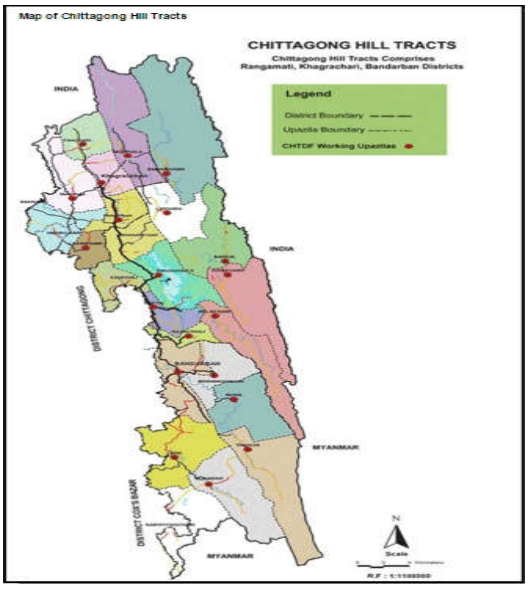
FINAL

GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

Consultancy Services for Feasibility, Detailed Survey and Design of Chittagong Hill Tracts Connectivity Connecting Thegamukh and Chittagong Port

CONTRACT PACKAGE NO. MOS-S4



MAIN FEASIBILITY REPORT – VOLUME IA OF IV

JUNE 2016

LOCAL GOVERNMENT ENGINEERING DEPARTMENT (LGED)

SAI Consulting Engineers Pvt.Ltd.,
SAI House, Satyam Corporate Square
B/hRajpath Club, Bodakdev
Ahmedabad–380059,INDIA

In association with

BETS Consulting Services Ltd.,
House-10,Road-135,Gulshan-1,
Dhaka-1212
Bangladesh

Volume I A: Main Feasibility Report

Project: Consultancy services for Feasibility, Detailed Survey and Design of Chittagong Hill Tracts (CHT) Connectivity Connecting Thegamukh and Chittagong Port.

Table of Contents for Detailed Feasibility Report

Bibliography

List of Tables

LIST OF FIGURES

Abbreviation

Q_p	Maximum Flood Discharge in m^3/s
A	Catchment Area in km^2
AADT	Annual Average Daily Traffic
AASTHO	American Association of State Highway and Transportation Officials
ACGR	Annual Compound Growth Rate
ACV	Aggregate Crushing Value
ADB	Asian Development Bank
ADT	Average Daily Traffic
ALO	Alternative Livelihood Options
ASCE	American Society of Civil Engineers
ASEAN	Association of Southeast Asian Nations
ASTM	American Society for Testing and Materials
BADC	Bangladesh Agricultural Development Corporation
BBS	Bangladesh Bureau of Statistics
BCIM	Bangladesh China India Myanmar
BDT	Bangladeshi Taka
BFDC	Bangladesh Fisheries Development Corporation
BFRI	Bangladesh Fish Research Institute
BGB	Border Guard Bangladesh
BH	Bore Hole
BIDS	Bangladesh Institute of Development Studies
BIWTA	Bangladesh Inland Water Transport Authority
BLPA	Bangladesh Land Ports Authority
BM	Bench Mark
BMD	Bangladesh Meteorological Department
BNBC	Bangladesh National Building Code
BOD	Biological Oxygen Demand
BPC	Bangladesh Petroleum Corporation
BPDB	Bangladesh Power Development Board
BRTA	Bangladesh Road Transport Authority
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
C	Dimensionless Run-off Coefficient
CBD	Convention on Biological Diversity
CBR	California Bearing Ratio
CBR	Cost Benefit Ratio
CCC	Chittagong City Corporation
CCF	Chittagong-Cox's Bazar Fold
CCHTL	Cherrapunjee-Chittagong Hill Tracts Landscape
CDA	Chittagong Development Authority
CDMPII	Comprehensive Disaster Management Programme Phase II
CES	Cumulative Environmental Sensitivity
CHT	Chittagong Hill Tracts
CHTDB	Chittagong Hill Tract Development Board
CNG	Compressed Natural Gas
CTFB	Chittagong-Tripura Fold Belt
dBa	Decibel
DEO	District Education Officer
DHM	Department of Hydrology and Meteorology
DO	Dissolved Oxygen
DoArch	Department of Architecture

DoE	Directorate of Environment
DoF	Department of Forests
DoF	Department of Forest
DPHE	Department of Public Health Engineering
EA	Environmental Assessment
ECA	Environmentally Critical Area
ECCR	Environmentally Critical Conservative Rules
ECP	Environmentally Critical Projects
ECR	Environmental Compliance Review
EGL	Existing Ground Level
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
EPP	Environmental Protection Policy
EPZ	Export Processing Zone
EQS	Environment Quality Standards
E_s	Apex Distance
ESA	Equivalent Standard Axles
ESIA	Environmental and Social Impact Assessment
FGD	Focus Group Discussion
FL	Finished Level
FM	Fineness Modulus
FY	Fiscal Year
GCM	Global Climate Model
GCM	General Circulation Models
GDP	Gross Domestic Product
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GO	Government
GoB	Government of Bangladesh
GPS	Global Positioning System
GSB	Geologic Survey of Bangladesh
GWT	Ground Water Table
h	Height of Object Above Pavement Surface
H	Height of Eye Level of Driver Over
H.I.P	Horizontal Intersection Point
HBB	Herring Bone Bond
HDM	Highway design and Maintenance
HFL	High Flood Level
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
HSD	High Speed Diesel
HWF	Hill Women Federation
I	Rainfall Intensity Within the Time of Concentration in mm/hr
IBAs	Important Bird Areas
ICIMOD	International Centre for Integrated Mountain Development
ICS	Institute of Chinese Studies
ICS	Institute of Chinese Studies
ICTP	International Conventions, Treaties and Protocols
ICWFM	International Conference on Water and Flood Management
IFC	International Finance Corporation
IGA	Income Generating Activities
IL	Invert Level
IP	Indigenous People
IPCC	Intergovernmental Panel on Climate Change

IPDP	Indigenous People's Development Plan
IRC	Indian Roads Congress
IRR	Internal Rate of Return
ISG	Improved Sub Grade
IUCN	International Union for Conservation of Nature
IWT	Inland Water Transport
IWTA	Inland Water Transport Authority
JICA	Japan International Cooperation Agency
JRC	Jumma Regional Council
JSG	Joint Study Groups
JSG	Joint Supply Group
JSS	Jana SamhatiSamiti
KII	Key Informant Interview
KM	Kilometre
KPH	Kilometer Per Hour
LAAV	Los Angles Abrasion value
LAD	Least Available Depth
L_c	Length of Circular Curve
LCV	Light Commercial Vehicle
LDD	Land Development Desk Top
LFD	Load Factor Design
LFL	Low Flood Level
LGED	Local Government Engineering Department
LPG	Liquid Petroleum Gas
LRFD	Load & Resistance Factor Design
L_s	Length of Transition
M	Minimum Set-back Distance
MCC	Manual Classified Counts
MEA	Multilateral Environmental Agreements
MoC	Ministry of Commerce
MOEF	Ministry of Environment & Forests
MoH	Ministry of Helth
MoLG	Ministry of Local Government
MoS	Ministry of Shipping
MPN	Most probable number
MS	Motor Spirit
MSA	Million Standard Axles
MSL	Mean Sea Level
MT	Metric Tons
MW	Mega Watts
n	Coefficient of Surface Roughness
N	Deviation Angle
N/A	Not Applicable
n_1	Ascending Gradient
n_2	Descending Gradient
NGO	Non-Government Organization
NNW-SSE	North North West-South South East
NPV	Net Present Value
N-S	North-South
ŋ	Distance Between Center Line of Carriageway and Center Line of Inside Lane
OD	Origin Destination
OP	Operation Policies
OPC	Ordinary Portland Cement

OSD	Overtaking Sight Distance
PAP	Project Affected People
PBCP	ParbatyaBangaleeChattraParishad
PBM	Primary Bench Marks
PC	Public Consultation
PCC	Plain Cement Concrete
PCC	Project Coordinating Consultants
PCJSS	ParbatyaChattagram Jana SamhatiSamiti
PCP	Pahari ChattraParishad
PGP	Pahari GonoParishad
PIA	Project Influence Area
PPB	Perspective Plan of Bangladesh
PSC	Pre-Stressed Concrete
PVC	Present Value of Cost
PWD	Public Works Department
QA	Quality Assurance
QAP	Quality Assurance Plan
QSS	Quality Assurance System
R	Radius of Circular Curve
R_{24}	24 hours Maximum Rainfall (mm)
RAP	Resettlement Action Plan
RBD	Retail Business Development
R_c	Radius of Circular Curve
RCC	Reinforced Cement Concrete
RF	Reserve Forest
RHD	Roads and Highway Department
RHDC	Rangamati Hill District Council
RL	Reduced Level
ROW	Right Of Way
R_{tc}	Rainfall Intensity in t_c Hours (mm/hr)
RTK	Real Time Kinematic
RUC	Road User Cost
s	Shift
S	Sight Distance
SAA	Somo Adhikar Andolon
SAARC	South Asian Association for Regional Co-operation
SAP	Settlement Action Plan
SDGs	Sustainable Development Goals
SHWL	Standard High Water Level
SI	International System
SMCE	Spatial Multiple Criteria Evaluation
SME	Small & Medium Enterprises
SOB	Survey of Bangladesh
SPARSO	Space Research & Remote Sensing Organization
SPM	Suspended Particulate Matter
SPT	Standard Penetration Test
SRCWP	Strengthening Regional Co-operation for Wildlife Protection
SSD	Stopping Sight Distance
T.P.	Tangent Point
TBM	Temporary Bench Marks
t_c	Time of Concentration in hr
TDS	Total Dissolve Solid
TL	Team Leader

TOR	Terms of Reference
TPDP	Tribal People Development Plan
TPDP	Tribal People's Development Plan
TRRL	Transport and Road Research Laboratory (UK)
TS	Topo Survey
T_s	Tangent Distance
UN	United Nation
UNDP	United Nations Development Programme
UNFCCC	UN Framework Convention on Climate Change
UNO	Upazila Nirbahi Officer
UP	Union Parishad
UP	Union Parishad
UPDF	United Peoples Democratic Front
US$	United States Dollar
USF	Unclassified State Forest
UTM	Universal Transverse Mercator
UTM	Universal Transverse Mercator
UZ	Upazilla
V	Speed in Km/h
VAT	Value Added Tax
VCF	Village Common Forests
VGF	Vulnerable Group Feeding
VOC	Vehicle Operating Cost
VOC	Vehicle Operating Cost
VPD	Vehicles Per Day
WB	World Bank
ZOI	Zone of Influence
Δ	Total Deviation Angle
Δ^c	Deviation and Central Angle of Circular Arc
θ_s	Deviation Angle of Transition Curve

EXECUTIVE SUMMARY

The Government of Bangladesh has aimed to provide efficient and effective transport connectivity from Chittagong Port to remote area of North East (N-E) districts, that may lead to development of cross- border transit corridors to N-E states of India. These corridors could be combination of water and land routes in order to improve accessibility for the marginalized people of Chittagong Hills Tract area connecting to the border. One of the borders crossing points is at Thegamukh, which lies in the Chittagong Hills Tract districts on the eastern side of Kaptai Lake and at the border with the State of Mizoram in India. At present, the place is inaccessible by road. The Government had identified eight tentative routes including waterway and roads for providing motorized connectivity between the existing road heads to Chittagong in the Kaptai Lake area. In this respect, the Government has identified four probable land routes and four other routes based on combination of waterway requiring dredging and land routes for the screening of route option leading to detailed feasibility study for one selected land and one multimodal route. .

- **Project Objectives**

The objective of the consulting service is to carry out the study to identify most viable transportation routes from Chittagong Port to remote area of Chittagong Hill Tracts Districts of Bangladesh that may lead to the development of cross-border transit corridors to North Eastern states of India, particularly through Thegamukh. The identification of the routes shall be based on technical, environmental and social screening of the probable routes in order to select the preferred road alignment and combination of waterways and roads, leading to the detailed feasibility study of one road option and one multimodal option.

- **Screening of Land Routes and Multimodal Routes**

The alignment options for screening and their lengths as determined after surveys, investigations and analysis were as follows:

a) ***Only road alignments***:
   1. Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh (about 123.54 km):
   2. Langadu–Bagachattar–Barkal–Thegamukh (50.25 km);
   3. Sajek–Majhipara–Dokanghat–Horina–Thegamukh (97.17 km); and
   4. Bangchara (kaptai)–Chitmaran–Chakuwapara–Bhangamurapara–Bilaichhari–Silchhari–mitngapara (Jurachhari)–Barkal–Chhotoharina- thegamukh (106.12 km).

b) ***Multimodal routes*** 1. Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (about 7.98 km); 2. Rangamiti–Barkal(37.5 Km) waterway and then Thegamukh (23.30 Km) by road; 3.Kaptai–Barkal waterway (64.81 Km) and Thegamukh by road (29.30 Km); 4. Kaptai–Chhotoharina–by waterway (89.62 Km) and Thegamukh by road (7.98 Km).

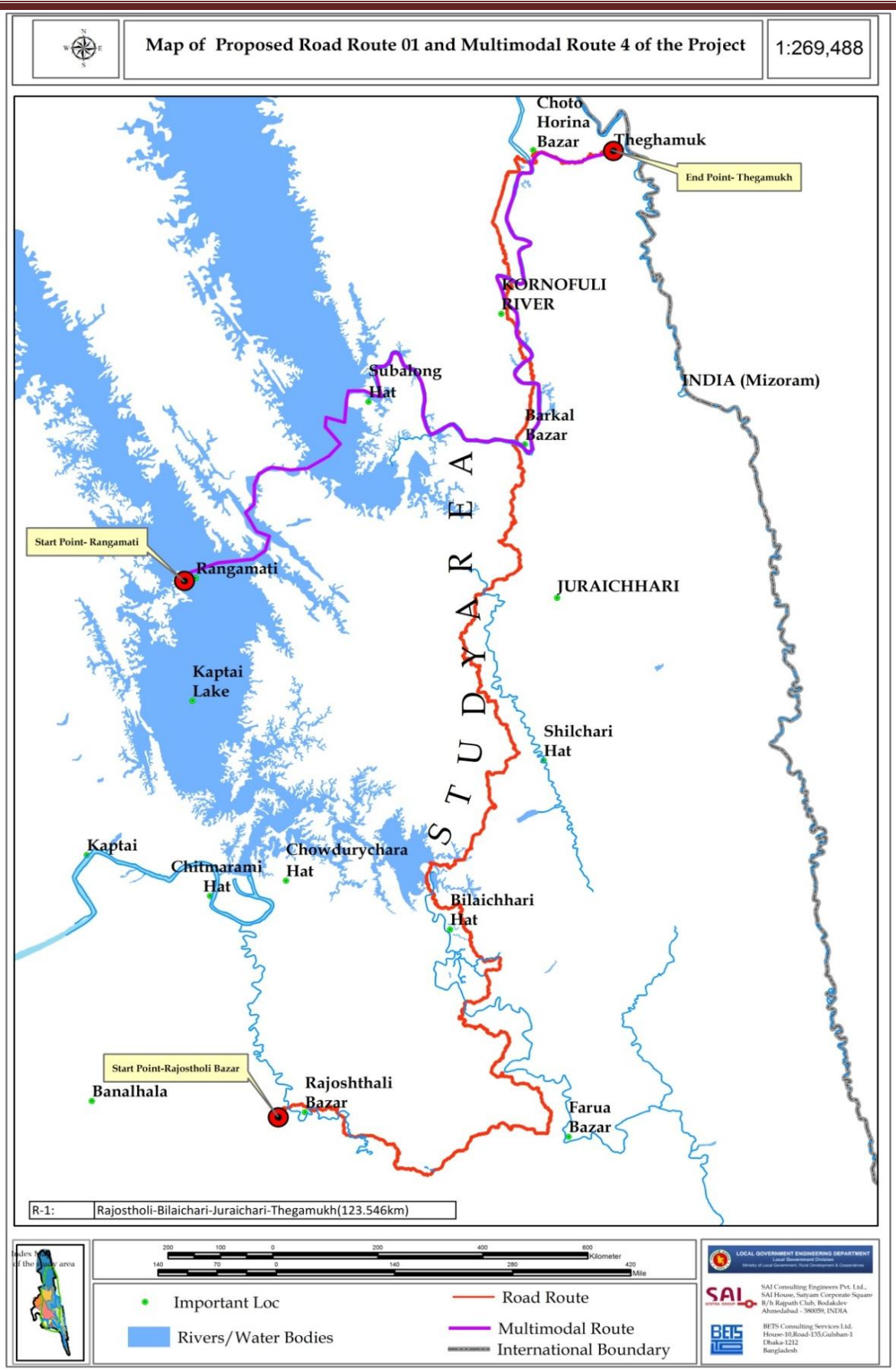
The Screening of above four road routes and four Multimodal routes deals with screening under Engineering, Environmental and Social criterion. The data was collected through Secondary and Primary sources. Under Primary Sources the reconnaissance surveys with GPS, river soundings to assess the dredging requirements, community consultations, traffic assessment for both local and cross border, Social, Environmental Surveys etc. had been done. Extensive data collection was done by consultants through secondary sources and background information, reports, maps, studies, plans, district and village profile and databases etc. had been collected.

- The following criteria and the weights/scores has been used for ranking the routes. The details are provided in Screening Report.

Criteria for screening of routes	Points/weight
1. Technical and Engineering Feasibility	10
2. Adverse Environmental Impact	10
3. Social Impact	10
4. Poverty	10
5. Present Inaccessibility to reach the road head	10
6. Travel time saving after construction from origin of proposed Route to Thegamukh	05
7. Less improvement required to existing road to Chittagong	10
8. Less time of travel between Chittagong to Thegamukh	10
9. Population served per Km of connectivity within zone of Influence	05
10. Length of the road covered by spending US$ 1 million project	10
11. People's Perception for the Project	10
	Total: 100

- Under the Technical and Engineering Feasibility the sub criteria were selected as length, geometrics, condition of existing road on proposed alignment/ availability of draft (for Multimodal routes), cross drainage structures, other structures/landing facilities (for multimodal routes), traffic, slope stability and other criteria like erosion, landslides etc. for road routes/ cost and quantity of dredging (for multimodal routes). Similarly under environmental impact land slippage, severe wind damage, gradient, access to areas/resources, land use, habitats of fish/wildlife, diversion of water, encroachment on tropical rain forests/ wetland, querying of construction material, waste disposal and dredging have been accounted for. Social criteria accounts for land acquisition, Number of house hold rehabilitated, Impacts on economic structures, impacts on cultural properties, loss of agricultural land, loss of commercial land, impact on tribal people and positive impact on population is considered.
- In addition to above other criteria as mentioned above like accessibility of road to Thegamukh/Cost of Operation for water way of Multimodal routes, travel time saving after construction of roads, Poverty, No of bridges and culverts required on existing road, widening and geometrics to be improved, travel time from Chittagong to Thegamukh, how much population is benefitted and construction cost of project is given due weightage. Apart from all this the perception of people about a particular road and in general about project is also given due importance for selecting the best route.
- A multi–criteria analysis had been carried out to evaluate and rank each of the 4 water routes and 4 land routes using above mentioned criteria and sub criteria. The results of Multi-Criteria analysis indicates that
  - Among four land routes the road alignment: Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh(123.54 km) and
  - Among the Multimodal routes the alignment:Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (about 7.98 km) have the highest score.

