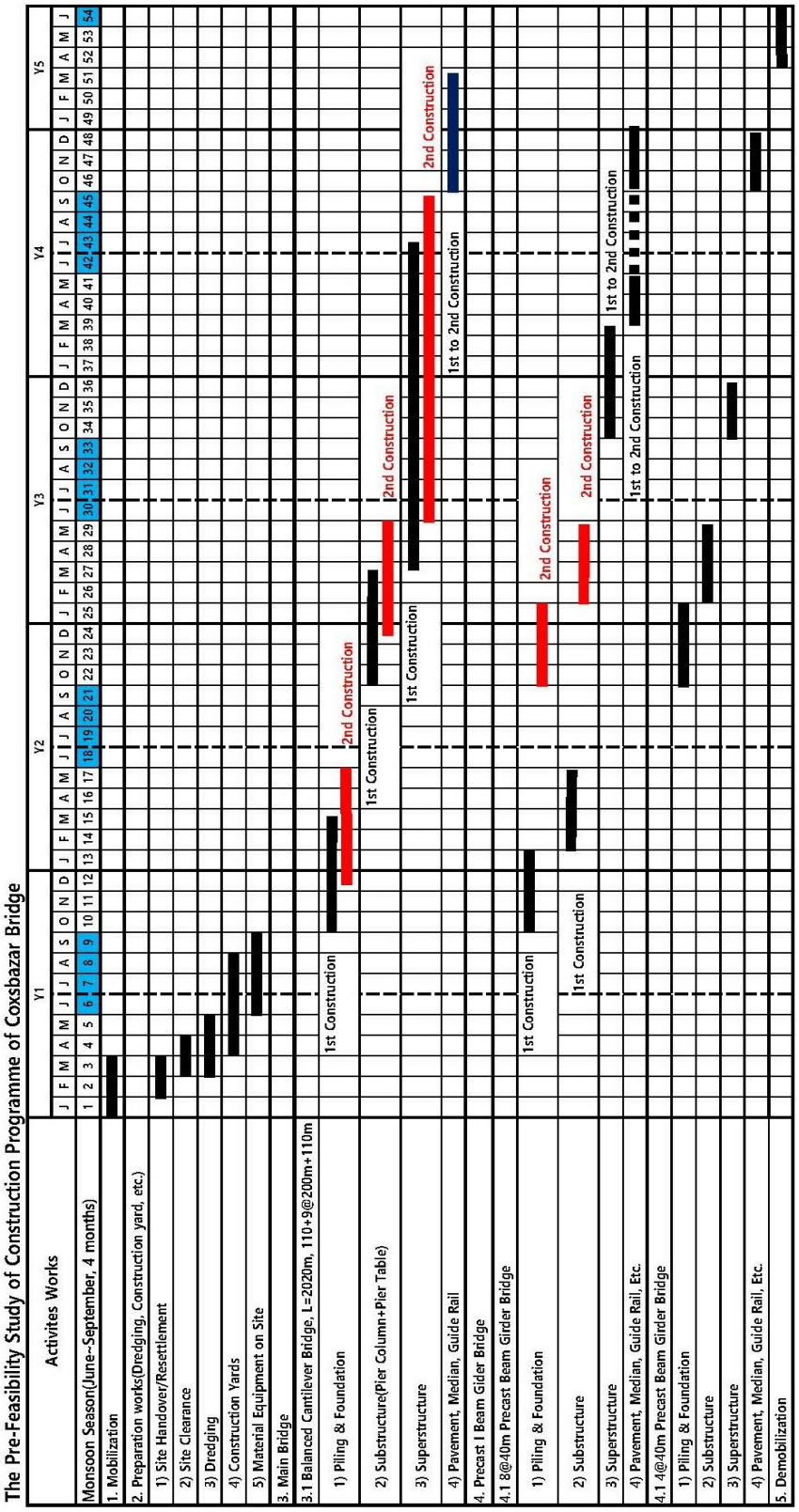

Figure 36. Project construction work programme.

5. ENVIRONMENTAL SUSTAINABILITY, CLIMATE RESILIENCE AND DISASTER RISK ANALYSIS

5.1. Environmental, Climate Change and Disaster Risk Analysis

The Coxsbazar-Moheshkhali Bridge project has been assessed to pose some environmental risks. Some of these are only anticipated in the construction phase while the others are anticipated during 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. By the use of 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 Assessment have been undertaken through a series of consultations and review sessions. The principals 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. Induced Environmental Impacts at Regional Level

The Induced Environmental Impacts at Regional Level due to the project has been presented in the following table and are developed within the main report in full detail.

Table 21: Environmental Scoping Matrix-Impacts due to Project.

