SMEC
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SYSTRA ACE BANGLADESH

CONSULTANCY SERVICES FOR DETAILED FEASIBILITY STUDY AND DESIGN FOR CONSTRUCTION OF 01 (ONE) BRIDGE ADJACENT TO ZERO POINT IN MYMENSINGH TOWN, 02 (TWO) BRIDGES ADJACENT TO MYMENSINGH EPZ, 04 (FOUR) BRIDGES ON BORDER ROAD AND 2ND SOMESHWARI BRIDGE RESPECTIVELY OF MYMENSINGH ZONE UNDER ROADS AND HIGHWAYS DEPARTMENT, BANGLADESH.

Bridge Construction and Maintenance Circle
Roads and Highways Department

FINAL

FEASIBILITY STUDY REPORT (SOMESHWARI BRIDGE-3)

VOLUME 4 – SUMMARY REPORT

1 July 2024

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ABBREVIATIONS

AACE	Association for the Advancement of Cost Engineering
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
AP	Affected People
ARIPA	Acquisition and Requisition of Immovable Property Ordinance
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi Taka
BGB	Border Guard Bangladesh
BHMS	Bridge Health Monitoring System
BIWTA	Bangladesh Inland Water Transport Authority
BNBC	Bangladesh National Building Code
BOT	Build, Operate and Transfer
CAAB	Civil Aviation Authority Bangladesh
CBR	California Bearing Ratio
CCL	Cash Compensation Law
CPR	Community Property Resources
CTC	Classified Traffic Count Survey
DTM	Digital Terrain Model
ECC	Environmental Clearance Certificate
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EPC	Engineering, Procurement and Construction
ESA	Equivalent Single Axel
ESAL	Equivalent Single Axel Load
FFWC	Flood Forecasting and Warning Centre
GAD	General Arrangement Drawing
GDP	Gross domestic product
GIS	Geographic Information System
GVA	Gross Value Added
HYSD	High Yield Strength Deformed
IC	Intersection Count
IDC	Interest During Construction

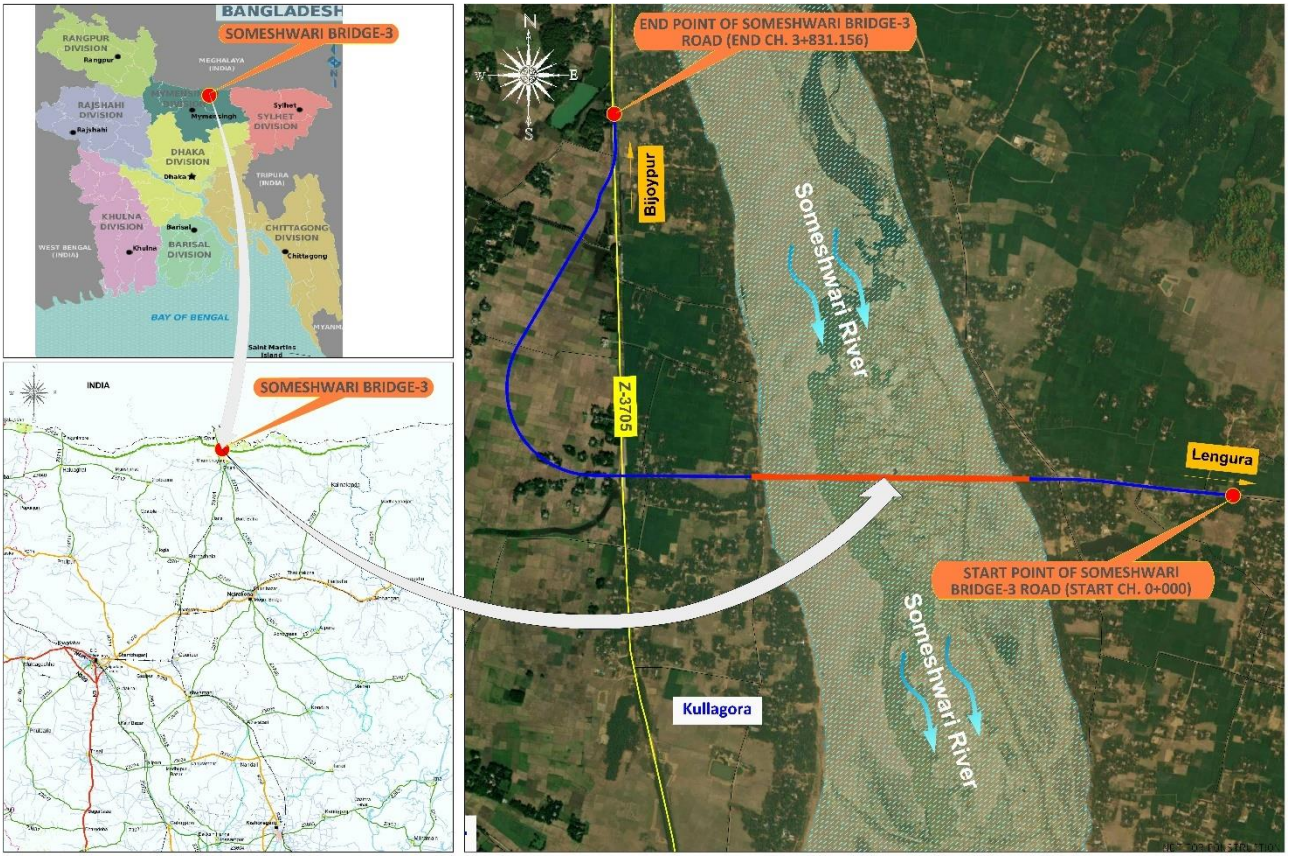
IEE	Initial Environmental Examination
IMF	International Monetary Fund
IRC	Indian Roads Congress
IRR	Internal Rate of Return
IWM	Institute of Water Modelling
LOS	Level of Service
MC	Mid-Block Count
MCA	Multi Criteria Analysis
MMA	Methyl-Meth-Acrylate
MMAT	Mean Monthly Ambient Temp
MORTB	Ministry of Road Transport and Bridges
MSA	Million Standard Axel
MSL	Mean Sea Level
NPV	Net Present Value
ODS	Origin-Destination Survey
PCSE	Passenger Car Space Equivalent
PCU	Passenger Car Unit
PPE	Personal Protective Equipment
RE	Reinforced Earth
RHD	Roads and Highways Department
ROW	Right of Way
RMMS	Road Maintenance Management System
RSI	Roadside Interview Survey
SHWL	Standard High-Water Level
SMVT	Slow Moving Vehicular Traffic
SPT	Standard Penetration Test
VOS	Vehicle Occupancy Survey
VPS	Video Pedestrian Count Survey
VTS	Video Traffic Count Survey
WMAPT	Weighted Mean Annual Pavement Temperature
WPI	Wholesale Price Index
WTP	Willingness to Pay Survey
TPC	Total Project Cost

EXECUTIVE SUMMARY

INTRODUCTION

This Final Feasibility Report aims to assess the best option of the Someshwari Bridge-3 and the Project Alignment, by examining all aspects of a project preparation, including technical, environmental, social aspects as well as economic viability.

LOCATION MAP



NEED FOR SOMESHWARI BRIDGE-3 OVER SOMESHWARI RIVER

The Border Road Z-2834 traversing through Mymensingh and Netrokona Districts connects Kalmakanda & Durgapur Upazila of Netrokona District and Haluaghat & Dhobaura Upazila of Mymensingh district. Length of the border road (Z-2834) in Mymensingh district is 42 km and 34 km in Netrokona district. With the construction of proposed Someshwari Bridge-3 at 35th kilometre of this border road along with Mahadev, Ganeshwari, and Nitai Bridge on the 9th, 21st, and 48th kilometre respectively, the road will be fully integrated and Indian border area of Netrokona district will be directly connected with Mymensingh District. The road is also important for expansion of business & trade between Bangladesh, India, and other land locked nearby countries. Further this will enhance the connectivity to various centres of tourist attraction located in Netrokona district. The border road would also create an infrastructure, having potentiality to facilitate movement of international transit traffic which would promote international trade and commerce for adjoining countries as well as for Bangladesh. This would contribute in economic development of Bangladesh and also generate additional revenue.

At present, river ferry service is available for passengers, motorcycles to cross the river. The border road is not fully usable due to the absence of a bridge over Someshwari River. Therefore, the proposed bridge over the Someshwari River, near Durgapur, is the most critical element in achieving the larger transport

connectivity of this road along with establishment of direct communication between the two banks of the river.

TRAFFIC SURVEYS AND TRAFFIC ANALYSIS

- Traffic Surveys

The following Traffic Surveys have been conducted:

1. Video Traffic Count Survey (VTS)
2. Video Pedestrian Count Survey (VPS)
3. Roadside Interview Survey (RSI), comprising
   - Origin-Destination Survey (ODS)
   - Vehicle Occupancy Survey (VOS)
   - Willingness to Pay Survey (WTP)

- Traffic Analysis – Base Traffic

Base AADT as on August 2023 and corresponding PCU for the existing road (Z2834) on the proposed Someshwari bridge-3 location have been presented below

Year	Types of traffic		Truck	Bus	Microbus	Utility vehicle	Car	Baby Taxi/ CNG/Auto	Tempo/ Leguna	Motorcycle	Bicycle	Rickshaw	Rickshaw Van	Cart	Total
Base year 2023	Existing Traffic (2023)		-	-	-	-	-	-	-	-	-	-	-	-	-
Opening year 2027	Applying growth rate on present traffic		-	-	-	-	-	-	-	-	-	-	-	-	-
	Mode shift waterway to roadway		10	38	40	49	41	44	44	58	38	38	-	-	398
	Diverted traffic	Only for Someshwari 3 Bridge	123	13	20	17	16	31	766	1,145	238	142	33	5	2,548
		For four bridges (Regional traffic through border roads)	241	119	58	22	90	-	-	-	-	-	-	-	530
	Land port traffic (between Bangladesh and India)		497	7	8	4	4	-	-	-	-	-	-	-	519
	Transit traffic (India to India traffic using Bangladesh Road)		99												99
	Tourist traffic		3	10	5	5	6	2	28	30	6	10	1	2	107
	Induce traffic		4	2	1	0	2	0	9	34	13	0	1	0	67
	Total		977	190	131	97	157	77	847	1,267	294	190	34	7	4,268

- Traffic Capacity Analysis – Proposed Lane Configuration

On the basis of present traffic data analysis and projected AADT, the number of lanes has been considered for the proposed Someshwari Bridge-3. The salient points of the calculations are as per following.

Projection Period	Year	Traffic Volume in AADT		Traffic Volume in PCU		Lane Number (Based on peak hour demand)		Lane Number (Round up the number)	
		Daily	Peak hour	Daily	Peak hour	LOS B	LOS C	LOS B	LOS C
Base year	2023	0	0	0	0	-	-	-	-
Traffic opening year	2027	4,268	510	6,151	736	0.84	0.58	2.00	2.00
Opening +5 year	2032	6,054	724	8,216	983	1.12	0.77	2.00	2.00
Opening +10 year	2037	7,786	931	10,074	1,205	1.38	0.94	2.00	2.00
Opening +15 year	2042	10,182	1,218	12,521	1,498	1.71	1.17	2.00	2.00
Opening +20 year	2047	12,436	1,487	14,733	1,762	2.01	1.38	4.00	2.00

ENGINEERING SURVEYS AND INVESTIGATIONS

- Road Inventory and Road Condition Surveys

Road Inventory and Road Condition Survey has been done through vehicle mounted video camera along with visual inspection from approximately Km 31+800 to Km 41+000 along border road.

The existing carriageway width varies from 5.00 m to 7.30 with flexible bituminous pavement. The existing pavement has been found in good condition. Drainage system was found inadequate.

- Drone Videography Survey

The Consultant carried out drone videography along the proposed alignment options. This included aerial view of at least 150 m on both side of the proposed alignment centreline and the videography file has been submitted to RHD as soft copy. The consultants also prepared an “Aerial Reconnaissance Report” to have preliminary assessment of the impact of the proposed project corridor would render on the existing social and environmental set-up.

- Topographic Survey

Based on the DFSR workshop held on March 13, 2024, Alignment Option 1 received approval from RHD. Detailed topographic survey has been conducted along the approved alignment. Generally, detailed survey work covered an area, 30m on either side of the proposed alignment. The topographic Survey Report along with soft copy of the topographic survey drawing has also been submitted.

GPS main control points were established based on WGS-84 coordinates of the Survey of Bangladesh, and drawings were produced using the UTM projection system, after applying necessary corrections Three nos. Permanent Benchmarks of size 400 x 400 x 1000mm, were installed at suitable locations. With reference to the PBMs and secondary TBM pillars, detailed Topographic survey have been conducted using Total Station. Cross sections at every 25m distance along the alignment have been surveyed and recorded.

OUTLINE OF THE OPTION STUDY RESULTS

Someshwari Bridge-3 has been envisaged to provide a seamless connectivity through the Broder Road Z-2834 between Mymensingh and Netrokona districts.

Based on detailed site reconnaissance and map study, two alternative alignment options have been proposed identifying suitable Bridge locations over the Someshwari River. Among these options, the Alignment Option 1 emerged as the most preferred choice based on reports such as the Alignment Option Study Report and Multi-criteria Analysis. Accordingly, the Draft Feasibility Study Report (DFS) recommended Alignment Option 1 with a Extradosed bridge.

Following this recommendation, a workshop was held on March 13, 2024, where RHD (Roads and Highways Department) officials approved **Alignment Option 1** with the **Extradosed + Balance Cantilever Bridge**. **The form has been preferred to overcome the aesthetical monotony of applying one type of bridge form to a 990m long section along with cost effectiveness**.

Subsequently, a topographic survey was conducted, resulting in minor adjustments to the preferred alignment based on actual survey data and geometric design parameters.

- Alignment Option Study

In this study, these two alignment options have been evaluated based on some assigned parameters for highway & bridge engineering, social, environmental, hydro-morphological and cost aspects. The calculation of the evaluation has shown below.

DECISION MATRIX OF ALIGNMENT OPTION STUDY

BASIC ASPECTS	PARAMETERS	UNIT	RELATION	MAX. SCORE	WEIGHTAGE	WEIGHTED MAXIMUM SCORE	OPTION - 1		OPTION - 2	
							QTY	SCORE	QTY	SCORE
Highway Engineering	Total Length	km	Equation 1	10	0.050	0.500	3.98	0.50	4.71	0.42
	Length of at grade highway	km	Equation 1	10	0.050	0.500	2.07	0.50	2.52	0.41
	Horizontal Geometry: Total length of curves having Superelevation	m	Equation 1	10	0.050	0.500	1080.54	0.50	1959.16	0.28
	Horizontal Geometry: Total deflection angle	degree	Equation 1	10	0.050	0.500	156.31	0.50	188.47	0.41
Bridge Engineering*	Total Length of Main Bridge	km	Equation 1	10	0.300	3.000	0.99	3.00	0.99	3.00
	Total Length of viaduct section of the bridge	km	Equation 1	10	0.300	3.000	0.92	3.00	1.20	2.30
	Score of the Best option	score	Equation 2	10	0.300	3.000	128.31	3.00	128.31	3.00
Social	Approximate no. of Structures to be dismantled	Nos.	Equation 1	10	0.075	0.750	18.00	0.54	13.00	0.75
	Number of Sensitive Buildings like mosque, graveyard, etc. to be dismantled	Nos.	Equation 1	10	0.075	0.750	2.00	0.75	4.00	0.38
	Livelihood Impact/Impact on local market (No of Shops affected)	Nos.	Equation 1	10	0.075	0.750	10.00	0.75	13.00	0.58
	Approximate Total land to be acquired	Ha	Equation 1	10	0.075	0.750	10.49	0.75	13.82	0.57
	Approximate Agricultural Land to be acquired	Ha	Equation 1	10	0.075	0.750	7.27	0.75	8.80	0.62
Environment	Approximate Fisheries Land to be acquired	Ha	Equation 1	10	0.075	0.750	0.00	0.75	0.00	0.75
	Impact on Vegetation (Approximate no. of trees affected)	Nos.	Equation 1	10	0.075	0.750	187.00	0.75	273.00	0.51
	Impact on Waterbody (Area of Pond excluding Fisheries)	Ha	Equation 1	10	0.075	0.750	0.04	0.75	0.46	0.07
Hydro-Morphological#	Rank of the Bridge Option	Rank	Equation 1	10	0.200	2.000	1.00	2.00	1.00	2.00
	River Training Works - Approximate Bank Length	m	Equation 1	10	0.200	2.000	3200.00	2.00	3200.00	2.00
Indicative Cost*	Approximate Cost of the Viaduct Section	Cr (BDT)	Equation 1	10	0.300	3.000	218.73	3.00	285.30	2.30
	Approximate Total Capital Cost	Cr (BDT)	Equation 1	10	0.300	3.000	1384.42	3.00	1474.15	2.82
Total Score				**190**		**27**		**26.79**		**23.16**
Percentage Score				**100**				**99.23**		**85.78**
RANK								**1.00**		**2.00**

** The parameter values pertain to the Bridge Option 1B in Alignment Option 1 & Bridge Option 2B in Alignment Option 2. Refer "Bridge Option Study Report (Someshwari Bridge-3)" – Document No.: 5060143-8BRP-STR-RPT-003-R1*

 # The parameter values pertain to Bridge Site A (nearly matches with both the Bridge Location at Alignment Option 1 and Alignment Option 2). Bridge Site B & Bridge Site C as shown in the Hydro-morphological report is 1300 m and 2700 m downstream of the existing connectivity route on the 2 sides of the river. Hence, these locations are as such not considered. Refer "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh Portion) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM).

From the overall consideration of the evaluation, the **Alignment option 1** holds the **Rank 1 position**.

○ Bridge Option Study

In the bridge option study, a set of span arrangement with three different bridge forms have been presented for each alignment option. All the options have been merited on the basis of scoring marks representing various evaluation criteria. Suitable bridge option has been proposed by evaluation through decision matrix and on the basis of highest scoring. All the bridge options are as detailed below:

Bridge Options in Alignment Option 1 & 2

- Option A: PSC Box Girder-Balanced Cantilever Bridge
- Option B: Extradosed Bridge
- Option C: Steel Arch Bridge

It is noted that three bridge options (A, B and C) as described above were submitted in bridge option study report to RHD on November 1, 2023. Subsequently, several meetings were held between the Consultant and RHD, and one more bridge option has been adopted combining the bridge form of the Balanced Cantilever bridge and the Extradosed bridge to overcome the aesthetical monotony of applying one type of bridge form to a 990m long section along with cost effectiveness.

- Option D: Balanced Cantilever Bridge + Extradosed Bridge

Suitable bridge options have been proposed by updated evaluation through decision matrix and best scoring, as shown below:

DECISION MATRIX OF BRIDGE OPTION STUDY – ALIGNMENT OPTION 1 and 2

Sl. No.	Basic Aspects	Parameter	Unit	Relation	Weightage	Max Score	Option A (Bal. Cantilever)		Option B (Extradosed)		Option C (Network Arch)		Option D (Extradosed + Bal. Cantilever)	
							Qty	Score	Qty	Score	Qty	Score	Qty	Score
A1	Design & Serviceability	Depth of superstructure (max.)	m	Equation-1	15%	10	7.00	3.86	5.30	5.09	2.70	10.00	5.30	5.09
A2	Design & Serviceability	Skew angle (wrt direction of flow)	degree	Equation-1		5	0.00	5.00	0.00	5.00	0.00	5.00	0.00	5.00
A3	Design & Serviceability	Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Annexure-1		10	120.00	9.81	160.00	10.00	140.00	8.75	160.00	10.00
A	Sub Score - Design & Serviceability					25		18.67		20.09		23.75		20.09
	Weightage Score					15		11.20		12.06		14.25		12.06
B1	Constructability	Total bridge length (main bridge)	m	Equation-1	15%	10	990.00	9.90	990.00	9.90	980.00	10.00	990.00	9.90
B2	Constructability	Maximum single span Length (for Difficulty, duration, safety hazards)	m	Annexure-2		15	120.00	15.00	160.00	8.73	140.00	11.21	160.00	10.00
B	Sub Score - Constructability					25		24.90		18.63		21.21		19.90
	Weightage Score					15		14.94		11.18		12.73		11.94
C1	Aesthetic	Suitability with the terrain and culture	Based on Judgement		20%	15	Good	5.00	Better	10.00	Better	10.00	Best	15.00
C2	Aesthetic	Integrity between superstructure and substructure				15	Better	10.00	Best	15.00	Good	5.00	Best	15.00
C	Sub Score - Aesthetic					30		15.00		25.00		15.00		30.00
	Weightage Score					20		10.00		16.67		10.00		20.00
D1	Environment	Total carbon consumption propotionate to structural concrete quantity	cum	Equation-1	20%	10	77000.0	6.62	72000.0	7.08	51000.0	10.00	87000.00	5.86
D2	Environment	Obstruction in waterway due to structure inside the perinial river	m	Equation-1		20	128.00	12.03	96.00	16.04	77.00	20.00	141.00	10.92
D	Sub Score - Environment					30		18.65		23.13		30.00		16.78
	Weightage Score					20		12.44		15.42		20.00		11.19
E1	Indicative Cost	Relative Cost of Substructure & Foundation	Cr (BDT)	Equation-1	30%	15	312.200	13.42	284.900	14.71	279.400	15.00	297.76	14.08
E2	Indicative Cost	Relative Cost of Superstructure	Cr (BDT)	Equation-1		15	278.800	15.00	330.000	12.67	711.300	5.88	307.50	13.60
E3	Indicative Cost	Relative Maintenance cost for entire service life	Cr (BDT)	Equation-1		15	265.700	15.00	307.400	12.97	594.400	6.71	339.90	11.73
E	Sub Score - Cost					45		43.42		40.35		27.58		39.40
	Weightage Score					30		28.95		26.90		18.39		26.27
	Total Score					155		120.64		127.20		117.54		126.18
	Total Weightage Score				100%	100		77.53		82.22		75.37		81.45
Preferred Option							**Option B (Extradosed)**							

From the overall consideration of the evaluation, the **Bridge Option B (Extradosed Bridge)** is observed as **preferred option for both Alignment option 1 and 2**.

From the table above, it can be seen that score of option B (extradosed) is the highest and option D (combined) is 2nd highest. However, the score of these two options varies within a range of 1% only. In the above analysis 30% weightage has been given to cost. Environment and aesthetic aspects have been considered with 20% weightage each. Hence, it can be inferred that the preferred option is always dependent on the weightage given to a particular aspect. Considering the socio-economic condition of Bangladesh and to give a sustainable solution for selection of preferred bridge option, aesthetic, cost, environment and social needs have been given the utmost importance which is the present day's needs in finalizing any development proposal. Accordingly, as discussed and agreed in a **DFSR workshop meeting with RHD, Option D (combination of Extra-dosed + Balanced Cantilever) has been selected as preferred bridge option**. **The form has been preferred to overcome the aesthetical monotony of applying one type of bridge form to a 990m long section along with cost effectiveness.**

Few additional advantages of combined bridge option in context of the project purpose are as below:

- In case of extradosed+ balanced cantilever bridge longer span can be adopted which helps to reduce the numbers of substructure and foundation.
- Superstructure depth can be optimized by increasing eccentricity of stay cables of the extradosed portion at support location.
- Due to higher degree of redundancy, overall safety and performance against seismic action, is higher in case of extradosed bridges.
- Due to the combination of balanced cantilever and extra-dosed bridge (with pylons and stay cables), aesthetically it is more pleasant than normal balanced cantilever construction.
- Reference could be made from recent projects in Bangladesh having similar terrain and topography like Lalon Shah Bridge (balanced cantilever with 1.7 Km total length), (Pyara Bridge (extradosed with 630m total length) and Shah Amanat Bridge (extradosed with 830m total length).

The salient features of the preferred option are given below:

For alignment option 1 & option 2 – Preferred span arrangement and bridge form option is D:

Span arrangement -	(60+2x100+60) m + (95+160+95) m+(60+2x100+60) m
Total length of main bridge -	990.0m
Skew angle -	0 degrees
Superstructure type -	PSC box-girder & Stayed Cable
Overall Deck width -	21.7m
Support condition -	Monolithic at main piers (no bearings)
Lane configuration -	2 lanes + 2 SMVT
Special feature -	• Integral connection between superstructure and substructure
	• No bearing requirement at main pier

For the option of the bridge, soffit level takes into account the climate change effect (0.38 m anticipated sea level rise) as inferred in the "Hydro-Morphological study of Someshwari Bridge at 36th Km of Border Road (Netrokona and Mymensingh) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM).

The preferred bridge options have been shown below schematically.

SCHEMATIC VIEW OF SOMESHWARI BRIDGE-3 (EXTRADOSED + BALANCE CANTILEVER) IN ALIGNMENT OPTION 1

- Multicriteria Analysis

The final decision matrix for concurring the Alignment Option was developed by combining the individual scores of the parameters with the application of weightage for different Criteria as detailed below.

CRITERIA	WEIGHTAGE
Highway Engineering Criteria	0.050
Bridge Engineering Criteria	0.300
Social Criteria	0.075
Environment Criteria	0.075
Hydro-Morphological Criteria	0.200
Indicative Cost Criteria	0.300
Total	1.00

After considering the weighted criteria, Option 1 obtained a score of 99.68%, outperforming Option 2, which scored 95.10%. This margin indicates the clear preference for Option 1, emphasizing its superior suitability for the project. For a detailed breakdown, please refer to the Multicriteria Decision Matrix in **Section 10** of the report.

The choice for the Alignment Option was also ratified through Sensitivity Analysis. "Sensitivity of the final scoring with respect to the adopted weightages" has been done, by developing decision matrixes in 4 scenarios with different weightage combinations, as detailed below.