Thus these alignments have been proposed for detailed feasibility study. These two alignments are indicated in the enclosed map.


Map of Proposed Road Route 01 and Multimodal Route 4 of the Project
1:269,488
Choto Horina Bazar
Theghamuk
End Point- Thegamukh
KORNOFULI RIVER
Subalong Hat
INDIA (Mizoram)
Barkal Bazar
STUDY AREA
Start Point- Rangamati
Rangamati
JURAICHHARI
Kaptai Lake
Shilchari Hat
Kaptai
Chowdurychara Hat
Chitmarami Hat
Bilaichhari Hat
Start Point-Rajostholi Bazar
Banalhala
Rajoshthali Bazar
Farua Bazar
R-1:
Rajostholi-Bilaichari-Juraichari-Thegamukh(123.546km)
Kilometer
Mile
Important Loc
Rivers/Water Bodies
Road Route
Multimodal Route
International Boundary
LOCAL GOVERNMENT ENGINEERING DEPARTMENT
SAI Consulting Engineers Pvt. Ltd., SAI House, Satyam Corporate Square B/h Rajpath Club, Bodakdev Ahmedabad - 380059, INDIA
BETS Consulting Services Ltd. House-10,Road-135,Gulshan-1 Dhaka-1212 Bangladesh

Feasibility study of Selected Routes

Existing Conditions of Proposed Routes

The above two routes were selected for feasibility study and topographic survey was conducted.The existing road in land Route Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukhisof length was reduced to 114.751 km due to further refinement of alignment during topographic survey.Due to refinement of alignment all other sections length is slightly changed.

The first segment of the proposed alignment, i.e.

a) **Rajosthali to Bilaichari (49.100 km)** is found 674.67m(Avg. carriage way 4.4m) paved by bituminous carpeting (BC) in green vicinity in hilly terrain and other parts are earthen road where 8 nos (645.90m). RCC Bridges/Culvert are existing. Some missing links are found which aggregated 3226.68m. It is surveyed that 14 nos. Bridges/Culverts are required in different locations.
b) **Bilaichari–Jurichari (29.436 km.)** portion 1053.72 m paved road by Herring Bone Bond (HBB) with 3.217 m width is seen and 6 nos.(142.17m) Bridges/Culvert are existed. It is surveyed that further 15 nos. Bridges/Culverts are required in this portion. Some missing links aggregated 235.121 m are found in different locations. Other parts of the alignment are earthen roads. In this portion remarkable numbers of water lands (Chhara/Canal)) are seen.
c) **Jurichari–Barkal(6.849 km.)** section 3 nos (87.81m)existing Bridges are found.In this initially proposed alignment total 7 nos of Bridges/Culverts are required. In the hilly terrain the proposed alignment following the existing walkway or village road passes almost north direction within the green vicinity.
d) **Barkal–Chhotoharina (21.277 km.)** section 1187.40 m HBB road with 3 m width and 14 nos(308.49m) Bridges/Culverts are seen. Other parts of the alignment are earthen road where 22 nos Bridges/Culverts are required.
e) **Chhotoharina–Thegamukh (8.089 km.)** section 134.19 m HBB road with very narrow width of 1.5 m and 2 nos (79.32m) Bridges have been seen. Further 3 nos. Bridges are required in this section.

Multimodal Route 1: ***Rangamati - Chotoharina by waterway (63 km) and Thegamukh by road (8.089 km), (Proposed total length: 71.089 Km)***

This route enroutes to Chotohorina via Shobolong, Barkal, Bhusionchar. It is about 63km.Chotohorina to Thegamukh is 8.089 km by road. Rangamati to Barkal37.5 km is navigable round the year for small launches and boats. For larger cargo vessels navigable depth will need to be increased by dredging. Barkal to Chotohorina is navigable during monsoon for 3-4 months. This part of the waterway (25.5 km) will need massive dredging to increase navigable depth. **Chhotoharina–Thegamukh** portion 134.19m paved road by Herring Bon Bond (HBB) with 1.5 m width is seen and other parts are earthen road. 2 nos (79.32m) Bridges are existed & 2 Bridges are required.

Traffic Surveys, Analysis and Forecasts

Available traffic data from RHD and other secondary sources were all reviewed. A two-day classified traffic count was conducted at three identified locations namely; Ghagra, Chandraghona and Bangalhalia. Based on these data, base year traffic estimates were prepared. Using the medium and long term GDP growth rates, estimated transport elasticity and base year traffic

estimates, traffic forecasts were made till the year 2040 for three growth scenarios–low, medium and high The traffic forecasts for medium scenario which formed the basis for economic appraisal. In the case of IWT (multi-modal) option, base year traffic assessment is based on data collected from field surveys and discussions with local government agencies and Launch Owners' Association at Rangamati. Projections are made using average GDP growth rate of 6% per year.

Future Potential projects

The future potential coming up projects are namely:

i. Bangladesh-China-India-Myanmar (BCIM) Economic Corridor
ii. Mizoram State Roads II - Regional Transport Connectivity project, India
iii. 22.0 km section of Lunglei –Tlabung–Kawrpuichhuah Road on the border with Bangladesh;
iv. The 27.5km Champhai-Zokhawthar Road on the border with Myanmar; and
v. The 41.7km Chhumkhum-Chawngte North-South alignment connecting to the border roads with Bangladesh to the west and Myanmar to the south.

The above projects have great potential for cross border traffic and the possibility to generate/divert traffic on the proposed corridors of this study. However it requires some more detailed data and in-depth analysis for appropriately allocating this traffic to relevant routes

Design Standards

Principally RHD Geometric Design Standards Manual (Revised) 2005 has been followed for design parameters. Besides the following reference recommendations and standards have been consulted for references

- AASHTO "A policy on Geometric Design of Highway and Streets" 2005
- IRC_SP_48_1998
- Overseas Road Note 6 "A Guide to Geometric Design"
- Nepal Road Standards 2020(July 2013), Government of Nepal, Ministry of Physical Infrastructure and Transport. Department of Roads, Kathmandu, Nepal

AASHTO–Load & Resistance Factor Design (LRFD) method is used as Design Standard for Bridge and culvert design and other drainage structures.Structural analysis and design of Bridge and culverts are made in accordance with American Association of State Highway and Transportation Officials (AASHTO). For vehicular loading, Standard specification for Highway bridges latest edition HL-93 is presently used in Bangladesh. The design method LFD (Load Factor Design) is adopted in design. RHD pavement design manual has been used for the road portion.

Engineering Surveys and Investigations

Following surveys and Investigations have been carried out for collection of field data

- Road and Bridge Inventory and Condition Survey
- Topographical Surveyfor Roads and Bridges
- Soil and MaterialInvestigationsfor Roads
- Hydrological and Hydrographic Investigations
- Environmental Surveys for Roads and Multimodal Route
  i. Assessment of Air pollution
  ii. Assessment of Ground water quality
  iii. Assessment of Surface water quality
  iv. Noise levels at Sensitive locations

Improvements

As mentioned above two lane road with 7.3 m bituminous carriage way as per RHD standards has been developed. During the design process in order to provide acceptable gradients the length of land route is further reduced to 109.67 Km and land portion of Multi Modal Route is reduced to 7.37 Km and total length of Multi Modal Route is 70.37 Km. The lengths from Chittagong Port to Thegamukh by land route via Rajasthali is 184.97 Km while via Rangamati by Multimodal route is 142.88 Km.It is proposed to construct new bridges in place of existing bridges. In total 40 bridges and 21 culverts are proposed. Bridges are of RCC and PCC types as per requirement. Similarly slab culverts of different sizes are proposed as per requirement Earth retaining structures are also essential in the hilly area in order to have protection and slope stability failures. At crucial locations earth retaining structures are proposed. Surface drains are designed and as per discharge requirement they have been proposed.

The details related to waterway Rangamati to Chhotoharina

RangamatitoBarkal 37.5 km is navigable round the year for small launches and boats. For larger cargo vessels navigable depth will need to be increased by dredging. Barkal to Chotohorina25.5 km is navigable during monsoon for 3-4 months. This part of the waterway (25.5 km) will need massive dredging to increase navigable depth.

Dredging quantity:

With Least Available Depth 3.00 m and Width of cutting 61 m. Length from Rangamati to Chhotoharina via Barkal.Dredging quantity & cost are calculated for the portion from Rangamati to Chhotoharina.

Rangamati to Barkal (37.5 km) =	1.18 million m3
Barkal to Chotohorina (25.5 km) =	7.08 million m3
Maintenance Dredging Volume=	0.25 million m3
Total =	**8.51 million m3**

Cost Estimates

Estimation of cost is also done for improvement of existing road like Chittagong Port to Rajosthali and Rangamati. Estimates are also made for new proposed road and waterway routes. Following are the estimates for various sections.

Road Route	Million TK	Million US$
i). Cost for Improvement of Existing Road (Chittagong Port to Rajosthali)	1251.16	16.21
ii). Cost for Construction of New Proposed Road(Rajosthali to Thegamuk)	21,398.66	277.19
iii) Cost Of Environmental Mitigation Measures For Proposed Road Route	1050.00	13.60
Total=	**23699.82**	**307**

Multi Modal Route	Million TK	Million US$
i). Cost for Improvement of Existing Road (Chittagong to Rangamati)	142.4	1.85
ii). Cost for Improvement of Waterway (Rangamati to Chottoharina)	2291.58	29.68

Multi Modal Route	Million TK	Million US$
iii). Cost for Construction of New Proposed Road (Chottoharina to Thegamukh)	1,475.75	19.12
iv) Cost of Environmental Mitigation Measures for proposed Multimodal Route	161	2.09
Total=	**4070.73**	**52.74**

For development of cost estimate latest LGED/R&HD/BIWTA Rate Schedules have been used.

Economic Appraisal

All Road Project: Chittagong-Rajosthali-Thegamukh

Major benefit of road improvement/construction is reduction in vehicle operating cost (VOC) which in turn translates to reduced transport costs for passengers and goods traffic. Upgrading of the project road would result in savings to road users as well as to the society in terms of reduced transport costs and travel time, and improved environmental conditions. Since, the road projects have lengthy operational (or design) lives, the HDM IV model which allows life cycle costing has been used for assessing the costs and benefits traceable to the road upgrading project during its entire economic (design) life period. Within this framework, two mutually exclusive project alternatives viz. i) with the project and ii) without the project, have been considered for assessing the economic viability of proposed road project.

Economic analysis has been carried out based on medium traffic forecast. While the project cost included capital cost of road upgrading/construction work and maintenance cost (routine and periodic), the quantifiable project benefits were savings in vehicle operating costs. Economic analysis results indicate that all the project options have a high Economic Internal Rate of Return (EIRR).

Based on the economic analysis of the proposed project, as well as overall engineering and traffic assessment, construction of the new road between Rajosthali and Thegamukh along with widening of the existing road between Chittagong and Rajosthali with an EIRR of 21.8%, is preferable for the entire project road. Even under the most pessimistic scenario of 15% increase capital cost and 15% decrease in project benefits, the project yields an EIRR of 17.0 % which is much higher than the cut-off rate of 12% applicable in Bangladesh. The EIRR Value for the section Rajosthali to Thegamukh is also 13.3% if considered independently.

Multi-Modal Route: Chittagong-Rangamati-Chotohorina-Thegamukh

Under this, movement between Rangamati and Chotohorina is by water transport and that between i) Chittagong and Rangamati and ii) Chotohorina and Thegamukh is by road. For each of these three constituent sections of the multi-modal route, the investments are economically viable with EIRR more than 12%, the cut-off rate. Here also for new sections Rangamati to Chottoharina(Waterway) EIRR Value is 20.1% and Chottoharina to Thegamukh(Road Portion) EIRR Value is 14.8% which is more than 12% cut of rate.

Environmental Scoping

Biodiversity

Evaluation Objective

To minimize adverse effects on native vegetation and habitat and on threatened flora and fauna species and ecological communities, including any relevant species listed under the Forest Act, and address opportunities for offsetting potential losses consistent with relevant policy.

Key issues

- Direct loss of native vegetation and any associated listed threatened flora and fauna species known or likely to occur in the project site.
- Direct habitat loss for listed threatened fauna species.
- Indirect loss of vegetation or habitat quality resulting from edge effects, habitat fragmentation or other disturbance impacts.
- Potential for other indirect impacts on biodiversity values including changes in hydrology and risk of significantly increasing mortality of Forest Act listed species

Fisheries:Kaptai Lake is the largest manmade lake in the South Asia (App. 725 sq. Km). There is more than 4000 charas/ rivulet falling into the lake. About 1200 charas/ rivulets are directly connected and discharges into the lake. It is one of the largest sources of biodiversity and fish. Substantial amount of fish are being supplied by this charas falling into lake and comparatively higher per area fish are available than Lake.. According to the research of Bangladesh Fish Research Institute (FRI); 2 species of Shrimp, 1 species of Dolphin and 2 species of Tortoise are available in the lake. There are 68 species of local and 8 species of alien fish are available in the lake. At present, 42 species of fish are commercially collected from the lake. The local fish species are mainly come into the lake from the river and nearby wetland after the lake were created.

Flora: The hills, rivers and cliffs are covered with dense bamboo breaks, tall trees and creeper jungles. The valleys are covered with thick forest. The vegetation is characterised by semi-evergreen (deciduous) to tropical evergreen dominated by tall trees belonging to *dipterocarpaceae, euphorbiaceae, lauraceae, leguminacae* and *rubiaceae.*

Fauna: The fauna mainly includes monkey, fox, jungle cat, fishing cat, wild boar, land turtle, king cobra, reticulated python, rat snake and other non-poisonous snakes together with large number of species of lizards and amphibians like frog and toad, and tree frogs. The bird life of the Chittagong Hill Tracts is wonderfully rich. More than 60 families of birds are found.

Endangering Ecosystem

Hunting, fishing and collecting wood and gathering non-timber forest products Many traditional occupations relate to daily livelihood/subsistence activities involving the use of biological resources, such as fishing/fisheries, hunting, gathering of non-timber forest products , such as wild plants, medicinal herbs, fruits, nuts, mushrooms, etc. These activities take place in diverse ecosystems (e.g. marine or inland waters, tropical or boreal forests).

Many species of wildlife have now become critically endangered in the Chittagong Hill Tracts (CHT) due to indiscriminate poaching and rapid depletion of forests. Rare species of wildlife like Yak (goyal), Tiger, Panther (chitabagh), large and small civet cat, Pangolin, Gibbon (Ulluk), Barking deer and Samber, Slow Loris (LajjabatiBanor) and peacock are already on the verge of extinction in the CHT forests. At the same time many common species are also fleeing the forests

across the border as illegal poaching and fast depleting of forests reserves are causing their safe abode to shrink faster, observe zoologists. There is an Elephant Trail close to Barkal and Elephant is traveling across the proposed alignment for food in the area. This route of Elephant trail need to be protected for the benefit of Elephants and the population living in the area.

***Forestry*:** Sources at Department of Forest (DoF) said illegal logging, growing population, lack of wildlife conservation and awareness campaign and hunting by the indigenous people are the major reasons behind depletion of forests and disappearance of wildlife. A survey conducted in 1975 found 76 species of wild mammals, 183 species of wild birds, seven species of amphibious animals and 25 species of reptiles and snakes in the CHT forests. But many of these, including wild elephants, wild pigs, deer, wild dogs, porcupines, wild cocks, snakes, some species of monkeys, baboons (honuman), jackals, hares, few species of frogs, mongoose, leopards, wild buffaloes are now rarely seen in the forests. Even the Jhum cultivation through denudation of hills in and around the reserve forests areas also threatened biodiversity. (Shantimoy Chakma, Rangamati (Daily Star) Thursday, August 12, 2010).

Wild Life Sanctuary Protected area in Chittagong Hill Tract

PABLAKHALI WILDLIFE SANCTUARY
IUCN Management Category: IV (Managed Nature Reserve)
Biogeographical Provine: 4.09.04 (Burmna Monsoon Forest)

RAMPAHAR-SITAPAHAR WILDLIFE SANCTUARY
IUCN Management Category: Proposed
Biogeographical Provine: 4.04.01 (Burmna Rainforest)

Threat to the wildlife sanctuaries in project area.
Transport connectivity route are particularly sensitive from an environmental perspective, especially the areas of the Rampahar and Pablakhali Wildlife Sanctuaries. These areas among others to be studied under the project will require particular attention to ensure appropriate identification of critical habitats (including but not limited to designated protected areas and wildlife sanctuaries).

Rampahar-Sitapahar Wildlife Sanctuary at Rangunia is close to the access road between Chittagong port to Rangamati. If Kaptai road is used for multimodal transportation then Rampahar-Sitapahar Wildlife Sanctuary can be avoided. Pablakhali Wildlife Sanctuary is a bit close at the tip of Rajosthali-Theghamuk road (Chotohorina-Thegamukh). However the road is not passing through the wildlife sanctuary and may not harm it. Care should be taken so that user of this road can't get easy access to the sanctuary.

Social Scoping

Socio-economic situation of CHT districts is different from rest of the parts of Bangladesh due to variant geographical conditions. Most of the areas in CHT are hilly terrains and diverse ethnics groups reside there. Among the tribal people Chakma, Marma, Tanchungya, Tripura, Morung, Pangkhua, etc. are thr main communities.

From the social impact points of view among the road alignments number-1: Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh (about 114.751 km) and from the multi-modal

alignment–1: Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (about 8.089 km) has been recommended.

For social criteria, accounts for land acquisition, number of household to be rehabilitated and mitigation measures to be made, impacts on economic structures, cultural properties, loss of agricultural land, loss of commercial land, impact on tribal people, key poverty impacts, impact of risk on the project and positive impact on population were considered.