Items	Without Mitigation	With Mitigation	When to Implement (Project Stage)
A) NATURAL ENVIRONMENT			
• *Physico-Chemical Recourses*			
Regional Hydrology	-2	2	Design
River Erosion and Siltation	-2	2	Design, Construction and Operation & Management (O&M)
Drainage Congestion	-2	2	Design and Construction
Air Pollution	-2	3	Design, Construction and O&M
Surface Water Pollution	-2	2	Design, Construction and O&M
Ground Water Pollution	-1	2	Design, Construction and O&M
Noise & Vibration	-2	2	Design, Construction and O&M
Soil Contamination	-1	1	Design, Construction and O&M
Waste (General & Construction)	-1	2	Design, Construction and O&M
• *Ecological Resources*			
Trees/Vegetation	-2	3	Pre-construction and O&M
Wildlife	-1	1	Design and Construction
Environmental Sensitive Areas	-1	1	No environmental sensitive areas in and around the project area
B) HUMAN/SOCIAL ENVIRONMENT			
• *Socio-Economic Resources*			
Land acquisition	-2	1	Pre-construction
Homestead	-2	-1	Pre-construction
Commerce	-2	3	Pre-construction
Industry	-2	3	Construction and operation
Agriculture	-1	2	Pre-construction
Fisheries	-1	2	Pre-construction and O&M
Job opportunities	-2	3	Construction
Community spilt	-2	-1	Design and Construction
Health and safety	-2	3	Design, Construction and O&M

Items	Without Mitigation	With Mitigation	When to Implement (Project Stage)
Navigation/ boat communication	-2	3	Design, Construction and O&M
Transport facilities	-2	3	O&M
Cultural & Historical heritage	-1	1	Design and Construction
Landscape	-1	2	Design, Construction and O&M
Environmental Risks (cyclone and earthquake and road accident)	-2	2	Design, Construction and P&M
Total Score	- 43	+49	

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 Resilience 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 in 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 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.

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.

5.5. EMP Cost

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 2.98 Cr BDT.

5.6. Environmental Study Conclusion

Environmental aspects have been incorporated in the design of the project. A balanced cantilever bridge has been proposed 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.

The project needs further environmental assessment as Environmental Impact Assessment (EIA) according to ECR 2023.

The 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 is estimated that around 308.60 acres of land will require acquisition for the project. A total of 130 project affected structures (Household, business and CPRs), will be affected by losing their immoveable assets. Apart from the primary structures a significant quantity of secondary structures will also be affected. All these impacts are compensated as per ARIPA, 2017.

A total of 2,090 nos. of trees would be affected due to the project. This loss can be mitigated by plantation of trees seedlings and 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 will be having length of more than 500 m in each instance, so it is in red category as per DoE, GoB and require environmental clearance from DoE, GoB. Which require various documents – IEE is one of them.

The impacts during construction can easily be mitigated by taking advance adequate precautions and some additional measures appropriate to the construction. An EMP has been formulated to control/ mitigate the negative impacts arising from construction related activities. Contractors will be directed to follow the mitigation measures mentioned in the EMP provided in the report. Consultants will check and ensure that EMP is working well according to the plan.

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. The impact on housing and commercial structures can be compensated by providing adequate compensations and alternative job opportunities as per RAP.

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

6. SOCIAL SAFEGUARD ASSESSMENT

6.1. Project Area and Socio-economic Profile

After carrying the Social Impact Assessment (SIA), by the Consultant team of experts and the specialized subconsultant (KMC), it has been estimated that land acquisition needed for Option A would be 365.76 Acres, land acquisition requirement for **Option B would amount to 308.60 Acres** and the Option C would involve a relatively smaller quantity of land acquisition 139.75 Acres.

The project affected units for Option A would be 172, Option B 130, and Option C with 53. Including CPRs for Option A 12, Option B 6, and Option C only 4. The above units' signifying effects on the different categories of primary structure; totaling 219,299 sq ft in A, 14,1571 sq ft in B and 85,550 sq ft in C and secondary structure also found in both A, B and C. respectively.

In addition, 8,846 and 10,817 trees in A and B will be affected along affected areas, and there is a signifying number of trees affected in option C (which is under government land).

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 Coxsbazar-Moheshkhali 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.

Alternative Analysis of Coxsbazar Side

Alternative Analysis of Option-A: The proposed Option-A introduces a new alignment for the bridge and approach road, connecting Sadar Upazila and Eidgaon Upazila from Coxsbazar-Chokoria Road. The implementation of this option necessitates land acquisition, impacting various aspects such as agricultural land, water bodies, and both commercial and residential establishments. The developmental activities associated with the bridge and road construction will bring about changes in the affected areas.

Alternative Analysis of Option-B: The starting point for Option-B is at Uttarpara village, Ward No-7, Chapaldondi Union of Sadar Upazila Coxsbazar. The road traverses through Ward 4, 5, 6, and 7 of villages like Uttarpara, Sikdarpara, Hyderpara, and Chofoldondi. These areas predominantly consist of vacant land, with no houses or shops found. On the right side, there is a hilly area, graveyard, and mostly vacant or paddy fields, with some eucalyptus trees that may be affected.

Alternative Analysis of Option-C: Option-C starts from Kurushkul village, Kurushkul Union, Sadar Upazila, Coxsbazar. The area around the starting point is notable for Chingri production Gher on both sides of the road. To the east, there is a mangrove forest, while to the west, there are extensive Ghers for salt and Chingri production. In the south, the road leads to Coxsbazar town and the sea, while in the north, it connects with Chofoldondi Union, Eidgaon Union, and the upazila, meeting the highway road.