Aspect	Weightage Adopted in Different Scenarios			
	Scenario I	Scenario II	Scenario III	Scenario IV
Highway Engineering Criteria	0.050	0.050	0.050	0.167
Bridge Engineering Criteria	0.300	0.300	0.300	0.167
Social Criteria	0.050	0.075	0.050	0.167
Environment Criteria	0.050	0.075	0.050	0.167
Hydro-Morphological Criteria	0.200	0.250	0.300	0.167
Indicative Cost Criteria	0.350	0.250	0.250	0.167
Total	**1.00**	**1.00**	**1.00**	**1.00**

Scenario	Option 1	Option 2
Scenario I	99.79%	95.87%
Scenario II	99.67%	95.16%
Scenario III	99.77%	96.05%
Scenario IV	99.12%	88.38%
Preferred Option	**Preferred**	

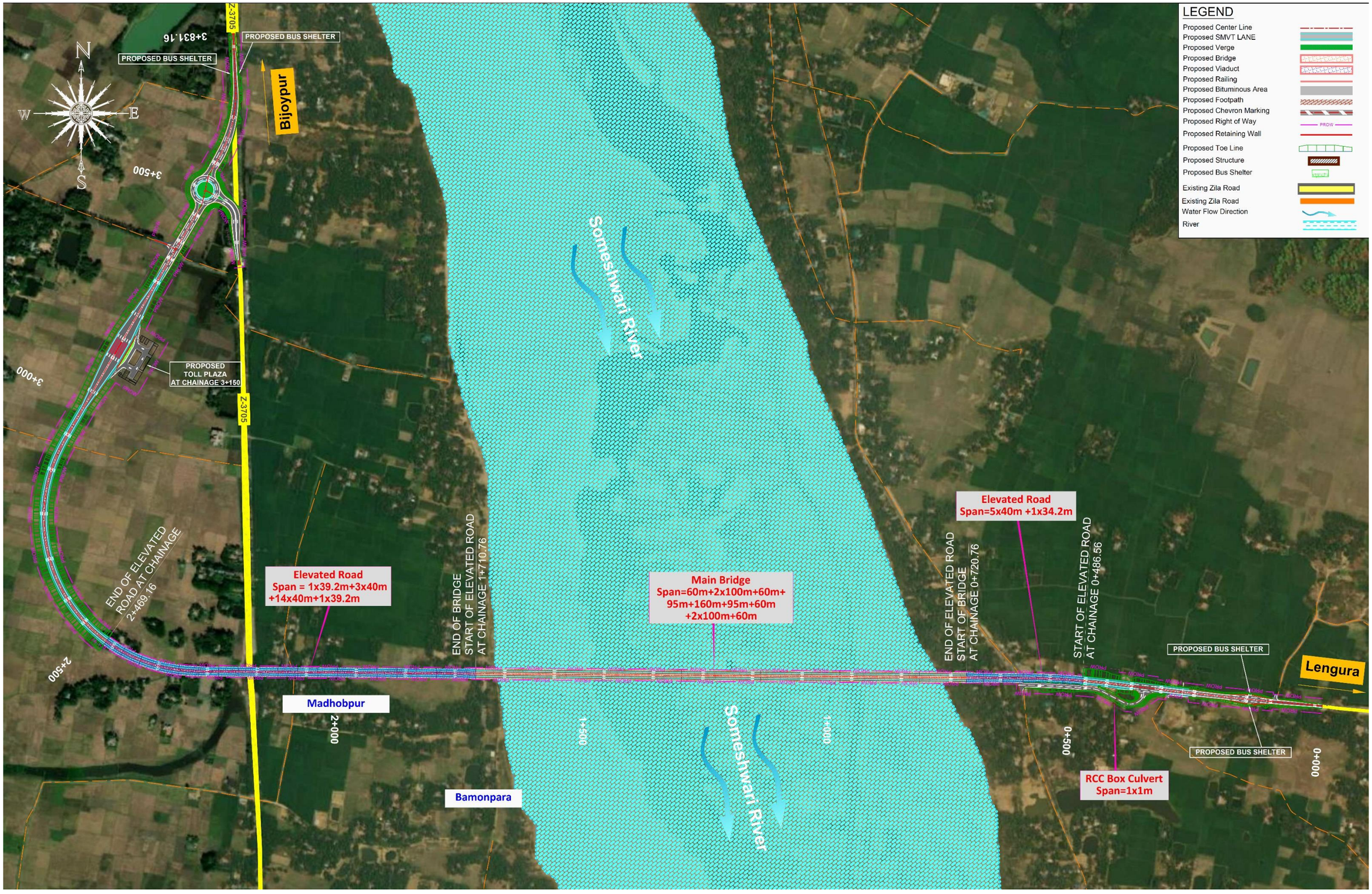
The results of Tables above infer very clearly the Alignment Option 1 as the Rank 1 in all the Scenarios, the detailed Multicriteria Decision Matrix of the scenarios is in **Section 10** of the report. The difference in the score between the two Alignment Options ranges from 3.72% to 10.74%. The high score of the Alignment Option 1 is attributable to its superiority, primarily with respect to Bridge Engineering, Hydro–Morphological Studies and Indicative Cost aspects.

Hence it can be well inferred that Alignment Option 1 is the preferred as well as approved alignment with respect to the Bridge location as well as overall Project Road Alignment.

Further, it may please be noted that, **the proposed Bridge Location in the Alignment Option 1 also matches closely with the Preferred Option as per Hydro-morphological Study carried out in 2021 by Institute of Water Modelling (IWM).**

The Preferred Alignment Option 1 along with the Bridge and viaduct/ elevated road locations has been schematically presented in below.

SCHEMATIC PLAN OF APPROVED ALIGNMENT OPTION



PRELIMINARY ENGINEERING AND DEVELOPMENT PROPOSAL

- Geometric Design

The Someshwari bridge-3 road is a **Rural Collector Road**, and the **Design Speed of the proposed road is 80 kmph**. The total length of the project road is **3.831 km**. The engineering study has been carried out based on the approved alignment (Based on the DFS workshop held on 13th March 2024) and Extradosed + Balance Cantilever bridge form**.** The geometric design of the road has been done following "A Policy on Geometric Design of Highways and Streets (AASHTO) 2018, 7th Edition". The design parameters for horizontal and vertical alignment have been validated and briefly detailed in this study.

- Typical Cross-section

The summary of the typical cross sections proposed has been presented below.

Sr. No.	TCS Type	TCS Description	Proposed ROW	Length (Km)
1	TCS 1	Typical Cross Section for Merging with Existing Road with Embankment Height Less Than 2m at Rural Areas	30	0.023
2	TCS 2	Typical Cross Section for Merging with Existing Road with Paved Shoulder (Varies) with Embankment Height Less Than 2m at Rural Areas	30	0.125
3	TCS 3	Typical Cross Section for Two Lane Carriageway with Paved Shoulder with Embankment Height Less Than 2m at Rural Areas	30 to 50	0.043
4	TCS 4	Typical Cross Section for Two Lane Carriageway with Bus Bay (Varies) in Rural Areas	38	0.095
5	TCS 5	Typical Cross Section for Two Lane Carriageway with Paved Shoulder with Embankment Height Less Than 2m at Rural Areas	38	0.010
6	TCS 6	Typical Cross Section for Two Lane Carriageway with Varies SMVT Lane with Embankment Height 2m to 3m at Rural Areas	38	0.065
7	TCS 7	Typical Cross Section for Two Lane Carriageway with SMVT Lane with Retaining Wall on Left Side	28.5	0.045
8	TCS 8	Typical Cross Section of Two Lane Carriageway with SMVT Lane and 7.3m Service Road on Left Side	70 to 77	0.035
9	TCS 9	Typical Cross Section of Two Lane Carriageway (with SMVT Lane) with Retaining Wall and 7.3 M Service Road on Left Side	61 to 75	0.039
10	TCS 10	Typical Cross Section of Two Lane Carriageway (with SMVT Lane) with Retaining Wall with Separator and 7.3m Service Road on Left Side	61	0.033
11	TCS 11	Typical Cross Section for Two Lane Carriageway at Elevated Road Sections (With SMVT Lane) & 7.3m At-Grade Service Road (with Both Side Footpath Cum Drain) on Left Side of Elevated Road	43	0.133
12	TCS 12	Typical Cross Section for Two Lane Carriageway at Elevated Road Sections (with SMVT Lane)	24	0.859
13	TCS 13	Typical Cross Section for Two Lane Carriageway at Extradosed Bridge (with SMVT Lane)	24	0.990
14	TCS 14	Typical Cross Section for Two Lane Carriageway with SMVT Lane with Embankment Height 3m to 6m at Rural Areas	50 to 54	0.556

Sr. No.	TCS Type	TCS Description	Proposed ROW	Length (Km)
15	TCS 15	Typical Cross Section of Two Lane Carriageway with SMVT Lane at Merging Section with Toll Plaza	50 to 116	0.220
16	TCS 16	Typical Cross Section for Toll Plaza Location (with SMVT Lane)	116	0.055
17	TCS 17	Typical Cross Section for Four Lane Carriageway with Paved Shoulder for Embankment Height 3m to 5m at Rural Areas	50	0.182
18	TCS 18	Typical Cross Section for Four Lane Carriageway (Varies) Merging with Two Lane Carriageway with Paved Shoulder	50	0.121
19	TCS 19	Typical Cross Section for Two Lane Carriageway with SMVT Lane for Embankment Height 2m to 3m	38	0.020
20	-	Major Junction Development	Varies	0.103
21	-	Minor Junction Development	Varies	0.080
Total Length (km)				**3.831**

- Service Road

Existing 5.5m wide bituminous road is being developed as approach for proposed Someshwari bridge – 3 from km 0+350 to km 0+620. To provide access with the project road and to ensure local connectivity, a service road has been proposed with a minor junction at km 0+350 for entry and exit from the main thoroughfare. The proposed service road of width 7.3m, extends from km 0+350 to km 0+620 on left sides of the proposed highway.

- Junction

The proposed road corridor includes development of 1 nos. of major intersections, 3 no. of minor intersection and 5 nos. of Cross roads. The proposed junction drawings are illustrated in the Final Feasibility Study Report of Someshwari Bridge-3, Volume-III

- Access Strategy

The project road serves as an access route to the Someshwari Bridge – 3 over Someshwari River, running in the vicinity of the existing road with nearby settlements and intersecting local roads. To minimize disruption to the existing road network, an access strategy has been devised, segmenting the project into 4 nos. zones based on the entry points to the proposed road which are defined below.

  - Zone A: Access via at-grade junction with earthen road at km 0+095 and start location of project road.
  - Zone B: Access via at-grade junction with service road at 0+350.
  - Zone C: Access via at-grade junction with RHD road at 3+503 and end location of project road.
  - Zone D: Access via at-grade junction at 3+368.

- Pavement Design

The recommended pavement composition based on AASHTO method is given below

Based on AASHTO method for design traffic of 24 MSA, the recommended pavement composition for the project road has been presented below

Layers	Thickness (mm)
Asphalt Wearing Course	50
Asphalt Base Course	195 (In three layer- 60, 60 & 75 mm each)

Aggregate Road Base (Base Type I)	200
Granular Subbase	100
Improved Subgrade (CBR 8%)	300

The pavement system for the concrete bridge deck and viaduct/ elevated road shall have a total thickness of approx. 54 mm and consists of the following components:

- Wearing course: 50 mm dense graded Bituminous concrete
- Tack coat: approx. 200 micrometres
- Waterproofing membrane: 2-4 mm synthetic resin-based membrane (sprayed in two layers)
- Primer: concrete deck primer (sprayed)

The waterproofing system shall be an elastomeric polyurethane or Methyl-Meth-Acrylate (MMA) based waterproofing system for concrete bridge decks.

- Embankment Design & Slope Stability Analysis

Considering the aforementioned road safety considerations, the following have been adopted in the project.

- The minimum side slope of 2:1 (H: V) for embankments higher than 2 meters ensures stability by preventing excessive lateral movement.
- For embankments less than 2 meters in height, a gentler slope of 3:1 (H:V) is implemented.

As per the available secondary data and previous experience, the summary of Slope stability analysis is tabulated below.

Chainage	Fill Height (m)		GWT (m)	FOS-Short Term (static)	FOS-Short Term (Seismic)	Remark
	LHS	RHS				
0+486	6.5	1 m BGL	1.86	1.31	Safe	0+486
2+470	7	1 m BGL	1.58	1.10	Safe	2+470

- Drainage Design

The project roads are approach roads to the proposed Bridge. A significant portion of this road comprises high embankments. The measures that have been considered for drainage mitigation are as follows:

- Provision of Chute drain has been provided for embankment sections more than 3.0m.
- 2.0m wide toe drain with PCC lining has been provided in all highway sections except slip road, Toll Plaza, Bridge and Viaduct locations.
- 1.0m and 1.5m wide footpath cum drain are proposed on the slip road section and Toll Plaza section, respectively.
- Standard crossfall and Drainage spouts has been provided to ensure drainage at Bridge and Viaduct sections.

- Design of Auxiliary Functions

Toll Plaza & Weighbridge

A 3+3 lane toll plaza has been proposed at Km 3+138 and a space of 124m x 50m has been kept for provision of Toll Administrative Building and other ancillary facilities. However, considering entire alignment of border road, provision of toll plaza will be finalised as per directive from the RHD. Only, Space proofing for proposed

Toll Plaza has been done at this stage. The operational and other aspects will be thoroughly addressed in subsequent stages in discussion with RHD officials.

Weigh bridge facility has not been considered for this project since the length of the project corridor is 3.8km only and serves primarily as an approach to the Someshwari Bridge-3. Hence, provision of an axle load regulatory control station has not been envisaged. Further, there is a need for internal discussion by RHD keeping in view of the "Installation of Axle Load Control Stations at the Source of Freight Transport on Important Highways of Roads and Highways Department" project, being undertaken by RHD. Provision of weigh bridge for this project can be further decided based on this discussion. However, additional land will be required for provision of weigh bridge facility.

Bus Bays & Stopping Places

Two locations have been identified for proposing bus stops with bus bays and two additional locations for bus stops without bus bays along the project corridor.

Sl. No.	Chainage	Side	Location	Remarks
1	0+147	RHS	Near start of project road at km 0+000	Bus Stop with Bus Bay
2	0+147	LHS		Bus Stop with Bus Bay
3	3+750	RHS	Near end of project road at km 3+831	Bus Stop Without Bus Bay
4	3+750	LHS		Bus Stop Without Bus Bay

- Retaining Wall

The retaining wall has been proposed between the proposed main carriageway and service road. The total length of proposed retaining wall is 117m with the height varying from 2.0m to 5.0 m.

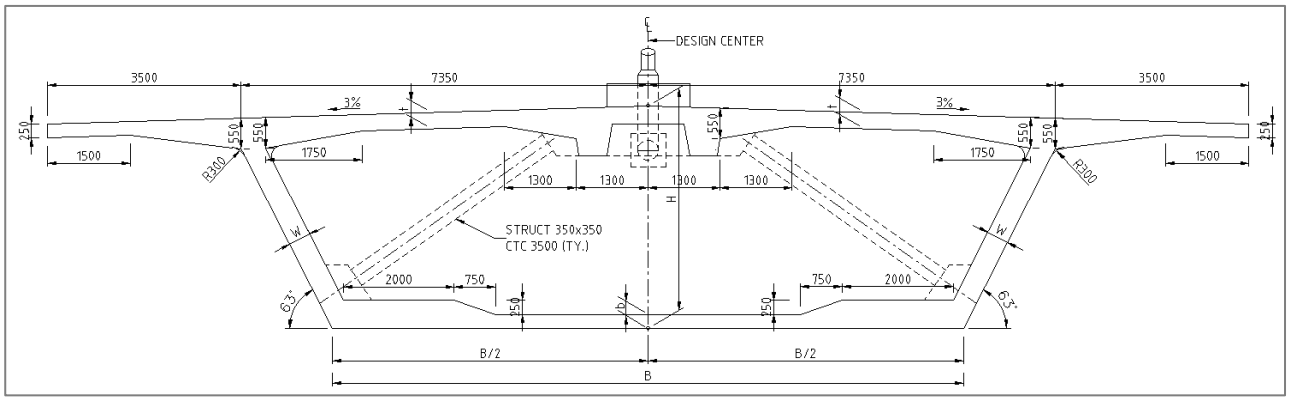
PRELIMINARY ENGINEERING – BRIDGE

Since the river is designated as Navigational Class IV, in accordance to the BIWTA norms horizontal clearance of 20m and vertical clearance of 5m has been considered. Standard High-Water Level (SHWL) value of 14.24 mPWD has been considered as per BIWTA clearance certificate. This SHWL value also considers the climate change effect (0.38 m anticipated sea level rise).

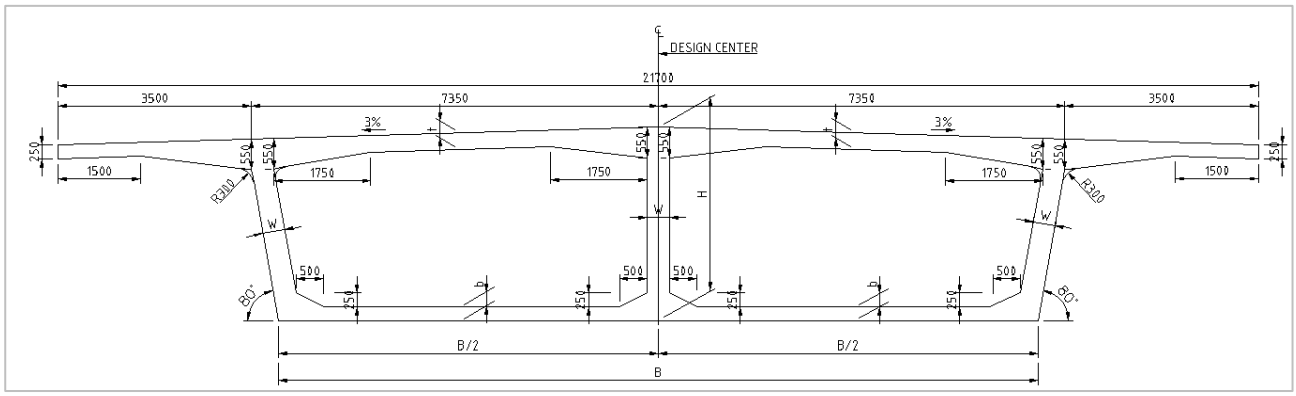
Span Arrangements

Section	Superstructure	Span Arrangement
Elevated Road (Bijoypur Side)	PSC I Girder	19x40 = 760m
Main Bridge	Extradosed + Balance Cantilever	60x2+100x2+95+160+95+100x2+60x2 = 990m
Elevated Road (Lengura Side)	PSC I Girder	6x40 = 240

Typical Main Bridge Cross Section for Extradosed Bridge Section



Typical Main Bridge Cross Section for Balance Cantilever Bridge Section



Geotechnical overview of the Bridge Site

Geotechnical investigation for foundation design has not been carried out for this bridge site as on date. In absence of data the secondary data shared by RHD "Report on geotechnical investigation for the proposed 1422.15 m long P.C girder Brahmaputra Bridge- 3 over Brahmaputra River on Rahmatpur- Ramvadrapur road Ch: 0+415 under Mymensingh road division, Mymensingh." has been used. The sub-soil has five distinct layers / stratum of more or less uniform thickness throughout as follows:

Stratum-I-Very loose silty fine sand (3 m thick)

Stratum-II-Medium dense silty fine sand (15 m thick)

Stratum-III-Stiff Clay (9 m thick)

Stratum-IV-Dense Sand, (14.5 m thick)

Stratum-V-Very Dense Sand, (8.5 m thick)

The thickness of scourable strata at this bridge site is taken as 12.10 m as per hydro morphological report titled, "Hydro-Morphological Study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh Portion) during the year 2019-2020" conducted by IWM.

PRELIMINARY ENVIRONMENTAL ASSESSMENT

- Scope of Environmental Assessment

The proposed project falls under the **Red Category** as per the Environmental Conservation Rules (ECR), 2023. An Environmental Impact Assessment (EIA) study is required for the project and the project would require Environment Clearance from the Department of Environment (DoE), Bangladesh.

The study will encompass several key objectives such as evaluation of the existing environmental conditions within the Project Impact Area (PIA) and surrounding regions. Moreover, it will identify potential positive and negative environmental impacts or risks throughout the project's lifecycle, from pre-construction to construction and operation phases. It will also address various risks, including those related to the environment, health and safety, climate change, and disaster risk, by formulating appropriate mitigation measures. Finally, it will propose suitable institutional mechanisms to effectively implement and manage an Environmental Management Plan (EMP).

- Environmental, Climate Change and Disaster Risk Analysis

The anticipated impacts of the project spanning environmental, climatic, and disaster-related aspects by the preliminary assessment. These impacts embrace alterations to the landscape of that area and geological conditions, disruptions to both terrestrial and aquatic ecosystems, soil erosion, and the generation of debris and dust. Construction activities are expected to increase sediment load and water pollution, degrade air quality through the release of dust and gas emissions from construction machinery, and degrade noise pollution due to excessive vehicles for construction. The destruction of habitats for flora and fauna, along with health and safety risks for workers and local communities, are significant concerns. Furthermore, the effects of climate change and natural disasters like flash floods and heavy rainfall could intensify these impacts. Socio-economic consequences such as increased poverty, healthcare issues, reduced ecological resilience, and energy insecurity are also anticipated. This holistic view underscores the multifaceted nature of the project's potential repercussions, emphasizing the need for comprehensive mitigation strategies to address these varied challenges.

- Impacts and Mitigation Measures

Based on the preliminary assessment due to implementation of proposed project, a summary of impacts and possible mitigation measure are presented below:

Parameters	Impacts	Mitigation Measures
Land	Acquisition of land	• Avoid or minimize the area of acquisition. • Preparation and approval of land acquisition plans before implementation
	Impact on land use	• Construction activities to be restricted within PRoW.
Biological Environment	Loss of trees and vegetation	• Avoid or minimize the cutting of trees. • Compensatory plantation should be done as per prevalent rules & regulations
	Impact on Wildlife	• Protective measures for wildlife conservation • Avoid habitat destruction & fragmentation. • Awareness Training to workers for wildlife conservation, antipoaching, etc.
	Impact on Avian Fauna	• Avoid habitat destruction
Ambient Air	Dust generation due to movement of	• The unpaved roads shall be sprinkled with water to control the fugitive dust emissions.

Parameters	Impacts	Mitigation Measures
	vehicles on unpaved roads	
	Air pollution from hot mix/ Concrete/ asphalt plants	• It will be ensured that the Concrete, Asphalt and Hot Mix Plants are licensed and authorized for operation by concerned authorities
	Increased dust levels due to earth work and construction activities	• Immediate shifting of excavated earth in covered vehicles • Frequent sprinkling of water on excavated earth
	Increased air pollution from machineries	• Preventive maintenance of machineries to meet emission standards
	Air Pollution due to operation of DG sets	• DG sets, if used, shall adhere to air emission standards as per prevailing laws of GoB. • Stack heights shall be maintained as per standards
Noise	Increased Noise Levels during Construction	• Maintenance of equipment and vehicles to meet noise level standards as per laws. • Provision of Personal Protective equipment, earmuffs, etc. for the construction labour • Avoiding construction activities during night-time
	Noise impact due to operation of DG sets	• DG sets, if used, shall adhere to noise level standards as per prevailing laws of GoB.
	Impact of Noise on Sensitive Receptors	• Provision of Noise Barrier • Delineation of Silence Zone/Signage
Water Resources	Changes to hydrological regime, increased flooding, siltation hampering stream flows, etc.	• Minimal disruption to natural stream flow • Minimum erosion of riverbanks • Revegetation for physical stabilization
	Degradation of Riverbanks due to excavation and construction activities	• Preventive measures like provision of silt fencing, oil interceptors etc during construction shall be adopted
Occupational Health & Safety	Occupational Health & Safety	• Adequate provision of PPE and safety equipment's • Periodic Safety trainings & safety audit • Periodic Health awareness and health check-up camps for workers
	Community Health & Safety	• Provision of Safety barriers and signages/ warning measures • Periodic Health awareness and health check-up camps for local community

Parameters	Impacts	Mitigation Measures
Natural Hazards	Cyclones, Floods & Earthquake Hazard	• Design and construction methods should be modified/ updated as to adopt the projected impact. • Use of alternative material & technology

INITIAL SOCIAL ASSESSMENT AND PRELIMINARY LAND ACQUISITION

- Land Use

The approach roads of Someshwari bridge-3 is situated in the rural area of Durgapur Upazila, Netrokona District. Following table has been shown the land use for acquisition.

SL No	Land Category	Area (Sqm2)	Area (acre)	Area (hector)	Percentage (%)
1	Agricultural	85731.77	21.18	8.57	54.19
2	Barren Land	9344.57	2.31	0.93	5.91
3	Commercial	2396.11	0.59	0.24	1.51
4	Residential	8378.99	2.07	0.84	5.30
5	River	21265.40	5.25	2.13	13.44
6	Transportation	13024.65	3.22	1.30	8.23
7	Vegetation	10814.35	2.67	1.08	6.84
8	Waterbody	7256.61	1.79	0.73	4.59
Total		**158212.45**	**39.10**	**15.82**	**100**

- Poverty Rate and Sex Ratio

The following table has been shown the poverty rate and sex ratio of Netrokona District & Durgapur Upazila.

Content by District	Netrokona	Durgapur
Average Poverty Rate in HIES 2016 (Upper limit)	41.1	41.1
Sex Ratio	96.15	99

- Potentially Affected Structures and Categories

The extent of impacts of the affected structures could not be analysed here in this stage of study without authenticated field observations that has been presented below.

Category of the Structure	Use Type of Structure at the Someshwari Bridge-3					Total (Unit)
	Multi-storied	Pucca	Semi-Pucca	Tin-made	Katcha/Jupri	
Residential	0	0	11	28	1	40
Commercial	0	0	6	6	0	12
CPR	0	0	1	0	0	1
Total=	0	0	18	34	1	53

Addressing The Impact on Affected Indigenous People's Structure (Baptist Church)

The proposed preliminary design of Someshwari-3 bridge affects 3 indigenous (Garo) families and their only one religious structure, a Baptist Church. This minority indigenous community and the Church have no alternative for relocation if they are displaced. Considering the scenario and to prevent the displacement of the community as per ADB/AIIB safeguard policy an elevated road will be constructed over the affected structures. As a result, the 3 households including their religious structure need not to be displaced, even during the construction phase. the structures will remain there, where those are now. These issues were thoroughly discussed with the affected indigenous community and affected households including the Church Authority and Management. They are happy and satisfied that they need not to move anywhere. But a MOU needs to be signed among all parties, the affected community, Church Authority and the client RHD agreeing with all accepted conditions. So that there will be no conflicts in future. Furthermore, all safety issues will be addressed to protect the road infrastructure and the property of the indigenous community.

COST ESTIMATE

Cost Estimate is an important component of the feasibility study as it provides vital input to economic evaluation. The cost estimation has been prepared for the approved alignment, based on the improvement proposals and preliminary design adopted at this stage. However, in absence of Geotechnical Report, this Cost Estimate is approximate and will be further updated in the next stages of study based on detailed investigations and further designs. The summary of project cost has been presented below.

Note: According to the Cost Estimation Classification Matrix prepared by the AACE International (The Association for the Advancement of Cost Engineering) the cost estimate prepared during the feasibility stage may vary from -+20%.