After tentative selection of the road and multimodal alignments through pre-feasibility study, a further feasibility study as part II of phase 1 has been carried out through community consultation throughout and along the selected route alignments. Public Consultation along the selected alignments was carried out with different stakeholders to assess different opportunities, threats and cost effectiveness for re-settlements works. And Public Consultations were conducted to gather local people's opinion relevant to identifying social and environmental issues and ensuring the appropriateness and viability of selected alignments.

For feasibility study of Road Alignment-1 and Multimodal Alignment -1, Public Consultation was carried out purposively along the selected 114.751 km long road alignment. The field team conducted 52 Public Consultations throughout the road alignment. The consultation covered the Upazila Officials, Upazila Chairmen, Headman, Karbaries, etc., including the common people along the alignment. Number of consultations was different at different places of the alignments because of the density of the population and problems of movement at different places due to forests and hills. Following the same method Multimodal selected route number 1, starting from Rangamati–Cotohorina along waterway and land up to Thegamukh was done. The investigators carried out 36 Public Consultation along this alignment.

During the feasibility study the respondents reported that the poverty situation has considerably **reduced** during the 5 years period and parameters they mentioned:

1. Rate of education increased and enrolment in schools has also been increased
2. Condition of living house structure improved
3. Increased use of sanitary latrines
4. Food intake in terms of quantity and quality has improved
5. Using solar panel, some Upazila got electricity connection
6. Use of TV, mobile and motorbike increased
7. Movement to other districts increased
8. Job opportunity increased
9. Increased employment in local government offices
10. Increased entrepreneurship

Some 90% participants in public consultation were from potentially affected tribal people. Tribal households were involved in fruit and timber gardening, producing turmeric and ginger, livestock rearing, trading, fishing and operating boat on rent basis. In the PC, it came out that the affected tribal population need to be re-settled in their own original profession, which they consider would be the best option for them. Besides that they are also interested in Income Generating activities (IGA), Alternative Livelihood Options (ALO) and Small & Medium Enterprises (SMEs). Some of them mentioned about training on motor driving.

However, it was found that they were interested both for financial and technical support. Options for support they mentioned include: (i) support for making fruit garden; (ii) support for buying

boat for fishing; (iii) support for starting small business; (iv.) arrange well-resourced IGA training. They tentatively estimated BDT 50,000 for IGA for each affected Tribal household.
\
Following Table highlighted the Socio-economic findings of the Road Alignment-1
Road Alignmen1:Rajosthali ----Belaichhari---Juraichhari---Barkal---Thegamukh—114.750 km

Sl. No.	Name of item	Quantity	Unit	Remark
1	Land to be acquire(approx)	114	Acres	
2	No. of household affected	564	Nos	
3	No. of commercial structure	157	Nos	
4	Agricultural affected(Garden)	241	Nos	
5	Cultural Structure Affected	10	Nos	3 Mosque 3 Temples 4 Schools
6	Water bodies Affected(Pond)	32	Nos	

The tentative cost for Land acquisition and Resettlement has been worked out as BDT/Km 13,56,923 Tk

Some Suggestions from the PAPs:

- In the PC people opined that the Road Construction should be done by the LGED or other similar organization.
- The present proposed Road alignment is supposed to pass through Jurachuri Sadar, then it would need to remove all establishments of Upazila and oher buildings. So, the people opined that the alignment should be changed to save those establishments. They proposed that if the route passes by the Upazila Police station-LabourPara–Kalika Para-Barkal then the upazila establishments will be saved and road length would be shortened by 4-5 km.
- If the Road Alignment follows the old KPM road that passes through Farua, Akuzzapara, Taktanala, and Alikhong to downbridge, then it would be cost effective and a lot of houses and buildings would be saved from acquisition.
- For preparing Road Alignment Maps, important locations should be demarcated on the maps. And at the same time during consultation, investigators should be advised to use Mouza Maps to find out the exact alignment locations and would easily point out the position of the possession to locate.

It would be very much fruitful, if there would be one day small workshop for review of the design and alignment in each of the four Upazilas, through which the road alignment has been passing with the presence of Headmen, Karbari, UNO, UP Chairmen, UP members, Upazila Chairman, Vice-Chairman, etc. These workshops would help the project to do re-settlement works easily.

Bibliography

- K.U. Reimann, 1993. Geology of Bangladesh. With a contribution by K. Hiller. GebruderBorntraeger, Stuttgart, ISBN 3-443-11020-7.
- Curray, J. R., and D. G. Moore, Sedimentary and tectonic processes in the Bengal deep sea fan geo-syncline, in Geology of Continental Margins, edited by C. A. Burk and C. L. Drake, Springer, New York, 1974.
- Maroof Khan, M. A., 1980. Bangladesh: a brief account on geology and hydrocarbon exploration.
- Curray, J. R., and D. G. Moore, Sedimentary and tectonic processes in the Bengal deep sea fan geo-syncline, in Geology of Continental Margins, Springer, New York, 1971.
- Guha DK. 1976. Tectonic Frame work and Oil and Gas Prospects of Bangladesh. Proceedings of the 4th Annual Conference, Bangladesh Geological Society, Dhaka.
- Geological Survey of Bangladesh (GSB).
- Warrick, R. A., Bhuiya, A. H., and Mirza, M. Q. (1996). The greenhouse effect and climate change, In The implications of climate and sea-level change for Bangladesh, R. A. Warrick and Q. K. Ahmad, eds., Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Brammer, H., Asaduzzaman, M., and Sultana, P. (1996). Effects of climate and sea-level changes on the natural resources of Bangladesh, In The implications of climate and sea-level change for Bangladesh, R. A. Warrick and Q. K. Ahmad, eds., Kluwer Academic Publishers, Dordrecht, The Netherlands.
- Alam, Mozaharul; Ain-Un Nishat; and Saad M. Siddiqui (1999) "Water Resources Vulnerability to Climate Change with Special Reference to Inundation", in: SaleemulHuq; Z. Karim; M. Asaduzzaman; and F. Mahtab (eds.) Vulnerability and Adaptation to Climate Change for Bangladesh (Dordrecht, The Netherlands: Kluwer Academic Publishers).
- Mondal, M.S. and Wasimi, S.A. 2004. Impact of climate change on dry season water demand in the Ganges Delta of Bangladesh, In Contemporary Environmental Challenges, M.M. Rahman, M.J.B. Alam, M.A. Ali, M. Ali and K. Vairavamoorthy, eds., CERM and ITN, BUET and WEDC, IDE, Loughborough University, UK.
- Divya, and Mehrotra, R. (1995). Climate change and hydrology with emphasis on the Indian Subcontinent, Hydrological Sciences Journal.
- Singh, N., and Sontakke, N. A. (2002). On climatic fluctuations and environmental changes of the Indo-Gangetic plains, India, Climate Change.
- Irfanullah, HaseebMd; Md. Belayet Hussain; and Tajul Islam Chowdhury (2005) Baira – The Floating Garden for Sustainable Livelihood (Dhaka: Government of the People's Republic of Bangladesh (GoB), Ministry of Environment and Forestry (MoEF); UNDP; BCAS; and IUCN Bangladesh).
- Salick, J. and Byg, A. (2007). Indigenous Peoples and Climate Change. A Tyndall Centre Publication Tyndall Centre for Climate Change Research, Oxford May 2007.
- Nadim, Farrokh; OddvarKjekstad, UlrikDomaas, RamezRafat, and Pascal Peduzzi (2006) "Global Landslides Risk Case Study", in: Margaret Arnold;; Robert S. Chen; Uwe Deichmann; Maxx Dilley; Arthur L. Lerner-Lam; Randolph E. Pullen; and Zoe Trohanis (eds.) (2006) Natural Disaster Hotspots Case Studies (Washington, DC: World Bank, Hazard Management Unit).

- Jashimuddin M (2009). Baseline Survey Report: Community Based Conservation of Forest Resources and Enhancing Rural Livelihood in Rangamati, CHT. 1-14. Dhaka, Arannayk Foundation.
- Alamgir, M. 2004. KaptaiRhod: MatshyaShampad O Babasthapana (Kaptai lake: Fisheries resources and management). In: Z.A. Khan et al. (ed.) Rangamati: Boichitrer. Oikata (Rangamati: harmony of diversity), Published by the District administration of Rangamati Hill District, Bangladesh.
- Kohinoor A.H.M., Islam M.L., Wahab M.A. and Thilsted S.H. (1998). Effect of mola (Amblypharyngodonmola Ham.) on the growth and production of Carps in polyculture. Bangladesh Journal of Fisheries.
- IPCC. 2007. Climate change 2007: Impacts, adaptation and vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, UK.

CHAPTER - 1

Introduction

CHAPTER - 1

Introduction

1.1 General

In order to improve key multi-modal transport corridor and networks that would address current transport bottlenecks for trade and help boost national, regional and international trade for Bangladesh, the World Bank is providing a Recipient-Executed grant to the Government of Bangladesh (GoB) to finance economic, financial, technical, environmental and social safeguards studies and technical assistance for: (i) dredging of priority inland waterways; (ii) provision of vessels, navigational aids, and safety equipment and improvement of selected river ports along priority waterways; (iii) construction of a new container terminal and improving operational efficiency at Chittagong Port; (iv) investments in selected equipment and improving operational efficiency at Mongla Port; (v) addressing missing links for road and inland waterways to establish transport connectivity between Chittagong Port, Chittagong Hill Tracts Districts, and NE states in India; and (vi) improving selected key priority border posts. These interventions are expected to facilitate domestic trade, international trade with third countries, as well as regional trade with neighboring countries including India, Nepal and Myanmar. These studies and technical assistance are expected to inform decisions on potential Investment opportunities. The Government of Bangladesh has aimed to provide efficient and effective transport connectivity from Chittagong Port to remote area of North East (N-E) districts, that may lead to development of cross-border transit corridors to N-E states of India. These corridors could be combination of water and land routes in order to improve accessibility for the marginalized people of Chittagong Hill Tracts area connecting to the border.

Bangladesh being a reverine country, Inland Water Transport (IWT) is a major mode for transport of goods and people. IWT sector is important for the poor as well as for the competitiveness and economic growth as it is the cheapest mode of transport compared to road & rail. In the previous day waterway routes were neglected for development & maintenance. In the recent years the Bangladesh Govt. has given due attention to develop and maintain the water routes. Bangladesh inland water transport Authority has the chartered responsibilities to develop& maintain the water ways. BIWTA was fighting against the dead & dying rivers with only 8 no. of cutter suction dredgers procured in the year1975 which are very old insufficient with the increasing demand of development & maintenance dredging. Now BIWTA has 18 Nos. of dredgers. 32Nos. of dredgers has been collected by private sector which is engaged to meet dredging need of BIWTA.

Bangladesh is the biggest delta in the world formed with non-cohesive alluvial soil. Erosion and siltation is a continuous process with formation of shoals in the river bed raising river beds continuously high which create navigational hazards.

Total length of the rivers is 24,000km Out of this total river length 6,000km are accessible for plying motor and mechanized vessels during the monsoon. About 3800 kms remains navigable round the year. The rivers are classified in four categories from the point of Least Available Depth (LAD). Classification is as under in **Table 1.1A (Figure no. 1.1 and Annex–1.1)**

Table 1.1A: Classification of Rivers

IWTA Classification	Length (km)	Depth(m)
Class 1	683	3.66-3.96
Class 2	1000	2.10-2.44
Class 3	1885	1.52-1.83
Class 4	2400	Less than 1.52

Source: *BIWTA master plan study*

For connectivity from Chittagong sea port to Thegamukh by waterway is the river Karnaphuli. The route is of class III category which is not normally maintained. The river Karnaphuli originates from the "LUSAI HILL" of Assam (India) and enters into Bangladesh near to Thegamukh. It flows downstream and falls into the Bay of Bengal travelling Chottoharina, Barkal, Shovolong, Rangamati, Kaptai Lake, Chittagong main sea port and Patenga. From Kaptai or Rangamati to Chhotohorina many growth centers have been developed on both banks of the river. There are Bazers, schools, Launch Stations, BGB Check post, College, Police Camps, Other important growth centes are like Bhusionchara, Bamland, Arabunia, Kalabunia, south Kalabunia, Butchara, Simoltala, Baraitala, Maisharia etc. It is the longest river route of the district which proceeds up to Chhotohorina then10 km toThegamukh by road. Different waterway routes (launch routes) of Rangamati district are given in **Table 1.1B**

Table 1.1B: Different Waterway launch Routes of Rangamati District

Name of waterways	Number of launches plying as per route permission of BIWTA.
1.Rangamati - Marisha 2.Rangamati–Chottoharina	31
3.Rangamati- Juracha	6
4.Rangamati–Khagrachari	3
5. Rangamati–Farua via Kaptai route	1
6. Rangamati–Balichari	2
7. RangamatiMaischari	1
8. Kaptai–Maischari	2

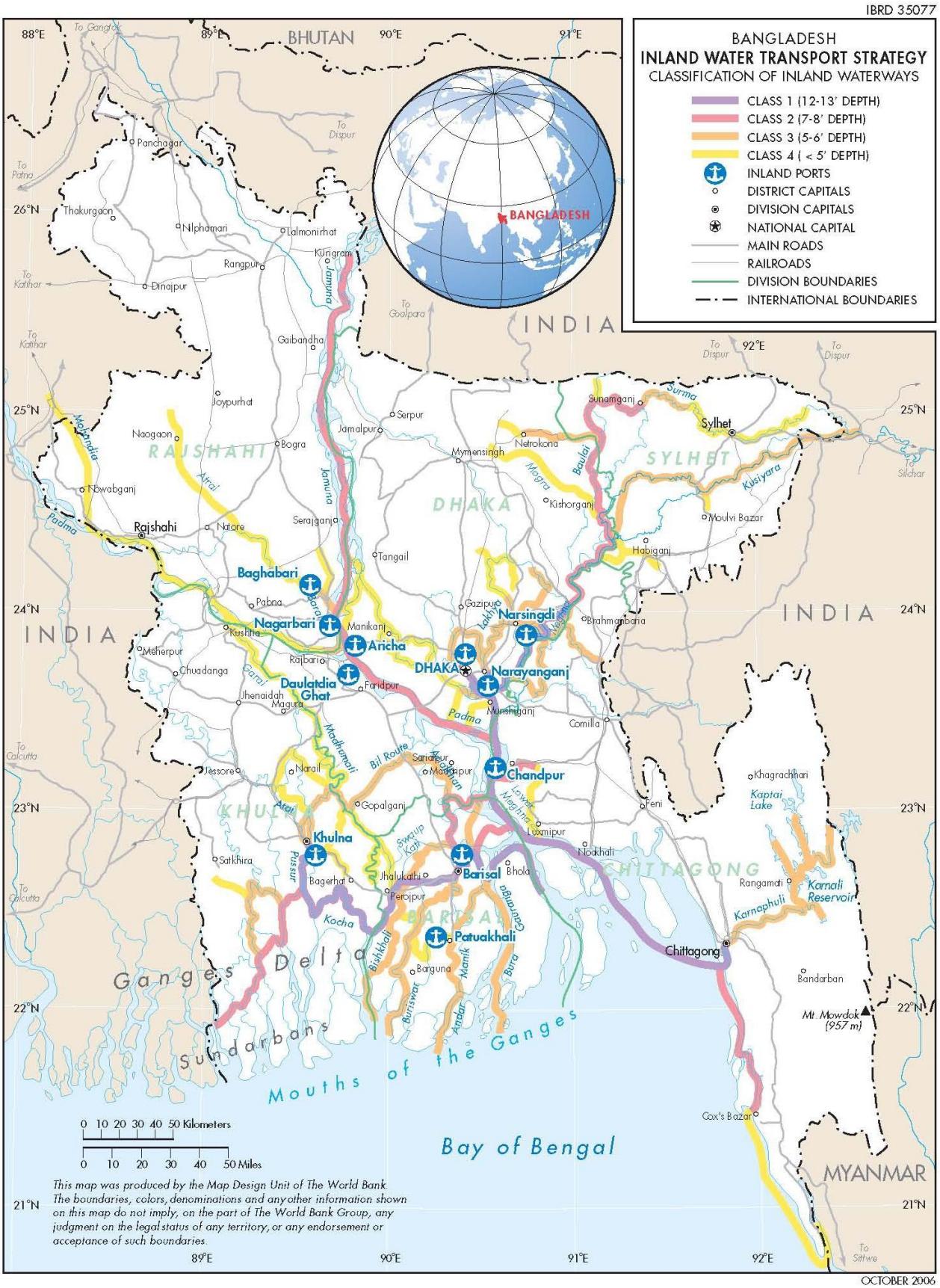


Figure 1.1: Rivers as per IWTA Classification

1.1.1 Development of Transport Connectivity in Chittagong Hill Tracts Area

The Government of Bangladesh has aimed to provide efficient and effective transport connectivity from Chittagong Port to remote area of North East (N-E) districts, that may lead to development of cross- border transit corridors to N-E states of India. These corridors could be combination of water and land routes in order to improve accessibility for the marginalized people of Chittagong Hill Tracts area connecting to the border. One of the borders crossing points is at Thegamukh, which lies in the Chittagong Hill Tracts districts on the eastern side of Kaptai Lake and at the border with the State of Mizoram in India. At present, the place is inaccessible by road. The Government has identified eight tentative routes including waterway and roads for providing motorized connectivity between the existing road heads to Chittagong in the Kaptai Lake area. In this respect, the Government has identified four probable land routes and four other routes based on combination of waterway requiring dredging and land routes for the screening of route option leading to detailed feasibility study.

1.2 Engagement of Consultancy Services

The Contract Agreement for "Consultancy Services for Feasibility, Detailed Survey and Design of Chittagong Hill Tract Connectivity Connecting Thegamukh and Chittagong Port"was signed by the Government of the Peoples Republic of Bangladesh represented by Local Government Engineering Department (LGED) and SAI Consulting Engineers Pvt. Limited of India in association with BETS Consulting Services Ltd, Bangladesh, on May 20, 2015. The following are the various agencies involved in the execution of the project:

Client	:	Government of the Peoples Republic of Bangladesh
Executing Agency	:	Local Government Engineering Department (LGED, Bangladesh
Consultant	:	SAI Consulting Engineers Pvt. Limited of India in association with BETS Consulting Services Ltd, Bangladesh
Funding Agency	:	World Bank

1.3 Project Objectives

The objective of the consulting service is to carry out the study to identify most viable transportation routes from Chittagong Port to remote area of Chittagong Hill Tracts Districts of Bangladesh that may lead to the development of cross-border transit corridors to North Eastern states of India, particularly through Thegamukh.Thegamukh lies in Mizoram in India. Mizoram's capital Aizawl is approximately 98 Km away from Thegamukh. Its latitude is $22^0$52'43" and Longitude $92^0$26'44.5". The routes will be selected in consideration of quick benefits achieved in the short-term and sustainable project effectiveness in the longer-term for designed life cycle cost of the project. The identification of the routes shall be based on technical, environmental and social screening of the probable routes in order to select the preferred road alignment and combination of waterways and roads, leading to the detailed feasibility study of one road option and one multimodal option.