Alternative Analysis of Moheshkhali Side

Alternative Analysis of Option-A: In the Moheshkhali part of Option-A, the alignment is situated at Rabibazar, Panirchora, and Zila Road of Z1004. Noteworthy features include a roundabout with a north-side Zila Road connected to Koila Biddut Kendro of Matarbari-Chokoria and Dhaka. To the south, Panirchora Bazar and several commercial shops/houses/CPRs exist. The western side features houses and the Kaladia River, while the eastern side is characterized by the presence of Shaplapur Union.This reconnaissance information provides a preliminary insight into the current landscape and potential impacts of Option-A on both Coxesbazar and Moheshkhali areas, setting the stage for further analysis and evaluation.

Alternative Analysis of Option-B: From the roundabout, heading north, there is a large Putibila Graveyard, but the alignment is planned to pass along the side of the graveyard. On the south side, there are villages such as Putivila, 2 No Ward Yar Mohammad Para, 3 No Ward Putibila, and Dasi Majhipara. Approximately 115/120 households, structures, and community property resources (CPRs) are likely to be affected. This alignment connects towards Coxsbazar and the Moheshkhali road, crucial for the export of salt, dry fish, and pan from the Bak Khali river to various districts.

Alternative Analysis of Option-C: Starting from Gorokghata village in the municipality or pourashava of the Sadar Upazila of Moheshkhali, Option-C intersects with the Jetty Ghat Road. This road, close to the option, passes through the mangrove forest along the Bak Khali River. The starting point of the option is near the Jetty Ghat Road, where approximately 8/10 households and numerous commercial shops may be affected in government land. The Jetty Ghat Road connects Matarbari, Chokoria, the left side of the sea, and the right side of Bak Khali River.

Table 22. Summary of project's social Impacts.

Sl. No.	Project Impacts	Option A	Option B	Option C
A	Land Use Survey			
A.1.1	Bridge Approach land in Acres	233.76	176.60	19.75
A.1.2	Land for other purposes in Acres	132	132	120
A.1.3	**Total land acquisition is required in Acres**	**365.76**	**308.60**	**139.75**
B	Number of Mouza	6	5	2
C	**Number of Household**	**160**	**124**	**49**
C1	Number of Male Headed Household	150	109	48
C2	Number of Female Headed Household	10	15	1
D	Total number of Project Affected Units	172	130	53
D1	Number of HH with Residence	110	87	1
D2	Number of HH with Business	45	34	45
D3	Number of HH with Residence and Business	5	3	3
D4	Number of CPRs affected	12	6	4
E	Total number of affected persons	740	548	160
E1	Total number of Male affected people	440	307	97
E2	Total number of Female affected people	300	241	63
F	Number of Rented businesses affected	64	56	74
G	Number of Rented Residence	6	3	0
H	Number of Employee affected	4	13	10
I	Number of trees affected	8846	10817	*-[2]
J	Number of primary structures affected	198	147	55
K	Area (Sft) of primary structure affected	219299	141571	85050
L	**Recognizing the advantages of the project**			
L1	Number of tentative districts receiving benefits from the bridge		27	
L2	Number of tentative Upazilas experiencing benefits from the bridge		216	
L3	Number of residents deriving benefits from the bridge.		96,291,034	
M	**Utility Line Identification Survey**			

[2] *Total number of affected trees are around 90,000 which are under Govt. Forest Department. So no compensation will required for social purposes.*

Sl. No.	Project Impacts	Option A	Option B	Option C
M1	Optical Fiber Cable Installation Routes	0	0	0
M2	Electrical Poles Network	45	22	10
M3	High-Voltage Power Transmission Structure	0	0	0
M4	High-Pressure Gas Pipeline Network	0	0	0
M5	Water Supply Pipeline Infrastructure	0	0	0
Q2	Advancing Regional Connectivity	Yes	Yes	Yes
Q3	Boosting Business Prospects, Product Promotion, and More	Yes	Yes	Yes
Q4	Enhanced Access to Healthcare Facilities	Yes	Yes	Yes
Q5	Enhanced Access to Educational Facilities	Yes	Yes	Yes

6.3. Estimated LAP and RAP Cost

Table 23. Overall RAP and LAP estimated cost.

Summary of LAP and RAP estimated cost (BDT)						
Items	Total Quantity (Acres)			Estimated Budget (BDT)		
	Option A	Option B	Option C	Option A	Option B	Option C
Cost of Land in Acres	233.76	176.61	19.75	5,730,975,852	2,344,212,756	727,202,112
Land for other purposes in Acres	132	132	120	3,677,523,637	3,677,523,637	3,134,269,562
Proposed total Land	**365.76**	**308.60**	**139.75**	**9,408,499,489**	**6,021,736,393**	**3,861,471,674**
Cost for primary & Secondary Structures (sft and Rft)	222,740	142,865	232,125	562,733,236	296,388,652	304,785,104
Cost estimate of Trees	10,602	2,090	-	71,181,760	19,476,200	-
Sub Total A (BDT)				10,042,414,485	6,337,601,245	4,166,256,778
Cost for other purposes						
Utility shifting (Electrical pole in No)	45	22	10	2,500,000	1,500,000	1,000,000
Provision for construction of resettlement area	LS	LS	LS	100,000,000	100,000,000	100,000,000