Division	Description	Total Amount (BDT)	Total Amount (Cr. BDT)
A.	**Construction Cost**		
1	General & Site Facilities (2% Of Construction Cost)	193,503,895.72	19.35
2	Earth Work	135,890,337.00	13.59
3	Sub-Base, Base-Courses	85,641,884.00	8.56
4	Bituminous Pavement Courses	204,152,788.00	20.42
5	Cross Drainage Structures - Culverts	2,483,952.00	0.25
6.01	Elevated Road	1,546,235,600.00	154.62
6.02	Structures – Viaduct/ Elevated Road	1,015,168,700.00	101.52
6.03	Structures - Main Bridge	5,789,800,740.49	578.98
7	Drainage & Protection Works	81,251,685.50	8.13
8	Traffic Signs, Marking And Road Appurtenances	26,686,581.00	2.67
9	Toll Plaza	273,118,120.00	27.31
10	River Training Works	443,214,398.11	44.32
11	Electromechanical Works	59,550,000.00	5.96
12	Bridge Health Monitoring System	12,000,000.00	1.20
A.	**Total Construction Cost**	**9,868,698,682**	**986.87**

Division	Description	Total Amount (BDT)	Total Amount (Cr. BDT)
B.	**Non - Civil Works**		
1	Land Acquisition, Resettlement & Compensation (10% of Civil Cost)	986,869,868.18	98.69
2	Utility Shifting (Lump Sum)	10,000,000.00	1.00
B.	**Total Non-Civil works Cost**	**996,869,868**	**99.69**
C.	**Total Capital Cost (A+B)**	**10,865,568,550**	**1,086.56**
D.	**Contingency**		
1	Price Adjustment (15% of Civil Cost)	1,480,304,802	148.03
2	Contingency		
a)	Physical Contingency (2% of Civil Works)	197,373,974	19.74
b)	Price Contingency (2% of Civil Works)	197,373,974	19.74
D.	**Total Price Adjustment and Contingency Cost**	**1,875,052,750**	**187.51**
E.	**Total Project Cost (C+D)**	**12,740,621,300**	**1,274.06**

ECONOMIC ANALYSIS

The Economic Analysis has been done in a combined perspective, considering the overall total cost and benefit of all the four bridges namely Nitai, Someshwari-3, Ganeshwari, and Mahadev. This has been done keeping in view of the fact that the overall benefit of the project influence area can only happen once the through connectivity of Z-2834 has been established between Haluaghat to Sunamganj, for which construction of all four bridges is essential.

The benefits on the construction of the bridges are as briefed as below -

- Saving in VOC and Time cost.
- Reduction in Emission.
- Incremental Output from Govt. Expenditure
- Impact on Economic Activities and Income Augmentation

Following are the results of Economic Analysis and Sensitivity Analysis:

Estimation of EIRR and NPV

- EIRR: 20.6%
- NPV @12%: 1430.8 Crores BDT
- EBCR: 1.8

Sensitivity Analysis – 10% rise in cost

- EIRR: 19.0%
- NPV @12%: 1253.8 Crores BDT
- EBCR: 1.6

Sensitivity Analysis – 20% drop in Benefits

- EIRR: 17.0%
- NPV @12%: 782.7 Crores BDT
- EBCR: 1.4

Sensitivity Analysis – All cases together

- EIRR: 15.6%
- NPV @12%: 605.1 Crores BDT
- EBCR: 1.3

Considering immense socio-economic benefits to the Project influence area, the project is strongly recommended for consideration of implementation for having high EIRR of 20.6%.

FINANCIAL ANALYSIS

The detailed financial analysis of the project has been conducted on finalization of preliminary engineering and cost estimation. The total cost of entire project is BDT. 1385.7 Cr. including interest during construction. The construction is assumed to commence in 2024 and will be completed by the end of 2026. The facility will be opened in 2027. The land acquisition cost & rehabilitation cost are included in "Total Project Cost without IDC" (BDT. 1274.1 Cr.) since that will be borne by the Government of Bangladesh. The details are presented in the table below.

Sl. No.	Cost Items	Amount (BDT. Cr.)
A	Total Project Cost without IDC	1274.1
B	Interest During Construction (IDC)	111.6
C	Total Project Cost to the authority	**1385.7**

Financial Model (Annuity Based Model)

The following assumptions have been made for Financial Analysis:

- Construction Start Year: 2024.
- Construction End Year: 2026.
- Construction Period: 3.0 Years.
- Opening of the facility: 2027.
- Loan from Bank: 70% and Equity from private party: 30%.
- Inflation Rate: 5.0% per annum.
- Interest rate during and after construction: 8.5% per annum.

The summary of Financial Analysis (Annuity based model) is shown below

Fund Details	Project IRR	Project NPV	Nominal WACC	Equity IRR	Equity NPV	Average DSCR	Average LLCR
Grant-0%, Debt-70% & Equity-30%	12.2%	BDT. 196.2 Cr.	10.8%	16.0%	BDT. 0.1 Cr.	2.15	2.89

Financial Model (Revenue based model)

This considers two distinct costs: the total capital cost and the total project cost. The entire cashflow, Project Internal Rate of Return (PIRR) and Net Present Value (NPV) have been presented below.

- Financial Analysis – Considering total capital cost.
  - PIRR: 2.23%
  - NPV@5%: -798.9 Crores BDT
  - Total Capital Cost: 1271.1 Crores BDT
  - FBCR: 0.36
- Financial Analysis – Considering total project cost.
  - PIRR: -1.37%
  - NPV@5%: -628.7 Crores BDT
  - Total Project Cost: 1086.6 Crores BDT
  - FBCR: 1.10

The financial analysis precisely shows that, the bridge does not have high revenue generating capability due to low level of traffic in the region. The toll revenue does not even recover the initial investment even in first thirty years of operation. Hence, net financial support will be required from Govt. of Bangladesh.

RISK AND SENSITIVITY ANALYSIS

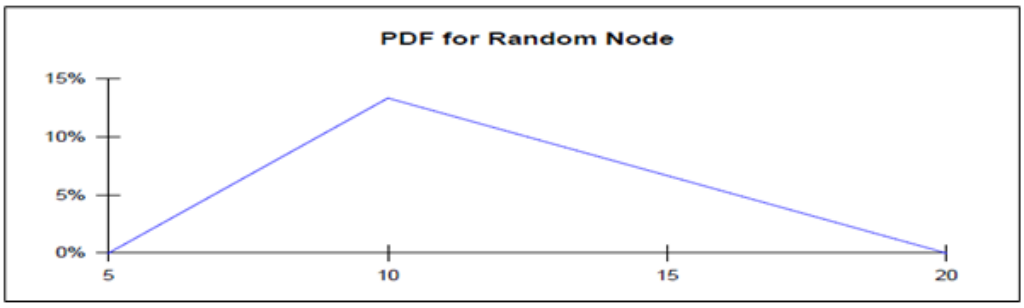
The prime objective of quantitative risk assessment of any project asserts the associated risk of cost overrun which will impact the completion target of the project with respect to planned time horizon. In most of the cases, the cost overrun causes delay in project completion as the authority needs further approval of additional unplanned funds from its government or from the lending agency. Hence, the 'delay' creates shorter economic life of the asset or the infrastructure which is incapable of generating economic benefits to the society (which is fundamental objective of any infrastructure projects)—hence, delay due to cost overrun causes limited generation of social well-being and deprives society from its claimed pleasure and well-being.

This section focuses on the quantitative risk assessment of the project with respect to possibility of the cost overrun due to change in cost parameters during construction period. Moreover, the analysis is an ex-ante risk analysis which intimate the authority about possible degree of risk of cost overrun, so that the authority knows the amount of unplanned need of budget in advance during construction period—hence, the project does not get delayed due to arrangement of unplanned additional funds with the same level of predetermined scope of work

Estimation of Probability of Total Project Cost (TPC)

- Triangular Distribution

The following figure shows Probability Density Function for analysis of discrete value of parameters for Random Node of Triangle Distribution. The 'trend' primitive has the format as shown below Trend (lower limit, most likely, upper limit)



Source: Vanguard Manual

The table below shows the different parameters which will be used in the Monte Carlo Simulation by using the Vanguard to estimate the Total Project Cost (TPC) based on the aggregate civil cost.

Stochastic Variables	Lower Value	Most Likely	Higher Value
General & Site Facilities (2% Of Construction Cost)	1.38%	1.52%	1.69%
Earth Work	1.01%	1.07%	1.28%
Sub-Base, Base-Courses	0.64%	0.67%	0.81%
Bituminous Pavement Courses	1.52%	1.60%	1.92%
Cross Drainage Structures - Culverts	0.02%	0.02%	0.02%
Structures - Minor Bridge	10.27%	12.14%	13.07%
Structures – Viaduct/ Elevated Road	6.74%	7.97%	8.58%
Structures - Main Bridge	41.99%	45.44%	50.30%
Drainage & Protection Works	0.63%	0.64%	0.77%
Traffic Signs, Marking And Road Appurtenances	0.21%	0.21%	0.25%
Toll Plaza	2.12%	2.14%	2.57%
River Training Works	3.44%	3.48%	4.17%
Electro Mechanical Works	0.46%	0.47%	0.56%
Bridge Health Monitoring System	0.09%	0.09%	0.11%
Land Acquisition, Resettlement & Compensation (Lump Sum)	7.67%	7.75%	9.30%
Utility Shifting (Lump Sum)	0.08%	0.08%	0.08%
Price Adjustment	11.62%	11.62%	11.62%
Physical Contingency	1.55%	1.55%	1.55%
Price Contingency	1.55%	1.55%	1.55%

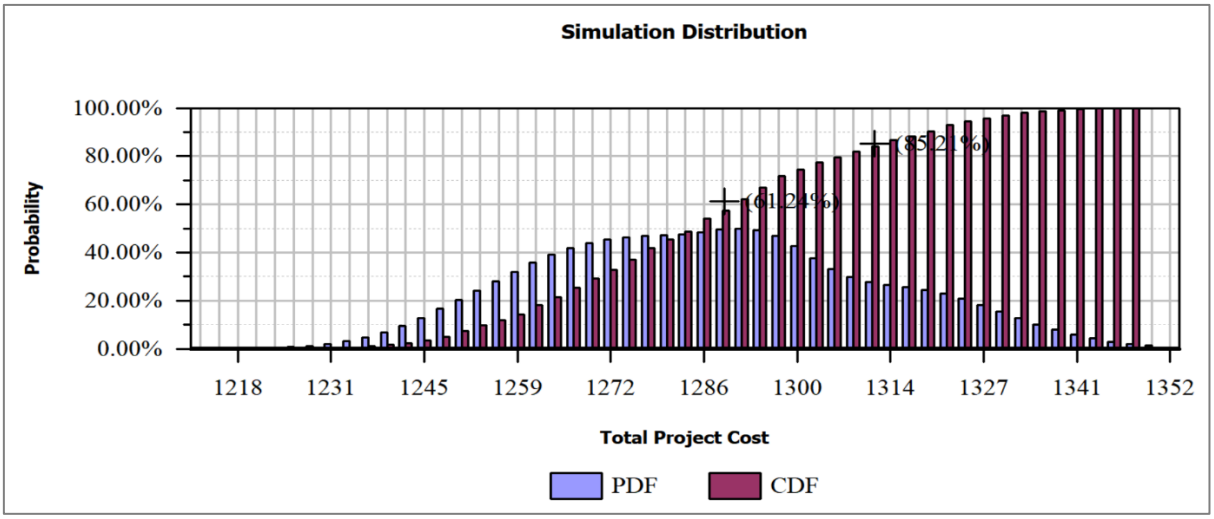
Simulation Analysis

The summary sheet from of Monte Carlo simulation shows that mean TPC is BDT. 1287 Cr. The maximum TPC may be BDT. 1352 Cr. and the minimum maybe BDT. 1215 Cr. The likely TPC, that is, mean TPC is BDT. 1287 Cr. The mean and median are almost the same that is a normal distribution. The following figure is showing both Cumulative and Probability Distribution Functions (CDF & PDF) of Total Project Cost. The Monte Carlo Simulation of TPC is showing that there is 80% chance that the TPC of New Bridge under current civil cost will be below BDT. 1306 crore and 60% chance the TPC would be BDT. 1288 Cr.

Simulation Summary

Measure	Total Project Cost
Observations	1,000
Mean	1287
Standard Deviation	24
Posterior STD	1
Variance	568
Minimum	1215
5th Percentile	1250
Median	1287
95th Percentile	1329
Maximum	1352

The Figure below displays both the Cumulative Distribution Function (CDF) and the Probability Distribution Function (PDF)of the Total Project Cost.



The risk analysis assesses the potential impact of various risks that might affect the project cost overrun overtime. Understanding these risks is crucial for project authorities to allocate additional funds in advance, which could prevent delays in project completion.

HUMAN RESOURCES AND ADMINISTRATIVE SUPPORT ANALYSIS

The Someshwari bridge-3 has been proposed as an extradosed + balance cantilever long span bridge with span arrangement of (60+2x100+60)m + (95+160+95)m+(60+2x100+60)m. The implementation of this Project thus needs specific technical expertise pertinent to extradosed long span bridges. The Roads and Highways Department (RHD) has successfully implemented the commissioning of the Payra Bridge at Lebukhali which is also an Extradosed Bridge with a span arrangement of 1 x 115m 2 x 200m + 1 x 115m and Shah Amanat Bridge (3rd Karnaphuli Bridge) with span arrangement of 1 x 115m+ 3 x 200m + 1 x 115m. RHD has also implemented the commissioning of the 3rd Shitalakshya Bridge at Bandar, Narayanganj which is a balanced cantilever box girder with span arrangement of 1 X 53.0m + 3 X 98.0m + 1 X 53.0m, 8th Bangladesh-China Friendship Bridge at Bekutia, Pirojpur with span arrangement of 1 X 72.0m + 7 X 122.0m + 1 X 72.0m, Lalon Shah Bridge at Pabna with span arrangement of 1 X 72.0m + 15 X 110.0m + 72.0m and Khan Jahan Ali Bridge at Rupsa, Khulan with span arrangement of 1 X 70.0m +5 X 100.0m + 1 X 70.0m. Thus, they have the right technical and managerial work force to implement the Someshwari bridge-3 Bridge also. At the same

time, RHD is successfully operating and maintaining the Payra Bridge, Shah Amanat Bridge (3rd Karnaphuli Bridge), 3rd Shitalakshya Bridge, 8th Bangladesh-China Friendship Bridge, Lalon Shah Bridge, Khan Jahan Ali Bridge and hence is organisationally well equipped to maintain the functional output of the proposed bridge.

INSTITUTIONAL AND LEGAL ANALYSIS

The Road Master Plan, 2009 stipulates that new bridges should be constructed on missing links. Besides, a target has been fixed to construct 37,500 meters of bridge/culvert as a strategy of the road transport sector in the 8th Five Year Plan (2021-2025) to achieve the Perspective Plan 2041. Thus, construction of the Someshwari Bridge-3 envisaged by the Roads and Highways Department, at critical missing link over Someshwari River has been envisaged within the legal purview of the Road Master Plan, 2009, 8th Five Year Plan (2021-2025) & the Perspective Plan 2041. The Assets of Roads and Highways Department have been conservatively estimated at Taka 46,000 crore (US$8,000 million) of which by far the largest proportion is the value of the 22,096.303 kms of road and the 18,258 nos. bridges. These assets are probably the greatest asset of any organisation in Bangladesh and maintaining their value is vital to its economy. This places a great responsibility on the Roads and Highways Department. Thus, the policy and institutional setup of RHD is well aligned with the successful implementation of the proposed Someshwari Bridge-3. The Roads and Highways Department (RHD) has successfully implemented the commissioning of the Payra Bridge at Lebukhali which is also an Extradosed Bridge with a span arrangement of 1 x 115m 2 x 200m + 1 x 115m and Shah Amanat Bridge (3rd Karnaphuli Bridge) with span arrangement of 1 x 115m+ 3 x 200m + 1 x 115m. RHD has also implemented the commissioning of the 3rd Shitalakshya Bridge at Bandar, Narayanganj which is a balanced cantilever box girder with span arrangement of 1 X 53.0m + 3 X 98.0m + 1 X 53.0m, 8th Bangladesh-China Friendship Bridge at Bekutia, Pirojpur with span arrangement of 1 X 72.0m + 7 X 122.0m + 1 X 72.0m, Lalon Shah Bridge at Pabna with span arrangement of 1 X 72.0m + 15 X 110.0m + 72.0m and Khan Jahan Ali Bridge at Rupsa, Khulan with span arrangement of 1 X 70.0m +5 X 100.0m + 1 X 70.0m. Thus, they have the right technical and managerial work force to implement the Someshwari Bridge-3 also. As RHD is well experienced in implementing similar projects as such no governance issue has been envisaged in implementing this Project.

CONCLUSION AND RECOMMENDATION

- The Border Road (Z-2834) is the critical element of connecting the border areas of Kalmakanda, Durgapur, Dhobaura & Haluaghat Upazila and eventually connecting the border area with Sunamganj, Netrokona and Mymensingh district centres. There is a major gap at 35th Km of the existing road near Tinali Bazar due to Someshwari River. Thus, the proposed Someshwari bridge-3 has extreme importance for ensuring connectivity between the border areas.
- The border road would also create as infrastructure, having potentiality to facilitate movement of international transit traffic which would promote international trade and commerce for adjoining countries as well as for Bangladesh. This would contribute in economic development of Bangladesh and generate additional revenue.
- The construction of the bridge will lead to savings in VOC, time costs and reduction in emission.
- The construction of the new bridge will increase the health care facilities and will also enhance the educational opportunities.
- The bridge will lead to the development of tourism industry.
- The Project (comprising Nitai, Someshwari-3, Ganeshwari & Mahadev) has been found to be economically viable with an EIRR of 20.60% and Net Present Value (at 12% Discount rate) of 1430.8 Crores BDT.

Considering immense socio-economic befits to the Project Influence Area and economic viability**, this Project is recommended to be executed as per the approved Alignment Option and approved Bridge form, mentioned in this report**.

1 BASIC INFORMATION

1.	Name of the Project	:	Consultancy Services for Detailed Feasibility Study and Design for Construction of 01 (one) bridge adjacent to Zero Point in Mymensingh town, 02 (two) bridges adjacent to Mymensingh EPZ, 04 (four) bridges on Border Road and 2nd Someshwari bridge respectively of Mymensingh Zone under Roads and Highways Department, Bangladesh
2.	(a) Sponsoring Ministry/Division (b) Implementing Agency	: :	Government of Bangladesh (GoB)
3.	Project Objectives (Project to be taken based on the study)	:	The feasibility study of Someshwari Bridge-3 aimed to evaluate the viability of proposed development projects in the region. Through comprehensive analysis of infrastructure, market dynamics, and socio-economic factors, it provided valuable insights into potential opportunities and challenges. The findings from this study will inform strategic decision-making and facilitate the sustainable growth of the area.
4.	Estimated Project Cost (Taka in Crore)	:	1,274.06
5.	Sector & Sub-Sector	:	RHD
6.	Project Category (Based on Environment Conservation Rules 1997)	:	Red category
7.	Projection Geographic Location (a) Countrywide (b) Division (c) District (d) Upazila (e) Others (City Corporation/Pourashva)		 Bangladesh Mymensingh Netrokona Durgapur
8.	Project Duration	:	Construction Start Year: 2024. Construction End Year: 2026. Construction Period: 3.0 Years. Open for traffic for Commercial Operation from 2027.

2 INTRODUCTION

2.1 Project Background

Bangladesh with its fast-growing economy aspires to become a middle-income country which in return would require improved land route connectivity to support the potential need in the growth of vehicular movement due to growth in the GDP. The economic growth will induce growth in freight traffic and higher socio-economic growth, which would contribute in increase in the usage of private vehicles, whereas population growth would maintain the demand of public transport. Hence the demand of road network is growing while a good road network will allow the benefit of the economic growth to spread across the country and reveal new opportunities.

Since the country is covered by rivers and water bodies there are many road networks rely on ferry service for the connectivity. The existing ferry services have their own limitations to achieve uninterrupted flow, due to capacity and availability of the service. Therefore, it is essential to construct bridges to ensure safer uninterrupted traffic flow and availability of service around the clock.

The Road Master Plan 2009 has made specific recommendations for the construction of bridges in the road network. In addition, the 8th Five-Year Plan (2021-2025) has set a target of constructing 36,500 m bridges & culverts as a strategy for the road transport sector.

Mymensingh Division is the eighth administrative division of the nation. In 2015, The division has been formed by separation from Dhaka division consisting the districts of Mymensingh, Jamalpur, Sherpur and Netrokona. The bridges along the border districts will play a crucial role in improving the trading between Bangladesh and land locked countries to utilise the Bangladesh ports for their exports & imports.

Considering the above scenario and in line with the policy of gradual construction of new bridges, RHD has selected 8 channel gaps to construct new bridges, in various locations of Mymensingh Zone of RHD, considering their strategic location, river width, AADT and socio-economic potential of the project areas. The studies are being carried out keeping in view of local conditions like, availability of skilled manpower, local construction material, accessibility issues, etc. Name of these bridges and extend of study are -

- Brahmaputra Bridge adjacent to Zero Point in Mymensingh Town over Brahmaputra River: Detailed Feasibility Study and Detailed Design
- Mahadev Bridge over Mahadev River at 9th km of Broder Road (Z2834): Detailed Feasibility Study and Detailed Design
- Ganeshwari Bridge over Ganeshwari River at 21st km of Broder Road (Z2834): Detailed Feasibility Study and Detailed Design
- Someshwari Bridge-3 over Someshwari River at 35th km of Broder Road (Z2834): Detailed Feasibility Study and Detailed Design
- Nitai Bridge over Nitai River at 47th km of Broder Road (Z2834): Detailed Feasibility Study and Detailed Design
- Brahmaputra Bridge (Ishwarganj) at Ishwarganj-Uchakhila-Ahmedabad Bazar-Trishal Road (Z3043) over Brahmaputra River: Detailed Feasibility Study and Conceptual / Preliminary Design
- 1 (one) bridge at 11th km of Ishwarganj-Uchakhila-Ahmedabad Bazar-Trishal Road (Z3043): Detailed Feasibility Study and Conceptual / Preliminary Design
- Someshwari Bridge-2 over Someshwari River at 36th km of Shyamganj-Zaria-Birishiri-Durgapur Road (Z3704): Detailed Feasibility Study and Conceptual / Preliminary Design

The Project Location Map showing the 8 Bridges has been presented in Figure 2-1, below.

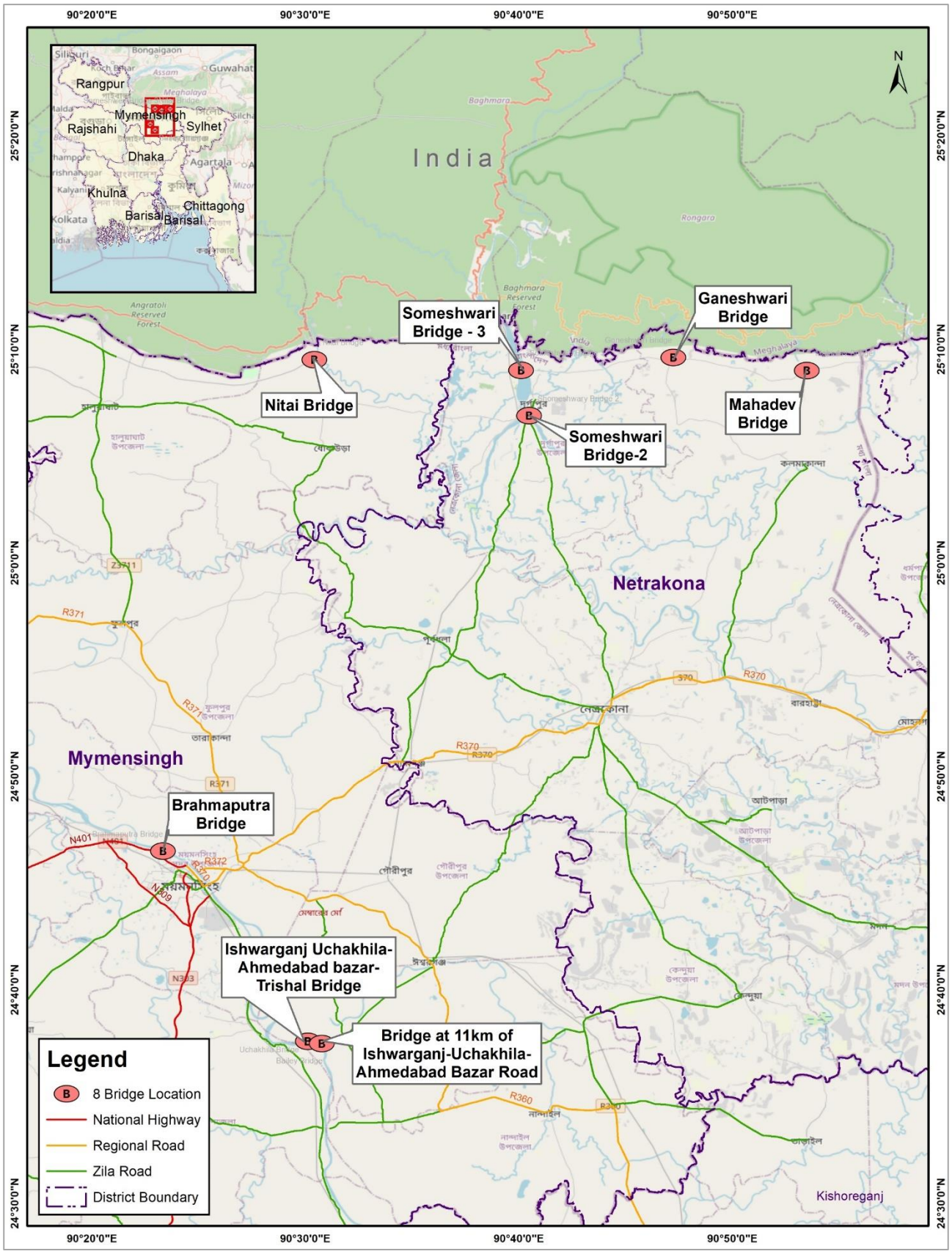


Figure 2-1: Project Location Map

2.2 Objective

The objective of the entire study is to provide a safe, reliable, and uninterrupted road connectivity over Someshwari River in Durgapur, Netrokona districts. Further the Feasibility Study aims to concur on the best alignment option and main bridge form encompassing all techno – economical as well as Social, Environmental and Financial parameters. The framework of the study is primarily based on the guidelines of the Planning Commission, Government of Bangladesh. Furthermore, the Consultant has conducted a further detailed study mainly with regard to the Option Studies and other technical aspects.