Once the preferred route is selected for further investment based on the findings of the detailed feasibility study, the Employer may activate or contract for Phase II of the consulting service to carry out a survey, detailed engineering design, Cost estimating and preparation of bid documents for the construction of the selected road.

1.4 Scope of Consultancy

The consultancy services are to be provided in two phases

i) Screening including environmental and social screening and alternative analysis of all eight routes, and feasibility study of one road option and a multimodal route for connectivity between Thegamukh and Chittagong Port
ii) Survey, Detailed Design, Cost estimates and preparation of Bid Documents for the selected road option to connect Chittagong Port and Thegamukh that are found feasible.

Review the report as per TOR mention in the Annexure 1.4

1.5 Summary of components associated with the project

As discussed the project has been taken up to boost national, regional and international trade for Bangladesh. The project would address missing links for road and inland waterway to establish transport connectivity between Chittagong Hill Tract Districts, and NE states in India.

Through this project an efficient and effective transport connectivity from Chittagong Port to remote area of North East (N-E) districts will be developed. Following Eight corrdidors have been identified by Governement out of which four are by road and four are by multimodal i.e. water way and road combination.

Road Alignments:

1. Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh (about 123.54 km):
2. Langadu–Bagachattar–Barkal–Thegamukh (50.25 km) ;
3. Sajek–Majhipara–Dokanghat–Horina–Thegamukh (97.17 km); and
4. Bangchara (kaptai)–Chitmaran–Chakuwapara–Bhangamurapara–Bilaichhari–Silchhari–mitngapara (Jurachhari)–Barkal–Chhotoharina- thegamukh (106.12 km).

Multimodal Routes

1. Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (about 7.98 km);
2. Rangamiti–Barkal (37.5 Km) waterway and then Thegamukh (23.30 Km) by road;
3. Kaptai–Barkal waterway (64.81 Km) and Thegamukh by road (29.30 Km);
4. Kaptai–Chhotoharina–by waterway (89.62 Km) and Thegamukh by road (7.98 Km).

Among these eight corridors two routes one by road and other by multi modal i.e.combination of water way and road would be selected after screening. The detailed feasibility study would be carried out of these selected routes. Thus the project involves two major components:

- *Screening and selection of Alignment options*
- *Detailed feasibility study of one road and one multimodal alignment option.*

Brief activities involved in above components are as follows:

- ***Screening and selection of Alignment options***

i. Data Collection

a. Collection of data through primary surveys especially field surveys using GPS and collection of topographic information of all eight route options. Also collection of hydrographic information, data related to Kaptai Lake, Karnfulli River and river sounding etc.

b. Environmental and Social surveys and data collection including public consultations.
c. Review of various reports, existing studies and Collection of data through secondary sources like Topo sheets, Arial photographs, Satellite images, contour maps, Socio economic data, District and Village profiles, Transport Infrastructure, Base maps, design standards , assessment of traffic etc.

ii. Preparation of various base maps like land use pattern, Digital Elevation model, Settlements in project site, flood map of project site, drainage system in project area, Rainfall details in CHT area, Population map, ecological, topographical map of project areaetc.

iii. Screening of route using Multi-criteria Analysis

a. **Identification of criteria** for analysis and selection of appropriate weights: Various criteria which are affecting the multicriteria analysis were identified as Technical and Engineering Feasibility, Adverse Environmental Impact, Social Impact, Poverty , Present Inaccessibility to reach the road head, Travel time saving after the project, Less improvement required to existing road to Chittagong, Less time of travel between Chittagong to Thegamukh, Population served per Km of connectivity with in zone of Influence, Length of the road covered by spending US$ 1 million project, People's perception for the Project. Apart from these in order to address multi modal route requirements criteria related to available draft on water routes, dredging volume and its cost, cost of operation for carrying goods, additional landing and other facilities/structures for water routes have been included for scoring purpose.
b. **Identification of sub- criteria:** The criteria like Technical and Engineering Feasibility, Adverse Environmental Impact, Social Impact were further splitted into subcrietria and their weights have been decided. Following are the subcriteria –

   Under the Technical and Engineering Feasibility the sub criteria were selected as length, geometrics, condition of existing road on proposed alignment/ availability of draft (for Multimodal routes), cross drainage structures, other structures / landing facilities (for multimodal routes), traffic, slope stability and other criteria like erosion, landslides etc. for road routes/ cost and quantity of dredging (for multimodal routes). Similarly under environmental impact land slippage, severe wind damage, gradient, access to areas/resources, land use, habitats of fish/wildlife, diversion of water, encroachment on tropical rain forests/ wetland, querying of construction material, waste disposal and dredging have been accounted for. Social criteria accounts for land acquisition, Number of house hold rehabilitated, Impacts on economic structures, impacts on cultural properties, loss of agricultural land, loss of commercial land, impact on tribal people and positive impact on population is considered.
c. **Allocation of weights/scoring:** Appropriate weights/scores need to be allocated depending on severity and dominance against each subcriteria/ criteria and total score for each route has to be assessed. One road route and one Multi–modal route which scoremaximum weight / score has been considered the most feasible and selected for further investigation.

- ***Detailed feasibility study of one road and one multimodal alignment option.***

As discussed for the selected road and multimodal route detailed feasibility study need to be carried out. The activities involved for this stage are:

a. Fixing the design standards for the proposed alignments
b. Engineering Surveys and preliminary engineering design: Various surveys and field investigations like Topographic, soil and sub soil investigations, Traffic surveys, Hydraulic and hydrological investigations etc to be carried out.
c. Environmental and Social Surveys and Investigations
d. Stake holder meeting and Public consultations
e. Preliminary design of Road and Multimodal route
f. Preparation of Cost Estimates: Assessment of Preliminary quantities and associated costs including cost towards environmental and social mitigation and rehabilitation.
g. Economic and Financial Analysis: Assessment of Economic and Financial Internal Rate of Return using HDM 4, Sensitivity and risk analysis.
h. Preparation of Preliminary plan of proposed alignments and required drawings and reports for feasibility level.
i. Preparation of detailed draft TORs for full ESIA, EMP, RAP and Tribal People Development Plan of the selected routes.

1.6 Selection of Alignment accomplished in Screening Report

The alignment options for screening and their lengths as determined after Screening surveys, investigations and analysis were as follows:

a) ***Only road alignments***: 1.Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh (about 123.54 km): 2. Langadu–Bagachattar–Barkal–Thegamukh (50.25 km) ;3.Sajek–Majhipara–Dokanghat–Horina–Thegamukh (97.17 km); and 4. Bangchara (kaptai)–Chitmaran–Chakuwapara–Bhangamurapara–Bilaichhari–Silchhari–mitngapara (Jurachhari)–Barkal–Chhotoharina- thegamukh (106.12 km).
b) ***Multimodal routes*** 1. Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (about 7.98 km); 2. Rangamiti–Barkal (37.5 Km) waterway and then Thegamukh (23.30 Km) by road; 3.Kaptai–Barkal waterway (64.81 Km) and Thegamukh by road (29.30 Km); 4. Kaptai–Chhotoharina–by waterway (89.62 Km) and Thegamukh by road (7.98 Km).

The Screening of above four road routes and four Multimodal routes deals with screening under Engineering, Environmental and Social criterion. The data was collected through Secondary and Primary sources. Under Primary Sources the reconnaissance surveys with GPS, river soundings to assess the dredging requirements, community consultations, traffic assessment for both local and cross border, Social, Environmental Surveys etc. had been done. Extensive data collection was done by consultants through secondary sources and background information, reports, maps, studies, plans, district and village profile and databases etc. had been collected.

- To operationalize the base year traffic assessment methodology, the latest available AADT (i.e. for the year 2013) data have been collected from RHD for the road sections: Bangalhalia-Rajosthali, Dighinala-Langadu, Khagrachhari-Sajek, Chandragona-Kaptai, Manikchhari-Rangamati as these sections are contiguous to the new routes. The related population data has been gleaned from Bangladesh Bureau of

Statistics. AADT levels for base year (2013) have computed. With the help of population growth trends, Growth trends of motor vehicles, trends in fuel consumption sale and growth in GDP the transport demand elasticities have been calculated and growth rates have been derived which are quite encouraging. Traffic growth rates have been worked out for Pessimistic, Moderate and Optimistic scenarios. Traffic forecasts using the derived growth rates are presented in Screening Report. In studies of this nature, and where there is problem of paucity of relevant data, generated/induced traffic is assumed as percentage of estimated diverted/normal traffic. In the present case, to be on the conservative side, generated/induced traffic has been assumed as 20% of diverted traffic for all three scenarios. Forecasts for generated/induced traffic and total local traffic have been made and presented in Screening Report.

- The following criteria and the weights/scores has been used for ranking the routes.

Criteria for screening of routes	**Points/weight**
1. Technical and Engineering Feasibility	10
2. Adverse Environmental Impact	10
3. Social Impact	10
4. Poverty	10
5. Present Inaccessibility to reach the road head	10
6. Travel time saving after construction from origin of proposed Route to Thegamukh	05
7. Less improvement required to existing road to Chittagong	10
8. Less time of travel between Chittagong to Thegamukh	10
9. Population served per Km of connectivity within zone of Influence	05
10. Length of the road covered by spending US$ 1 million project	10
11. People's Perception for the Project	10
	Total: 100

- Under the Technical and Engineering Feasibility the sub criteria were selected as length, geometrics, condition of existing road on proposed alignment / availability of draft (for Multimodal routes), cross drainage structures, other structures / landing facilities (for multimodal routes), traffic, slope stability and other criteria like erosion, landslides etc. for road routes/ cost and quantity of dredging (for multimodal routes). Similarly under environmental impact land slippage, severe wind damage, gradient, access to areas/resources, land use, habitats of fish/wildlife, diversion of water, encroachment on tropical rain forests/ wetland, querying of construction material, waste disposal and dredging have been accounted for. Social criteria accounts for land acquisition, Number of house hold rehabilitated, Impacts on economic structures, impacts on cultural properties, loss of agricultural land, loss of commercial land, impact on tribal people and positive impact on population is considered.
- In addition to above other criteria as mentioned above like accessibility of road to Thegamukh / Cost of Operation for water way of Multimodal routes, travel time saving after construction of roads, Poverty, No of bridges and culverts required on existing road, widening and geometrics to be improved, travel time from Chittagong to Thegamukh, how much population is benefitted and construction cost of project is given due weightage. Apart from all this the perception of people about a particular

road and in general about project is also given due importance for selecting the best route.

- A multi–criteria analysis had been carried out to evaluate and rank each of the 4 water routes and 4 land routes using above mentioned criteria and sub criteria. The final results of multi–criteria analysis is presented below:

Table 1.6 A: Final Results of Multi Criteria Analysis

Proposed Route										
Sl No	Criteria	No of Points	Road Route				Multimodal Route			
			R-1 (Length =123.54 Km)	R-2 (Length=50.25 Km)	R-3 (Length=97.17 Km)	R-4 (Length=106.12 Km)	M-1 (Length=70.98 Km)	M-2 (Length=66.80 Km)	M-3 (Length=94.11 Km)	M-4 (Length=97.60 Km)
1	Technical and Engineering Feasibility	10	6.81	7.92	7.37	6.95	7.25	6.26	6.66	7.26
2	Adverse Environmental Impact	10	4.5	3.5	1.25	4.25	6.75	5.75	5.75	6.75
3	Social Impact	10	1.5	3	5.5	2.75	5.5	2.75	3	5.25
4	Poverty	10	7.5	10	7.5	5	5	5	5	5
5	Present Inaccessibility to reach the road head	10	9.37	9.49	9.63	9.74	7.13	2.15	1.83	6.82
6	Travel time saving after construction from origin of proposed Route to Thegamukh	5	4.5	4.41	4.38	4.5	1.24	3.15	2.59	0.95
7	Less improvement required to existing road to Chittagong	10	8.22	6.59	6.42	8.77	7.79	7.79	7.21	7.21
8	Less time of travel between Chittagong to Thegamukh	10	3.28	2.16	0	4.43	1.97	3.69	1.67	0
9	Population served per Km of connectivity within zone of Influence	5	2	5	3	4	5	5	2	2
10	Length of the road covered by spending US$ 1 million project	10	10	4.37	6.98	9.30	7.30	6.18	8.67	10
11	People's Perception for the Project	10	10	3	3	3	10	10	10	10
	Total Score	**100**	**67.68**	**59.44**	**55.03**	**62.69**	**64.93**	**57.72**	**54.38**	**61.24**

- The above results of Multi-Criteria analysis indicates that have the highest score. Thus these alignments have been selected for detailed feasibility study. **Figure 1.6** gives the selected route alignments.
  - Among four land routes the road alignment: **Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh (123.54 km) and**
  - Among the Multimodal routes the alignment: **Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (about 7.98 km)**

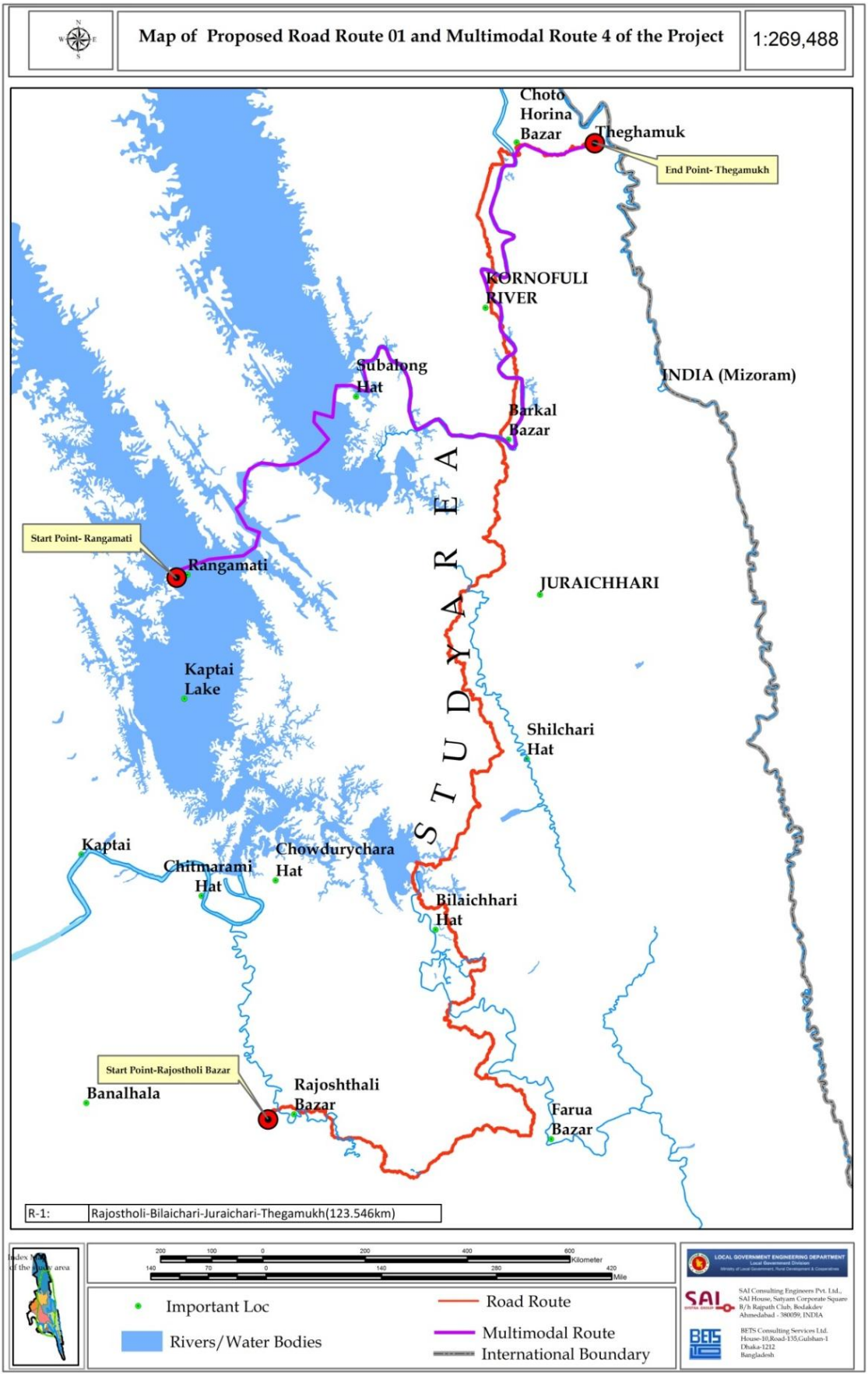


Figure 1.6 gives the selected route alignments.

Table 1.6 B: Lengths of Proposed Routes from Chittagong Port after Screening

Sl. No.	Road No.	Name of the Route	From Chittagong to Starting Point*	From Starting Point to Thegamukh#	Distance (Km)
All Road Routes					
1	R -1	Rajosthali-Bilaichhari-Jurichhari-Thegamukh	Chittagong-Rajosthali (79.062 Km)	Rajosthali-Bilaichhari-Jurichhari-Thegamukh (123.546 Km)	202.608
Multi-Modal (i.e. IWT and Road) Routes					
1	M -1	Rangamati-Chhotohornia by waterway and then by road up to Thegamukh	Chittagong–Rangamati (78.049 Km)	Rangamati- Chhotohornia by waterway and then by road up to Thegamukh (70.98 Km)	148.036

Note: ** The roads from Chittagong to the starting point are all-weather bitumen surfaced roads and are under Roads and Highway Department (RHD), Government of Bangladesh. From the starting point to Thegamukh, there are only tracks and are under Local Government Engineering Department (LGED), Government of Bangladesh*

- After selection of routes by multicriteria analysis the **Stake Holder Consultation** was done in the month of December 2015 and also stakeholder meeting was organized by Executive Engineer, LGED, Rangamati in the month of May 2016 and it was conveyed that out of eight alignments two have been selected and would be taken for feasibility study. The details of Stekeholder meeting is presented in **Volume ID Social Screening and Scoping Report.**

1.7 Feasibility Study of Selected Alignments

Topographic Surveyshave been conducted on the selected alignments and discussed in Chapter 5 and topographic details were indicated with the chainage called as ‘Existing Chainage’ later based on available topographic data highway design has been carried out and due to refinement of horizontal and vertical highway alignment the total length of proposed alignment has reduced from 114.751 Km to 109.675 km. The **Table 1.7 A and 1.7 B** gives design changes corresponding to existing changages for Road Route and Multimodal Route. This table has been included in order to avoid any confusion due to two chainage. Other details related to feasibility study are given in subsequesnt chapters of this report.