Summary of LAP and RAP estimated cost (BDT)						
Items	Total Quantity (Acres)			Estimated Budget (BDT)		
	Option A	Option B	Option C	Option A	Option B	Option C
Other Resettlement Benefits (Stamp Duty Reg. STG and SRG)	LS	LS	LS	859,646,378	859,646,378	6,000,000
Operation cost for RAP Implementing Agency /INGO	LS	LS	LS	40,000,000	40,000,000	40,000,000
Operation cost of External Monitoring Agency	LS	LS	LS	10,000,000	10,000,000	10,000,000
Sub Total B				1,012,146,378	1,011,146,378	157,000,000
Total (A+B)				11,054,560,863	7,348,747,623	4,323,256,778
Administrative and Contingency cost @% 7%				773,819,260	514,412,334	302,627,974
Grand Total (BDT)				11,828,380,123	7,863,159,957	4,625,884,752

7. ECONOMIC AND FINANCIAL ANALYSIS

7.1. Economic Analysis

In this section the Consultant presents **the socio-economic evaluation of the Coxsbazar-Moheshkhali bridge project.** Economic analysis or Cost-Benefit Analysis (CBA) is a method to evaluate the profitability of a project from a socio-economic point of view, by quantifying the costs and benefits of an investment project in monetary terms to allocate society resources in an efficient way[3].

7.1.1. Methodology

7.1.1.1. Incremental Scenarios for Appraisal

Prior to any economic estimation on a project requiring investments or benefits what is needed is a description of the potential trends and projections of results under an **incremental approach.** That is, estimating those effects when carrying out the project with respect to a reference scenario ("without project" scenario, or counterfactual scenario of not implementing the bridge program):

- ***"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.
- ***"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.

7.1.1.2. Key Economic Impacts

The following illustration framework of the calculation process addresses the below set of **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 37. Economic analysis by categories of impacts.

7.1.2. Project Capital Expenses

Required project capital expenses are basically composed of the main infrastructure components of the crossing and its access roads at both sides, Coxsbazar and Moheshkhali. The table below

[3] 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.

summarizes some basic elements that compose capital expenses. These costs are indicated without VAT and based (capitalized accordingly) on year 2027, when the estimation is carried out:

Table 24. Basic elements of the total project Capex (2027 monetary units).

Number	Item	Cr BDT
1	General and Site Facilities	359.08
2	Main Bridge (Balance Cantilever)	2,667.76
3	Approach Bridges	218.48
4	Approach Road including small structures	1,141.69
5	Toll Plaza & Engineering Facilities	593.21
6	Bank Protection Work	1,525.06
7	Provisional Sum for Physical Contingency	195.16
8	Provisional Sum for Price Contingency	402.03
9	Land Acquisition and Resettlement Costs	888.73
10	Design Cost	121.62
11	Construction Supervision)	304.05
	TOTAL	8,416.86

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

Table 25. Capital expenses deployment with project.

	2027	2028	2029	2030	2031	2032
Split by year of the CAPEX	1%	3%	25%	23%	23%	25%

7.1.3. Other Assumptions

7.1.3.1. Period of Analysis

The base year for study projections has been set in 2027 (1st January) and the horizon year in 2062 (31st December)

- Total Investments period: 6 years (2027 – 2032)
- Total operations period: 30 years (2033 – 2062)

7.1.3.2. Value of Time (VoT)

Value of time is one of the most determining inputs that are related with project appraisal. Since the bridge project offers significant time savings, the value of time helps to estimate an important part of the potential benefits of the project from the user point of view.

Table 26. Values for VoT.

Mode	VoT BDT/pass-h (2022)	VoT BDT/pass-h (2027)
Motorcycles	94.35 BDT/pass-h	113.06 BDT/pass-h
Light vehicles	105.45 BDT/pass-h	126.36 BDT/pass-h
Buses	83.25 BDT/pass-h	99.76 BDT/pass-h
Truck	3.89 BDT/ton-h	4.66 BDT/ton-h

7.1.3.3. 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 27. Vehicle operating costs by mode.

Mode	BDT / veh – km (2022)	BDT / veh – km (2027)
Motorcycles	11.10	14.48
Light vehicles	15.54	20.28
Buses	33.30	43.45
Truck	44.40	57.94

7.1.3.4. Externalities

Costing estimation for externalities was undertaken using data extracted from "*Update of the Handbook on External Costs of Transport" – European Commission – 2019*[4]. This Handbook summarizes the external costs, providing a cost expressed in economic units for each vehicle or passenger per km:

Table 28. 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	5.19	0.48	0.38	0.22
Light vehicles	1.82	0.47	0.77	0.25
Buses	0.40	5.86	3.54	1.16
Trucks	0.51	3.83	2.65	1.02

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

7.1.3.5. 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 29. 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	32.23	22.28	377.10	10.65
With project	21.84	10.49	318.62	4.29
Time Savings	**10.39**	**11.80**	**58.48**	**6.36**

Table 30. 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	815.23	162.84	559.23	15.61	**1,552.91**
With project	802.10	155.97	559.34	16.05	**1,533.46**
Distance Savings	**13.13**	**6.87**	**-0.12**	**-0.45**	**19.43**

7.1.4. Economic Analysis Conclusion

7.1.4.1. Projection of Economic Flows

The projection of economic flows for the different years considered in the period have been estimated and projected (in Cr BDT). They are represented in the following subsections.