2.3 Approach and Methodology

At this stage of the project, several critical tasks have been completed to facilitate the feasibility study:

- Traffic Surveys: Comprehensive studies including desktop analysis, survey planning, data collection, and capacity assessments
- Engineering Surveys: Involving reconnaissance, road inventory, condition assessments, drone videography, and topographic surveys.
- Market Demand Analysis: Assessing the need for the proposed infrastructure.
- Alignment Options and Bridge Forms: A thorough comparative study led to selecting the preferred option
- Preliminary Engineering Studies: Formulating development proposals based on analyses.
- Environmental and Social Assessments: Evaluating potential impacts, including land acquisition
- Initial Social Assessment and Preliminary Land Acquisition Assessment
- Cost, Economic, and Risk Analyses: Evaluating feasibility from various perspectives

2.4 Organisation of the Final Feasibility Report

- Volume I – Main Report
  - Executive Summary
  - Chapter 1 – Introduction
  - Chapter 2 – Traffic Surveys and Analysis
  - Chapter 3 – Engineering Surveys and Investigation
  - Chapter 4 – Market Demand Analysis
  - Chapter 5 – Option Study
  - Chapter 6 – Preliminary Engineering and Development
  - Chapter 7 – Preliminary Environmental Assessment
  - Chapter 8 – Initial Social Assessment and Preliminary Land Acquisition
  - Chapter 9 – Cost Estimate
  - Chapter 10 – Economical Analysis
  - Chapter 11 – Financial Analysis
  - Chapter 12 – Risk and Sensitivity Analysis
  - Chapter 13 – Human Resources and Administrative Support Analysis
  - Chapter 14 – Institutional and Legal Analysis
  - Chapter 15 – Conclusion and Recommendation
- Volume II – Sub Reports
- Volume III – Drawings
  - Part A – Roadworks
  - Part B – Structures
- Volume IV – Summary Report

3 MARKET DEMAND ANALYSIS

3.1 Problem Statement

The direct impact of the proposed bridges will be on the people of Kalmakanda & Durgapur Upazilas of Netrokona districts and Haluaghat & Dhobaura of Mymensingh districts. These four Upazilas will be connected via proposed four bridges with each other. Hence, Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge on the new road alignment plays the most vital role to improve the connectivity between two districts on the road alignment of Z2834. The entire old route via Z3712, Z3707, Z3704 and Kalmakanda-Durgapur Road is about 128.4 km long which will be replaced by 44.8 km road length including proposed Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge on the new road alignment. The Figure 3-1 shows the proposed new road on which all four bridges are situated at 9th, 21st, 35th and 48th km with respective bridges like, Mahadev bridge, Ganeshwari bridge, Someshwari bridge, and Nitai bridge, Again, the existing route has been depicted through bold redline which is approximately 75 km from Panchogaon Notun Bazar (near Mahadev bridge) and Nitai bridge of Mymensingh district.

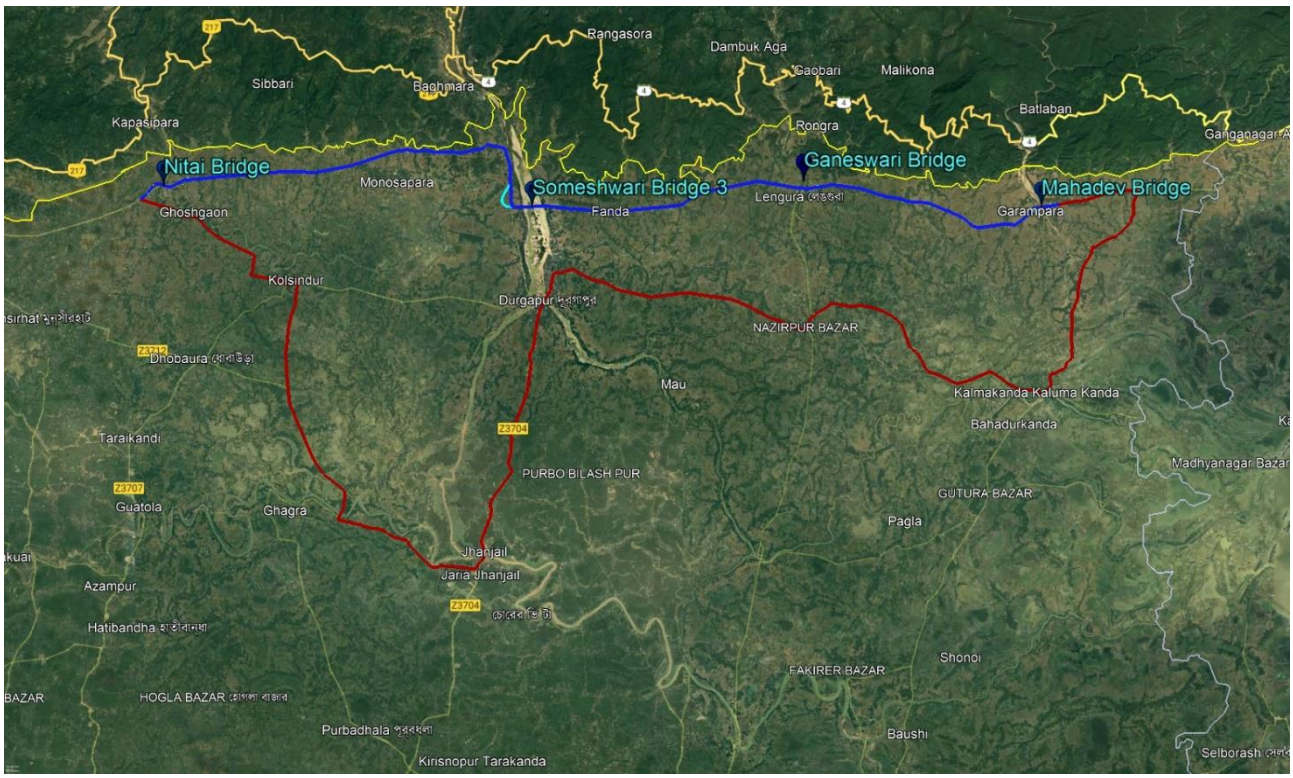


Figure 3-1: Existing Vehicular Route (red line) vs Proposed Route (blue line)

The proposed bridges will have severe impact on the people of peripheral and adjacent areas of the alignment from Nitai Bridge to Panchogaon Notun Bazar. Hence, Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge of new alignment plays the most vital role to improve the intra and inter regional connectivity which will improve the equitable distribution of economic power which will lead to equitable economic growth.

However, it is very evident, the local inhabitants of these Upazilas, mainly, Kalamunda, Durgapur of Netrokona district and Haluaghat & Dhobaura Upazilas of Mymensingh district facing severe connectivity problem with district headquarter Netrokona Sadar and Mymensingh Sadar, respectively. There is significant amount potential loss due to connectivity issue. The data show there are skewed distribution of social fundamental amenities in two Sadar compare to other Upazilas. It is also true that overnight these livelihood facilities are not possible to establish as that will create huge cost to the government and suboptimal demand & allocation of resources. Hence, smooth connectivity facility will be a win-win situation for both parties

which will be fulfilled by the proposed bridge. A brief socio-economic profile of these Upazilas is depicted below:

Table 3-1 : Brief Socio-Economic Profiles

Economic Parameters	Netrokona Sadar	Kalmakanda	Durgapur	Mymensingh Sadar	Haluaghat	Dhobaura
Land Area (Sq. km)	341.71	376.22	278.28	281	357.11	
Mouza	279	179	134	132	145	96
Population in 2001	372785	271912	224893	674452	290043	172152
Population Density (no/sq. km)	1091	1848	805	1736	812	686
Literacy Rate (%)	44.04%	-	39.50%	49.9%	57%	36.75%
Growth Centres	16	31	19	61	29	-
Land Area under Irrigation (Hctr.)	237.92	23500	20470	25780	28350	-
Primary Schools	29	2	9	132	167	-
Secondary Schools	32	22	25	6	25	-
Hospital	1	0	0	1	1	-
Colleges	5	1	4	9	5	-
Bank	7	3	6	56	-	-
Factory Heavy Industry	0	0	0	1	-	-
Factory Small Industry	222	134	15	5534	-	-

Source: District Websites

3.2 Relevance of the Project

The need of the proposed bridge has already been substantiated by a brief socio-economic data but that is not limited to it. There are some other broader aspects of the bridge:

1. Savings in journey time and cost of travelling of existing passengers and freight traffic on the said alignment due to construction of proposed bridges.
2. The direct impact of the proposed bridges will be on the people of peripheral and adjacent areas of the alignment from Nitai Bridge to Panchogaon Notun Bazar. Hence, Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge of new alignment plays the most vital role to improve the intra and inter regional connectivity which will improve the equitable distribution of economic power which will lead to equitable economic growth.
3. Construction of new bridge will increase health care facilities and will save time, cost of treatment and life of several hundred people of the region of new proposed connectivity to be established; especially of new born babies who are referred to nearest districts sadar for urgent attention.
4. Construction of Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge on the road alignment will increase educational opportunities and facilities. The bridges will save cost of education as well as will bring opportunities of higher education within their means. This will be a boon especially

to girl students of region and to the students of poor families who cannot afford to provide residential facilities at Mymensingh and Dhaka or near to national Capital Region (NCR).

5. There will be considerable impact on price level in the area as the transportation cost of consumer goods will be reduced substantially owing to reduction in time of transporting goods from Mymensingh and Netrokona districts.
6. There will be widening of marketing facilities of agricultural products of Mymensingh and Netrokona districts for having majority of growth centres including fish export enabling rise in income of people engaged in fishing and fishery activities and farming activities
7. Construction of bridge will increase manifold arrival of domestic as well as international tourists which will lead to development of tourism as industry.
8. There will be rise in local income level for construction of Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge on the road alignment. The bridges will ensure all weather connectivity leading to more generation of economic activities owing to marketing of surplus agricultural products, growth in tourist traffic, rise in domestic and international trade etc.

There will be substantial improvement in favour of 'law & order' near the international border area due to accessibility of police, army and border security forces. Moreover, there will be substantial improvement in import-export between India and Bangladesh. Presently, Gobrakura Land Port is active in Mymensingh district with India in Meghalaya and the import-export operations are taking place through manual Land Custom Station (LCS). An upgradation proposal is on the way to upgrade the manual system to electronic custom system (ECS) which will facilitate faster movement of inter-border goods along with passenger movements. Hence, there will be an economic boom for the region in terms of income augmentation of the districts and upazilas.

3.3 Proposed Project Interventions

The direct impact of the proposed bridges will be on the people of Kalmakanda & Durgapur upazilas of Netrokona districts and Haluaghat & Dhobaura of Mymensingh districts. These four upazilas will be connected via proposed four bridges with each other. Hence, Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge on the new road alignment plays the most vital role to improve the connectivity between two districts on the road alignment of Z2834. The entire old route via Z3712, Z3707, Z3704 and Kalmakanda-Durgapur Road is about 128.4 km long which will be replaced by 44.8 km road length including proposed Nitai Bridge, Someshwari Bridge 3, Ganeshwari Bridge, and Mahadev Bridge on the new road alignment. The following Figure 8.1 shows the scenario and road user savings has been estimated accordingly with help of HDM4. The blue bold line shows the proposed new road on which all four bridges are situated at 9th, 21st, 35th and 48th km with respective bridges like, Mahadev bridge, Ganeshwari bridge, Someshwari bridge, and Nitai bridge, Again, the existing route has been depicted through bold redline which is approximately 75 km from Panchogaon Notun Bazar (near Mahadev bridge) and Nitai bridge of Mymensingh district.

3.4 Stakeholders

Consultant will establish the following stakeholders as internal and external at both design and construction phase of the project and the list will be updated as project staff begin to open workshops.

Internal Stakeholders	External Stakeholders
Government of Bangladesh (GoB)	Other planning and implementation agencies
Roads and Highways Department (RHD)	Government Ministries
Project Steering Committee	Bangladesh Rural Electrification Board
Project Implementation Committee	Border Guard Bangladesh

Contractors	Municipalities
Suppliers	Office of the DCs
	NGOs

3.5 Demand Analysis

3.5.1 Current Demand

The current socio-economic data show there are significant amount of people who are suffering from road connectivity issue and the economic cost to the society is significantly very high.

3.5.2 Future Demand

The future demand will be significantly on higher side as Bangladesh is one of the high growth rate economies having almost 1.1% of population growth rate as per The World Bank data. The exact future demand analysis could be done after complete traffic survey where actual potential need of the bridge will get reflected. It is also evident that there exist high elasticity value of net export and road sector gross value added due to nearest land port presence with India. The export import data shows there exist 3.75% of growth rate per year in Bangladesh which will promote further development of the region.

3.5.3 Constraints

The prime constraint of any connectivity improvement focused bridge is the funding and loan repayment. Since the purchasing power of rural people are comparatively low compared to the urban habitats. The bridge will improve the economy of the locality overtime but loan repayment will start from the starting of first construction day. However, funding is the only constraint here.

3.6 SWOT Analysis

The SWOT analysis shows the Strength-Weakness-Opportunity-Threat of the project which has been discussed in subsequent section of this report:

Strength: The Prime Strength of the project is the social need of the project in terms of development of the local economy. Presently, connectivity is the only issue which is being faced significantly by the local people and potential economic loss due high waiting time at ferry ghat.

Weakness: The major Weakness of the project is funding, as the project is not financially very lucrative due to two reasons: a) the affordability of local people is very low for having low economic activity where the connectivity is the major issue and b) funding of the project and loan repayment if any, having low traffic intensity in the area which will increase overtime.

Opportunity: This the most vital aspect of the bridge which is the enhancement of new economic Opportunities for the local people as all-weather connectivity will be established and will act that as a game changer in the region. There will substantial improvement in human capital as the limitation of education and health care hurdles will be almost removed or will be significantly minimized. The economic activities will increase and that will lead to a higher economic growth in the locality.

Threat: In this this case he Threat and weakness is almost same due same nature of the problem—funding of the bridge. If the construction gets delayed or it get cancelled due to lack of fund that will be disastrous situation for the locality as the suffering continue for another long finite time horizon and suffering will increase overtime.

4 TECHNICAL/TECHNOLOGICAL & ENGINEERING ANALYSIS

4.1 Location

The proposed bridge over Someshwari River is located at 36th Km of border road Z-2834 near Tinali Bazar, at Durgapur, Netrokona. The total length of the project road is **3.831 km.**

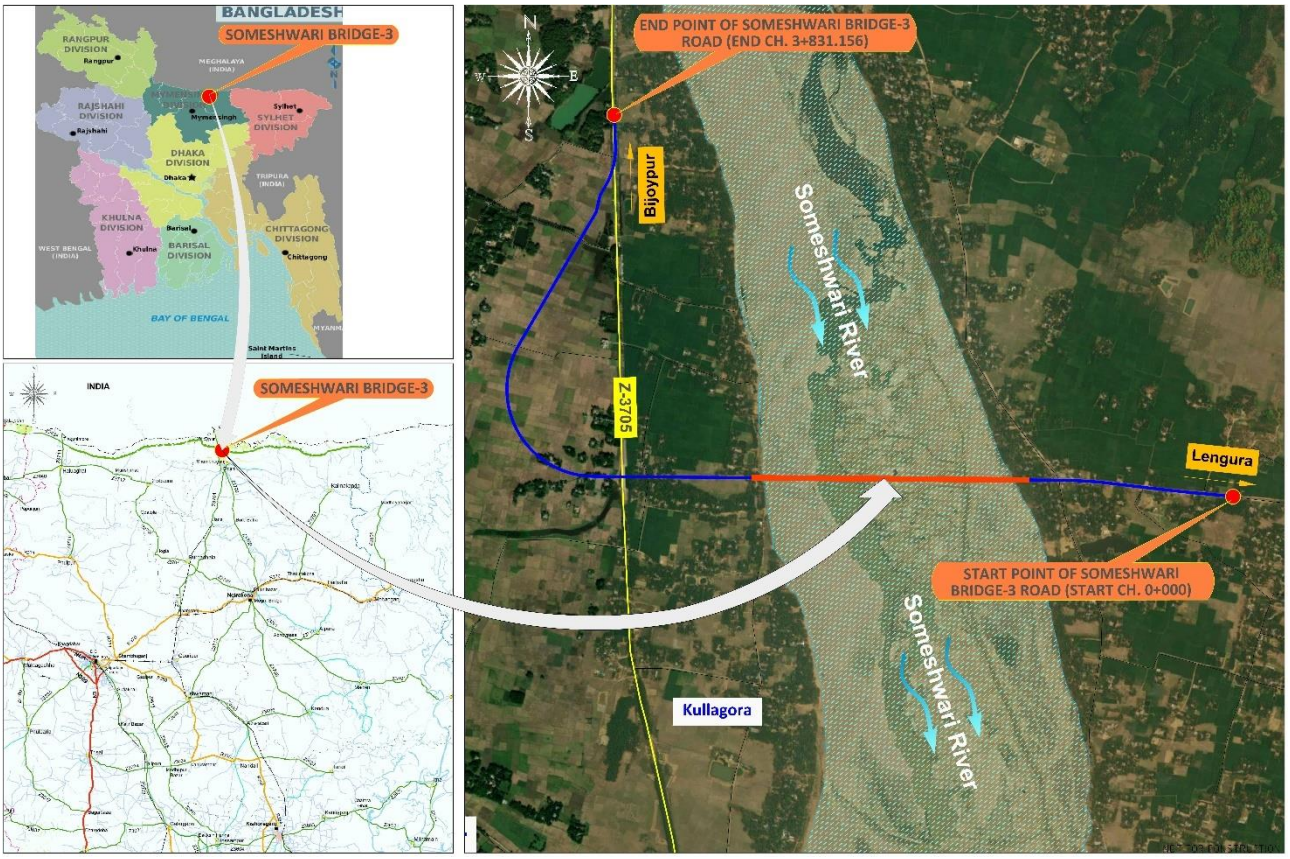


Figure 4-1: Proposed Someshwari Bridge-3 Location Map

The Project site, the Someshwari Bridge-3 and its approach road at both ends are situated in the rural area of Netrokona District. Throughout the proposed alignment, land use distribution comprises agricultural land 21.18 acres (54..19%) of total land required, river occupied is the 2nd highest about 5.25 acres (13.44%), transportation/road occupied 3.22 acres (8.23%), Vegetation occupied 2.67 acres (6.84%), barren land occupied 2.31 acres (5.91%), residential area occupied 2.07 acres (5.30%), waterbody consists of ponds and canals occupied 1.79 acres (4.59%), and commercial land occupies is very minimum 0.59 acres (1.51%) of total land.

In assessing potentially affected structures, housing stands as a fundamental human right. These structures serve residential, commercial, and community purposes, categorized by construction materials. The assessment identifies 40 residential , 12 commercial structures and one CPR emphasizing the diverse roles these buildings play within the community.

Throughout the Project alignment, it was determined that the project requires a land area of 39.10 acres initially. Following the completion of georeferencing mouza maps, these will be accurately overlaid to create a plot schedule. Subsequently, a Land Acquisition Plan (LAP) with detailed drawing is on the preparation stage and will be submitted to the client for review.

In addition to the LAP drawings, a utility shifting drawing has been prepared and submitted to the client for review. This plan ensures seamless coordination for relocating utilities, underscoring our commitment to a smooth construction process for the Someshwari bridge-3 project.

4.2 Technical Design

4.2.1 Traffic Surveys & Analysis

In conducting a feasibility study, comprehensive traffic surveys play a crucial role in assessing the viability and potential impact of a proposed project. For the study purpose the following Traffic Surveys have been conducted:

- Video Traffic Count Survey (VTS)
- Video Pedestrian Count Survey (VPS)
- Roadside Interview Survey (RSI), including.
  - Origin-Destination Survey (ODS)
  - Vehicle Occupancy Survey (VOS)
  - Willingness to Pay Survey (WTP)

The forecasted traffic for the proposed Someshwari bridge-3 area incorporates various factors, including organic growth, induced/generated traffic from future economic zones, land ports and potential international transit traffic due to proposed infrastructure developments.

To capture this short-term additional traffic, 2% (an assumption by the transport planning team) of the total traffic of the opening year has been added for a period of 5 years.

Table 4-1 shows the calculated opening year traffic of 2027 as well as the base year traffic of 2023. The opening year traffic considered generated traffic, diverted traffic, land port traffic, potential transit traffic, induced traffic etc., which are categorized in the table.

Table 4-1: Classified calculated opening year traffic (2027)

Year	Types of traffic		Truck	Bus	Microbus	Utility vehicle	Car	Baby Taxi/ CNG/Auto	Tempo/ Leguna	Motorcycle	Bicycle	Rickshaw	Rickshaw Van	Cart	Total
Base year 2023	Existing Traffic (2023)		-	-	-	-	-	-	-	-	-	-	-	-	-
Opening year 2027	Applying growth rate on present traffic		-	-	-	-	-	-	-	-	-	-	-	-	-
	Mode shift waterway to roadway		10	38	40	49	41	44	44	58	38	38	-	-	398
	Diverted traffic	Only for Someshwari 3 Bridge	123	13	20	17	16	31	766	1,145	238	142	33	5	2,548
		For four bridges (Regional traffic through border roads)	241	119	58	22	90	-	-	-	-	-	-	-	530
	Land port traffic (between Bangladesh and India)		497	7	8	4	4	-	-	-	-	-	-	-	519
	Transit traffic (India to India traffic using Bangladesh Road)		99												99
	Tourist traffic		3	10	5	5	6	2	28	30	6	10	1	2	107
	Induce traffic		4	2	1	0	2	0	9	34	13	0	1	0	67
	Total		977	190	131	97	157	77	847	1,267	294	190	34	7	4,268

The number of required lanes for the Someshwari Bridge-3 is estimated based on the traffic data analysis, projected AADT and above mention assumptions.

The proposed number of lanes is calculated for the Someshwari Bridge-3 as illustrated in Table 4-2. The considerations of the calculations are as follows;

- The number of lanes required is estimated from the peak hour traffic.
- Design speed is considered as 80 kmph
- The lane calculation of the proposed bridge is based on the Level of service LOS B (875 PCU/ lane/hr) and the Level of service LOS C (1,275 PCU/lane/hr).

Table 4-2: Number of lanes for the proposed Someshwari bridge-3

Projection Period	Year	Traffic Volume in AADT		Traffic Volume in PCU		Lane Number (Based on peak hour demand)		Lane Number (Round up the number)	
		Daily	Peak hour	Daily	Peak hour	LOS B	LOS C	LOS B	LOS C
Base year	2023	0	0	0	0	-	-	-	-
Traffic opening year	2027	4,268	510	6,151	736	0.84	0.58	2.00	2.00
Opening +5 year	2032	6,054	724	8,216	983	1.12	0.77	2.00	2.00
Opening +10 year	2037	7,786	931	10,074	1,205	1.38	0.94	2.00	2.00
Opening +15 year	2042	10,182	1,218	12,521	1,498	1.71	1.17	2.00	2.00
Opening +20 year	2047	12,436	1,487	14,733	1,762	2.01	1.38	4.00	2.00

The calculation suggests that in the opening year of 2027, the proposed Someshwari Bridge 3 will require 2 lanes up to 2042 (15 years after the opening year) to support peak hour traffic demand in LOS B. In 2047 (20 years after the opening year), Considering land port and transit traffic, the bridge will require 4 lanes for LOS B. On the other hand, 2 lane bridge is sufficient until 2047 for LOS C.

4.2.2 Design Standards - Highway

The summary of design standards is as follows:

- Geometric Design –
  - "A Policy on Geometric Design of Highways and Streets (AASHTO) 2018, 7th Edition".
  - "Geometric Design Standards Manual of RHD (Revised) June 2005"
- Typical Cross-section –

  The cross sections have been prepared in reference to MOM Ref. no: GEN-MOM-004, dated June 06, 2023 (Volume 1 – Appendix I) which considers elements from the "Bridge Design Standards for Roads & Highways Department January 2004" and the "Geometric Design Standards Manual of RHD (Revised) June 2005".
- Pavement Design –
  - The pavement design has been finalized as per "AASHTO Guide for Design of Pavement Structures, AASHTO, Washington, D.C., 1993".
  - Comparative analysis has also been done based on "Guidelines for the Design of Flexible Pavements, IRC :37-2018, 4th Revision, 2018", "AASHTO Guide for Design of Pavement Structures, AASHTO, Washington, D.C., 1993" and "Geometric Design Standards Manual of RHD (Revised) June 2005".

  - Weather factors like temperature change, rainfall etc. for pavement design are considered from Austroads guidelines.
- Embankment Design & Slope Stability Analysis –
  - "A Policy on Geometric Design of Highways and Streets (AASHTO) 2018, 7th Edition".
- Road Furniture –
  - "Geometric Design Standards Manual of RHD (Revised) June 2005"
  - "A Policy on Geometric Design of Highways and Streets (AASHTO) 2018, 7th Edition"

4.2.3 Geometric Design

The main components included in the geometric design of road alignment are:

- Alignment and Geometry
  - Horizontal alignment
  - Vertical alignment
- Cross-sectional elements
- Service Road/Slip Road
- Junctions

These components are essential for ensuring the safe, efficient, and sustainable design of road alignments, as outlined in the Final Feasibility Study Report of Someshwari Bridge-3, Volume-I.

The road is a Rural collector road with a Design Speed of 80 kmph with total length of 3.831 km.

- Recommended Pavement Design for Road

Based on AASHTO method for design traffic of 24 MSA, the recommended pavement composition for the project road has been presented below.

Table 4-3: Recommended Pavement Design

Layers	Thickness (mm)
Asphalt Wearing Course	50
Asphalt Base Course	195 (In three layer- 60, 60 & 75mm each)
Aggregate Road Base (Base Type I)	200
Granular Subbase	100
Improved Subgrade (CBR 8%)	300

The pavement system for the concrete bridge deck and viaduct/ elevated road shall have a total thickness of approx. 54 mm and consists of the following components:

- **Wearing course**: 50 mm dense graded Bituminous concrete
- **Tack coat**: approx. 200 micrometres
- **Waterproofing membrane**: 2-4 mm synthetic resin-based membrane (sprayed in two layers)
- **Primer**: concrete deck primer (sprayed)

The waterproofing system shall be an elastomeric polyurethane or Methyl-Meth-Acrylate (MMA) based waterproofing system for concrete bridge decks.

The recommended pavement composition for Toll Plaza and service/slip road for design traffic of 10 MSA based on AASHTO method is represented in the **Final Feasibility Study Report of Someshwari Bridge-3, Volume-I.**

4.2.4 Design Standards- Bridge

The Design Standards of Bangladesh would be followed in principle for design and analysis of bridges in this project. If any provision is not available in local codes, other standards like AASHTO/IRC will be referred. Some of the standards and codes that will be used for design of bridges as per RFP are listed below:

- RHD bridge designer's handbook.
- BNBC code and pertinent design standard can be used to design the earthquake resilient structure.
- AASTHO - LRFD
- Road Note
- Indian Road Congress
- Austroads

Analysis and design of bridges, viaducts, elevated roads and other structures will be carried out as per above standards and guidelines.

4.2.5 Bridge Form

Table 4-4 outlines the evaluation of final bridge form along with approach viaducts/ elevated road, considering key guiding aspects such as navigational requirements, data from hydrological and morphological reports, and bridge aesthetics. Following a Multi-Criteria Analysis (MCA), the highest scoring bridge option under the preferred alignment was identified and recommended by the consultant. Based on the recommendation, DFSR workshop was held and final bridge form has been approved. For detailed information on the Option Study and Recommendation on Bridge form and Span arrangements, please refer to **Section-10** of the report.

Table 4-4: Details of the Main Bridge & Viaduct/ Elevated Road

Section	Superstructure	Span Arrangement
Elevated Road (Bijoypur Side)	PSC I Girder	19x40 = 760m
Main Bridge	Extradosed + Balance Cantilever	60x2+100x2+95+160+95+100x2+60x2 = 990m
Elevated Road (Lengura Side)	PSC I Girder	6x40 = 240

After evaluation of various options, Option 1D, characterized as Extradosed + Balance Cantilever Bridge, is approved for the project. The decision comes following careful consideration of factors such as navigational requirements, hydrological and morphological data, ease of construction as well as bridge aesthetics.