Table 1.7A: Details of Existing Chainange and Design Chainage for Road Route.

Section of the Road	Existing Chainage		Design Chainage	
	Start to End	Length (km)	Start to End	Length (km)
a. Rajosthali to Bilaichari	Ch.0+000-49+100	49.1	Ch.0+000-47+066	47.066
b.Bilaichari - Jurichari	Ch.49+100-78+536	29.436	Ch.47+066-75+157	28.091
c. Jurichari - Barkal	Ch.78+536-85+385	6.849	Ch.75+157-81+600	6.443
d. Barkal to Chottohorina	Ch 85+385-106+662	21.277	Ch.81+600-102+098	20.498
e. Chotohorina to Thegamukh	Ch 106+662-114+751	8.089	Ch.102+098-109+675	7.577
Total Length=		**114.751**		**109.675**

Table 1.7B: Details of Existing Chainange and Design Chainage for Multimodal Route.

Section of the Road	Existing Chainage		Design Chainage	
	Start to End	Length (km)	Start to End	Length (km)
a. Rangamati-Chotohorina	Waterway	63	Waterway	63
b.Chotohorina-Thegamukh	Ch.0+000-8+089	8.089	Ch.0+000-7+370	7.370
Total Length=		**71.089**		**70.370**

1.8 Structure of the Feasibility Report

This Feasibility report is prepared in accordance with Reporting Requirements of the Contract agreement. The report contains the following Volumes with contents mentioned below:

Volume IA **Main Feasibility Report**

Executive Summary

Chapter 1 - Introduction

Chapter 2 - Description of Existing Proposed Project Road and Existing Road connecting Chittagong Port to Origin of Proposed Road Route/ Multimodal Route

Chapter 3 - Traffic Analysis and Forecasts for Road and Multimodal Routes

Chapter 4 - Design Standards for Road and Waterways

Chapter 5 - Engineering Surveys and Investigations

Chapter 6 - Improvement Proposals for Proposed Road and Multimodal Routes

Chapter 7 - Economic Appraisal of Road and Multimodal Route

Chapter 8 - Conclusions and Recommendations

Volume IB **Annexure**

Volume IC **Environmental Screening and Scoping Report**

Volume ID **Social Screening and Scoping Report**

Volume II **Cost Estimates**

Volume II A: Cost Estimates for Road Route

Volume II B: Cost Estimates for Multi Modal Route

Volume III **Structural Drawings of Road and Multimodal Route**

Volume III A

1. **General Alignment Plan (1:25000 Scale)**
   - i) Road Route (Rajosthali to Thegamukh)
   - ii) Waterway (Rangamati to Chotoharina)
   - iii) Section of waterway
   - iv) Longitudinal Profile of waterway
   - v) Road Part of Multimodal route (Chottoharina to Thegamukh)
2. **Plan with GPS Coordinates (1:5000 vertical & 1:50000 horizontal Scale)**
   - i) Road Route (Rajosthali to Thegamukh)

ii) Road part of Multimodal route (Chottoharina to Thegamukh)

3. **Drawings of Structures (Bridges, Culverts, Retaining Wall and other structures for Road way, Structures for Water way)**

Volume III B
Drawings of Plan & Sectional Elevation of Bridge in 1:200 Scale

Volume IV — **Digitized GPS Photographs with Coordinates Presented in Compact disk (7Copies)**
&
Stakeholder Consultation Meeting Video Program, Photograph & Attendence Sheet are presented in Compact Disk (7 Copies)

CHAPTER - 2

Description of Existing Proposed Project Road and Existing Road Connecting Chittagong Port to Origin of Proposed Road Route/ Multimodal Route

CHAPTER - 2

Description of Existing Proposed Project Road and Existing Road Connecting Chittagong Port to Origin of Proposed Road Route/ Multimodal Route

2.1 General

This project basically aims to improve the connectivity between Chittagong port to remote area of North–East (N-E) districts, which may lead to development of cross border transit corridors to N–E states of India.As decided in Screening report these corridors are combination of water and land routes in order to improve accessibility for the marginalized people of Chittagong Hill Tracts area connecting to the border. One of the borders crossing points is at Thegamukh, which lies in the Chittagong Hill Tracts districts on the eastern side of Kaptai Lake and at the border with the State of Mizoram in India. At present, the place is inaccessible by road; the **Figure 2.1** gives details of existing roads in the CHT area. The physical feature in this area is rolling hills with limited plains, full of vegetation with some forests. The soil geology is mostly silt clay with soft sand stone in some areas. Although "katcha" motor able roads are shown in the LGED map for the proposed routes. Only a stretch of about 14101.01 m was found along the alignment to have Herring Bone Bond (HBB) roads with some old jeeps used as public transportation. People use waterway and foot trails to reach their settlements in these areas including Thegamukh.

After screening the consultant has identified two routes one by land and otherone is Multimodal i.e. combination of land and waterway for providing connectivity between Chittagong port to Thegamukh. The identified routes are:

Land Route: Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh (Survey (Existing) 114.751 km, Design Length: 109.67 Km)

Multimodal Route: Rangamati–Chhotoharina–connected by waterway (63 Km) and Thegamukh by road (Survey (Existing) 8.089 km, Design Length: 7.37Km)

The following section discusses the existing site conditions related to these routes.

2.2 Existing Project Roads and Water ways

Existing road from Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukh, Survey Existing 114.751 km, Design Length: 109.67 Km

The existing road in land Route Rajosthali–Bilaichhari–Juraichhari–Barkal–Thegamukhisof length 114.751 km. The first segment of the proposed alignment, i.e.

a) **Rajosthali to Bilaichari (49.100 km)** is found 674.67m(Avg. carriage way 4.4m) paved by bituminous carpeting (BC) in green vicinity in hilly terrain and other parts are earthen

road where 8 nos(645.90m). RCC Bridges/Culvert are existed. Some missing links are found which aggregated 3226.68m. It is surveyed that 14 nos. Bridges/Culverts are required in different locations.

b) **Bilaichari–Jurichari (29.436 km.)** portion 1053.72 m paved road by Herring Bone Bond (HBB) with 3.217 m width is seen and 6 nos. (142.17m) Bridges/Culvert are existed. It is surveyed that further 15 nos. Bridges/Culverts are required in this portion. Some missing links aggregated 235.121 m are found in different locations. Other parts of the alignment are earthen roads. In this portion remarkable numbers of water lands (Chhara/Canal)) are seen.

c) **Jurichari–Barkal(6.849 km.)** section 3 nos (87.81m)existing Bridges are found.

In this initially proposed alignment total 7 nos of Bridges/Culverts are required. In the hilly terrain the proposed alignment following the existing walkway or village road passes almost north direction within the green vicinity. In **d) Barkal–Chhotoharina (21.277 km.)** section 1187.40 m HBB road with 3 m width and 14 nos(308.49m) Bridges/Culverts are seen. Other parts of the alignment are earthen road where 22 nos Bridges/Culverts are required. In **e) Chhotoharina–Thegamukh (8.089 km.)** section 134.19 m HBB road with very narrow width of 1.5 m and 2 nos (79.32m) Bridges have been seen. Further 3 nos. Bridges are required in this section.

Multimodal Route 1: Rangamati - Chotoharina by waterway (63 km) and Thegamukh by road (8.089 km), (Proposed total length: 71.089 Km)

This route enroutes to Chotohorina via Shobolong, Barkal, Bhusionchar. It is about 63km. Chotohorina to Thegamukh is 8.089 km by road. Rangamati to Barkal 37.5 km is navigable round the year for small launches and boats. For larger cargo vessels navigable depth will need to be increased by dredging. Barkal to Chotohorina is navigable during monsoon for 3-4 months. This part of the waterway (25.5 km) will need massive dredging to increase navigable depth. **Chhotoharina–Thegamukh** portion 134.19m paved road by Herring Bon Bond (HBB) with 1.5 m width is seen and other parts are earthen road. 2 nos (79.32m) Bridges are existed & 2 Bridges are required.

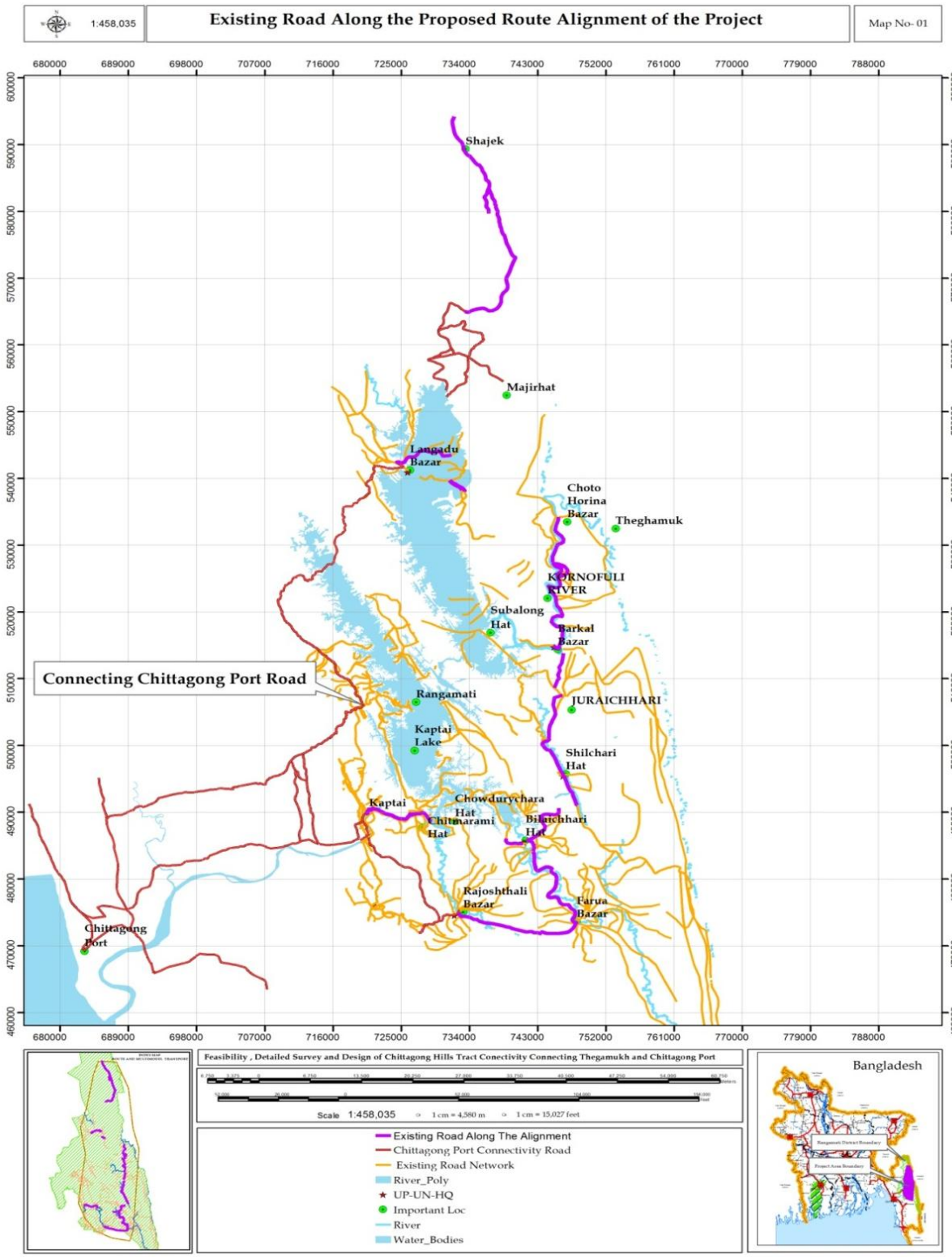


Figure 2.1: Details of existing roads in the CHT area

Following Table 2.2 A and 2.2B indicates the details of road exising from Rajosthali to Thegamukh and Rangamati to Thegamukh and their details in terms of width of road, type of roads, missing link etc are given in **Annex 2.2A and 2.2B**

Table 2.2A: Details of Existing Road Inventory from Rajosthali to Thegamukh (Road Route)

Section of the Road	Owner of the Road	Location	Length (km)	Earthen Road (m)	Pavement Road (m)	RCC Road (m)	Bridge		Culvert		HBB Road (m)	Missing Link (m)	Remark
							Nos	Length (m)	Nos	Length (m)			
a.Rajosthali to Bilaichari (Ch.0+000-49+100)	LGED	**Upozila**: Rajostholi, Bilaichari **District:** Rangamati	49.100	32713.12	674.67	113.90	7	642.60	1	3.30	11725.7	3226.68	
b.Bilaichari - Jurichari (Ch.49+100-78+536)	LGED	**Upozila:** Bilaichari, Juraichhari **District**: Rangamati	29.436	28005.43	N/A	N/A	5	139.30	1	2.87	1053.72	235.121	
c.Jurichari - Barkal (Ch.78+536-85+385)	LGED	**Upozila:** Juraichhari, Barkal **District:** Rangamati	6.849	6237.84	N/A	N/A	3	87.81	N/A	N/A	N/A	522.63	
d. Barkal to Chottohorina (Ch 85+385-106+662)	LGED	**Upozila:** Barkal **District:** Rangamati	21.277	15704.09	N/A	N/A	14	308.49	N/A	N/A	1187.40	4076.86	
e. Chotohorina to Thegamukh (Ch 106+662-14+751)	LGED	**Upozila:** Barkal **District:** Rangamati	8.089	7845.05	N/A	N/A	2	79.32	N/A	N/A	134.19	30.55	
Total Length=			**114.751**										

Table 2.2 B: Details of Existing Road Inventory fromRangamati to Thegamukh (Multimodal Route)

Section of the Road	Owner of the Road	Location	Length (km)	Type of way	Earthen Road (m)	Pavement road (m)	RCC Road (m)	Bridge		Culvert		HBB Road (m)	Missing Link (m)	Remark
								Nos	Length (m)	Nos	Length (m)			
a.Rangamati to Chotoharina	BIWTA	**Upozila:** Rangamati Sadar, Barkal **District:** Rangamati	63	Waterway	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
b.Chotoharina to Thegamukh (Ch.0+000-8+089)	LGED	**Upozila:** Barkal **District:** Rangamati	8.089	Roadway	7845.05	N/A	N/A	2	79.32	N/A	N/A	134.19	30.55	
Total Length=			**71.089**											

2.3 Traffic Flows on Road Routes and Multimodal Routes

The proposed routes from the starting point up to Thegamukh are walking tracks and are under the Local Government Engineering Department (LGED) of GOB.While for RHD road sections traffic data i.e. Annual Average Daily Traffic (AADT) are collected by RHD through volume count surveys, no such data are available for LGED sections as these are tracks and no vehicle traffic moves on them. Given this situation, it is not possible to collect AADT for a base year through conduct of traffic volume counts. In view of this, the consultants have attempted to make a broad estimate of AADT for the base year on these LGED sections assuming continuation of the "***existing RHD road sections into the new sections from the starting point up to Thegamukh***". Thus a part from some upazillas like Barkal which can be reached by IWT, the only means of connectivity in most of the study area (i.e. upazillas through which the proposed route alignments pass through) are "***walking tracks.***

In the case of IWT traffic movements (goods as well as passenger) by inland water transport (IWT) between Rangamati and Chotoharina, all the services are run by private operators and no recorded data are available. During the Consultants discussions with senior officials of Rangamati Hill District Council (RHDC) and Secretary Launch Owners' Association, Rangamati, the following points emerged.

- Every day three launches operate each way between Rangamati and Chotohorina
- Each launch trip, on an average, carries 100 passengers
- On an average, these launches operate for 330 days/year
- Every day about 35 trucks, which carry fish, fruits, forest and agriculture product, etc that are collected from the study area (i.e. Rangamati–Barkal–Chotohorina–Thegamukh) by IWT, move out of Rangamati towards Chittagong and beyond.
- Similar number of trucks comes into Rangamatieveryday and these goods are further transported by IWT for destinations in the study area.
- Each truck, on an average, carries 8 tonnes.
- On an average, each truck operates for 330 day/year

Based on the above information, base year (2015) traffic estimates have been worked for IWT and are presented in **Table 2.3**

Table 2.3: Base Year (2015) IWT Traffic Estimate

O-D Pair	Traffic	Base Year 2015
Goods Traffic		
Rangamati-Chotohorina	Tonnes/day	280
	Tonnes/year	92,400
Chotohorina-Rangamati	Tonnes/day	280
	Tonnes/year	92,400
Total – Bothways	Tonnes/day	560
	Tonnes/year	184,800
Passenger Traffic		
Rangamati-Chotohorina	Passengers/day	600
	Passengers/year	198,00
Chotohorina-Rangamati	Passengers/day	600
	Passengers/year	198,00
Total–Both ways	Passengers/day	1,200
	Passengers/year	396,000

Further details related to base year traffic. Analysis and forecasts are provided in Chapter 3 of this report.