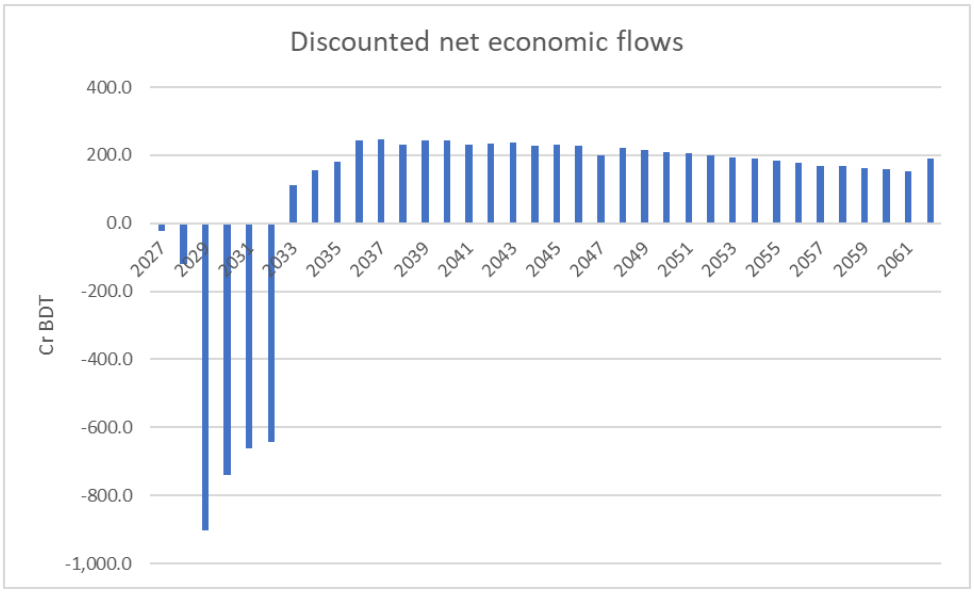

Figure 38. Discounted economic flows.

The main net costs arise during construction period (2027 - 2032) and then, during the first operations years, flows start to become positive and grow yearly[5]. When cumulative discounted flows are represented, it is observed that after some construction outflows the cumulative flow reaches a minimum peak financing (in 2031) and then with increasing operation growth the cumulative economic flows increase.

The cumulative discounted net economic flows reach zero between 2046 and 2047 and turn into positive values from 2047 onwards, as it can be seen below.

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

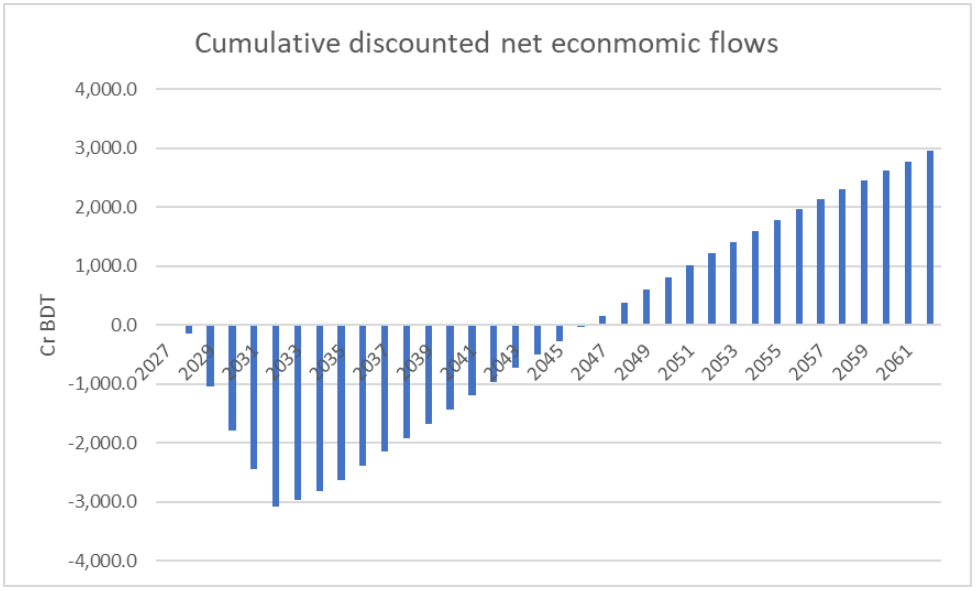

Figure 39. Discounted economic flows.

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 80%.