The summary of HMS and hydrological assessment have been given below.

Sl. No.	Description	Quantity	Remark
1	Standard High-Water Level (SHWL) With Climate Change Effect	14.24 m SOB	Refer Section 6.3.2.6 Volume 1.
2	Design High Water Levels including climate change impact (m SoB)	17.48 m SOB	Refer Section 6.3.2.4 Volume 1.
3	Vertical Clearance for navigation	5.00 m	Refer Section 6.3.2.4 Volume 1.
4	Depth of bridge superstructure (From Soffit to Finished Deck Top Level)	5.30 m	As per GAD (Refer FFSR Volume III, Part B- Structure Drawings)

Sl. No.	Description	Quantity	Remark
5	Minimum Required Finished Road level at main bridge portion	24.54 m SOB	
6	Proposed finished road level at Center	25.80 m SOB	Considering 5.7m vertical clearance for roads at east banks.

Below is the proposed Schematic General Arrangement Plan of The Proposed Bridge.

Figure 4-2: Schematic General Arrangement Plan of The Proposed Bridge & Viaduct/ Elevated Road

4.3 Output Plan

- Cross Sectional Elements

The total length of the project road is 3.831 km. The proposed carriageway primarily consists of a two-lane configuration with SMVT lanes on both sides. Each lane on the main carriageway is 3.65 meters wide, while SMVT lanes are 3 meters wide. Additionally, a 1.5-meter-wide paved shoulder is proposed for normal two-lane carriageways, with a 1.0-meter-wide verge on both sides.

At bridge and viaduct sections, the footpath width is proposed to be 1.2 meters, while a 1.0-meter-wide footpath cum drain is planned for slip road sections. Utility corridors of 2.0 meters width are allocated within the Right-of-Way (ROW) on both sides of the carriageway for utility services.

- Typical Cross-Section

The project road is recommended to be a two-lane carriageway with SMVT lane on both sides. The summary of Typical Cross Sections for proposed Someshwari Bridge-3 Alignment has been presented in Table 4-5.

Table 4-5: Summary of Typical Cross sections

Sr. No.	TCS Type	TCS Description	Proposed ROW	Length (Km)
1	TCS 1	Typical Cross Section for Merging with Existing Road with Embankment Height Less Than 2m at Rural Areas	30	0.023
2	TCS 2	Typical Cross Section for Merging with Existing Road with Paved Shoulder (Varies) with Embankment Height Less Than 2m at Rural Areas	30	0.125
3	TCS 3	Typical Cross Section for Two Lane Carriageway with Paved Shoulder with Embankment Height Less Than 2m at Rural Areas	30 to 50	0.043
4	TCS 4	Typical Cross Section for Two Lane Carriageway with Bus Bay (Varies) in Rural Areas	38	0.095
5	TCS 5	Typical Cross Section for Two Lane Carriageway with Paved Shoulder with Embankment Height Less Than 2m at Rural Areas	38	0.010
6	TCS 6	Typical Cross Section for Two Lane Carriageway with Varies SMVT Lane with Embankment Height 2m to 3m at Rural Areas	38	0.065
7	TCS 7	Typical Cross Section for Two Lane Carriageway with SMVT Lane with Retaining Wall on Left Side	28.5	0.045
8	TCS 8	Typical Cross Section of Two Lane Carriageway with SMVT Lane and 7.3m Service Road on Left Side	70 to 77	0.035
9	TCS 9	Typical Cross Section of Two Lane Carriageway (with SMVT Lane) with Retaining Wall and 7.3 M Service Road on Left Side	61 to 75	0.039
10	TCS 10	Typical Cross Section of Two Lane Carriageway (with SMVT Lane) with Retaining Wall with Separator and 7.3m Service Road on Left Side	61	0.033
11	TCS 11	Typical Cross Section for Two Lane Carriageway at Elevated Road Sections (With SMVT Lane) & 7.3m At-Grade Service Road (with Both Side Footpath Cum Drain) on Left Side of Elevated Road	43	0.133

Sr. No.	TCS Type	TCS Description	Proposed ROW	Length (Km)
12	TCS 12	Typical Cross Section for Two Lane Carriageway at Elevated Road Sections (with SMVT Lane)	24	0.859
13	TCS 13	Typical Cross Section for Two Lane Carriageway at Extradosed Bridge (with SMVT Lane)	24	0.990
14	TCS 14	Typical Cross Section for Two Lane Carriageway with SMVT Lane with Embankment Height 3m to 6m at Rural Areas	50 to 54	0.556
15	TCS 15	Typical Cross Section of Two Lane Carriageway with SMVT Lane at Merging Section with Toll Plaza	50 to 116	0.220
16	TCS 16	Typical Cross Section for Toll Plaza Location (with SMVT Lane)	116	0.055
17	TCS 17	Typical Cross Section for Four Lane Carriageway with Paved Shoulder for Embankment Height 3m to 5m at Rural Areas	50	0.182
18	TCS 18	Typical Cross Section for Four Lane Carriageway (Varies) Merging with Two Lane Carriageway with Paved Shoulder	50	0.121
19	TCS 19	Typical Cross Section for Two Lane Carriageway with SMVT Lane for Embankment Height 2m to 3m	38	0.020
20	-	Major Junction Development	Varies	0.103
21	-	Minor Junction Development	Varies	0.080
Total Length (km)				**3.831**

The typical cross sections drawings have been presented in the Final Feasibility Study Report of Someshwari Bridge-3, Volume-III Part A.

- Cross Section of Extradosed + Balance Cantilever Bridge & Viaduct/ Elevated Road

Extradosed Bridge type superstructure of 160m (L) & Balance Cantilever type of 100m (L) main span has been proposed to minimize the numbers of piers under main river and to satisfy the requirement of Navigational criteria. It mainly consists of Concrete girder & concrete deck along with steel cables at extradosed span only. The cross sections of main bridge is presented in the figure below.

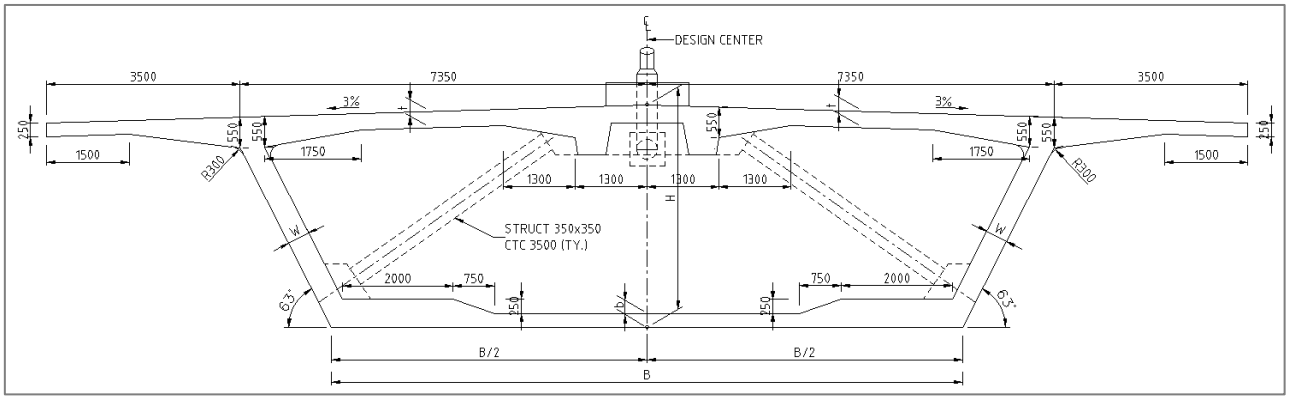


Figure 4-3: Cross Section of Extradosed Bridge Section

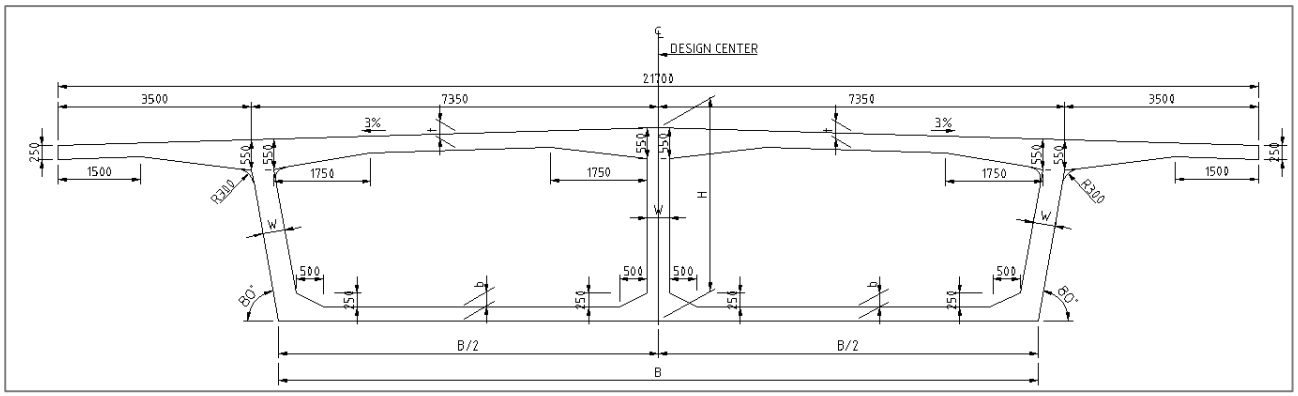


Figure 4-4: Cross Section of Balanced Cantilever Bridge section

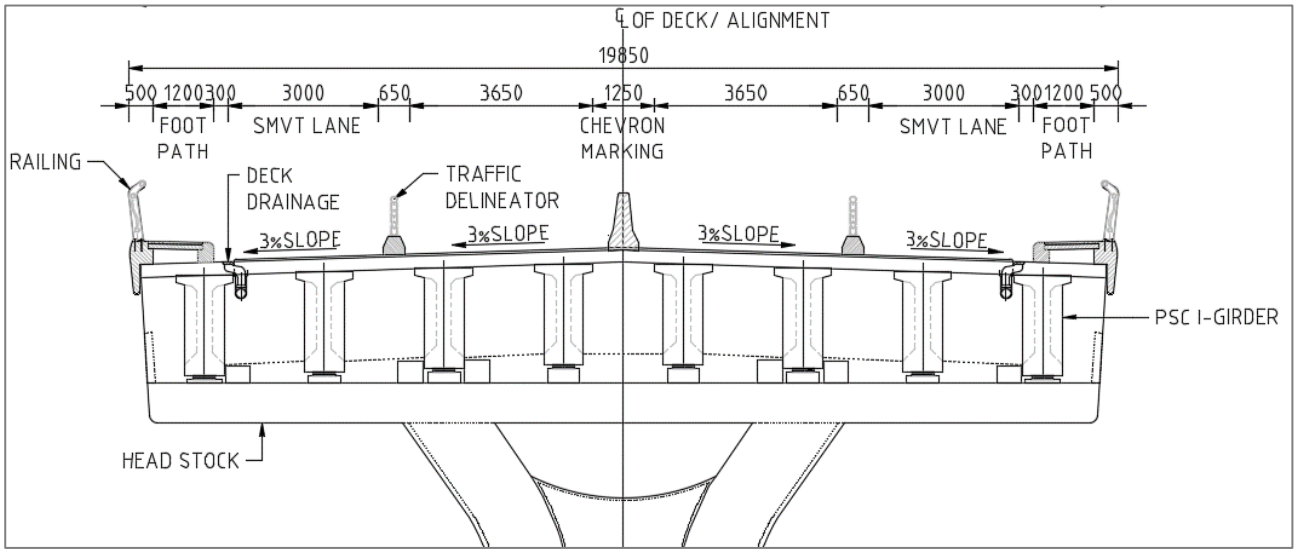


Figure 4-5: Cross Section of PSC I-Girder Type Viaduct/ Elevated Road

- Service Road

A service road has been proposed with a minor junction at km 0+350 for entry and exit from the main thoroughfare. The proposed service road of width 7.3m, extends from km 0+350 to km 0+620 on right side of the proposed highway.

- Access Strategy

The project road serves as an access route to the Someshwari Bridge – 3 over Someshwari River, running in the vicinity of the existing road with nearby settlements and intersecting local roads. To minimize disruption to the existing road network, an access strategy has been devised, segmenting the project into 4 nos. zones based on the entry points to the proposed road which are defined below.

- Zone A: Access via at-grade junction with earthen road at km 0+095 and start location of project road.
- Zone B: Access via at-grade junction with service road at 0+350.
- Zone C: Access via at-grade junction with RHD road at 3+503 and end location of project road.
- Zone D: Access via at-grade junction at 3+368990.

Details of access plan have been presented in Table 4-6 below. Also, a schematic representation of Access Plan has been presented in Figure 4-6 below.

Table 4-6: Details of Access Strategy

Location of Cross Road	Type of Cross Road	Access Zone	Access Strategy
0+095	Earthen Road	Zone A	Access via at-grade junction at km 0+095 and start of project road
0+315	Earthen Road	Zone B	Access via service road and at-grade junction at km 0+350
0+615	Pucca Road		
0+745	Earthen Road		
1+678	Earthen Road	Zone C	Access via roundabout at km 3+503 and end of project road
2+164	RHD Road		
2+300	Earthen Road		
2+912	Earthen Road (Right Side)		
3+368	Pucca Road (Right Side)		
2+912	Earthen Road (Left Side)	Zone D	Access via at-grade minor junction at km 3+368
3+368	Pucca Road (Left Side)		

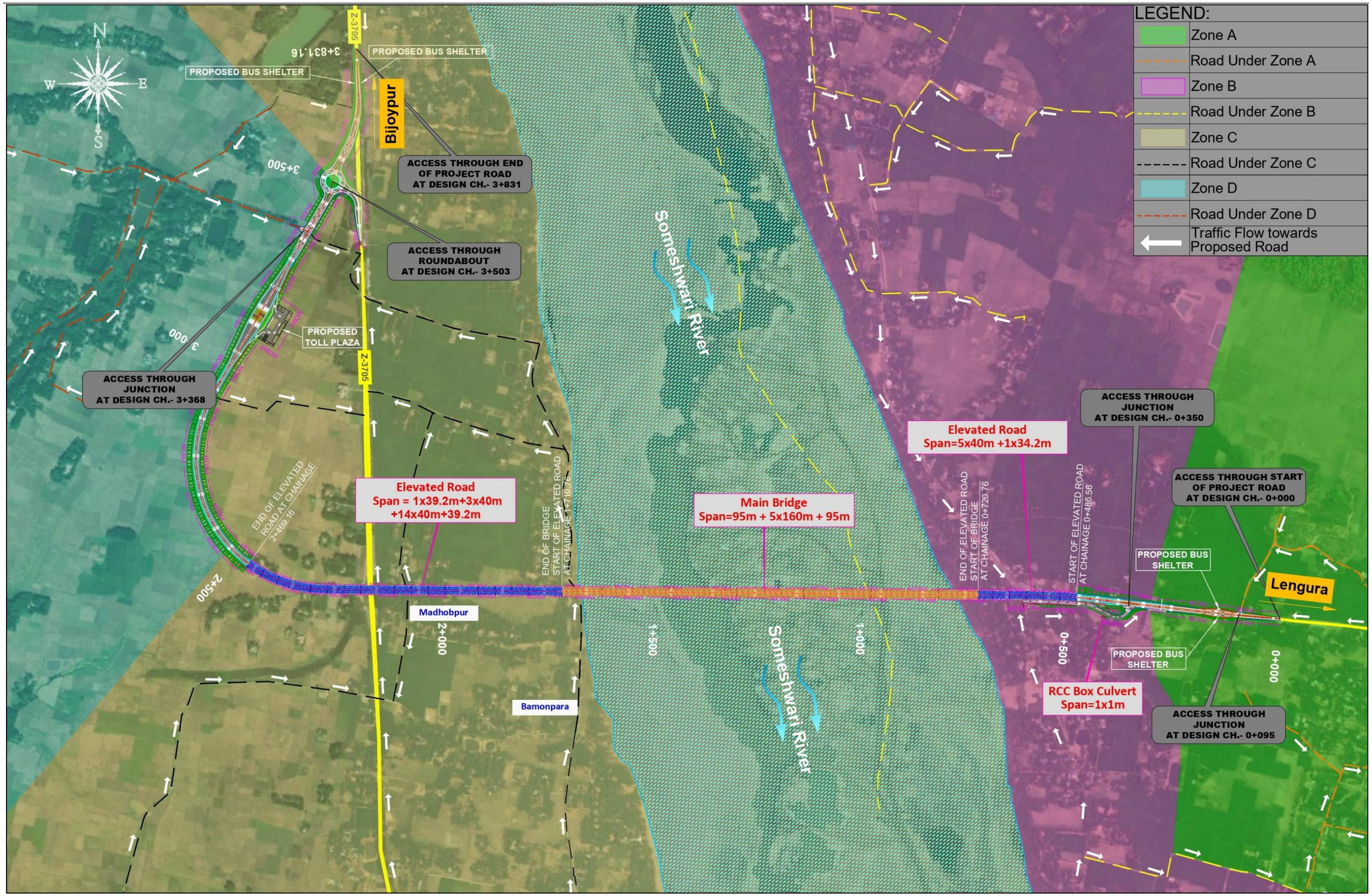


Figure 4-6: Schematic Plan of Access Strategy

- Toll plaza & Weighbridge

A 3+3 lane toll plaza has been proposed at Km 3+138.

The 3+3 lanes toll plaza has been proposed with each toll lane having a width of 3.2 m. Additionally, SMVT lanes of 3.0 m width has been proposed in both directions for slow moving local traffic. Traffic islands of 1.9m width has been placed between each toll lanes to accommodate toll booths.

Weigh bridge facility has not been considered for this project since the length of the project corridor is 3.831 km only and serves primarily as an approach to the Someshwari Bridge-3. Hence, provision of an axle load regulatory control station has not been envisaged. Further, there is a need for internal discussion by RHD keeping in view of the "Installation of Axle Load Control Stations at the Source of Freight Transport on Important Highways of Roads and Highways Department" project, being undertaken by RHD. Provision of weigh bridge for this project can be further decided based on this discussion. However, additional land will be required for provision of weigh bridge facility.

- Bus bays & stopping place

The bus stop and bus bay design will be addressed in the subsequent study phase. Currently, two locations have been identified for proposing bus stops with bus bays and two additional locations for bus stops without bus bays along the project corridor.

Table 4-7: Location of Proposed Bus Stop and Bus Bay

Sl. No.	Chainage	Side	Location	Remarks
1	0+147	RHS	Near start of project road at km 0+000	Bus Stop with Bus Bay
2	0+147	LHS		Bus Stop with Bus Bay
3	3+750	RHS	Near end of project road at km 3+831	Bus Stop Without Bus Bay
4	3+750	LHS		Bus Stop Without Bus Bay

- Road Furniture

Road markings, Road Signs, Road Delineators have been proposed along the entire length of project highway in accordance with Bangladesh Road Sign Manual (Volume I &II), March 2000 at this stage. These will be further validated as per the Road Safety Audit report. Additionally, traffic Safety Barriers have been proposed as per Clause no. 5.2.1 of 'Roadside Design Guide 2011 (AASHTO)'.

The proposed road furniture includes a comprehensive array of traffic signs, road markings, road delineators, and safety barriers to enhance safety and guidance for road users. These measures aim to ensure efficient traffic flow, improve visibility, and mitigate risks on the roadway.

The usage of traffic signs, road markings, delineators, and traffic barriers are comprehensively outlined in Volume-I of the Final Feasibility Study Report for the Someshwari Bridge-3.

4.4 Cost Estimate

The cost estimation has been prepared for the approved alignment, based on the improvement proposals and preliminary design adopted at this stage. However, in the absence of Geotechnical Report, this Cost Estimate is approximate and will be further updated in the next stages of study based on detailed investigations and further designs.

The Cost Estimate prepared for the approved alignment (Alignment Option 1) and approved Bridge Option D (Extradosed + Balance Cantilever bridge) has been presented below.

Table 4-8: Cost of the Proposed Project

Division	Description	Total Amount (BDT)	Total Amount (Cr. BDT)
A.	**Construction Cost**		
1	General & Site Facilities (2% Of Construction Cost)	193,503,895.72	19.35
2	Earth Work	135,890,337.00	13.59
3	Sub-Base, Base-Courses	85,641,884.00	8.56
4	Bituminous Pavement Courses	204,152,788.00	20.42
5	Cross Drainage Structures - Culverts	2,483,952.00	0.25
6.01	Elevated Road	1,546,235,600.00	154.62
6.02	Structures – Viaduct/ Elevated Road	1,015,168,700.00	101.52
6.03	Structures - Main Bridge	5,789,800,740.49	578.98
7	Drainage & Protection Works	81,251,685.50	8.13
8	Traffic Signs, Marking and Road Appurtenances	26,686,581.00	2.67
9	Toll Plaza	273,118,120.00	27.31
10	River Training Works	443,214,398.11	44.32
11	Electromechanical Works	59,550,000.00	5.96
12	Bridge Health Monitoring System	12,000,000.00	1.20
A.	**Total Construction Cost**	**9,868,698,682**	**986.87**
B.	**Non - Civil Works**		
1	Land Acquisition, Resettlement & Compensation (10% of Civil Cost)	986,869,868.18	98.69
2	Utility Shifting (Lump Sum)	10,000,000.00	1.00
B.	**Total Non-Civil works Cost**	**996,869,868**	**99.69**
C.	**Total Capital Cost (A+B)**	**10,865,568,550**	**1,086.56**
D.	**Contingency**		
1	Price Adjustment (15% of Civil Cost)	1,480,304,802	148.03
2	Contingency		
a)	Physical Contingency (2% of Civil Works)	197,373,974	19.74
b)	Price Contingency (2% of Civil Works)	197,373,974	19.74
D.	**Total Price Adjustment and Contingency Cost**	**1,875,052,750**	**187.51**
E.	**Total Project Cost (C+D)**	**12,740,621,300**	**1,274.06**

4.5 Implementation Timeline

The construction of the project is scheduled to commence in 2024 and will conclude in 2026. The Project Road is expected to be accessible to traffic at the end of 2027.

5 ENVIRONMENTAL SUSTAINABILITY, CLIMATE RESILIENCE AND DISASTER RISK ANALYSIS

5.1 Environmental, Climate Change and Disaster Risk Analysis

As a part of the preliminary assessment, an Environmental Impact Assessment (EIA) Report has been conducted to evaluate the project's risks concerning environmental, climate, and disaster aspects. This assessment aims to determine the extent to which climate change and natural hazard risks affect short-term, medium-term, and long-term socio-economic and strategic development goals, plans, programs, and targets. Climate change significantly impacts a country's vital ecosystems and sectors, including agriculture, forestry, health, local economic activities, and biodiversity. Additionally, climate change exacerbates local and regional issues such as poverty, inadequate healthcare, unequal resource distribution, declining ecological resilience, and energy insecurity.

Constructing climate-resilient bridges necessitates strategic selection of materials. Utilizing Supplementary Cementitious Materials (SCMs) such as fly ash and slag cement not only reduces the carbon footprint but also enhances the structural strength of the bridges. Epoxy-coated and galvanized steel are essential for preventing corrosion. A concrete deck and concrete box girder have been designed for the main bridge. Carbon-resilient cables provide additional durability for cable-stayed bridge. Other effective materials include geopolymer cement, high-performance concrete (HPC), and fusion-bonded epoxy (FBE)-coated Thermo-Mechanically Treated (TMT) bars. For river protection, it is crucial to understand tidal influences and erosion patterns. Considering factors such as wind load, seismic effects, and sea level rise is essential to ensure the structural integrity of the bridges. Additionally, implementing mitigation measures during construction is vital to minimize environmental impact.

5.1.1 Impacts of Environmental, Disaster & Climate Change

The preliminary assessment identified several potential project impacts across environmental, health, and disaster-related aspects. The acquisition of land will alter land use patterns, loss of trees and vegetation, which adversely affects wildlife and avian fauna. Mostly agricultural land will be impacted by constructing the new bridge and its approach roads. Dust generation from vehicle movement for transport machinery, air pollution from hot mix, concrete, asphalt plants etc. as well as machinery and diesel generator (DG) sets, will deteriorate air quality. Construction activities will increase sediment load and water pollution, elevate dust levels, and raise noise levels, impacting sensitive receptors. Waterbodies will be impacted by oil spillage, chemical waste from machinery, concrete waste and wastewater from the project side. Hydrological changes, such as increased flooding and siltation, impact on river morphology and degrade riverbanks due to excavation and construction activities. The loss of floral and faunal habitats, health and safety concerns for workers and nearby communities are significant issues. Additionally, climate change and natural hazards like thunderstorms, flash floods, and earthquakes could intensify these impacts, leading to socio-economic repercussions such as poverty, healthcare challenges, reduced ecological resilience, and energy insecurity. These potential impacts underscore the need for comprehensive mitigation strategies to address environmental degradation and protect human health and safety.

5.1.2 Counter measures to reduce the impacts

Any kind of impact degrades the existing environmental, social and economic condition. To minimize land acquisition, the area will be retained to a minimum, with land acquisition plans approved prior to implementation. Construction activities will be restricted within the Project Right of Way (PROW) to manage land use impacts. To counter the loss of trees and vegetation, minimal agricultural land acquisition, tree cutting will be minimized, and a compensatory plantation program will be executed as per regulations. Wildlife and avian fauna will be protected by avoiding habitat destruction, implementing conservation measures, and conducting awareness training for workers on wildlife protection and anti-poaching. Dust generation from vehicle movement will be controlled by sprinkling water, and air pollution from hot mix, concrete, and asphalt plants will be managed by ensuring these plants are maintained regularly. Dust from

earthwork and construction activities will be mitigated by shifting excavated earth in covered vehicles and frequent water sprinkling. Stockpiling soil or riverbed material and construction machinery would be maintained by covering. Preventive maintenance of machinery and adherence to emission standards for diesel generator (DG) sets will address air pollution. Noise levels during construction will be controlled by building noise barriers, maintaining equipment, providing personal protective equipment (PPE), and avoiding night-time activities. Noise from DG sets will comply with noise standards, and noise barriers and silence zones will protect sensitive receptors. Hydrological changes will be managed by minimizing stream flow disruption, preventing riverbank erosion, and stabilizing banks through tree-plantation. The Someshwari River is classified as class-IV according to the BIWTA. The vertical clearance of the bridge is 5 m SOB and horizontal clearance is 20 m SOB. The Standard High-Water Level (SHWL) is 11.50 m SOB. The Design Flood Levels including climate change impact were calculated to be 17.48 m SOB for 100 years. A change of 0.38 m SOB in water level was considered as the effect from climate change. The minimum required soffit level of the bridge at navigable portion was 16.88 m SOB. To control the creating climate change impact due to construction of bridge would be taken mitigation measure through river training work and embankment protection work. Occupational health and safety will be ensured through PPE provision, safety training, and health check-ups, while community health and safety will be supported by safety barriers, signage, and health awareness programs. Finally, design and construction methods will be updated to withstand storms, floods, and earthquakes, incorporating alternative materials and technologies to enhance resilience.