2.4 Cross Drainage Structures & Road Ownership on Road Route and Road Portion of Multimodal Route.

Existing cross drainage structures have been studied and also probability of provision of new cross drainage structures have been identified at missing link.Following **Table 2.4 A and 2.4 B** give details of then along with Ownwrship of road

Table: 2.4 A Indicating cross draianage structure (Road Route)

From Chittagong to Rajosthali

Location	ID	Name	Chainage (km)	Length (m)	Carriageway/ Witdh (m)	Condition	Type	Bridge Name
Chittagong Port to Raster Mata	1	Bridge	2.000	320.000	16.00	Good	Bridge	Dewan Hat Bridge
	2	Bridge	6.500	7.100	31.00	Good	Box Culvert	
	3	Bridge	7.282	5.400	18.00	Good	Box Culvert	
	4	Bridge	8.069	3.800	18.00	Good	Box Culvert	
	5	Bridge	8.385	5.800	21.00	Good	Box Culvert	
	6	Bridge	8.717	4.400	29.70	Good	Box Culvert	
	7	Bridge	9.056	7.400	21.00	Good	Box Culvert	
	8	Bridge	9.674	4.700	20.00	Good	Box Culvert	
	9	Bridge	10.139	23.000	9.00	Good	Bridge	
	10	Bridge	10.923	2.100	27.00	Good	Box Culvert	
Raster Matha To Chandragona	1	Bridge	0.953	9.600	8.00	Good	Box Culvert	
	2	Bridge	3.130	5.100	7.00	Good	Box Culvert	
	3	Bridge	3.680	8.000	12.00	Good	Box Culvert	
	4	Bridge	4.608	20.600	8.00	Good	Bridge	
	5	Bridge	4.926	224.200	6.50	Good	Bridge	
	6	Bridge	6.267	3.600	17.50	Good	Pipe Culvert	
	7	Bridge	7.338	3.600	17.50	Good	Pipe Culvert	
	8	Bridge	7.480	3.600	17.50	Good	Pipe Culvert	
	9	Bridge	7.680	3.600	17.80	Good	Pipe Culvert	
	10	Bridge	8.060	3.600	17.80	Good	Pipe Culvert	
	11	Bridge	9.871	3.600	17.80	Good	Pipe Culvert	
	12	Bridge	10.668	25.000	7.50	Good	Bridge	
	13	Bridge	11.395	1.600	14.70	Good	Pipe Culvert	
	14	Bridge	11.510	3.600	17.80	Good	Pipe Culvert	
	15	Bridge	11.795	3.500	9.90	Good	Box Culvert	
	16	Bridge	12.225	3.500	9.10	Good	Box Culvert	
	17	Bridge	13.105	2.800	9.10	Good	Box Culvert	
	18	Bridge	13.360	24.200	6.00	Good	Sluice gate Bridge	Nawahat Sluice gate
	19	Bridge	13.959	1.600	17.70	Good	Pipe Culvert	
	20	Bridge	14.662	10.000	9.80	Good	Pipe Culvert	
	21	Bridge	15.192	3.600	17.80	Good	Box Culvert	

Location	ID	Name	Chainage (km)	Length (m)	Carriageway/ Witdh (m)	Condition	Type	Bridge Name
	22	Bridge	16.827	6.600	9.80	Good	Box Culvert	
	23	Bridge	19.099	1.600	14.70	Good	Box Culvert	
	24	Bridge	20.490	1.600	14.70	Good	Pipe Culvert	
	25	Bridge	20.940	1.600	15.30	Good	Pipe Culvert	
	26	Bridge	21.484	1.800	14.80	Good	Box Culvert	
	27	Bridge	22.971	12.900	8.00	Good	Box Culvert	
	28	Bridge	23.059	3.800	9.50	Good	Box Culvert	
	29	Bridge	23.911	11.000	10.50	Good	Box Culvert	
	30	Bridge	24.269	1.600	10.50	Good	Box Culvert	
	31	Bridge	24.704	3.800	9.70	Good	Box Culvert	
	32	Bridge	25.248	15.500	7.80	Good	Box Culvert	
	33	Bridge	25.651	54.600	6.00	Good	Sluice gate Bridge	Rajarhat Sluice gate Bridge
	34	Bridge	25.753	34.400	6.50	Good	Sluice gate Bridge	Rajarhat Sluice gate Bridge
	35	Bridge	26.476	2.000	18.20	Good	Box Culvert	
	36	Bridge	27.594	18.500	6.00	Good	Sluice gate Bridge	
	37	Bridge	28.342	3.400	9.20	Good	Box Culvert	
	38	Bridge	28.957	3.400	9.30	Good	Box Culvert	
	39	Bridge	29.567	3.400	9.30	Good	Box Culvert	
	40	Bridge	30.239	9.900	6.40	Good	Sluice gate Bridge	
	41	Bridge	32.446	5.800	9.40	Good	Box Culvert	
Chandragona To Bangalhalia		River	20.175	315.000	315.00	River		
	1	Bridge	21.085	21.500	4.00	Good	Bailey Bridge	Raikhali Bridge
	2	Bridge	21.738	1.600	7.50	Good	Box Culvert	
	3	Bridge	22.711	1.600	9.00	Good	Box Culvert	
	4	Bridge	23.275	1.600	9.00	Good	Box Culvert	
	5	Bridge	26.959	1.800	8.60	Good	Box Culvert	
	6	Bridge	32.085	18.400	4.00	Good	Bailey Bridge	Bangalhalia Bridge
Bangalhalia To Rajasthali	1	Bridge	0.038	1.800	7.00	Good	Box Culvert	
	2	Bridge	0.194	1.800	7.00	Good	Box Culvert	
	3	Bridge	3.019	25.000	3.70	Good	Bailey Bridge	
	4	Bridge	3.104	6.800	6.80	Good	Box Culvert	
	5	Bridge	3.584	1.100	6.50	Good	Box Culvert	
	6	Bridge	17.640	42.800	9.60	Good	Bridge	
	7	Bridge	19.623	61.600	4.00	Good	Bailey Bridge	

From Rajosthali to Thegamukh

Location	Chainage(m)			Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
	Ch-Start	To	CH-End					
Rajostholi to Bilaichhari	0.000	to	23.961	Pavement Road			LGED	UNR-484783004
	23.961	to	27.261	3.300	6.100	UNR-484783004	LGED	
	27.261	to	348.064	walkway				
	348.064	to	409.958	61.895	4.108	UNR-484783004	LGED	
	409.958	to	739.865	Pavement Road			LGED	UNR-484783004
	739.865	to	3742.484	HBB Road			LGED	UNR-484783004
	3742.484	to	5129.191	Earthen Road				UNR-484783004
	5129.191	to	5161.306	32.115	Chhara			
	5161.306	to	8358.958	Earthen Road				
	8358.958	to	8387.152	28.195	Chhara			
	8387.152	to	11834.515	Earthen Road				
	11834.515	to	11864.893	30.379	Chhara			
	11864.893	to	14717.324	Footpath				
	14717.324	to	19333.349	Earthen Road				
	19333.349	to	19344.035	10.686	Chhara			
	19344.035	to	20964.871	Earthen Road				
	20964.871	to	20973.654	8.783	1.654	UZR-484292001	LGED	UZR-484292001
	20973.654	to	21030.301	Earthen Road				
	21030.301	to	21035.704	5.403	1.064	UZR-484292001	LGED	UZR-484292001
	21035.704	to	21212.085	Earthen Road				
	21212.085	to	21217.312	5.227	1.051	UZR-484292001	LGED	UZR-484292001
	21217.312	to	22772.354	Earthen Road				
	22772.354	to	22886.256	RCC Road			LGED	UZR-484292001
	22886.256	to	22952.760	Earthen Road				UZR-484292001
	22952.760	to	22956.183	3.422	Chara			
	22956.183	to	33468.496	Earthen Road				UZR-484292001
	33468.496	to	33509.626	41.130	Chhara	UZR-484292001		
	33509.626	to	39587.275	Earthen Road				UZR-484292001
	39587.275	to	39815.599	228.324	Footpath	UZR-484292001		
	39815.599	to	40106.141	290.542	5.694	UZR-484292001	LGED	
	40106.141	to	47788.051	HBB Road			LGED	UZR-484292001
	47788.051	to	47918.691	130.640	4.310	UZR-484292001	LGED	
	47918.691	to	48183.769	HBB Road			LGED	UZR-484292001
	48183.769	to	48323.886	140.116	5.370	UZR-484292001	LGED	
	48323.886	to	49100.000	HBB Road			LGED	UZR-

Location	Chainage(m)			Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
	Ch-Start	To	CH-End					
								484292001
Bilaichhari to Juraichhari	49100.000	to	50153.721	HBB Road			LGED	UZR-484292001
	50153.721	to	50841.620	Earthen Road				UZR-484292001
	50841.620	to	50970.015	128.395	Chhara	Chhara		UZR-484292001
	50970.015	to	51829.465	Earthen Road				UZR-484292001
	51829.465	to	51846.363	16.897	Chhara	Chhara		UZR-484292001
	51846.363	to	59896.056	Earthen Road				UZR-484292001
	59896.056	to	59903.271	7.215	Chhara	Chhara		UZR-484292001
	59903.271	to	62201.521	Earthen Road				UZR-484292001
	62201.521	to	62209.349	7.828	Chhara	Chhara		UZR-484292001
	62209.349	to	62971.533	Earthen Road				UZR-484292001
	62971.533	to	62978.156	6.623	Chhara	Chhara		UZR-484292001
	62978.156	to	64093.074	Earthen Road				UZR-484292001
	64093.074	to	64095.938	2.865	4.056	Existing Culvert	LGED	UZR-484292001
	64095.938	to	65335.951	Earthen Road				UZR-484292001
	65335.951	to	65370.102	34.151	1.270	Wooden Bridge		UZR-484292001
	65370.102	to	65608.381	Earthen Road				UZR-484292001
	65608.381	to	65611.988	3.608	4.487	Existing Bridge	LGED	UZR-484292001
	65611.988	to	66849.652	Earthen Road				UZR-484292001
	66849.652	to	66855.339	5.687	Chhara	Chhara		UZR-484292001
	66855.339	to	68975.895	Earthen Road				
	68975.895	to	68994.628	18.733	Chhara	Chhara		
	68994.628	to	70175.109	Earthen Road				
	70175.109	to	70183.944	8.835	Chhara	Chhara		
	70183.944	to	72235.415	Earthen Road				
	72235.415	to	72270.324	34.909	Chhara	Chhara		
	72270.324	to	77081.639	Earthen Road				
	77081.639	to	77089.830	8.191	2.870	Existing Bridge	LGED	UZR-484292005
	77089.830	to	77231.353	Earthen Road				UZR-484292005
	77231.353	to	77318.040	86.687	6.117	Existing Bridge	LGED	UZR-484292005

Location	Chainage(m)			Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
	Ch-Start	To	CH-End					
	77318.040	to	77940.857	Earthen Road				UZR-484292005
	77940.857	to	77947.520	6.663	6.235	Existing Bridge	LGED	UZR-484292005
	77947.520	to	78536.433	Earthen Road				UZR-484292005
Juraichhari to Barkal	78536.433	to	78779.785	243.351	Chhara/Missing	Missing Link		UZR-484472003
	78779.785	to	78884.999	Earthen Road				UZR-484472003
	78884.999	to	78896.643	11.644	4.384	Existing Bridge	LGED	UZR-484472003
	78896.643	to	78996.006	Earthen Road				UZR-484472003
	78996.006	to	79002.077	6.071	4.333	Existing Bridge	LGED	UZR-484472003
	79002.077	to	79292.012	Earthen Road				UZR-484472003
	79292.012	to	79362.111	70.099	1.274	Existing Bridge	LGED	UZR-484472003
	79362.111	to	80103.883	Earthen Road				UZR-484472003
	80103.883	to	80131.556	27.673	Chhara	Missing Link		UZR-484472003
	80131.556	to	83331.256	Earthen Road				UZR-484472003
	83331.256	to	83344.094	12.838	Chhara	Missing Link		
	83344.094	to	84588.964	Earthen Road				UZR-484472003
	84588.964	to	84599.817	10.853	Chhara	Missing Link		
	84599.817	to	85156.797	Earthen Road				UZR-484472003
	85156.797	to	85384.711	227.914	River	River		
Barkal to Chotoharina	85384.711	to	85414.863	30.152	Missing	Missing Link		
	85414.863	to	86918.927	Earthen Road				UPZ-484212001
	86918.927	to	86936.825	17.898	Chhara	Missing Link		
	86936.825	to	88126.540	Earthen Road				UPZ-484212001
	88126.540	to	88292.492	165.952	River	River		
	88292.492	to	91720.015	3427.523	Marshy Land/Chhara	Missing Link		
	91720.015	to	94291.406	Earthen Road				
	94291.406	to	95011.949					UPZ-484212001
	95011.949	to	95055.799	43.850	2.059	Existing Bridge	LGED	UPZ-484212001
	95055.799	to	95522.651	HBB Road			LGED	UPZ-484212001
	95522.651	to	95561.773	39.122	2.441	Existing Bridge	LGED	UPZ-484212001
	95561.773	to	95973.167	Earthen Road				UPZ-484212001

Location	Chainage(m)			Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
	Ch-Start	To	CH-End					
	95973.167	to	95996.472	23.305	2.469	Existing Bridge	LGED	UPZ-484212001
	95996.472	to	97334.003	Earthen Road				UPZ-484212001
	97334.003	to	97461.519	127.516	River	River		
	97461.519	to	97570.930	109.411	Missing	Missing Link		
	97570.930	to	100182.114	Earthen Road				UPZ-484212001
	100182.114	to	100193.891	11.778	4.364	Existing Bridge	LGED	UPZ-484212001
	100193.891	to	100944.814	Earthen Road				UPZ-484212001
	100944.814	to	100951.599	6.784	4.295	Existing Bridge	LGED	UPZ-484212001
	100951.599	to	101725.574	Earthen Road				UPZ-484212001
	101725.574	to	101755.251	29.676	4.370	Existing Bridge	LGED	UPZ-484212001
	101755.251	to	103338.302	Earthen Road				UPZ-484212001
	103338.302	to	103361.763	23.461	4.273	Existing Bridge	LGED	UPZ-484212001
	103361.763	to	103481.112	Earthen Road				UPZ-484212001
	103481.112	to	103489.055	7.943	4.272	Existing Bridge	LGED	UPZ-484212001
	103489.055	to	103709.674	Earthen Road				UPZ-484212001
	103709.674	to	103736.249	26.575	3.096	Existing Bridge	LGED	UPZ-484212001
	103736.249	to	103960.805	Earthen Road				UPZ-484212001
	103960.805	to	103987.271	26.466	3.109	Existing Bridge	LGED	UPZ-484212001
	103987.271	to	104069.610	Earthen Road				UPZ-484212001
	104069.610	to	104081.493	11.883	4.298	Existing Bridge	LGED	UPZ-484212001
	104081.493	to	104845.704	Earthen Road				UPZ-484212001
	104845.704	to	104855.780	10.076	4.295	Existing Bridge	LGED	UPZ-484212001
	104855.780	to	105377.157	Earthen Road				UPZ-484212001
	105377.157	to	105408.733	31.575	1.601	Existing Bridge	LGED	UPZ-484212001
	105408.733	to	106305.600	Earthen Road				UPZ-484212001
	106305.600	to	106321.598	15.998	4.331	Existing Bridge	LGED	UPZ-484212001
	106321.598	to	106463.144	Earthen Road				UPZ-484212001
	106463.144	to	106495.148	32.003	Missing	Missing Link		
	106495.148	to	106661.551	166.404	158.830	River		

Location	Chainage(m)			Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
	Ch-Start	To	CH-End					
Chotoharina to Thegamukh	106661.551	to	106832.850	Earthen Road				UNR-484213004
	106832.850	to	106894.025	61.175	1.563	Existing Bridge		UNR-484213005
	106894.025	to	108226.548	Earthen Road				UNR-484213006
	108226.548	to	108227.673	1.125	Chhara	Missing Link		
	108227.673	to	113130.745	Earthen Road				UNR-484213004
	113130.745	to	113160.170	29.425	Chhara	Missing Link		
	113160.170	to	114148.386	Earthen Road				UNR-484213004
	114148.386	to	114166.531	18.145	1.854	Existing Bridge	LGED	UNR-484213004
	114166.531	to	114304.224	Earthen Road			LGED	UNR-484213004
	114304.224	to	114438.415	HBB Road			LGED	UNR-484213004
	114438.415	to	114750.772	Earthen Road			LGED	UNR-484213004

Table: 2.4 B indicating cross draianage structure (Multimodal Route)

From Chittagong to Rangamati

Location	ID	Name	Chainage (km)	Length (m)	Carriageway /Witdh (m)	Condition	Type	Bridge Nsme
Chittagong port to Oxygen More	1	Bridge	2.000	320.000	16.000	Good	Bridge	Dewan hat Bridge
	2	Bridge	6.600	7.200	25.400	Good	Box Culvert	Nasirabad Bridge
	3	Bridge	7.252	7.200	29.400	Good	Box Culvert	
	4	Bridge	7.609	4.400	23.000	Good	Box Culvert	
	5	Bridge	8.402	4.400	23.000	Good	Box Culvert	
	6	Bridge	8.690	4.400	23.000	Good	Box Culvert	
	7	Bridge	9.267	4.400	23.000	Good	Box Culvert	
	8	Bridge	14.816	4.400	23.000	Good	Box Culvert	
	9	Bridge	15.368	17.100	20.000	Good	Bridge	
Oxygen More to Hathazari	10	Bridge	0.480	3.700	17.50	Under Conostraction	Box Culvert	Chadni Hall Culvert
	11	Bridge	0.648	2.300	7.00	Under Conostraction	Box Culvert	
	12	Bridge	0.822	16.900	3.60	Good	Box Culvert	
	13	Bridge	1.280	3.600	16.40	Good	Box Culvert	
	14	Bridge	2.156	13.300	11.00	Under Conostraction	Box Culvert	
	15	Bridge	2.532	18.700	7.30	Good	Bridge	Notun Para Bridge
	16	Bridge	3.317	4.500	17.00	Under Conostraction	Box Culvert	
	17	Bridge	3.552	6.200	10.20	Good	Box Culvert	
	18	Bridge	4.292	6.700	15.00	Under Conostraction	Box Culvert	
	19	Bridge	4.948	3.700	15.80	Under	Box Culvert	

Location	ID	Name	Chainage (km)	Length (m)	Carriageway /Witdh (m)	Condition	Type	Bridge Nsme
						Conostraction		
	20	Bridge	5.107	7.000	25.50	Under Conostraction	Box Culvert	
	21	Bridge	5.834	6.800	25.50	Good	Box Culvert	
	22	Bridge	6.642	9.200	17.80	Good	Box Culvert	
	23	Bridge	6.882	8.900	13.00	Under Conostraction	Box Culvert	
	24	Bridge	7.096	10.200	18.30	Good	Box Culvert	
	25	Bridge	7.294	6.800	14.70	Good	Box Culvert	
	26	Bridge	7.882	3.000	17.80	Good	Box Culvert	
	27	Bridge	8.271	10.100	16.10	Good	Box Culvert	
	28	Bridge	8.572	10.500	14.60	Good	Box Culvert	
	29	Bridge	8.880	13.700	10.00	Good	Bridge	
	30	Bridge	9.756	6.800	18.00	Good	Box Culvert	
	31	Bridge	11.239	5.400	17.50	Under Conostraction	Box Culvert	
	32	Bridge	11.918	13.100	18.00	Under Conostraction	Bridge	
	33	Bridge	13.552	10.100	7.30	Under Conostraction	Box Culvert	
	34	Bridge	14.082	10.100	7.30	Good	Box Culvert	
	35	Bridge	14.564	63.000	9.80	Good	Bridge	Sobeda Pukur Bridge
	36	Bridge	15.263	48.000	10.40	Good	Bridge	
	37	Bridge	16.191	11.200	12.00	Good	Box Culvert	
Hathazari To Ghagra	38	Bridge	16.872	103.000	9.80	Good	Bridge	
	39	Bridge	17.253	3.500	9.50	Good	Box Culvert	
	40	Bridge	17.956	26.200	11.10	Under construction	Bridge	
	41	Bridge	18.622	12.900	9.20	Good	Box Culvert	
	42	Bridge	18.921	3.600	11.60	Good	Box Culvert	
	43	Bridge	19.150	3.200	7.00	Good	Box Culvert	
	44	Bridge	19.723	3.500	6.90	Good	Box Culvert	
	45	Bridge	20.212	37.400	9.00	Good	Bridge	
	46	Bridge	20.850	26.200	11.50	Under construction	Bridge	
	47	Bridge	22.129	26.200	11.60	Under construction	Bridge	
	48	Bridge	22.367	3.800	11.30	Good	Box Culvert	
	49	Bridge	22.608	3.400	11.60	Good	Box Culvert	
	50	Bridge	22.981	18.200	7.00	Good	Bridge	
	51	Bridge	23.142	10.000	9.20	Good	Bailey Bridge	
	52	Bridge	23.425	26.200	11.60	Under construction	Bridge	
	53	Bridge	23.810	2.900	6.60	Good	Box Culvert	
	54	Bridge	24.100	13.000	10.50	Good	Box Culvert	
	55	Bridge	24.867	6.700	11.80	Good	Box Culvert	
	56	Bridge	25.151	10.000	9.10	Good	Box Culvert	
	57	Bridge	25.736	6.700	9.30	Good	Box Culvert	