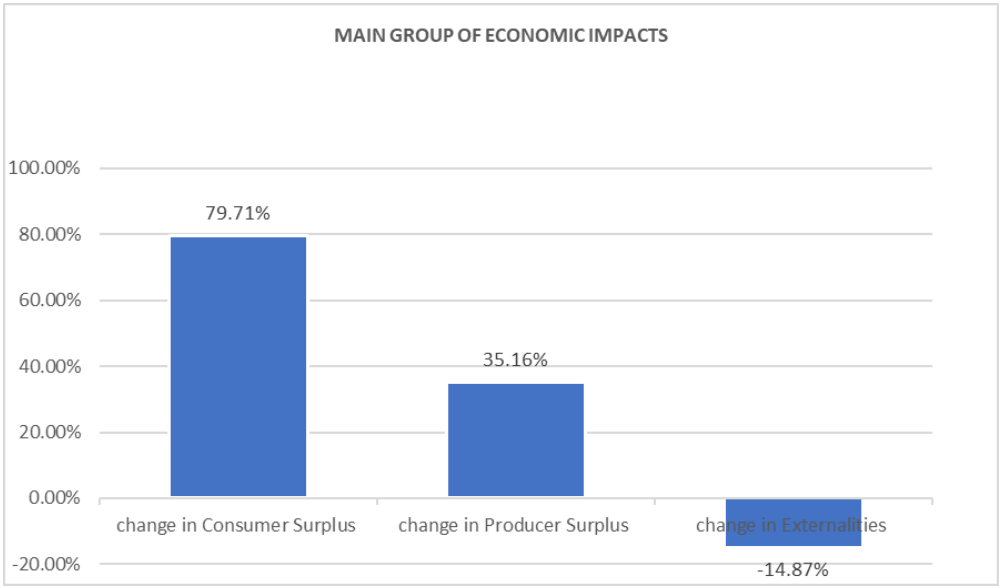

Figure 40. Main group of economic impacts.

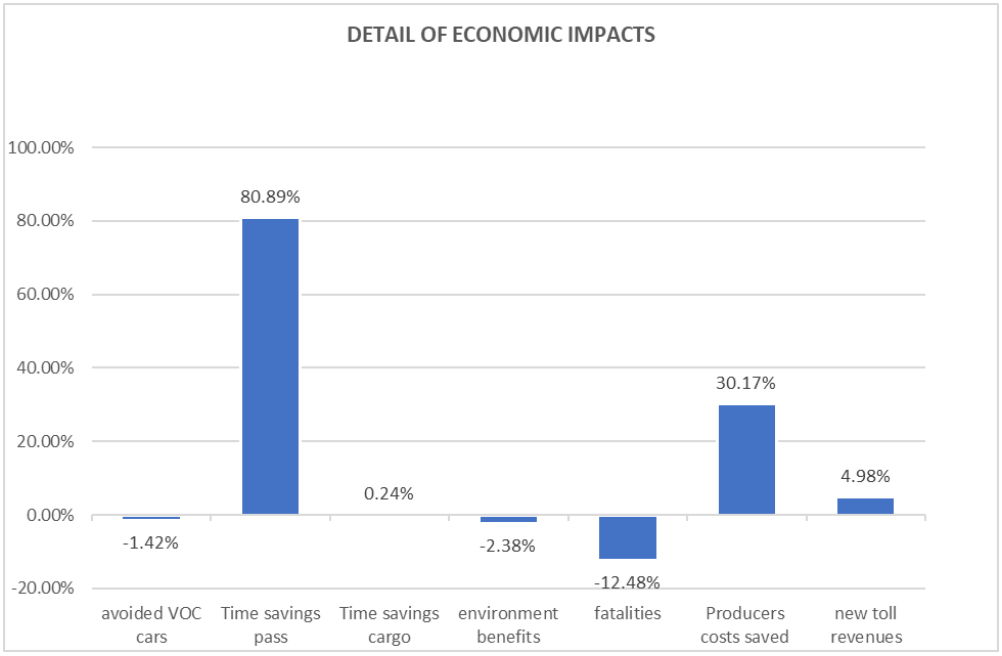

Figure 41. Main group of economic impacts.

7.1.4.2. CBA Analysis Conclusion

With the assumptions and the results obtained from the CBA model, it could be concluded that the Coxsbazar-Moheshkhali bridge would be a feasible project from a socio-economic point of view. All economic indicators show a positive potential impact in economic terms:

Table 31. Summary of results of CBA model.

Economic Net Present Value (Cr BDT):	2,960.46
Economic Internal Rate of Return (E-IRR):	17.03%
Benefit / Cost ratio	2.82
Pay back (year)	2047

The project is essentially intended to save time for road and ferry users since that is the main positive impact derived from project implementation.[6]

[6] *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

As part of the pre-feasibility studies of the Coxsbazar bridge project ("the 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. Said 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

First, the implementation period considers the total investment budget of Option B, which amounts 7,974.7 Cr BDT, VAT included, while total budget increased with expected inflation up to early 2027 (first year of implementation) and VAT not included is 8,389.5 Cr BDT. The initial investments during the 6 years of implementation are shown in the following chart.:

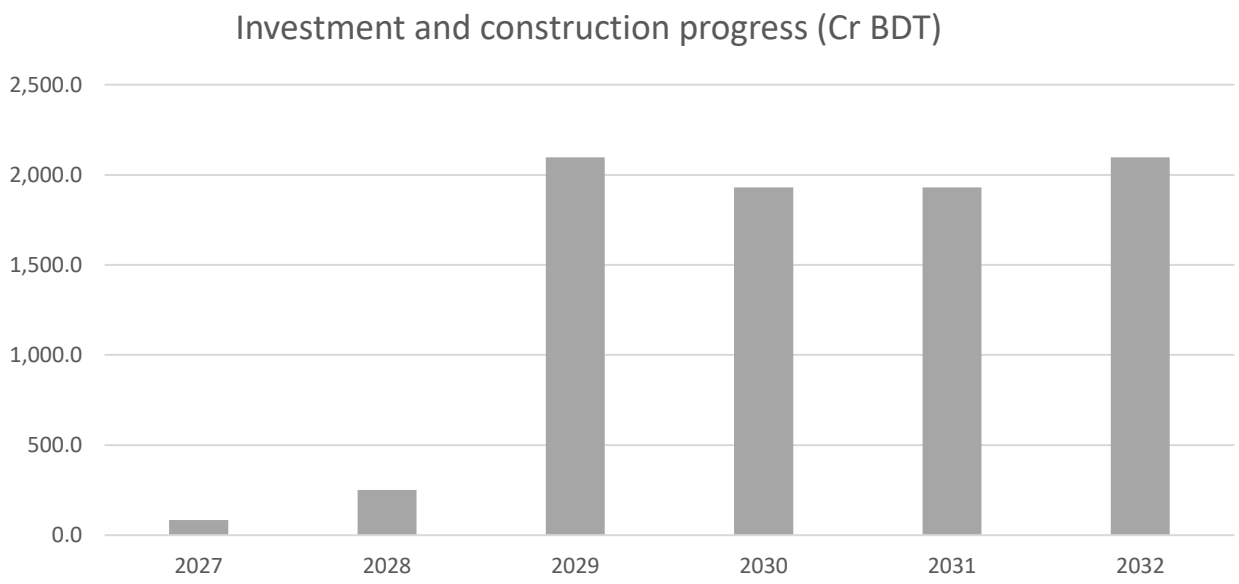

Figure 42. Implementation schedule.

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

Table 32. Maintenance expenses.

Maintenance (Cr BDT. VAT not included)	Investment	Mainten. / year
Main span (cable stayed)	2,650	37.1
Approaching viaducts	217	3.0
Approaching roads	1,134	18.1
Bank protection and river training	1,515	60.6
Toll Plaza	589	14.9
Total		133.80

As a result of the 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:

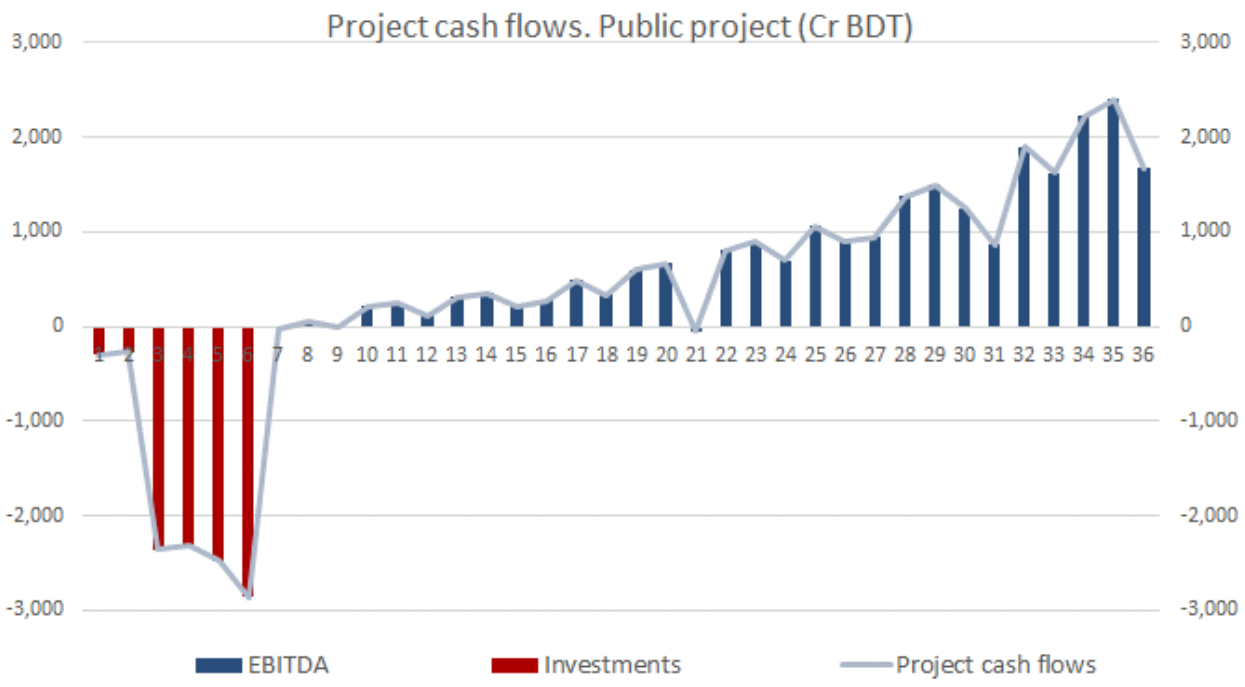

Figure 43. Project cash flows.

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 7, 9 due to the starting operations with lower traffic, and year 21 because of the high extraordinary maintenance costs.

7.2.3. Financial Analysis Conclusion

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

Table 33. Financial indicators. PPP contract structure.

FINANCIAL RESULTS	Bf Grants	After Grants
F-IRR Project (unlevered)	2.60%	12.0%
NPV (@ 12.0 %). Cr BDT	-5,171.7	0.0
GoB Grants required. Cr BDT		8,421.3
VGF required (% over total Project costs)		48.06%

As shown in the above table, results for the PPP Contract structure before and after grants have different values because of the capital grants. Results before grants are not sustainable. Both FIRR and FNPV for the project after capital grants are positive and they show that the feasibility of the Project is reached with 8,421 Cr BDT of GoB grants with a VGF estimated in 48.06% (> 40%), which means that the Project could not be implemented with a PPP contract structure involving private investors.