5.1.3 Cost for mitigation of the negative impacts

Environment management cost includes the cost of mitigation measures as proposed in the Environmental Monitoring Plan (EMP) to reverse the negative impacts of the project. The total cost of implementation of EMP is estimated to be 6.05 million BDT approximately (subjected to change in accordance with the final EIA report).

5.1.4 Alternative Costs

No such alternative costs have been proposed. The proposed project requires minimal environmental impact.

5.1.5 Assessment Type

The project has been categorized according to the laws and regulations of Department of Environment (DoE), Bangladesh.

According to the Environment Conservation Rules (2023), the proposed project falls under **Red Category as the proposed bridge length is 990 m**. Hence, as per the DoE requirements an Environmental Impact Assessment (EIA) Report will be submitted to the DoE for approval. The EIA report shall be submitted to the DoE getting Site Clearance Certificate (SCC) and Environmental Clearance Certificate (ECC).

5.1.6 Resettlement Issues

Field verification reveals that the Someshwari bridge project will displace 40 units, primarily rural households, and 12 commercial structures, mainly small shops, raising concerns about resettlement and potential livelihood losses for shop workers. The assessment needs to acquire at least 30.63 acres (except 8.47 acres of roads and river area) land for proposed new bridge construction that will be mitigated by the compensation still now. Compensation to be provided to those who are directly affected by the project.

5.2 Assessment of Disaster Resilience of the project

5.2.1 Contingency Plan for Emergency Disaster Management

A comprehensive contingency plan for emergency disaster management, prioritizing the safety of all parties involved is included in the plans for the Someshwari Bridge-3 project. The plan clearly outlines evacuation procedures, featuring marked routes, designated assembly points, and appointed personnel to guide evacuees, alongside regular drills to ensure everyone is familiar with the protocols. First Aid as a primary treatment and health care should be managed as a contingency plan for the engaged employees and workers. Institutional arrangements ensure the swift shutdown of utilities, with designated personnel and clear

protocols for managing electricity, gas, water, and other essential services. General safety procedures emphasize staying calm, following instructions, seeking refuge indoors or in open areas during earthquakes, and evacuating immediately in case of fire, floods, or cyclones or storms. This robust plan aims to minimize risks and ensure an effective response to emergencies throughout the project's lifecycle.

5.2.2 Business Continuity Plan

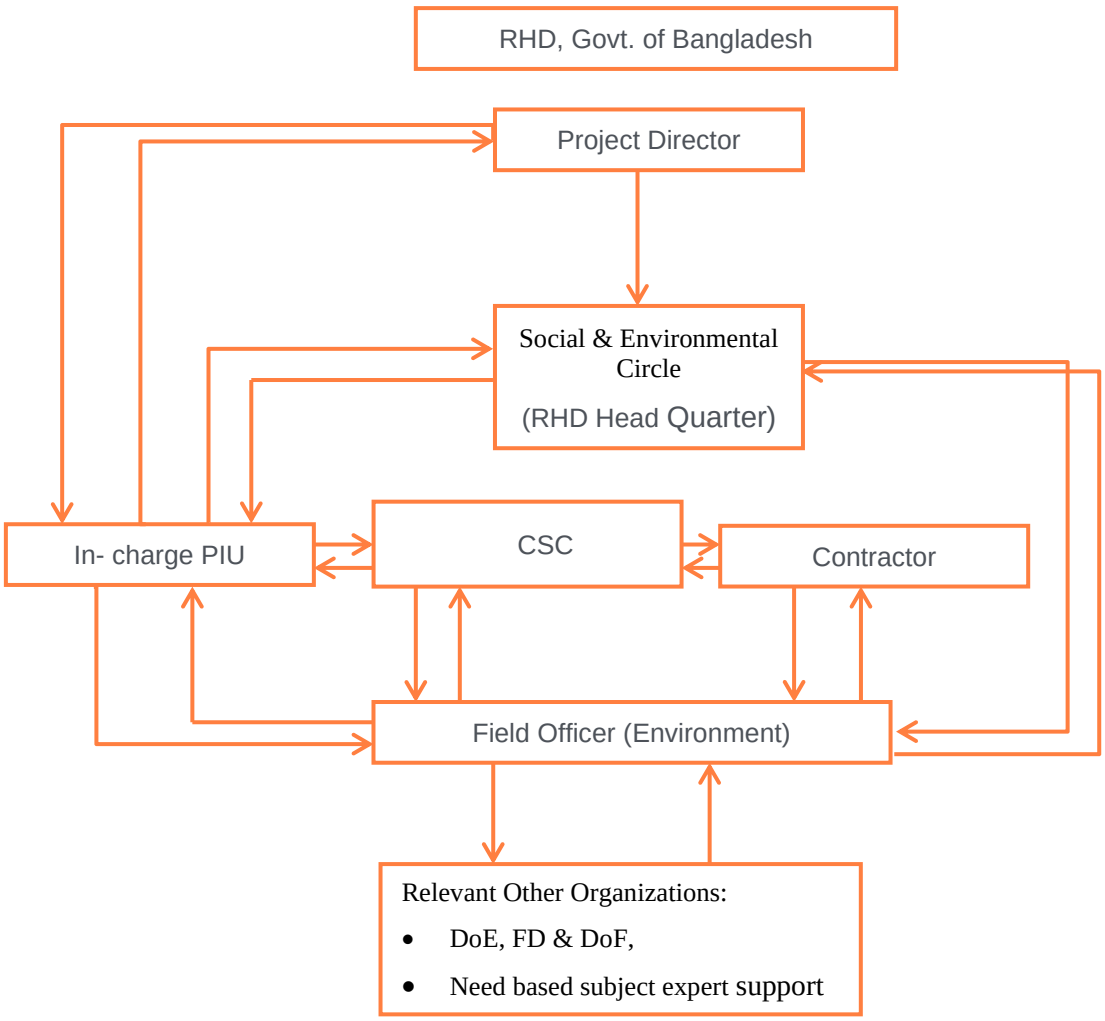
Response and recovery priorities, focusing on safety, infrastructure protection and sustainability, and utility service restoration are emphasized in the business continuity plan for the Someshwari Bridge-3 project. Ensuring the safety and security of personnel and surrounding communities is paramount, with emergency response teams mobilized immediately. Infrastructure protection measures are implemented to safeguard the bridge structure and prevent further damage. Restoring utility services, especially electricity, water supply, communication, and transportation, is prioritized. Efforts concentrate on restoring power to essential facilities, ensuring water availability, reestablishing communication networks, and maintaining transportation routes to ensure uninterrupted project operations. This comprehensive plan aims to maintain project continuity and minimize disruptions during emergencies.

5.2.3 Time of Recovery

The duration required for rehabilitation after a disaster, encompassing efforts to rebuild infrastructure, restore services, and assist affected communities is referred by the time of recovery. The proposed Someshwari Bridge-3 project is expected to be impacted by natural disasters like flash floods due to heavy rainfall at hilly area, thunderstorms and earthquake in the near future, as the designated site for proposed bridge project has been classified as a seismic zone of very severe earthquake zone (zone 4). The project area is in the northern region of Bangladesh, it is prone to flash flood, thunderstorms, and waterlogging, and these potential effects of climate change have been accounted for in the design. However, it is important to note that the recovery timeline is not fixed and can be influenced by various factors, including the availability of resources, the level of coordination among stakeholders, and the resilience of the affected communities.

5.2.4 Reporting of Residual Risks

Reporting is the urgent issue to find out the impact and identification of the right place in time. The reporting of residual risks involves identifying and documenting any remaining risks after implementing mitigation measures. This process is crucial for assessing the project's disaster resilience and allows stakeholders to proactively address vulnerabilities. The Environmental Field Officer will primarily report any residual risks to the Construction Supervision Consultant (CSC). The CSC is responsible for reporting progress to the Roads and Highways Department (RHD). The reporting procedure is illustrated in the figure below.


RHD, Govt. of Bangladesh
Project Director
Social & Environmental Circle
(RHD Head Quarter)
In- charge PIU
CSC
Contractor
Field Officer (Environment)
Relevant Other Organizations:
DoE, FD & DoF,
Need based subject expert support

6 COST-BENEFIT ANALYSIS

6.1 Financial Analysis

6.1.1 Component of Cost-Benefit Analysis

Based on the discussion held with the RHD officials on the alternative options it was informed by RHD that project may be implemented through government funds/international funds, hence revenue-based model & Annuity Based Model will be applicable to check the financial sustainability of the project from toll as prescribed by RHD Toll Policy, 2014. However, toll shall be imposed on the bridge and collected by the authority to generate sufficient revenues while still helping to improve accessibility.

Detailed calculation is presented in the Final Feasibility Study Report of Someshwari Bridge-3, Volume-I.

The entire 30 years of toll rate has been presented in following Table 6-1. The toll will be effective from 2027 and will be changing in every three years up to next 30 years, that is, 2053.

Table 6-1: Toll Rate Someshwari Bridge-3 from 2024 to 2053

Year	Vehicle Categories											
	HT	MT	LB	ST	Tractors	Mini Bus	Micro Bus	Utility	Car	Tempo/3W	2W	NMT
2027	415	330	165	150	125	100	85	65	65	40	20	5
2028	415	330	165	150	125	100	85	65	65	40	20	5
2029	415	330	165	150	125	100	85	65	65	40	20	5
2030	440	350	175	160	130	105	90	70	70	40	20	5
2031	440	350	175	160	130	105	90	70	70	40	20	5
2032	440	350	175	160	130	105	90	70	70	40	20	5
2033	460	365	185	170	140	110	95	75	75	45	20	5
2034	460	365	185	170	140	110	95	75	75	45	20	5
2035	460	365	185	170	140	110	95	75	75	45	20	5
2036	485	385	195	175	145	115	100	75	75	45	25	10
2037	485	385	195	175	145	115	100	75	75	45	25	10
2038	485	385	195	175	145	115	100	75	75	45	25	10
2039	510	405	200	185	155	120	105	80	80	50	25	10
2040	510	405	200	185	155	120	105	80	80	50	25	10
2041	510	405	200	185	155	120	105	80	80	50	25	10
2042	530	420	210	195	160	125	110	85	85	50	25	10
2043	530	420	210	195	160	125	110	85	85	50	25	10
2044	530	420	210	195	160	125	110	85	85	50	25	10
2045	555	440	220	205	165	130	115	90	90	55	25	10
2046	555	440	220	205	165	130	115	90	90	55	25	10

2047	555	440	220	205	165	130	115	90	90	55	25	10
2048	580	460	230	210	175	140	120	90	90	55	30	10
2049	580	460	230	210	175	140	120	90	90	55	30	10
2050	580	460	230	210	175	140	120	90	90	55	30	10
2051	600	480	240	220	180	145	125	95	95	55	30	10
2053	600	480	240	220	180	145	125	95	95	55	30	10
2052	600	480	240	220	180	145	125	95	95	55	30	10

The toll policy outlines exemptions for certain categories of vehicles, including emergency vehicles, police, defence force, and others as specified. These vehicles will not be charged to use the road, provided they produce official warrants or acceptable documentation as proof of exemption. Additionally, discounts will be offered to frequent users to ensure transportation fees remain affordable.

6.1.2 Monetary Value

The total project cost of entire stretch for Someshwari Bridge-3 including Land acquisition, Resettlement & Rehabilitation, Utility shifting, departmental supervision, Environmental Program Management (EMP) cost, Toll Plaza Construction Cost, Contingencies etc. is BDT 1274.1 crore. The construction is assumed to commence in 2024 and will be completed by the end of 2026. The new corridor will be opened for traffic in 2027. The broad components of construction cost are as follows.

6.1.3 Construct of Cash Flow

The goal of this analysis is ultimately to derive the project cash flows over the forecast period for the analysis of the investment return on selected implementation structure. The cash flows are calculated using a build-up approach. The analysis focuses on the annual cash flows arising from the project. The Internal Rate of Return (IRR) of project on net cash flow has been determined to understand the extent of financial return available to investors.

Total Project Cost (TPC)

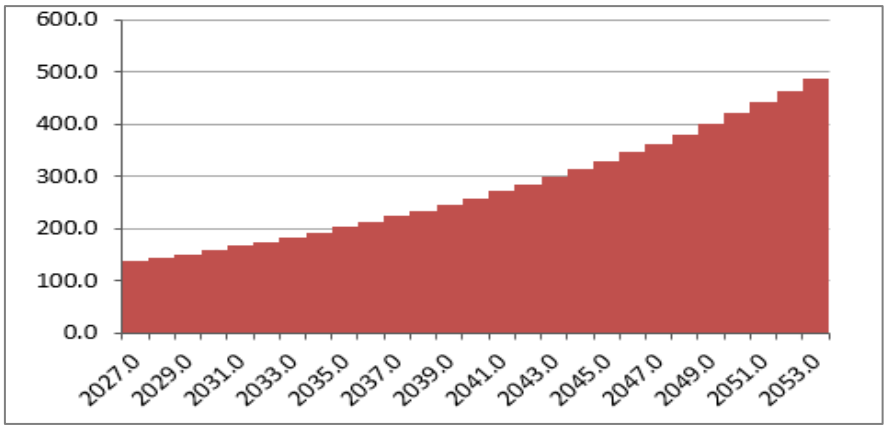
The total cost of entire project is BDT. 1385.7 Cr. including interest during construction. The construction is assumed to commence in 2024 and will be completed by the end of 2026. The facility will be opened in 2027. The land acquisition cost & rehabilitation cost are included in “Total Project Cost without IDC” (BDT. 1086.6 Cr.) since that will be borne by the Government of Bangladesh. Details are summarised in the table below.

Table 6-2: Total Project Cost (real price @ 2023 price level)

Sl. No.	Cost Items	Amount (BDT. Cr.)
A	Total Project Cost without IDC	1274.1
B	Interest During Construction (IDC)	111.6
C	Total Project Cost to the authority	1385.7

Financial Analysis—Annuity Based Model

The Government of Bangladesh to the private party and bank as a loan repayment method for 25 years among which first 3 years will be moratorium period and rest 22 years will be effective loan repayment period where Govt. of Bangladesh has to pay the loan with mutually agreed interest rate of 8.5%. The analysis shows the Net Present Value (NPV) of the project is positive and having Project IRR of more than 8.5% which is determined by the amount of inflation adjusted-annuity that would be paid to the private party and bank bi-annually.



Source: Financial Model

Figure 6-1: Nominal Revenue from Annuity Payment (BDT, Cr.)

The Table 6-3 below depicts the summary of the Financial Analysis under the current setting of analysis under this scenario:

Table 6-3: Summary of Financial Evaluation

Fund Details	Project IRR	Project NPV	Nominal WACC	Equity IRR	Equity NPV	Average DSCR	Average LLCR
Grant-0%, Debt-70% & Equity-30%	12.2%	BDT. 196.2 Cr.	10.8%	16.0%	BDT. 0.1 Cr.	2.15	2.89

The entire scenario of the analysis of Financial Evaluation outlined in Volume-I of the Final Feasibility Study Report for the Someshwari bridge-3.

The cash flow Figure 6-2 as shown below indicates that income from annuity has steady rising trend. The O&M costs increase over time. The following Table shows the Total Cash flow (Nominal) of the project in figures in every six months of interval.

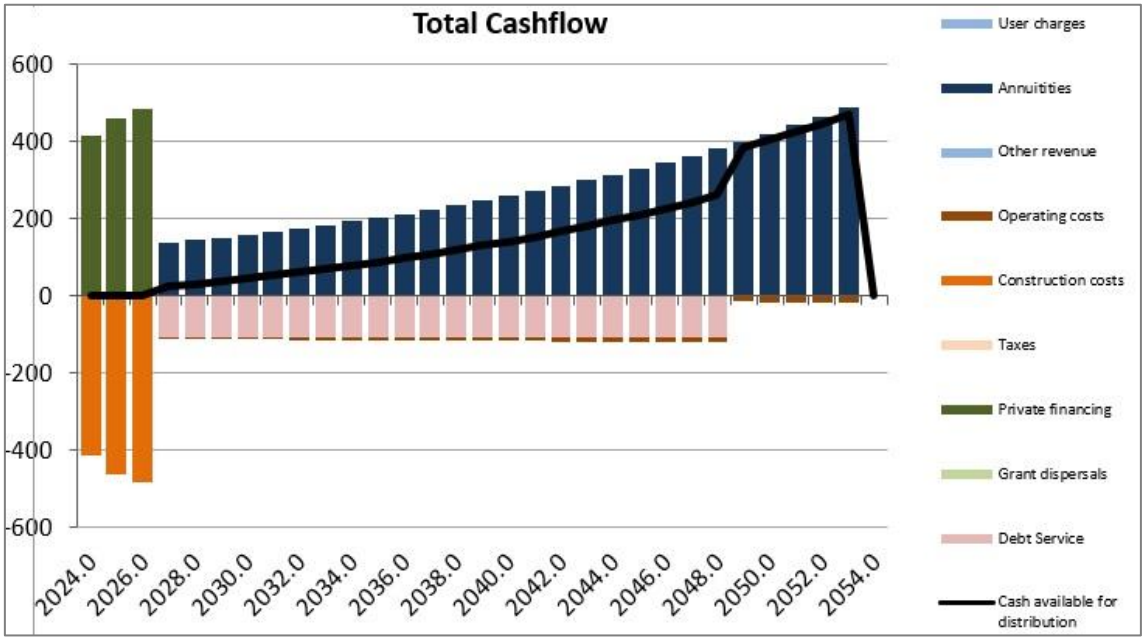


Figure 6-2: Total Cash Flow (BDT, Cr.)

The bi-annual project cash flow (nominal) is outlined in Volume-I of the Final Feasibility Study Report for the Someshwari Bridge. The analysis, based on this setup, covers the entire cash flow and summary. The project will operate from 2027 to 2053, covering a 30-year period.

6.1.4 Indicators (FNPV, FBCR, FIRR)

Three indicators for financial analysis include Financial Net Present Value (FNPV), Financial Benefit Cost Ratio (FBCR), and Financial Internal Rate of Return (FIRR).

Financial Analysis for selected option—Revenue Based Model

The results of the financial analysis are summarized below.

- Financial Analysis – Considering total capital cost.
  - PIRR: 2.23%
  - NPV@5%: -798.9 Crores BDT
  - Total Capital Cost: 1271.1 Crores BDT
  - FBCR: 0.36

The analysis shows that the project has weak revenue generating capability with respect to its total capital cost and financially unviable. The project yields IRR of -2.23% with NPV value of BDT. -798.9Cr.

- Financial Analysis – Considering total project cost.
  - PIRR: -1.37%
  - NPV@5%: -628.7 Crores BDT
  - Total Project Cost: 1086.6 Crores BDT
  - FBCR: 1.10

The analysis shows that the project has weak revenue generating capability with respect to its total project cost and financially unviable. The project yields IRR of -1.37% with NPV value of BDT. -628.7 Cr.

The financial analysis precisely shows that, the bridge does not have high revenue generating capability due to low level of traffic in the region. The toll revenue does not even recover the initial investment even in first thirty years of operation. Hence, net financial support will be required from Govt. of Bangladesh.

6.1.5 Estimation of Net Cashflow

Table 6-4 shows the net cashflow of the project. Column 3 shows the total fund required to fund the project by the private party and Column 2 shows the external support required from Govt. of Bangladesh to construct the bridge, as the toll revenue is incapable of generating required fund for annuity payments.

Table 6-4: Net Cashflow included required Govt. Support (BDT, Cr.)

Years	Revenue from Toll	Fund Required from GoB	Total Annuity Required	Maintenance Cost	Cash flow before financing	Bank Loan Repayment		Cash available for Dividend Payout	Dividends paid
						Interest	Principal		
Coln. No.	1	2	1+2=3	4	5	6	7	8	9
2027	15.4	121.4	136.8	-5.2	131.6	-88.8	-18.1	24.7	-24.7
2028	16.3	127.3	143.6	-5.4	138.2	-87.3	-19.7	31.2	-31.2
2029	17.3	133.5	150.8	-5.7	145.1	-85.6	-21.4	38.1	-38.1
2030	19.2	139.1	158.3	-6.0	152.4	-83.8	-23.2	45.4	-45.4

Years	Revenue from Toll	Fund Required from GoB	Total Annuity Required	Maintenance Cost	Cash flow before financing	Bank Loan Repayment		Cash available for Dividend Payout	Dividends paid
						Interest	Principal		
Coln. No.	1	2	1+2=3	4	5	6	7	8	9
2031	20.2	146.1	166.3	-6.3	160.0	-81.8	-25.1	53.0	-53.0
2032	21.2	153.4	174.6	-6.6	168.0	-79.7	-27.3	61.0	-61.0
2033	22.9	160.4	183.3	-6.9	176.4	-77.4	-29.6	69.4	-69.4
2034	23.8	168.7	192.5	-7.3	185.2	-74.9	-32.1	78.2	-78.2
2035	24.6	177.5	202.1	-7.6	194.5	-72.1	-34.9	87.5	-87.5
2036	27.2	185.0	212.2	-8.0	204.2	-69.2	-37.8	97.2	-97.2
2037	28.1	194.7	222.8	-8.4	214.4	-66.0	-41.0	107.4	-107.4
2038	29.3	204.7	234.0	-8.8	225.1	-62.5	-44.5	118.2	-118.2
2039	31.8	213.9	245.6	-9.3	236.4	-58.7	-48.3	129.4	-129.4
2040	32.9	225.0	257.9	-9.7	248.2	-54.6	-52.4	141.2	-141.2
2041	34.1	236.7	270.8	-10.2	260.6	-50.1	-56.9	153.6	-153.6
2042	36.5	247.9	284.4	-10.7	273.6	-45.3	-61.7	166.7	-166.7
2043	37.5	261.1	298.6	-11.3	287.3	-40.0	-66.9	180.4	-180.4
2044	38.5	275.0	313.5	-11.8	301.7	-34.4	-72.6	194.7	-194.7
2045	41.2	288.0	329.2	-12.4	316.8	-28.2	-78.8	209.8	-209.8
2046	42.2	303.4	345.7	-13.0	332.6	-21.5	-85.5	225.6	-225.6
2047	43.3	319.6	362.9	-13.7	349.3	-14.2	-92.8	242.3	-242.3
2048	47.2	333.9	381.1	-14.4	366.7	-6.3	-100.7	259.7	-259.7
2049	48.4	351.8	400.1	-15.1	385.1	0.0	0.0	385.1	-385.1
2050	49.5	370.6	420.1	-15.8	404.3	0.0	0.0	404.3	-404.3
2051	52.3	388.9	441.1	-16.6	424.5	0.0	0.0	424.5	-424.5
2052	53.4	409.8	463.2	-17.5	445.7	0.0	0.0	445.7	-445.7
2053	54.6	431.7	486.4	-18.3	468.0	0.0	0.0	468.0	-468.0

6.2 Economic Analysis

6.2.1 Component of Cost-Benefit

The reductions in disbenefits lead to savings. The total savings expressed in quantitative and qualitative terms are the total benefits arising from the bridge system. The total quantitative benefits and costs at economic prices determine the IRR and NPV of the project. However, the following components of benefits have been quantified in the main report of economic analysis.

- Saving in VOC and Time cost.
- Reduction in Emission.
- Incremental Output from Govt. Expenditure
- Impact on Economic Activities and Income Augmentation

6.2.2 Adjustments

All the data have been collected from secondary data sources (mentioned in the main report) and adjusted with help of well-practiced statistical tools (extensively explained in the main report).

6.2.3 Standard Conversion Factors (SCF)

The SCF has been determined by the export-import data of Bangladesh to convert the financial cost to economic cost of the project and presented in Table 6-5.

Table 6-5: SCF Calculation

Imports (c.i.f) (Tk., million)	8,573,922
Import Tariff (Tk., million)	437879
Exports (f.o.b.) (Tk., million)	6,581,506
Export Tariff (Tk., million)	0.0
Net Trade Taxes (Tk., million)	437,879
Total Trade (Tk., million)	15,155,428
SCF	**0.97**

6.2.4 The final Cash Flow of benefit streams

The final benefit stream has been presented with respect to the aforesaid benefits which are likely to be generated after successful completion of the project with the stipulated time frame. It is also to be noted that the total tangible and non-tangible benefits are not limited to these benefits.

Table 6-6: Cost-Benefit Streams of Someshwari Bridge-3 (combining four border bridges)

Years	Capital Investment	Road User Savings	Savings in SCC	ICOR	Import-Export GVA	Total Savings	Total Net Benefit
2024	876.8	0.0	0.0	0.0	0.0	0.0	-876.8
2025	657.6	0.0	0.0	0.0	0.0	0.0	-657.6
2026	657.6	0.0	0.0	0.0	0.0	0.0	-657.6
2027	6.4	37.0	10.4	429.4	56.4	533.2	526.8
2028	6.4	54.4	11.3	413.6	58.5	537.8	531.4
2029	6.4	63.8	12.4	399.5	60.7	536.3	529.9
2030	6.4	76.5	13.6	387.4	63.0	540.3	533.9
2031	6.4	95.7	15.2	376.6	65.3	552.8	546.4

2032	6.4	127.2	17.3	367.1	67.8	579.4	573.0
2033	6.4	173.8	20.1	358.6	70.3	622.8	616.4
2034	6.4	198.1	22.0	351.0	72.9	644.0	637.6
2035	6.4	200.6	23.1	344.1	75.7	643.5	637.1
2036	6.4	202.3	24.3	337.9	78.5	643.0	636.6
2037	6.4	205.9	25.5	332.2	81.5	645.1	638.7
2038	6.4	207.8	26.8	327.0	84.5	646.1	639.7
2039	6.4	207.1	28.1	322.2	87.7	645.1	638.7
2040	6.4	221.0	29.5	317.8	91.0	659.3	652.9
2041	6.4	225.8	31.0	313.8	94.4	664.9	658.5
2042	6.4	234.2	32.6	310.0	97.9	674.7	668.3
2043	6.4	243.3	34.4	306.5	101.6	685.8	679.4
2044	6.4	247.4	35.9	303.2	105.4	691.9	685.5
2045	6.4	251.0	37.5	300.2	109.4	698.1	691.7
2046	6.4	254.5	39.1	297.3	113.5	704.4	698.0
2047	6.4	259.6	40.8	294.6	117.7	712.8	706.4
2048	6.4	264.3	42.6	292.1	122.1	721.2	714.8
Capital Cost at Financial Price		2259.8	SCF	Economic Internal Rate of Return (EIRR)			20.6%
Capital Cost at Economic Price		2192.0	0.97	Net Present Value (NPV) at 12%			1430.8
Economic Benefit Cost Ratio (EBCR)							1.8

6.2.5 Assumptions

The following assumptions are made for the analysis:

- The analysis period is 25 years including construction period.
- The construction period is assumed to be for 3 years (2024 to 2026).
- The commercial operational date (COD) will be 2027.
- The analysis period is from 2024 to 2048.
- The standard conversion factors to convert financial price to economic price is 0.97.
- The HDM4 has been calibrated for L1 level only as per standard practice.
- The HDM4 input data has been used from RHD published data of 2017-2018, which has been updated for the year 2023-2024.