Location	ID	Name	Chainage (km)	Length (m)	Carriageway /Witdh (m)	Condition	Type	Bridge Nsme
	58	Bridge	26.112	1.400	8.50	Good	Box Culvert	
	59	Bridge	26.255	2.500	9.00	Good	Box Culvert	
	60	Bridge	29.154	15.300	7.30	Good	Bridge	Rawzan Khal Bridge
	61	Bridge	29.217	2.100	8.60	Good	Box Culvert	
	62	Bridge	30.247	3.500	11.80	Good	Box Culvert	
	63	Bridge	30.817	19.100	7.40	Good	Bridge	Godar Pahar Bridge
	64	Bridge	31.247	13.800	8.60	Good	Box Culvert	
	65	Bridge	31.347	1.400	10.40	Good	Box Culvert	
	66	Bridge	31.495	7.400	10.50	Good	Box Culvert	
	67	Bridge	31.596	5.200	9.50	Good	Box Culvert	
	68	Bridge	31.680	3.800	12.10	Good	Box Culvert	
	69	Bridge	31.861	10.100	11.80	Good	Box Culvert	
	70	Bridge	32.113	2.800	9.60	Good	Box Culvert	
	71	Bridge	32.354	1.700	9.30	Good	Box Culvert	
	72	Bridge	32.517	6.300	10.50	Good	Box Culvert	
	73	Bridge	32.672	3.100	7.08	Good	Box Culvert	
	74	Bridge	32.887	6.400	10.50	Good	Box Culvert	
	75	Bridge	32.999	8.600	8.80	Good	Box Culvert	
	76	Bridge	33.161	4.600	11.70	Good	Box Culvert	
	77	Bridge	33.480	2.800	9.20	Good	Box Culvert	
	78	Bridge	33.624	3.500	9.40	Good	Box Culvert	
	79	Bridge	33.738	3.600	9.10	Good	Box Culvert	
	80	Bridge	34.087	1.500	10.50	Good	Box Culvert	
	81	Bridge	34.220	3.600	12.00	Good	Box Culvert	
	82	Bridge	34.410	7.200	9.60	Good	Box Culvert	
	83	Bridge	34.440	1.600	10.40	Good	Box Culvert	
	84	Bridge	34.936	13.100	9.00	Good	Box Culvert	
	85	Bridge	35.020	5.100	9.60	Good	Box Culvert	
	86	Bridge	35.917	1.800	8.80	Good	Box Culvert	
	87	Bridge	36.024	2.000	11.70	Good	Box Culvert	
	88	Bridge	36.594	3.500	9.30	Good	Box Culvert	
	89	Bridge	36.827	9.100	9.40	Good	Box Culvert	
	90	Bridge	37.318	26.200	7.80	Good	Bridge	
	91	Bridge	37.459	3.700	12.10	Good	Box Culvert	
	92	Bridge	37.704	6.000	9.20	Good	Box Culvert	
	93	Bridge	38.086	1.900	11.70	Good	Box Culvert	
	94	Bridge	39.137	2.300	9.30	Good	Box Culvert	
	95	Bridge	39.639	5.200	12.10	Good	Box Culvert	
	96	Bridge	40.040	3.600	9.30	Good	Box Culvert	
	97	Bridge	40.892	130.000	7.50	Good	Bridge	Ranir Hat Bridge
	98	Bridge	41.364	6.600	12.50	Good	Box Culvert	
	99	Bridge	41.609	1.300	8.60	Good	Box Culvert	

Location	ID	Name	Chainage (km)	Length (m)	Carriageway /Witdh (m)	Condition	Type	Bridge Nsme
	100	Bridge	42.186	3.700	10.00	Good	Box Culvert	
	101	Bridge	42.349	10.000	12.00	Good	Box Culvert	
	102	Bridge	43.186	3.600	12.10	Good	Box Culvert	
	103	Bridge	44.000	11.400	11.90	Good	Box Culvert	
	104	Bridge	45.260	14.900	7.00	Good	Bailey Bridge	Moghachhary Bailey Bridge
	105	Bridge	45.735	3.100	11.90	Good	Box Culvert	
	106	Bridge	46.170	3.700	11.90	Good	Box Culvert	
	107	Bridge	46.422	1.700	13.00	Good	Box Culvert	
	108	Bridge	49.001	1.400	8.30	Good	Box Culvert	
	109	Bridge	49.617	6.800	12.00	Good	Box Culvert	
Ghagra To Rangamati	110	Bridge	49.720	5.200	10.30	Good	Box Culvert	
	111	Bridge	49.966	2.400	15.00	Good	Box Culvert	
	112	Bridge	50.365	3.000	9.10	Good	Box Culvert	
	113	Bridge	50.608	1.200	8.80	Good	Box Culvert	
	114	Bridge	50.910	4.400	8.90	Good	Box Culvert	
	115	Bridge	50.970	3.200	11.60	Good	Box Culvert	
	116	Bridge	51.118	3.800	8.60	Good	Box Culvert	
	117	Bridge	51.289	4.400	8.90	Good	Box Culvert	
	118	Bridge	51.780	4.400	8.70	Good	Box Culvert	
	119	Bridge	51.940	4.400	9.50	Good	Box Culvert	
	120	Bridge	52.145	4.000	11.70	Good	Box Culvert	
	121	Bridge	52.272	3.600	9.90	Good	Box Culvert	
	122	Bridge	52.361	9.800	9.50	Good	Box Culvert	
	123	Bridge	52.630	4.400	10.30	Good	Box Culvert	
	124	Bridge	53.511	1.400	9.10	Good	Box Culvert	
	125	Bridge	53.700	1.400	9.10	Good	Box Culvert	
	126	Bridge	54.410	4.600	9.10	Good	Box Culvert	
	127	Bridge	54.787	4.600	9.30	Good	Box Culvert	
	128	Bridge	57.142	75.800	8.60	Good	Bridge	Manikchhari Bridge

From Chotohorina to Thegamukh

Route ID	Location	Chainage (m)				Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
		CH-Start		TO	CH-End					
Multimodal Route Road Part	Chotoharin to Thegamukh	CH	0.000	to	171.298	171.298				UNR-484213004
		CH	171.298	to	232.473	61.175	1.563	Existing Bridge	LGED	UNR-484213005
		CH	232.473	to	1564.891	1332.417				UNR-484213006
		CH	1564.891	to	1566.015	1.125	Chhara	Missing Link		
		CH	1566.015	to	6469.088	4903.072				UNR-484213004

Route ID	Location	Chainage (m)				Length (m)	Road/Bridge Width (m)	Existing Feature Types	Ownership	LGED Road Code No
		CH-Start		TO	CH-End					
		CH	6469.088	to	6498.513	29.425	Chhara	Missing Link		
		CH	6498.513	to	7486.729	988.216				UNR-484213004
		CH	7486.729	to	7504.873	18.145	1.854	Existing Bridge	LGED	UNR-484213004
		CH	7504.873	to	7642.566	137.693				UNR-484213004
		CH	7642.566	to	7776.758	134.192				UNR-484213004
		CH	7776.758	to	8089.114	312.356				UNR-484213004

2.5 Details of Existing Roads Connecting Chittagong Port for Road and Multimodal Routes

Connectivity of Chittagong to Rajosthali: Rajosthali - Bilaichhari - Juraichhari - Barkal - Thegamukh, about 114.751 km)

For traffic movement from Chittagong Port to Rajosthali there are three existing Route Options as shown in **Figure no.2.5** such as

a) Chittagong Port–Mohora–Chondraghona–Banglahalia–Rajosthali (Total length 75.302 km.),
b) Chittagong Port–Kalurghat–Boalkhali–8 km. missing link–Banlahalia–Rajosthali (Total length 79.321 km.),
c) Chittagong Port–Kalurghat–Fultol- 8 km. missing link–Banglahalia–Rajosthali (71.328 km.)

During investigation it is found in the **Route Option "a"** that existing road width on an average is 5.3 m after the City area portion which needs widening as required for double lane road. In Chandraghona area a big Bridge about 315 m long is required. Total length of road up to Rajosthali is 75.302 km.

In the **Route Option"b"**existing road width is 3.78 m only and total length of the road up to Rajosthali is 79.321 km where about 8 km. missing link is there. Also in one place at least 40 m long Bridge is required. Moreover, existing single lane 614 m Kalurghat Bridge has to be replaced by double Lane Bridge of same length. A long portion of this road is going beside the river which becomes very vulnerable during flood season. About 7/8 km. existing road is going through hilly area.

In the **Route option "c"** existing road width is 4.4 m only which needs to be widen. There is about 8 km. missing link where hilly area is existing. Total length of this road is 71.328 km.
Based on all the investigations, data analysis, and experts' discussion/decision it is opinioned that Route Option "a" i.e., Chittagong Port –Mohora-Chondraghona-Bagalhali-Rajostholi Route is more feasible to take into consideration under this project having length of 75.302 Km.

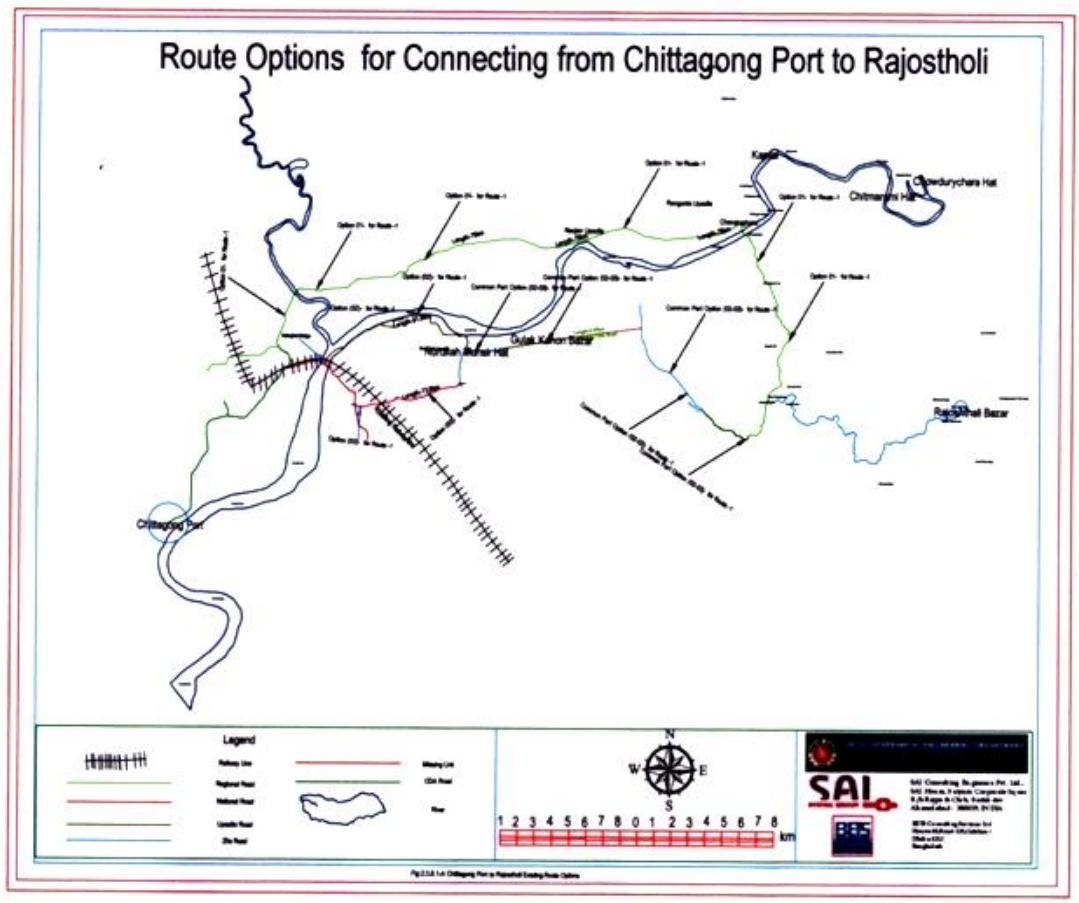


Fig 2.5: Connectivity of Chittagong to Rajosthali

Multi–Modal Route

Connectivity of Chittagong to Rangamati (Route No 1) :

Rangarnati-Chhotoharina connected by waterway (63 Km) andThegamukh by road (about 8.089 km) Total: 71.089Km

There is only one existing route from Chittagong Port to Rangamati via Oxygen more. The total length of existing road is 72.51 Km with 21 bridges and 107 culverts. The existing road is of BC with an average width of 7.1 m. Thus no major improvements are required on this road.

Table 2.5Agives details of existing routes from Chttagong Port to Rajasthali / Rangamati and **Table 2.5B** gives lengths of proposed route from Chittagong Port.

Table No 2.5A: Details of Existing Roads from Chittagong Port to Origins of Proposed routes

Sl. No	Details of Existing road	Length (Km)	Average carriageway (m)	Pavement type	Widening required (Sq. m.)	Total no of existing bridges	Existing bridge length (m)	Existing Culvert Length in m (Nos)	No of Sharp Turns	Improvement
Road Routes										
1	Chittagong Port - Mohora-Chondraghona-Banglahalia-Rajosthali	75.302	4.34 to 6.20	BC Road	116794.38	15	923.70	213 (49)	83	About 315 m bridge is required on the Karnafuly river at Chandraghona ferry ghat, 21.5,18.4,25,61.6 m baily bridge will replace by RCC/PC girder bridge
Multi-Modal Routes										
1	Chittagong Port - Oxygen More - Rangamati	72.51	6.80 to7.45	BC Road	18669.5	21	1048.3	575.9 (107)	48	16.9 m ,2.9m box culvert will be replace by RCc bridge & 15m baily bridge will replace by RCC bridge

Table 2.5B: Lengths of Proposed Routes from Chittagong Port

Sl. No.	Road No.	Name of the Route	From Chittagong to Starting Point*	From Starting Point to Thegamukh#	Distance (Km)
All Road Routes					
1	R -1	Rajosthali-Bilaichhari-Jurichhari-Thegamukh	Chittagong-Rajosthali (75.302 Km)	Rajosthali-Bilaichhari-Jurichhari-Thegamukh (114.751 Km)	190.053
Multi-Modal (i.e. IWT and Road) Routes					
1	M -1	Rangamati- Chhotohorniaby waterway and then by road up to Thegamukh	Chittagong -Rangamati (72.51 Km)	Rangamati- Chhotohornia by waterway and then by road up to Thegamukh (71.089Km)	143.599

Note: ** The roads from Chittagong to the starting point are all-weather bitumen surfaced roads and are under Roads and Highway Department (RHD), Government of Bangladesh. From the starting point to Thegamukh, there are only tracks and are under Local Government Engineering Department (LGED), Government of Bangladesh*

In case of all the proposed routes, the road sections from Chittagong up to the starting point of the new route are all-weather bitumen top roads and are under the jurisdiction of the Roads and Highway Department (RHD) of the Government of Bangladesh (GoB). Whereas the proposed routes from the starting point up to Thegamukh are walking tracks and are under the Local Government Engineering Department (LGED) of GoB.

2.6 Details of existing waterway:

Multimodal Route 1: Rangamati - Chotoharina by waterway (63 km) and Thegamukh by road (8.089 km), (Proposed total length: 71.089 Km)

This route enroutes to Chotohorina via Shobolong, Barkal, Bhusionchar. It is about 63km. Chotohorina to Thegamukh is 8.089 km by road. Rangamati to Barkal 37.5 km is navigable round the year for small launches and boats. For larger cargo vessels navigable depth will need to be increased by dredging. Barkal to Chotohorina is navigable during monsoon for 3-4 months. This part of the waterway (25.5 km) will need massive dredging to increase navigable depth. **Chhotoharina–Thegamukh (8.089Km)** portion 134.19 m paved road by Herring Bon Bond (HBB) with 1.5 m width is seen and other parts are earthen road. 2 nos. Bridges/Culverts are existed & 2 Bridges/Culverts are required.

2.6.1 Available draft for movement of vessels:

Multimodal Route 1: Rangamati - Chotoharina by waterway (63 km) and Thegamukh by road (8.089 km), (Proposed total length: 71.089 Km)

Rangamati to Barkal 37.5 km is navigable round the year for small launches and boats. For larger cargo vessels navigable depth will need to be increased by dredging. Barkal to Chotohorina 25.5 km is navigable during monsoon for 3-4 months. This part of the waterway (25.5 km) will need massive dredging to increase navigable depth.

CHAPTER - 3

Traffic Analysis and Forecasts for Road and Multimodal Route

CHAPTER - 3

Traffic Analysis and Forecasts for Road and Multimodal Route

3.1 Preliminary Traffic Assessment (Base Year) for Different Proposed Routes

3.1.1 Background

This section briefly set out the methodology adopted and data used for assessing base year traffic levels on each of the two identified routes – one all road route and the other multi-modal (i.e. water way and road combination) route. The two routes have been identified on the basis of multi-criteria analysis which takes into account various aspects like: i) technical and engineering feasibility, ii) adverse environmental impact, iii) social impact, iv) poverty alleviation, v) present inaccessibility to reach the road head, vi) travel time savings with the new road, vii) less improvement required to the existing road up to Chittagong, viii) less travel time between Chittagong and Thegamukh, ix) population served per Km of connectivity within zone of influence, x) length of road constructed per US$ 1 million and xi) People's Perception for the project.