This alternative procurement (Public Project) generates the following financial indicators:

Table 34. Financial indicators. Public Project contract structure.

FINANCIAL RESULTS	After Grants
F-IRR Project (unlevered)	3.63%
NPV (@ 12.0 %). Cr BDT	-5,746.7
F-IRR Project (levered)	4.55%
Total GoB net contributions (@ 12.0 %). Cr BDT	-1,949.2

As detailed in the table above, the Project cash flows after GoB contributions generate a positive FIRR of 3.63 % (unlevered) and a FNPV of -5,747 Cr BDT. Total net contributions from the GoB during the whole period of analysis are estimated in 1,949 Cr BDT. As a conclusion, the Project would not be feasible from the financial point of view considering the FDR of 12.00 %.

The conclusions arisen from this unleveraged approach of the financial assessment of 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 slightly negative EBITDA (years 7, 9 and 21) due to starting operations and lower traffic, and the high extraordinary maintenance costs, respectively.
- 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 8,421 Cr BDT, which represents 48.1 % of total project costs, higher than the legal limit of 40 %, which means that the Project could not be implemented as a PPP Contract.
- Financial indicators, with the Public Project contract structure, show a Project with a positive FIRR of 3.63 %, which is lower the FDR (12.00 %), so generating a negative FNPV of -5,747 Cr BDT. Total net contributions from the GoB during the whole period of analysis are estimated in 1,949 Cr BDT.

8. CONCLUSION

The bridge project that would connect Coxsbazar Sadar and Moheshkhali upazilas over the Moheshkhali Channel, 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 in 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 investment cost standpoints for the three options. The conclusion from the economic and financial analysis for the pre-selected alignment option.

The proposed solution, **a bridge 2.50 km long**, crossing the Moheshkhali Channel at the selected **alignment B**, through the designed **balanced cantilever bridge 2,020 m (110m x1 + 200m x9 + 110m x1), plus 480 m of accessing spans and 6.29 km of approach roads,** has been selected amongst several options, covering three different alignments, and various bridge typology for each.

The selected **option B has been assessed as the optimum** one after carrying out a thorough multi-criteria analysis. The alignment option C might also be viable, being recommended as second preferred option due to various reasons, amongst them, the proximity to the Coxsbazar airport, which entails OLS restrictions (CAAB) in height that could pose issues during the construction phase of the bridge and the proximity to the 60 MW Wind Power Plant.

Currently at the completion stage of the detailed design, the Marine Drive Expressway Project (RHD) was duly analysed aiming to assess any issue and to ensure the appropriate coordination between both projects. The mentioned project has been assessed not to entail any direct conflict with the proposed bridge alignments B or C. However, roads connectivity solution shall be duly coordinated, and responsibility taken the competent agency under the MoT in the case of any additional intervention needed. It has been observed that part of the road link to the Marine Drive Project would need to be improved at the moment of the implementation of the project. The proposed bridge site (Option D) included in the Marine Drive Project has been also analyzed being not a recommended option due to the closeness to the Coxsbazar Airport and due to hydrological and structural considerations.

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 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 in this part of the country.

The regional connectivity improved by the bridge would function as a key linkage between both areas, of potential interest for industrial growth and tourism objectives, now only connected by ferry. If the proposed bridge is built, a population of nearly 1.31 Cr, living in 11 districts belonging to Chattogram division would benefit from this major transportation improvement. The population belonging to the two directly connected 2 upazilas, Coxsbazar Sadar and Moheshkhali, that would benefit from the project is estimated to be 10 lakhs.

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 according to 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 with 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 (2027 to 2032), the operation phase would start in 2033 and would end in 2062 (30 years).

The investment **cost for the selected option (B)** has been estimated to be **7,974.72 Cr BDT**.

Traffic surveys were undertaken covering the area of influence of the project, and a traffic model was implemented by the Consultant, enabling the necessary traffic estimations at various scenarios. As a summarized output, the traffic forecast for the final year of operation (2062) was estimated as **50,474 vehicles** (the use of 3 wheelers were precluded from the study).

Economic Cost-Benefit Analysis (CBA), was carried out at the selected option (B), considering two scenarios.[7] The results obtained from the economic model are clearly positive from the socio-economic standpoint: **EIRR 17.03 %, ENPV 2,960.46 Cr BDT, C/B ratio 2.82** and **pay-back year 2047.**

[7] Two scenarios were considered in the socio-economic and financial assessment, "with project" case and "without project" case (ferry-ghat).

The Financial indicators, in the case of Public Project contract structure, showed a Project with a positive **FIRR of 3.63 %** (unlevered). The estimated FNPV is -5,747 Cr BDT with total net Government contributions of 1,949 Cr BDT.

The Project cannot be recommended to be implemented under a PPP structure as it would require a grant of 8,421 Cr BDT, which represents 48.01 % of total project costs (VGF). exceeding 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.

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 Coxsbazar and Moheshkhali upazilas, consisting of the 2.50 km long bridge, crossing the Moheshkhali at the selected alignment B, through the designed balanced cantilever bridge and a series of other needed associated components would be feasible.

Figure 44. Image of the proposed bridge over Moheshkhali Channel.

Figure 45. Image of balanced cantilever bridge proposed for Coxsbazar-Moheshkhali.

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