6.2.6 Key Results of Economic Analysis

Estimation of EIRR and NPV

- Economic Internal Rate of Return (EIRR): 20.6%
- Net Present Value (NPV) @12%: 1430.8 Crores BDT
- Economic Benefit Cost Ratio (EBCR): 1.8

Sensitivity Analysis – 10% rise in cost

- EIRR: 19.0%
- NPV @12%: 1253.8 Crores BDT
- EBCR: 1.6

Sensitivity Analysis – 20% drop in Benefits

- EIRR: 17.0%
- NPV @12%: 782.7 Crores BDT
- EBCR: 1.4

Sensitivity Analysis – All cases together

- EIRR: 15.6%
- NPV @12%: 605.1 Crores BDT
- EBCR: 1.3

Considering immense socio-economic benefits to the Project influence area, the project is strongly recommended for consideration of implementation for having high EIRR of 20.6%.

7 HUMAN RESOURCES AND ADMINISTRATIVE SUPPORT ANALYSIS

The Someshwari bridge-3 has been proposed as an extradosed + balance cantilever long span bridge with span arrangement of (60+2x100+60)m + (95+160+95)m+(60+2x100+60)m. The implementation of this Project thus needs specific technical expertise pertinent to extradosed long span bridges. The Roads and Highways Department (RHD) has successfully implemented the commissioning of the Payra Bridge at Lebukhali which is also an Extradosed Bridge with a span arrangement of 1 x 115m 2 x 200m + 1 x 115m and Shah Amanat Bridge (3rd Karnaphuli Bridge) with span arrangement of 1 x 115m+ 3 x 200m + 1 x 115m. RHD has also implemented the commissioning of the 3rd Shitalakshya Bridge at Bandar, Narayanganj which is a balanced cantilever box girder with span arrangement of 1 X 53.0m + 3 X 98.0m + 1 X 53.0m, 8th Bangladesh-China Friendship Bridge at Bekutia, Pirojpur with span arrangement of 1 X 72.0m + 7 X 122.0m + 1 X 72.0m, Lalon Shah Bridge at Pabna with span arrangement of 1 X 72.0m + 15 X 110.0m + 72.0m and Khan Jahan Ali Bridge at Rupsa, Khulan with span arrangement of 1 X 70.0m +5 X 100.0m + 1 X 70.0m. Thus, they have the right technical and managerial work force to implement the Someshwari bridge-3 Bridge also. At the same time, RHD is successfully operating and maintaining the Payra Bridge, Shah Amanat Bridge (3rd Karnaphuli Bridge), 3rd Shitalakshya Bridge, 8th Bangladesh-China Friendship Bridge, Lalon Shah Bridge, Khan Jahan Ali Bridge and hence is organisationally well equipped to maintain the functional output of the proposed bridge.

8 INSTITUTIONAL AND LEGAL ANALYSIS

The Road Master Plan, 2009 stipulates that new bridges should be constructed on missing links. Besides, a target has been fixed to construct 37,500 meters of bridge/culvert as a strategy of the road transport sector in the 8th Five Year Plan (2021-2025) to achieve the Perspective Plan 2041. Thus, construction of the Someshwari Bridge-3 envisaged by the Roads and Highways Department, at critical missing link over Someshwari River has been envisaged within the legal purview of the Road Master Plan, 2009, 8th Five Year Plan (2021-2025) & the Perspective Plan 2041. The Assets of Roads and Highways Department have been conservatively estimated at Taka 46,000 crore (US$8,000 million) of which by far the largest proportion is the value of the 22,096.303 kms of road and the 18,258 nos. bridges. These assets are probably the greatest asset of any organisation in Bangladesh and maintaining their value is vital to its economy. This places a great responsibility on the Roads and Highways Department. Thus, the policy and institutional setup of RHD is well aligned with the successful implementation of the proposed Someshwari Bridge-3. The Roads and Highways Department (RHD) has successfully implemented the commissioning of the Payra Bridge at Lebukhali which is also an Extradosed Bridge with a span arrangement of 1 x 115m 2 x 200m + 1 x 115m and Shah Amanat Bridge (3rd Karnaphuli Bridge) with span arrangement of 1 x 115m+ 3 x 200m + 1 x 115m. RHD has also implemented the commissioning of the 3rd Shitalakshya Bridge at Bandar, Narayanganj which is a balanced cantilever box girder with span arrangement of 1 X 53.0m + 3 X 98.0m + 1 X 53.0m, 8th Bangladesh-China Friendship Bridge at Bekutia, Pirojpur with span arrangement of 1 X 72.0m + 7 X 122.0m + 1 X 72.0m, Lalon Shah Bridge at Pabna with span arrangement of 1 X 72.0m + 15 X 110.0m + 72.0m and Khan Jahan Ali Bridge at Rupsa, Khulan with span arrangement of 1 X 70.0m +5 X 100.0m + 1 X 70.0m. Thus, they have the right technical and managerial work force to implement the Someshwari Bridge-3 also. As RHD is well experienced in implementing similar projects as such no governance issue has been envisaged in implementing this Project.

9 RISK AND SENSITIVITY ANALYSIS

The main goal of quantifying project risks is to understand the possibility of cost overruns, which can disrupt the project's completion within the planned time. These overruns often lead to delays because authorities require extra funds, shortening the asset's economic life and limiting its benefits to society. This chapter focuses on assessing the risk of cost overruns during construction by analysing potential changes in cost parameters. It's an early analysis that helps authorities anticipate and budget for potential overruns, ensuring the project stays on track without compromising its scope.

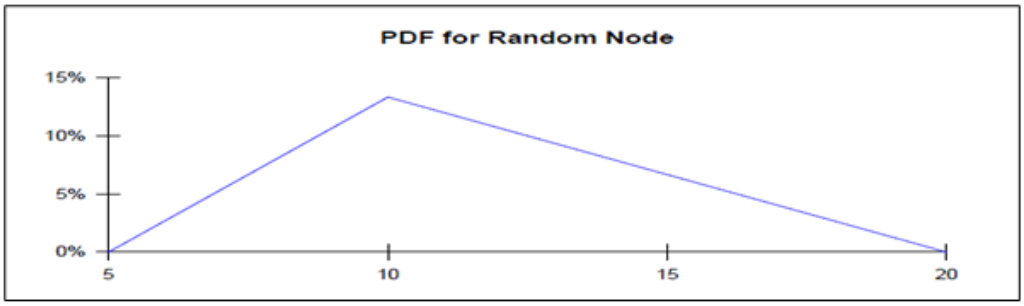
9.1 Estimation of Probability of Total Project Cost (TPC)

The below table shows the different parameters which will be used in the Monte Carlo Simulation by using the Vanguard to estimate the Total Project Cost (TPC) based on the aggregate civil cost.

Table 9-1: Stochastic Variable Inputs.

Stochastic Variables	Lower Value	Most Likely	Higher Value
General & Site Facilities (2% Of Construction Cost)	1.38%	1.52%	1.69%
Earth Work	1.01%	1.07%	1.28%
Sub-Base, Base-Courses	0.64%	0.67%	0.81%
Bituminous Pavement Courses	1.52%	1.60%	1.92%
Cross Drainage Structures - Culverts	0.02%	0.02%	0.02%
Structures - Minor Bridge	10.27%	12.14%	13.07%
Structures – Viaduct/ Elevated Road	6.74%	7.97%	8.58%
Structures - Main Bridge	41.99%	45.44%	50.30%
Drainage & Protection Works	0.63%	0.64%	0.77%
Traffic Signs, Marking And Road Appurtenances	0.21%	0.21%	0.25%
Toll Plaza	2.12%	2.14%	2.57%
River Training Works	3.44%	3.48%	4.17%
Electro Mechanical Works	0.46%	0.47%	0.56%
Bridge Health Monitoring System	0.09%	0.09%	0.11%
Land Acquisition, Resettlement & Compensation (Lump Sum)	7.67%	7.75%	9.30%
Utility Shifting (Lump Sum)	0.08%	0.08%	0.08%
Price Adjustment	11.62%	11.62%	11.62%
Physical Contingency	1.55%	1.55%	1.55%
Price Contingency	1.55%	1.55%	1.55%

The values considered for triangular distribution is presented in the Figure below:



Source: Vanguard Manual

Figure 9-1: Triangular Distribution.

9.2 Simulation Analysis

The Monte Carlo simulation shows that mean TPC is BDT. 1287 Cr. The maximum TPC may be BDT. 1352 Cr. and the minimum maybe BDT. 1215 Cr. The likely TPC, that is, mean TPC is BDT. 1287 Cr. The mean and median are almost the same that is a normal distribution. The following Figure 9-3 is showing both Cumulative and Probability Distribution Functions (CDF & PDF) of Total Project Cost. The Monte Carlo Simulation of TPC is showing that there is 80% chance that the TPC of New Bridge under current civil cost will be below BDT. 1306 crore and 60% chance the TPC would be BDT. 1288 Cr..

Simulation Summary

Measure	*Total Project Cost*
Observations	1,000
Mean	458
Standard Deviation	9
Posterior STD	3e-1
Variance	78
Minimum	432
5th Percentile	443
Median	458
95th Percentile	473
Maximum	481

Figure 9-2: Simulation Summary of Total Project Cost (BDT, Cr.)

The CDF and PDF of TPC (BDT, Cr.) is shown below.

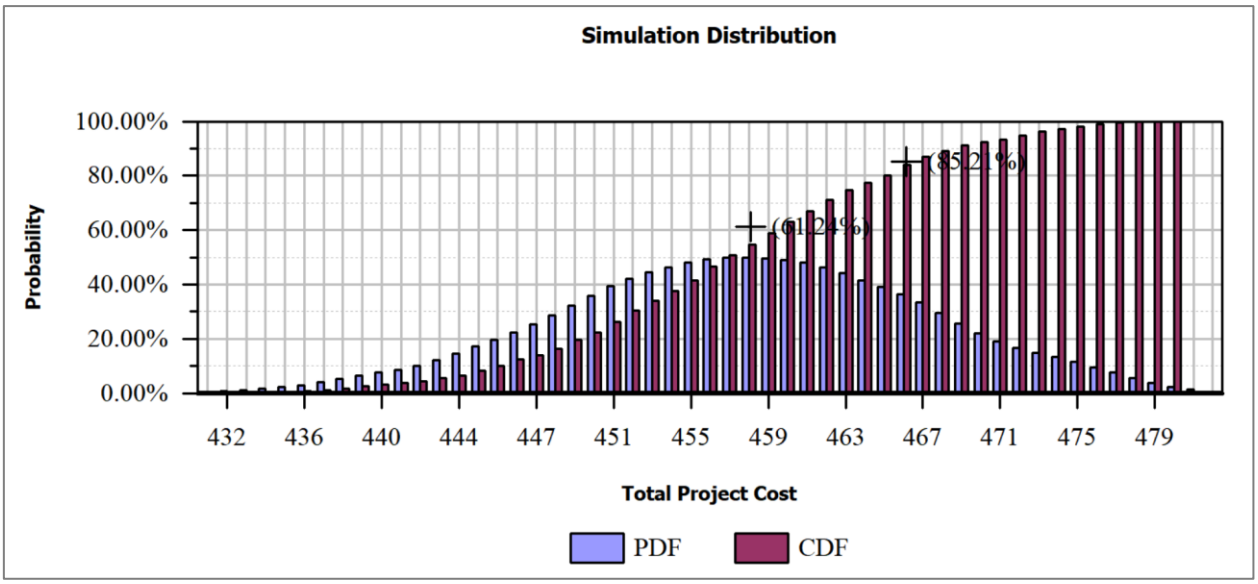


Figure 9-3: The CDF and PDF of TPC (BDT, Cr.)

9.3 Cost Escalation Risks

Table 9-2: Cost Escalation Risk

Type of Risk	Risk	Cost Driver	Mitigation
Force Majeure Risk	Weather	Life Cycle Cost and/or Performance Payment/Toll	In case of Force Majeure event the affected party will be compensated and impacts to be mitigated as per provision of agreement.
	Force Majeure during operations	O&M Cost and possibly Performance Payment/Toll	
	Uninsurable risks (throughout the period)	Life Cycle Cost and/or Performance Payment/Toll	
	Political Force Majeure	O&M Cost and possibly Performance Payment/Toll	
Revenue Risk	Non-availability of road	Government Budget	-
	Volume risk	O&M Cost and possibly Performance Payment/Toll	
	Underperformance caused by tolling system	O&M Cost and possibly Performance Payment/Toll	-
O&M Risk	Increased maintenance due to traffic volume	O&M Cost and possibly Performance Payment/Toll	-
	Incorrect estimates and cost overruns	O&M Cost and possibly Performance Payment/Toll	
	Actual operating and maintenance costs higher than anticipated	O&M Cost and possibly Performance Payment/Toll	-

Type of Risk	Risk	Cost Driver	Mitigation
	Equipment used becomes prematurely obsolescent	Life Cycle Cost	-
Performance Risk	Labour and material availability	Life Cycle Costs	
	Interface with sub-contractors	Life Cycle Costs	-
	Change in scope of service specifications by RHD	Life Cycle Costs	
	Expansion for traffic accommodation at ramps and interchanges due to traffic growth, or signalization	Life Cycle Costs	-
	Future interchanges or additional lanes	Life Cycle Cost	
	Damage caused by unauthorized tyres e.g., spikes	Life Cycle Costs	Responsibility of RHD
	Damage/injury to third parties	Life Cycle Costs	
	Damage to works, however caused, except as excluded	Life Cycle Costs	
	Water/air/soil pollution	Life Cycle Cost and/ or Performance Payment/Toll	
	Third party claims and accidents	Life Cycle Cost and/ or Performance Payment/Toll	
	Overloaded Vehicles	Life Cycle Cost and/or Performance Payment/Toll	
	Legal loading limits increased	Life Cycle Cost and/or Performance Payment/Toll	
	Traffic accidents	Life Cycle Cost and/or Performance Payment/Toll	
	Off road incidents	O&M Cost	
	Workplace Health and Safety	O&M Cost	
	Labour disputes	O&M Cost	
	Vandalism	Performance	

Type of Risk	Risk	Cost Driver	Mitigation
	Development Around Project Site Requiring Further Over Bridges or Under Passes or other Demographic Changes	Payment/Toll	
	Traffic Management	Life Cycle Cost	
Market Risk	Base interest rates to Financial Close	O&M Cost and possibly Performance Payment/Toll	
	Interest spread risk to Financial close	Life Cycle Costs	
	Currency fluctuations	Life Cycle Costs	
	Inflation on Construction Costs	Life Cycle Cost	
	Inflation on Operation, Maintenance, Rehabilitation	Life Cycle Cost	
	Costs of finance on change of requirements	Life Cycle Cost	
Other Market Risk	Change in law	Life Cycle Cost	
	General	Life Cycle Costs	
	Change in Toll operator	Life Cycle Costs	

9.4 General Description of Risk & Mitigation

Table 9-3: General Risk and Mitigation

Type of Risk	Risk	Cost Driver	Risk Allocation	Mitigation
Design Risk	Time overrun due to delays in approval of detailed design	Construction Costs	RHD	Timely Deployment of Proof Consultant
	Time overrun due to delays in approval of working drawings	Construction Cost	RHD	Timely Deployment of Construction Supervision Consultant
Site Risk	Land acquisition for the Project	Construction Cost	RHD	Proper Mitigation in the Contract Agreement between RHD & Contractor.
	Site Security	Construction Cost	RHD & Contractor	
	Environmental	Construction Cost	Contractor	

Construction Risk	Quality assurance and quality control	Construction Cost	Contractor	Proper Mitigation in the Contract Agreement between RHD & Contractor.
	Achieving Construction Standards and Specifications	Construction Cost	Contractor	
	Fit for purpose manuals, approvals and statutory certificates	Construction Cost	Contractor	
	Cost overrun and delay not caused by a relief or compensation event	Construction cost	Contractor	
	Shifting of utilities	Construction Cost	Contractor	
	Delays caused by Private Party	Construction Cost	Contractor	
	Delays due to Client's changes	Construction and possibly O&M cost	RHD	
	Labour disputes	Construction Cost	Contractor	
	Project management /integration / delay	Construction Cost	Contractor	
	Damage/injury to third parties	Construction Cost	Contractor	
	Adequacy of insurance	Construction Cost	Contractor	
	Sub-contractor insolvency	Construction Cost	Contractor	
Post-construction risk	Latent defects	Life Cycle Cost	Contractor	
	Workplace Health and Safety	Life Cycle Cost	Contractor	

9.5 Sensitivity of Risks

The following Table 9-4 shows the sensitivity of risks associated with the project and its duration to impact the project, mainly during construction.

Table 9-4: Sensitivity of Risks

Sl. No	Risk Area	Sensitivity	Relevance
1	Delays in land acquisition	High	Construction Period
2	External Linkages	Low	Construction Period
3	Financing Risk	Medium	Construction Period

Sl. No	Risk Area	Sensitivity	Relevance
4	Planning	Medium	Construction Period
5	Approvals	High	Construction Period
6	Design Risk	Medium	Construction Period
7	Construction Risk	Medium	Construction Period
8	Technology Risk	Low	Throughout
9	O&M Risk	Medium	Throughout
10	Traffic Risk	High	Throughout
11	Payment Risk	High	Throughout
12	Financial Risk	Medium	Throughout
13	Change in Law	Low	Throughout
14	Force Majeure	Low	Throughout
15	Sponsor Risk	Medium	Throughout
16	Government event risk	Low	Throughout
17	Guarantor Risk if Government	Low	Throughout

10 ALTERNATIVE/OPTION ANALYSIS

Based on the detailed site reconnaissance and map study, two alternative alignment options have been proposed considering the suitable Bridge locations over the Someshwari River. Further, a joint site visit of the Consultant with the RHD officials for the alignment review was done on 16 February 2024. Among these options, the Alignment Option 1 emerged as the most preferred choice based on reports such as the Alignment Option Study Report, Bridge Option Study Report, and Multicriteria Analysis. Consequently, the Draft Feasibility Study Report (DFS) recommended Alignment Option 1 with a Bowstring Steel Truss Bridge.

Following this recommendation, DFSR workshop was held on March 13, 2024, where RHD (Roads and Highways Department) officials approved **Alignment Option 1** with the **Extradosed + Balance Cantilever Bridge**. Subsequently, a topographic survey was conducted, resulting in minor adjustments to the preferred alignment based on actual survey data and geometric design parameters.

These adjustments do not have any significant impact on the overall suitability and ranking of the proposed alignment. Hence, the Alternative Alignment Option study, decision matrix, and sensitivity analysis prepared during the DFS stage have been retained.

10.1 Evaluation of Alternative Bridge Options through Decision Matrix

In this study, a set of span arrangements (3 options for Alignment Option 1 and 2) has been finalized for each alignment option. All the options have been evaluated based on some common parameters. Accordingly, a suitable bridge option has been decided based on the best scoring bridge. All the 3 options are detailed below:

Bridge Options in Alignment Option 1 and Alignment Option 2

- Option A: PSC Box Girder-Balanced Cantilever
- Option B: Extradosed Bridge
- Option C: Steel Arch Bridge

It is noted that three bridge options (A, B and C) as described above were submitted in bridge option study report to RHD on November 1, 2023. Subsequently, several meetings were held between the Consultant and RHD, and one more bridge option has been adopted combining the bridge form of the Balanced Cantilever bridge and the Extradosed bridge to overcome the aesthetical monotony of applying one type of bridge form to a 990m long section along with cost effectiveness.

- Option D: Balanced Cantilever Bridge + Extradosed Bridge

Suitable bridge option has been proposed through the best scoring according to evaluation through decision matrix as given presented below.

DECISION MATRIX OF BRIDGE OPTION STUDY – ALIGNMENT OPTION 1 and 2

Sl. No.	Basic Aspects	Parameter	Unit	Relation	Weightage	Max Score	Option A (Bal. Cantilever)		Option B (Extradosed)		Option C (Network Arch)		Option D (Extradosed + Bal. Cantilever)	
							Qty	Score	Qty	Score	Qty	Score	Qty	Score
A1	Design & Serviceability	Depth of superstructure (max.)	m	Equation-1	15%	10	7.00	3.86	5.30	5.09	2.70	10.00	5.30	5.09
A2	Design & Serviceability	Skew angle (wrt direction of flow)	degree	Equation-1		5	0.00	5.00	0.00	5.00	0.00	5.00	0.00	5.00
A3	Design & Serviceability	Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Annexure-1		10	120.00	9.81	160.00	10.00	140.00	8.75	160.00	10.00
A	Sub Score - Design & Serviceability					25		18.67		20.09		23.75		20.09
	Weightage Score					15		11.20		12.06		14.25		12.06
B1	Constructability	Total bridge length (main bridge)	m	Equation-1	15%	10	990.00	9.90	990.00	9.90	980.00	10.00	990.00	9.90
B2	Constructability	Maximum single span Length (for Difficulty, duration, safety hazards)	m	Annexure-2		15	120.00	15.00	160.00	8.73	140.00	11.21	160.00	10.00
B	Sub Score - Constructability					25		24.90		18.63		21.21		19.90
	Weightage Score					15		14.94		11.18		12.73		11.94
C1	Aesthetic	Suitability with the terrain and culture	Based on Judgement		20%	15	Good	5.00	Better	10.00	Better	10.00	Best	15.00
C2	Aesthetic	Integrity between superstructure and substructure				15	Better	10.00	Best	15.00	Good	5.00	Best	15.00
C	Sub Score - Aesthetic					30		15.00		25.00		15.00		30.00
	Weightage Score					20		10.00		16.67		10.00		20.00
D1	Environment	Total carbon consumption propotionate to structural concrete quantity	cum	Equation-1	20%	10	77000.0	6.62	72000.0	7.08	51000.0	10.00	87000.00	5.86
D2	Environment	Obstruction in waterway due to structure inside the perinial river	m	Equation-1		20	128.00	12.03	96.00	16.04	77.00	20.00	141.00	10.92
D	Sub Score - Environment					30		18.65		23.13		30.00		16.78
	Weightage Score					20		12.44		15.42		20.00		11.19
E1	Indicative Cost	Relative Cost of Substructure & Foundation	Cr (BDT)	Equation-1	30%	15	312.200	13.42	284.900	14.71	279.400	15.00	297.76	14.08
E2	Indicative Cost	Relative Cost of Superstructure	Cr (BDT)	Equation-1		15	278.800	15.00	330.000	12.67	711.300	5.88	307.50	13.60
E3	Indicative Cost	Relative Maintenance cost for entire service life	Cr (BDT)	Equation-1		15	265.700	15.00	307.400	12.97	594.400	6.71	339.90	11.73
E	Sub Score - Cost					45		43.42		40.35		27.58		39.40
	Weightage Score					30		28.95		26.90		18.39		26.27
	Total Score					155		120.64		127.20		117.54		126.18
	Total Weightage Score				100%	100		77.53		82.22		75.37		81.45
Preferred Option							Option B (Extradosed)							

From the overall consideration of the evaluation, the **Bridge Option B (Extradosed)** is observed as **preferred option for both Alignment option 1 and 2**.

it can be seen that the total score of option B (extradosed) is the highest and option D (combined) is 2nd highest. However, the score of these two options varies within a range of 1% only. In the above analysis 30% weightage has been given to cost. Environment and aesthetic aspects have been considered with 20% weightage each. Hence, it can be inferred that the preferred option is always dependent on the weightage given to a particular aspect. Considering the socio-economic condition of Bangladesh and to give a sustainable solution for selection of preferred bridge option, aesthetic, cost, environment and social needs have been given the utmost importance which is the present day's needs in finalizing any development proposal. Accordingly, as discussed and agreed in a DFSR workshop meeting with RHD, Option D (combination of Extra-dosed + Balanced Cantilever) has been selected as preferred bridge option. The form has been preferred to overcome the aesthetical monotony of applying one type of bridge form to a 990m long section along with cost effectiveness.

Few additional advantages of combined bridge option in context of the project purpose are as below:

- In case of extradosed+ balanced cantilever bridge longer span can be adopted which helps to reduce the numbers of substructure and foundation.
- Superstructure depth can be optimized by increasing eccentricity of stay cables of the extradosed portion at support location.
- Due to higher degree of redundancy, overall safety and performance against seismic action, is higher in case of extradosed bridges.
- Due to the combination of balanced cantilever and extra-dosed bridge (with pylons and stay cables), aesthetically it is more pleasant than normal balanced cantilever construction.
- Reference could be made from recent projects in Bangladesh having similar terrain and topography like Lalon Shah Bridge (balanced cantilever with 1.7 Km total length), (Pyara Bridge (extradosed with 630m total length) and Shah Amanat Bridge (extradosed with 830m total length).

The salient features of the preferred option are given below:

Option D: Balanced Cantilever Bridge + Extradosed Bridge:

Span arrangement -	(60+2x100+60) m + (95+160+95) m+(60+2x100+60) m
Total length of main bridge -	990.0m
Skew angle -	0 degrees
Superstructure type -	PSC box-girder & Stayed Cable
Overall Deck width -	21.7m
Support condition -	Monolithic at main piers (no bearings)
Lane configuration -	2 lanes + 2 SMVT
Special feature -	• Integral connection between superstructure and substructure • No bearing requirement at main pier

For both the options, soffit level considers the climate change effect (0.38 m anticipated sea level rise) as inferred in the "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh Portion)" Dated in November 2021, done by Institute of Water Modelling (IWM).

10.2 Evaluation of Multi-Criteria Analysis Through Final Decision Matrix

The final decision matrix for concurring the Alignment Option was developed by combining the individual scores of the parameters with the application of weightage for different Criteria as detailed below.

CRITERIA	WEIGHTAGE
Highway Engineering Criteria	0.050
Bridge Engineering Criteria	0.300
Social Criteria	0.075
Environment Criteria	0.075
Hydro-Morphological Criteria	0.200
Indicative Cost Criteria	0.300
Total	**1.00**

The choice for the Alignment Option was also ratified through Sensitivity Analysis. "*Sensitivity of the final scoring with respect to the adopted weightages*" has been done, by developing decision matrixes in 4 scenarios with different weightage combinations, as detailed below.

Aspect	Weightage Adopted in Different Scenarios			
	Scenario I	Scenario II	Scenario III	Scenario IV
Highway Engineering Criteria	0.050	0.050	0.050	0.167
Bridge Engineering Criteria	0.300	0.300	0.300	0.167
Social Criteria	0.050	0.075	0.050	0.167
Environment Criteria	0.050	0.075	0.050	0.167
Hydro-Morphological Criteria	0.200	0.250	0.300	0.167
Indicative Cost Criteria	0.350	0.250	0.250	0.167
Total	**1.00**	**1.00**	**1.00**	**1.00**

MULTICRITERIA DECISION MATRIX

BASIC ASPECTS	SUB ASPECTS	PARAMETERS	UNIT	RELATION	MAX. SCORE	WEIGHTAGE	WEIGHTED MAXIMUM SCORE	OPTION - 1		OPTION - 2	
								QTY	SCORE	QTY	SCORE
Highway Engineering		Total Length	km	Equation 1	10	0.050	0.50	3.80	0.50	4.71	0.40
		Length of at grade highway	km	Equation 1	10	0.050	0.50	2.07	0.50	2.52	0.41
		Horizontal Geometry: Total length of curves having Superelevation	m	Equation 1	10	0.050	0.50	1080.54	0.50	1959.16	0.28
		Horizontal Geometry: Total deflection angle	degree	Equation 1	10	0.050	0.50	156.31	0.50	188.47	0.41
Bridge Engineering*	Design	Depth of superstructure	m	Equation 1	10	0.300	3.00	5.30	3.00	5.30	3.00
		Skew angle (wrt direction of flow)	degree	Equation 1	5	0.300	1.50	0.00	1.50	0.00	1.50
		Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Equation 1	10	0.300	3.00	160.00	3.00	160.00	3.00
	Constructability	Total bridge length	m	Equation 1	10	0.300	3.00	990.00	3.00	990.00	3.00
		Maximum single span Length (for Difficulty, duration, safety hazards)	m	Equation 2	15	0.300	4.50	160.00	4.50	160.00	4.50
	Aesthetic	Suitability with the terrain and culture	Based on judgement		15	0.300	4.50	Best	4.50	Best	4.50
		Integrity between superstructure and substructure			15	0.300	4.50	Best	4.50	Best	4.50
	Environment	Total carbon consumption proportionate to structural concrete quantity	cum	Equation 1	10	0.300	3.00	72000	3.00	72000	3.00
		Obstruction in waterway due to structure inside the perennial river	m	Equation 1	20	0.300	6.00	111.00	6.00	111.00	6.00
Social		Approximate no. of Structures to be dismantled	Nos.	Equation 1	10	0.075	0.75	18.00	0.54	13.00	0.75
		Number of Sensitive Buildings like mosque, graveyard, etc. to be dismantled	Nos.	Equation 1	10	0.075	0.75	2.00	0.75	4.00	0.38
		Livelihood Impact/Impact on local market (No of Shops affected)	Nos.	Equation 1	10	0.075	0.75	10.00	0.75	13.00	0.58
		Approximate Total land to be acquired	Ha	Equation 1	10	0.075	0.75	10.49	0.75	13.82	0.57
		Approximate Agricultural Land to be acquired	Ha	Equation 1	10	0.075	0.75	7.27	0.75	8.80	0.62
Environment		Approximate Fisheries Land to be acquired	Ha	Equation 1	10	0.075	0.75	0.00	0.75	0.00	0.75
		Impact on Vegetation (Approximate no. of trees affected)	Nos.	Equation 1	10	0.075	0.75	187.00	0.75	273.00	0.51
		Impact on Waterbody (Area of Pond excluding Fisheries)	Ha	Equation 1	10	0.075	0.75	0.04	0.75	0.46	0.07
Hydro-Morphological Studies#		Rank of the Bridge Option	Rank	Equation 2	10	0.200	2.00	1.00	2.00	1.00	2.00
		Stability of the Bank: Approximate Bank Length requiring River Training Works	m	Equation 1	10	0.200	2.00	3200.00	2.00	3200.00	2.00
Indicative Cost*		Approximate Cost of the Viaduct Section	Cr (BDT)	Equation 1	10	0.300	3.00	218.73	3.00	285.30	2.30
		Approximate Cost of Substructure & Foundation	Cr (BDT)	Equation 1	15	0.300	4.50	284.90	4.50	284.90	4.50
		Approximate Cost of Superstructure	Cr (BDT)	Equation 1	15	0.300	4.50	330.00	4.50	330.00	4.50
		Approximate Maintenance cost for entire service life	Cr (BDT)	Equation 1	15	0.300	4.50	307.40	4.50	307.40	4.50
		Approximate Total Capital Cost	Cr (BDT)	Equation 1	10	0.300	3.00	1384.42	3.00	1474.15	2.82
Total Weighted Score							**65**		**64.29**		**61.34**
Percentage Score									**99.68**		**95.10**
RANK									**1.00**		**2.00**

** The parameter values pertain to the Bridge Option 1A in Alignment Option 1 & Bridge Option 2A in Alignment Option 2. Refer "Bridge Option Study Report (Mahadev Bridge)" – Document No.: 5060143-8BRP-STR-RPT-006-R1*

 # The parameter values pertain to Bridge Site B (nearly matches with the Bridge Location at Alignment Option 1) and Bridge Site A (nearly matches with the Bridge Location at Alignment Option 2). Bridge Site C and Bridge Site D as shown in the Hydro-morphological report is respectively 100 m and 800 m downstream of termination point of the Border Road on the left and right bank of Mahadev River. Hence, these locations are as such not considered. Refer "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM).

MULTICRITERIA DECISION MATRIX – SENSITIVITY ANALYSIS FOR SCENARIO I

BASIC ASPECTS	SUB ASPECTS	PARAMETERS	UNIT	RELATION	MAX. SCORE	WEIGHTAGE	WEIGHTED MAXIMUM SCORE	OPTION - 1		OPTION - 2	
								QTY	SCORE	QTY	SCORE
Highway Engineering		Total Length	km	Equation 1	10	0.050	0.50	3.80	0.50	4.71	0.40
		Length of at grade highway	km	Equation 1	10	0.050	0.50	2.07	0.50	2.52	0.41
		Horizontal Geometry: Total length of curves having Superelevation	m	Equation 1	10	0.050	0.50	1080.54	0.50	1959.16	0.28
		Horizontal Geometry: Total deflection angle	degree	Equation 1	10	0.050	0.50	156.31	0.50	188.47	0.41
Bridge Engineering*	Design	Depth of superstructure	m	Equation 1	10	0.300	3.00	5.30	3.00	5.30	3.00
		Skew angle (wrt direction of flow)	degree	Equation 1	5	0.300	1.50	0.00	1.50	0.00	1.50
		Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Equation 1	10	0.300	3.00	160.00	3.00	160.00	3.00
	Constructability	Total bridge length	m	Equation 1	10	0.300	3.00	990.00	3.00	990.00	3.00
		Maximum single span Length (for Difficulty, duration, safety hazards)	m	Equation 2	15	0.300	4.50	160.00	4.50	160.00	4.50
	Aesthetic	Suitability with the terrain and culture	Based on judgement		15	0.300	4.50	Best	4.50	Best	4.50
		Integrity between superstructure and substructure			15	0.300	4.50	Best	4.50	Best	4.50
	Environment	Total carbon consumption proportionate to structural concrete quantity	cum	Equation 1	10	0.300	3.00	72000	3.00	72000	3.00
		Obstruction in waterway due to structure inside the perennial river	m	Equation 1	20	0.300	6.00	111.00	6.00	111.00	6.00
Social		Approximate no. of Structures to be dismantled	Nos.	Equation 1	10	0.050	0.50	18.00	0.36	13.00	0.50
		Number of Sensitive Buildings like mosque, graveyard, etc. to be dismantled	Nos.	Equation 1	10	0.050	0.50	2.00	0.50	4.00	0.25
		Livelihood Impact/Impact on local market (No of Shops affected)	Nos.	Equation 1	10	0.050	0.50	10.00	0.50	13.00	0.38
		Approximate Total land to be acquired	Ha	Equation 1	10	0.050	0.50	10.49	0.50	13.82	0.38
		Approximate Agricultural Land to be acquired	Ha	Equation 1	10	0.050	0.50	7.27	0.50	8.80	0.41
Environment		Approximate Fisheries Land to be acquired	Ha	Equation 1	10	0.050	0.50	0.00	0.50	0.00	0.50
		Impact on Vegetation (Approximate no. of trees affected)	Nos.	Equation 1	10	0.050	0.50	187.00	0.50	273.00	0.34
		Impact on Waterbody (Area of Pond excluding Fisheries)	Ha	Equation 1	10	0.050	0.50	0.04	0.50	0.46	0.04
Hydro-Morphological Studies#		Rank of the Bridge Option	Rank	Equation 2	10	0.200	2.00	1.00	2.00	1.00	2.00
		Stability of the Bank: Approximate Bank Length requiring River Training Works	m	Equation 1	10	0.200	2.00	3200.00	2.00	3200.00	2.00
Indicative Cost*		Approximate Cost of the Viaduct Section	Cr (BDT)	Equation 1	10	0.350	3.50	218.73	3.50	285.30	2.68
		Approximate Cost of Substructure & Foundation	Cr (BDT)	Equation 1	15	0.350	5.25	284.90	5.25	284.90	5.25
		Approximate Cost of Superstructure	Cr (BDT)	Equation 1	15	0.350	5.25	330.00	5.25	330.00	5.25
		Approximate Maintenance cost for entire service life	Cr (BDT)	Equation 1	15	0.350	5.25	307.40	5.25	307.40	5.25
		Approximate Total Capital Cost	Cr (BDT)	Equation 1	10	0.350	3.50	1384.42	3.50	1474.15	3.29
Total Weighted Score							**66**		**65.61**		**63.04**
Percentage Score									**99.79**		**95.87**
RANK									**1.00**		**2.00**

** The parameter values pertain to the Bridge Option 1C in Alignment Option 1 & Bridge Option 2C in Alignment Option 2. Refer "Bridge Option Study Report (Mahadev Bridge)" – Document No.: 5060143-8BRP-STR-RPT-006-R1*

 # The parameter values pertain to Bridge Site B (nearly matches with the Bridge Location at Alignment Option 1) and Bridge Site A (nearly matches with the Bridge Location at Alignment Option 2). Bridge Site C and Bridge Site D as shown in the Hydro-morphological report is respectively 100 m and 800 m downstream of termination point of the Border Road on the left and right bank of Mahadev River. Hence, these locations are as such not considered. Refer "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM).

MULTICRITERIA DECISION MATRIX – SENSITIVITY ANALYSIS FOR SCENARIO II

BASIC ASPECTS	SUB ASPECTS	PARAMETERS	UNIT	RELATION	MAX. SCORE	WEIGHTAGE	WEIGHTED MAXIMUM SCORE	OPTION - 1		OPTION - 2	
								QTY	SCORE	QTY	SCORE
Highway Engineering		Total Length	km	Equation 1	10	0.050	0.50	3.80	0.50	4.71	0.40
		Length of at grade highway	km	Equation 1	10	0.050	0.50	2.07	0.50	2.52	0.41
		Horizontal Geometry: Total length of curves having Superelevation	m	Equation 1	10	0.050	0.50	1080.54	0.50	1959.16	0.28
		Horizontal Geometry: Total deflection angle	degree	Equation 1	10	0.050	0.50	156.31	0.50	188.47	0.41
Bridge Engineering*	Design	Depth of superstructure	m	Equation 1	10	0.300	3.00	5.30	3.00	5.30	3.00
		Skew angle (wrt direction of flow)	degree	Equation 1	5	0.300	1.50	0.00	1.50	0.00	1.50
		Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Equation 1	10	0.300	3.00	160.00	3.00	160.00	3.00
	Constructability	Total bridge length	m	Equation 1	10	0.300	3.00	990.00	3.00	990.00	3.00
		Maximum single span Length (for Difficulty, duration, safety hazards)	m	Equation 2	15	0.300	4.50	160.00	4.50	160.00	4.50
	Aesthetic	Suitability with the terrain and culture	Based on judgement		15	0.300	4.50	Best	4.50	Best	4.50
		Integrity between superstructure and substructure			15	0.300	4.50	Best	4.50	Best	4.50
	Environment	Total carbon consumption proportionate to structural concrete quantity	cum	Equation 1	10	0.300	3.00	72000	3.00	72000	3.00
		Obstruction in waterway due to structure inside the perennial river	m	Equation 1	20	0.300	6.00	111.00	6.00	111.00	6.00
Social		Approximate no. of Structures to be dismantled	Nos.	Equation 1	10	0.075	0.75	18.00	0.54	13.00	0.75
		Number of Sensitive Buildings like mosque, graveyard, etc. to be dismantled	Nos.	Equation 1	10	0.075	0.75	2.00	0.75	4.00	0.38
		Livelihood Impact/Impact on local market (No of Shops affected)	Nos.	Equation 1	10	0.075	0.75	10.00	0.75	13.00	0.58
		Approximate Total land to be acquired	Ha	Equation 1	10	0.075	0.75	10.49	0.75	13.82	0.57
		Approximate Agricultural Land to be acquired	Ha	Equation 1	10	0.075	0.75	7.27	0.75	8.80	0.62
Environment		Approximate Fisheries Land to be acquired	Ha	Equation 1	10	0.075	0.75	0.00	0.75	0.00	0.75
		Impact on Vegetation (Approximate no. of trees affected)	Nos.	Equation 1	10	0.075	0.75	187.00	0.75	273.00	0.51
		Impact on Waterbody (Area of Pond excluding Fisheries)	Ha	Equation 1	10	0.075	0.75	0.04	0.75	0.46	0.07
Hydro-Morphological Studies#		Rank of the Bridge Option	Rank	Equation 2	10	0.250	2.50	1.00	2.50	1.00	2.50
		Stability of the Bank: Approximate Bank Length requiring River Training Works	m	Equation 1	10	0.250	2.50	3200.00	2.50	3200.00	2.50
Indicative Cost*		Approximate Cost of the Viaduct Section	Cr (BDT)	Equation 1	10	0.250	2.50	218.73	2.50	285.30	1.92
		Approximate Cost of Substructure & Foundation	Cr (BDT)	Equation 1	15	0.250	3.75	284.90	3.75	284.90	3.75
		Approximate Cost of Superstructure	Cr (BDT)	Equation 1	15	0.250	3.75	330.00	3.75	330.00	3.75
		Approximate Maintenance cost for entire service life	Cr (BDT)	Equation 1	15	0.250	3.75	307.40	3.75	307.40	3.75
		Approximate Total Capital Cost	Cr (BDT)	Equation 1	10	0.250	2.50	1384.42	2.50	1474.15	2.35
Total Weighted Score							**62**		**62.04**		**59.24**
Percentage Score									**99.67**		**95.16**
RANK									**1.00**		**2.00**

** The parameter values pertain to the Bridge Option 1C in Alignment Option 1 & Bridge Option 2C in Alignment Option 2. Refer "Bridge Option Study Report (Mahadev Bridge)" – Document No.: 5060143-8BRP-STR-RPT-006-R1*

 # The parameter values pertain to Bridge Site B (nearly matches with the Bridge Location at Alignment Option 1) and Bridge Site A (nearly matches with the Bridge Location at Alignment Option 2). Bridge Site C and Bridge Site D as shown in the Hydro-morphological report is respectively 100 m and 800 m downstream of termination point of the Border Road on the left and right bank of Mahadev River. Hence, these locations are as such not considered. Refer "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM).

MULTICRITERIA DECISION MATRIX – SENSITIVITY ANALYSIS FOR SCENARIO III

BASIC ASPECTS	SUB ASPECTS	PARAMETERS	UNIT	RELATION	MAX. SCORE	WEIGHTAGE	WEIGHTED MAXIMUM SCORE	OPTION - 1		OPTION - 2	
								QTY	SCORE	QTY	SCORE
Highway Engineering		Total Length	km	Equation 1	10	0.050	0.50	3.80	0.50	4.71	0.40
		Length of at grade highway	km	Equation 1	10	0.050	0.50	2.07	0.50	2.52	0.41
		Horizontal Geometry: Total length of curves having Superelevation	m	Equation 1	10	0.050	0.50	1080.54	0.50	1959.16	0.28
		Horizontal Geometry: Total deflection angle	degree	Equation 1	10	0.050	0.50	156.31	0.50	188.47	0.41
Bridge Engineering*	Design	Depth of superstructure	m	Equation 1	10	0.300	3.00	5.30	3.00	5.30	3.00
		Skew angle (wrt direction of flow)	degree	Equation 1	5	0.300	1.50	0.00	1.50	0.00	1.50
		Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Equation 1	10	0.300	3.00	160.00	3.00	160.00	3.00
	Constructability	Total bridge length	m	Equation 1	10	0.300	3.00	990.00	3.00	990.00	3.00
		Maximum single span Length (for Difficulty, duration, safety hazards)	m	Equation 2	15	0.300	4.50	160.00	4.50	160.00	4.50
	Aesthetic	Suitability with the terrain and culture	Based on judgement		15	0.300	4.50	Best	4.50	Best	4.50
		Integrity between superstructure and substructure			15	0.300	4.50	Best	4.50	Best	4.50
	Environment	Total carbon consumption proportionate to structural concrete quantity	cum	Equation 1	10	0.300	3.00	72000	3.00	72000	3.00
		Obstruction in waterway due to structure inside the perennial river	m	Equation 1	20	0.300	6.00	111.00	6.00	111.00	6.00
Social		Approximate no. of Structures to be dismantled	Nos.	Equation 1	10	0.050	0.50	18.00	0.36	13.00	0.50
		Number of Sensitive Buildings like mosque, graveyard, etc. to be dismantled	Nos.	Equation 1	10	0.050	0.50	2.00	0.50	4.00	0.25
		Livelihood Impact/Impact on local market (No of Shops affected)	Nos.	Equation 1	10	0.050	0.50	10.00	0.50	13.00	0.38
		Approximate Total land to be acquired	Ha	Equation 1	10	0.050	0.50	10.49	0.50	13.82	0.38
		Approximate Agricultural Land to be acquired	Ha	Equation 1	10	0.050	0.50	7.27	0.50	8.80	0.41
Environment		Approximate Fisheries Land to be acquired	Ha	Equation 1	10	0.050	0.50	0.00	0.50	0.00	0.50
		Impact on Vegetation (Approximate no. of trees affected)	Nos.	Equation 1	10	0.050	0.50	187.00	0.50	273.00	0.34
		Impact on Waterbody (Area of Pond excluding Fisheries)	Ha	Equation 1	10	0.050	0.50	0.04	0.50	0.46	0.04
Hydro-Morphological Studies#		Rank of the Bridge Option	Rank	Equation 2	10	0.300	3.00	1.00	3.00	1.00	3.00
		Stability of the Bank: Approximate Bank Length requiring River Training Works	m	Equation 1	10	0.300	3.00	3200.00	3.00	3200.00	3.00
Indicative Cost*		Approximate Cost of the Viaduct Section	Cr (BDT)	Equation 1	10	0.250	2.50	218.73	2.50	285.30	1.92
		Approximate Cost of Substructure & Foundation	Cr (BDT)	Equation 1	15	0.250	3.75	284.90	3.75	284.90	3.75
		Approximate Cost of Superstructure	Cr (BDT)	Equation 1	15	0.250	3.75	330.00	3.75	330.00	3.75
		Approximate Maintenance cost for entire service life	Cr (BDT)	Equation 1	15	0.250	3.75	307.40	3.75	307.40	3.75
		Approximate Total Capital Cost	Cr (BDT)	Equation 1	10	0.250	2.50	1384.42	2.50	1474.15	2.35
Total Weighted Score							**61**		**61.11**		**58.83**
Percentage Score									**99.77**		**96.05**
RANK									**1.00**		**2.00**

** The parameter values pertain to the Bridge Option 1C in Alignment Option 1 & Bridge Option 2C in Alignment Option 2. Refer "Bridge Option Study Report (Mahadev Bridge)" – Document No.: 5060143-8BRP-STR-RPT-006-R1*

 # The parameter values pertain to Bridge Site B (nearly matches with the Bridge Location at Alignment Option 1) and Bridge Site A (nearly matches with the Bridge Location at Alignment Option 2). Bridge Site C and Bridge Site D as shown in the Hydro-morphological report is respectively 100 m and 800 m downstream of termination point of the Border Road on the left and right bank of Mahadev River. Hence, these locations are as such not considered. Refer "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM).

MULTICRITERIA DECISION MATRIX – SENSITIVITY ANALYSIS FOR SCENARIO IV

BASIC ASPECTS	SUB ASPECTS	PARAMETERS	UNIT	RELATION	MAX. SCORE	WEIGHTAGE	WEIGHTED MAXIMUM SCORE	OPTION - 1		OPTION - 2	
								QTY	SCORE	QTY	SCORE
Highway Engineering		Total Length	km	Equation 1	10	0.167	1.67	3.80	1.67	4.71	1.34
		Length of at grade highway	km	Equation 1	10	0.167	1.67	2.07	1.67	2.52	1.37
		Horizontal Geometry: Total length of curves having Superelevation	m	Equation 1	10	0.167	1.67	1080.54	1.67	1959.16	0.92
		Horizontal Geometry: Total deflection angle	degree	Equation 1	10	0.167	1.67	156.31	1.67	188.47	1.38
Bridge Engineering*	Design	Depth of superstructure	m	Equation 1	10	0.167	1.67	5.30	1.67	5.30	1.67
		Skew angle (wrt direction of flow)	degree	Equation 1	5	0.167	0.83	0.00	0.83	0.00	0.83
		Maximum single span Length (for Functionality, Analysis, indeterminacy, performance etc.)	m	Equation 1	10	0.167	1.67	160.00	1.67	160.00	1.67
	Constructability	Total bridge length	m	Equation 1	10	0.167	1.67	990.00	1.67	990.00	1.67
		Maximum single span Length (for Difficulty, duration, safety hazards)	m	Equation 2	15	0.167	2.50	160.00	2.50	160.00	2.50
	Aesthetic	Suitability with the terrain and culture	Based on judgement		15	0.167	2.50	Best	2.50	Best	2.50
		Integrity between superstructure and substructure			15	0.167	2.50	Best	2.50	Best	2.50
	Environment	Total carbon consumption proportionate to structural concrete quantity	cum	Equation 1	10	0.167	1.67	72000	1.67	72000	1.67
		Obstruction in waterway due to structure inside the perennial river	m	Equation 1	20	0.167	3.33	111.00	3.33	111.00	3.33
Social		Approximate no. of Structures to be dismantled	Nos.	Equation 1	10	0.167	1.67	18.00	1.20	13.00	1.67
		Number of Sensitive Buildings like mosque, graveyard, etc. to be dismantled	Nos.	Equation 1	10	0.167	1.67	2.00	1.67	4.00	0.83
		Livelihood Impact/Impact on local market (No of Shops affected)	Nos.	Equation 1	10	0.167	1.67	10.00	1.67	13.00	1.28
		Approximate Total land to be acquired	Ha	Equation 1	10	0.167	1.67	10.49	1.67	13.82	1.27
		Approximate Agricultural Land to be acquired	Ha	Equation 1	10	0.167	1.67	7.27	1.67	8.80	1.38
Environment		Approximate Fisheries Land to be acquired	Ha	Equation 1	10	0.167	1.67	0.00	1.67	0.00	1.67
		Impact on Vegetation (Approximate no. of trees affected)	Nos.	Equation 1	10	0.167	1.67	187.00	1.67	273.00	1.14
		Impact on Waterbody (Area of Pond excluding Fisheries)	Ha	Equation 1	10	0.167	1.67	0.04	1.67	0.46	0.15
Hydro-Morphological Studies#		Rank of the Bridge Option	Rank	Equation 2	10	0.167	1.67	1.00	1.67	1.00	1.67
		Stability of the Bank: Approximate Bank Length requiring River Training Works	m	Equation 1	10	0.167	1.67	3200.00	1.67	3200.00	1.67
Indicative Cost*		Approximate Cost of the Viaduct Section	Cr (BDT)	Equation 1	10	0.167	1.67	218.73	1.67	285.30	1.28
		Approximate Cost of Substructure & Foundation	Cr (BDT)	Equation 1	15	0.167	2.50	284.90	2.50	284.90	2.50
		Approximate Cost of Superstructure	Cr (BDT)	Equation 1	15	0.167	2.50	330.00	2.50	330.00	2.50
		Approximate Maintenance cost for entire service life	Cr (BDT)	Equation 1	15	0.167	2.50	307.40	2.50	307.40	2.50
		Approximate Total Capital Cost	Cr (BDT)	Equation 1	10	0.167	1.67	1384.42	1.67	1474.15	1.57
Total Weighted Score							**53**		**52.04**		**46.40**
Percentage Score									**99.12**		**88.38**
RANK									**1.00**		**2.00**

** The parameter values pertain to the Bridge Option 1A in Alignment Option 1 & Bridge Option 2A in Alignment Option 2. Refer "Bridge Option Study Report (Ganeshwari Bridge)" – Document No.: 5060143-8BRP-STR-RPT-002-R1*

 # The parameter values pertain to Bridge Site B (nearly matches with both the Bridge Location at Alignment Option 1 and Alignment Option 2). Bridge Site B helps in the existing connectivity route on the 2 sides of the river Bridge Site A, Bridge Site C & Bridge Site D as shown in the Hydro-morphological report is 200 m, 50 m upstream and 507 m downstream of existing Rubber Dam. Hence, these locations are as such not considered. Refer "Hydro-Morphological study of Mahadev Bridge at 9th Km, Ganeshwari Bridge at 20th Km, Someshwari Bridge at 36th Km and Nitai Bridge at 50th Km of Border Road (Netrokona and Mymensingh Portion) during the year 2019-2020" dated in November 2021 by Institute of Water Modelling (IWM)

The results from the Tables above infer very clearly the Alignment Option 1 as the Rank 1 in all the Scenarios. The difference in the score between the two Alignment Options, in the 4 Weightage Scenarios ranges only from 3.72% to 10.74%. The high score of the Alignment Option 1 accredits to its superiority, primarily with respect to Highway Engineering, Social, Environment, Hydro–Morphological Studies, and Indicative Cost aspects.

Hence it can be well inferred that Alignment Option 1 is the preferred alignment with respect to the Bridge location as well as overall Project Road Alignment.

Further, it can be noted that, **the proposed Bridge Location in the Alignment Option 1 also matches tentatively with the Preferred Option as per Hydrological and Morphological Study carried out in 2022 by Institute of Water Modelling (IWM).**

Based on the workshop was held on March 13, 2024, **RHD (Roads and Highways Department) officials approved Alignment Option 1 with the Extradosed + Balance Cantilever Bridge**.

11 RECOMMENDATION AND CONCLUSION

- The Border Road (Z-2834) is the critical element of connecting the border areas of Kalmakanda, Durgapur, Dhobaura & Haluaghat Upazila and eventually connecting the border area with Sunamganj, Netrokona and Mymensingh district centres. There is a major gap at 35th Km of the existing road near Tinali Bazar due to Someshwari River. Thus, the proposed Someshwari bridge-3 has extreme importance for ensuring connectivity between the border areas.
- The border road would also create as infrastructure, having potentiality to facilitate movement of international transit traffic which would promote international trade and commerce for adjoining countries as well as for Bangladesh. This would contribute in economic development of Bangladesh and generate additional revenue.
- The construction of the bridge will lead to savings in VOC, time costs and reduction in emission.
- The construction of the new bridge will increase the health care facilities and will also enhance the educational opportunities.
- The bridge will lead to the development of tourism industry.
- The Project (comprising Nitai, Someshwari-3, Ganeshwari & Mahadev) has been found to be economically viable with an EIRR of 20.60% and Net Present Value (at 12% Discount rate) of 1430.8 Crores BDT.

Considering immense socio-economic befits to the Project Influence Area and economic viability**, this Project is recommended to be executed as per the approved Alignment Option and approved Bridge form, mentioned in this report**.