Details of the two identified routes are presented in **Table 3.1.1.**

Table 3.1.1: Details of Proposed Routes from Chittagong

S. #	Road No.	Name of the Route	From Chittagong to Starting Point*	From Starting Point to Thegamukh#	Distance (Km)
All Road Route					
1	R -1	Rajosthali-Bilaichhari-Jurichhari-Thegamukh	Chittagong-Rajosthali (75.302 Km)	Rajosthali-Bilaichhari-Jurichhari-Thegamukh (109.675 Km)	184.977
Multi-Modal (i.e. IWT and Road) Route					
2	M -1	Rangamati- Chhotohornia by waterway and then by road up to Thegamukh	Chittagong – Rangamati (72.51Km)	Rangamati- Chhotohornia by waterway and then by road up to Thegamukh (70.370 Km)	142.880

***Note**: * The roads from Chittagong to the starting point are all-weather bitumen surfaced roads and are under Roads and Highway Department (RHD), Government of Bangladesh. #From the starting point to Thegamukh, there are only tracks and are under Local Government Engineering Department (LGED), Government of Bangladesh*

In case of both the identified routes, the road sections from Chittagong up to the starting point of the new route are all-weather bitumen top roads and are under the jurisdiction of the Roads and Highway Department (RHD) of the Government of Bangladesh (GOB). Whereas the proposed routes from the starting point up to Thegamukh are walking tracks and are under the Local Government Engineering Department (LGED) of GOB.

While for RHD road sections traffic data i.e. Annual Average Daily Traffic (AADT) are collected by RHD through volume count surveys, no such data are available for LGED sections as these are tracks and no vehicle traffic moves on them. Given this situation, it is not possible to collect AADT for a base year through conduct of traffic volume counts. In view of this, the consultants have attempted to make a broad estimate of AADT for the base year on these LGED sections assuming

continuation of the "***existing RHD road sections into the new sections from the starting point up to Thegamukh***". Before going into details of this approach, it is important to have a brief appreciation of the economic base of the influence zone of the new routes i.e. Rangamati District.

3.1.2 Economic Base of Rangamati District

Situated in the South-eastern side of Bangladesh, Rangamati district is the largest district (in terms of area – 6,116 sq. km of which 2,234 sq. km i.e. about 36.5% is under forest) of the country. Upazilla-wise population, total area and forest area for Rangamati district are presented in the **Table 3.1.2.**

Table 3.1.2 Upazilla-wise Population, Total Area and Forest Area – Rangamati Zilla

S.#	Upazilla	Population (Census 2011)	Total Area (Sq. Km)	Forest Area (Sq.km)	Population Density/Sq.km
1	Baghaichhari	96,899	1931.26	137.39	50
2	Barkal	47,523	760.88	64.65	62
3	Belaichhari	28,525	746.00	669.76	38
4	Juraichhari	27,786	606.05	407.52	46
5	Kaptai	59,693	259.00	120.62	230
6	Kwakhali	59,578	339.29	165.97	176
7	Langudu	81,548	388.50	173.78	210
8	Naniarchar	43,616	393.68	174.95	111
9	Rangamati Sadar	124,728	546.49	210.32	228
10	Rajosthali	26,083	145.04	108.88	180
Total		**595,979**	**6116.19**	**2233.84**	**97**

Total population of Rangamati district, as per census 2011, was 595,979 with an inter-census growth rate of 1.66 % per year. As expected, population density is higher in areas which are connected with all-weather bitumen roads i.e. Rangamati Sadar (220), Kaptai (230), Langadu (210), etc., whereas the density is very low in areas not connected by road i.e. Belaichhari (38), Juraichhari (46), Baghaichhari (50), etc.

Agriculture is the mainstay of Rangamati economy. Out of total 108,263 holdings of the district, 74.10% holdings are farms that produce varieties of crops namely local and HYV rice, wheat, vegetable, cash crops and others. Jackfruits and pineapples are abundantly grown in the district. The other important fruits are banana, guava, olive, papaya etc. Fish of special varieties ruhi, katal & chital abound in this district. All these varieties of fish are caught from lake. Besides crops, livestock, forestry and fishery are the main sources of household income. The district is very rich in forest resources.

The level of non-farming activities in the district is rather low. Main industrial activity in the district is rice milling (403 units) and textiles (17 units with 160 looms).

In spite of abundant agriculture and forest potential, the production levels are mostly subsistence due to the lack of market traceable mostly to the absence of proper connectivity. A part from some upazillas like Barkal which can be reached by IWT, the only means of connectivity in most of the study area (i.e. upazillas through which the proposed route alignments pass through) are "***walking tracks***". With availability of proper connectivity, there is great potential for surplus agriculture and horticultural production and establishment of agro-based industries. In this context it may be

pertinent to mention that most of the industrial and other economic activities in the district are concentrated in upazillas like Rangamati Sadar, Langadu, Kaptai, etc. which are connected by RHD roads.

3.1.3 Base Year Traffic Assessment

3.1.3.1 Road Traffic – Secondary Data

As mentioned earlier, no vehicular traffic is moving in the project area as the only means of connectivity in this area is ***walking tracks.*** As such traffic count data on the contiguous RHD road section were collected from RHD website. The AADT details collected from RHD website are presented in **Table 3.1.3.1**

Table 3.1.3.1: AADT (2013) on RHD Road Sections Contiguous to Study Area

Location	Details	Heavy Truck	Medium Truck	Small Truck	Large Bus	Medium Bus	Micro Bus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total - Motor Vehicles
Rajosthali	AADT	0	18	38	0	24	11	11	0	367	563	1032
	%Share	0%	2%	4%	0%	2%	1%	1%	0%	36%	55%	100%
Ghagra	AADT	0	137	122	73	22	99	38	75	692	521	1779
	%Share	0%	8%	7%	4%	1%	6%	2%	4%	39%	29%	100%
Chandraghona	AADT	1	238	224	146	97	203	52	164	4453	838	6416
	%Share	0%	4%	3%	2%	2%	3%	1%	3%	69%	13%	100%
Chittagong	AADT	0	776	362	197	220	281	217	296	5481	1078	8908
	%Share	0%	9%	4%	2%	2%	3%	2%	3%	62%	12%	100%
Munishihat	AADT	0	342	189	185	120	184	418	103	520	372	2433
	%Share	0%	14%	8%	8%	5%	8%	17%	4%	21%	15%	100%

***Source**: Latest RHD webs*

3.1.3.2 Traffic Surveys

Since the latest data available on RHD website relate to the year 2013, the Consultants identified the following three road side locations and conducted the traffic count and O-D survey as per details given in **Table 3.1.3.2 A**

Table 3.1.3.2 A: Location, Type, Date and Duration of Traffic Surveys

S.#	Location	Type of Survey	Date of Survey	Duration of Survey
1	Bangalhalia : Rajosthali Road	Traffic Count	19-12-2015 and 20-12-2015	16 hours (6 AM to 10 PM)
		O-D Survey	20-12-2015	24 hours (starting 6 AM)
2	Ghagra: Rangamati Road	Traffic Count	21-12-2015 and 22-12-2015	16 hours (6 AM to 10 PM)
		O-D Survey	21-12-2015	24 hours (starting 6 AM)
3	Rangunia: Chandraghona – Chittagong Road	Traffic Count	19-12-2015 and 20-12-2015	16 hours (6 AM to 10 PM)
		O-D Survey	19-12-2015	24 hours (starting 6 AM)

The locations were identified and surveys conducted as per the procedure outlined in **Manual Classified Traffic Counts – Instruction Guide, RHD, 2001.** The results of the two-day traffic count survey in terms of ADT (Average Daily Traffic) are presented in **Table 3.1.3.2**

Table 3.1.3.2 B: ADT - Based on Two-day Traffic Count

Location	Details	Heavy Truck	Medium Truck	Small Truck	Large Bus	Medium Bus	Micro Bus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total - Motor Vehicles
Rajosthali	ADT	0	64	61	0	32	37	20	35	595	550	1462
	%age	0%	4%	4%	0%	2%	3%	1%	2%	41%	38%	100%
Ghagra	ADT	69	200	180	136	140	266	54	153	635	464	2394
	%age	3%	8%	7%	6%	6%	11%	2%	6%	27%	19%	100%
Chandraghona	ADT	7	124	179	73	132	173	51	136	3004	662	4761
	%age	0%	3%	4%	2%	3%	4%	1%	3%	63%	14%	100%

***Source**: Traffic Count Survey by Consultants*

Since the traffic counts are done for 16 hrs in a particular month/season, these do not represent daily average on the one hand and the annual average traffic flow pattern i.e. Annual Average Daily Traffic (AADT) on the other. To address these two aspects, RHD have, based on their earlier surveys, developed traffic coefficient/expansion factors for converting 16 hr based traffic counts carried out in any particular month of a year into AADT. The expansion factors and monthly adjustment factors developed by RHD are as under:

Traffic AADT Expansion Factors

SL No	Vehicle Category	Type of Road		
		National	Regional	Zilla
1	Motorized	1.15	1.15	1.12
2	Non Motorized	1.06	1.06	1.06

***Source**: RHD, Bangladesh*

Traffic AADT Monthly Adjustment Factors

Month	Trucks	Other
January	0.92	1.00
February	0.90	0.98
March	0.90	0.98
April	0.97	1.01
May	0.97	0.96
June	0.99	0.95
July	1.04	0.96
August	1.10	0.99
September	1.17	1.04
October	1.16	1.07
November	1.03	1.04
December	0.95	1.02

***Source**: RHD, Bangladesh*

Applying these expansion/adjustment factors to the ADT figures given in **Table 3.1.3.2 B**, annual average daily traffic (AADT) figures at the three survey locations have been worked out. The same are presented in **Table 3.1.3.2 C**

Table 3.1.3.2 C: AADT - At Survey Locations - 2015

Location	Year	Heavy Truck	Medium Truck	Small Truck	Large Bus	Medium Bus	Micro Bus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total - Motor Vehicles
Rajosthali	AADT	0	68	65	0	38	43	23	40	697	645	1,619
	%share	0%	4%	4%	0%	2%	3%	1%	2%	43%	40%	100%
Ghagra	AADT	75	219	196	159	164	312	63	179	744	544	2,655
	%share	3%	8%	7%	6%	6%	12%	2%	7%	28%	20%	100%
Chandraghona	AADT	7	135	196	86	155	202	59	160	3,523	777	5,299
	%share	0%	3%	4%	2%	3%	4%	1%	3%	66%	15%	100%

***Source**: Consultants' Two-day Traffic Count Survey.*
***Note**: The %shares may not add up to 100 due to rounding-off.*

As can be seen from the figures set out in **Table 3.1.3.2 C**, the AADT level is the lowest at Rajosthali (1,619), followed by Ghagra (2,655) and Chandraghona (5,299). These levels are as expected because Rajosthli is on a zilla road, and Ghagra and Chandragona are on regional roads. Further, Chadraghona is a junction from where traffic flows in the directions of Ghagra as well as Rajosthali. As to the vehicle composition, irrespective of the locations auto-rickshaws and motor cycles accounted for the maximum share i.e. 83% at Rajosthali, 81% at Chandraghona and 48% at Ghagra. These higher shares are in line with the ground reality as these two modes are the major carriers for local and short distance passenger trips.

In order to validate the survey AADT data, a comparison is made with the available RHD traffic data (AADT). Since RHD data relate to the year 2013, the same has been updated using appropriate growth rate and compared with survey AADT. **Table 3.1.3.2** Dpresents a comparative statement of survey AADT and RHD AADT. The following comparisons have been done:

1) Comparing RHD AADT 2013 with Consultants' (SAI) AADT 2015
2) Comparing updated RHD AADT (2015) with Consultants' (SAI) AADT 2015

Under the first comparison, annual compound growth rate (ACGR) of AADT works out to 25% at Rajosthali and 22% at Ghagra. These two appear to be very high as compared to 10% ACGR normally adopted by RHD on national roads and 7% AGCR on regional and zilla roads. Since Consultants' AADT have been arrived at after adjusting for seasonality, the high growth rates do not find any reasonable explanation in terms of seasonal traffic relating to tourism, construction, etc. Further, AADT at Chadraghona as revealed from Consultants' survey registered a high negative growth (i.e. -9.12%) as compared to RHD AADT.

Under the 2nd comparison, RHD data has been updated using 10% ACGR and then compared with Consultants' survey-based AADT. Even in this case, Consultants' AADT figures are much higher as compared to RHD data i.e. 30% higher at Rajosthali and 23% more at Ghagra. At Chadraghona, however, the Consultants' survey-based AADT is about 68% of the RHD data.

The foregoing analysis points to some unusual features during the Consultant's survey period that contributed to very high/low level of traffic. Since these levels could not be rationally explained, the Consultants felt it prudent to use the RHD AADT data (**Table 3.1.3.1**) for the present purpose asThese data are broad-based and validated.

Table 3.1.3.2 D: Comparison of RHD and Consultants' (SAI)Traffic Count

AADT	Details	Agency	Year	Heavy Truck	Medium Truck	Small Truck	Large Bus	Medium Bus	Micro Bus	Utility	Car	Auto-Rickshaw	Motor Cycle	Total - Motor Vehicles	Average Annual Growth@	SAI/RHD (2015 AADT)$
Rajosthali	AADT	RHD	2013	0	18	38	0	24	11	11	0	367	563	1,032		
	AADT	SAI	2015	0	68	65	0	38	43	23	40	697	645	1,619	25.26%	
	AADT	RHD*	2015	0	22	46	0	29	13	13	0	444	681	1,249		1.30
	%Share	SAI	2015	0%	4%	4%	0%	2%	3%	1%	2%	43%	40%	100%		
	%Share	RHD	2015	0%	2%	4%	0%	2%	1%	1%	0%	36%	55%	100%		
Ghagra	AADT	RHD	2013	0	137	122	73	22	99	38	75	692	521	1,779		
	AADT	SAI	2015	75	219	196	159	164	312	63	179	744	544	2,655	22.16%	
	AADT	RHD*	2015	0	166	148	88	27	120	46	91	837	630	2,153		1.23
	%Share	SAI	2015	3%	8%	7%	6%	6%	12%	2%	7%	28%	20%	100%		
	%Share	RHD	2015	0%	8%	7%	4%	1%	6%	2%	4%	39%	29%	100%		
Chandraghona	AADT	RHD	2013	1	238	224	146	97	203	52	164	4,453	838	6,416		
	AADT	SAI	2015	7	135	196	86	155	202	59	160	3,523	777	5,299	-9.12%	
	AADT	RHD*	2015	1	288	271	177	117	246	63	198	5,388	1,014	7,763		0.68
	%Share	SAI	2015	0%	3%	4%	2%	3%	4%	1%	3%	66%	15%	100%		
	%Share	RHD	2015	0%	4%	3%	2%	2%	3%	1%	3%	69%	13%	100%		

Note 1 : *Latest RHD website is the source for RHD AADT*
Note 2 : *To work out AADT, Traffic Count Data collected by SAI has been adjusted with the Expansion Factors obtained from RHD.*
Note 3* : *For RHD, an annual growth rate of 10% has been used to arrive at 2015 AADT.*
Note 4 : *@The growth rate is RHD 2013 AADT vs SAI 2015 AADT*
Note 5 : *$Ratio of SAI 2015 AADT and RHD 2015AADT*

3.1.3.2.1 ***Base Year AADT Estimates***

Though no vehicle movement is taking place in the study area, at present consumer durables and other commodities which are required to meet the demands of the population of the study area (i.e. influence zone of the proposed routes) are transported into the area in 2 or 3 stages as under:

- Truck movement on Bitumen top RHD road up to the ***starting point*** of new route
- From ***starting point*** to the next point by IWT where available and from there by head loads to different population settlements; or
- From ***starting point*** by head loads to different population settlements

Since there is no significant industrial activity in the study area, whatever movements are taking place from/to the study area are mainly to meet the requirements of the study area population. The situation is not much different for upazillas like Rangamati Sadar, Kaptai, etc. which are connected by RHD roads. ***In other words, the commodity and allied movements from/to these areas are mainly population related; implying thereby that higher level of population results in higher level of movement i.e. higher traffic.***

Given the above situation, the following assumptions have been made to assess base year traffic levels (AADT) on the new routes:

- RHD roads that are contiguous to the ***starting point*** will continue up to Thegamukh, and
- Traffic level (AADT) on each road is proportional to population in its influence zone.

It may be clarified here that traffic data (AADT) for the new routes are not available from secondary sources. Further, there is no use conducting volume counts on the new road alignment as no vehicle movements are observed on these routes. In this backdrop, an attempt is made here to make an AADT estimate under the above two assumptions.

To operationalize the base year traffic assessment methodology, the latest available AADT (i.e. for the year 2013) data have been collected from RHD for the 3 locations on RHD road sections that are contiguous to the new route. The AADT figures are presented in **Table 3.1.3.1**

The related population data has been gleaned from Bangladesh Bureau of Statistics (BBS) website. Using these two sets of data, AADT for 1000 population have been worked out. This statistic ranged between 8.09 and 39.57 with an average of 17.29. Applying this average of 17.29 to the population figures of the study area population, the corresponding AADT levels for base year (2013) have computed and presented in **Table 3.1.3.2.1**.

Table 3.1.3.2.1: Base Year (2013) Traffic Assessment
Rajosthali-Biliaichari-Jurichhari-Thegamukh (Rangamati Zilla)

Section of the Road	Owner of the Road	Location	Average Population	Traffic AADT (2013)
i. Rajosthali to Bilaichari	LGED	**Upozila**: Rajostholi, Bilaichari	27,304	472
ii Bilaichari to Jurichhari	LGED	**Upozila:** Bilaichari, Juraichhari	28,156	487
iii. Jurichhari to Thegamukh	LGED	**Upozila:** Juraichhari, Barkal	37,655	651

The above AADT, on an average, composed of 6% trucks (medium and small), 3% buses, 1% cars and utility, 36% auto-rickshaws and 54% motor cycles.
To sum up, the above AADT estimates are based on the following assumptions:

- RHD roads that are contiguous to the ***starting point*** will continue up to Thegamukh, and
- Traffic level (AADT) on each road is proportional to population in its influence zone.

3.1.3.3 IWT Traffic Estimates – Base Year

In the case of IWT traffic movements (goods as well as passenger) by inland water transport (IWT) between Rangamati and Chotoharina, all the services are run by private operators and no recorded data are available. During the Consultants discussions with senior officials of Rangamati Hill District Council (RHDC) and Secretary Launch Owners' Association, Rangamati, the following points emerged.

- Every day three launches operate each way between Rangamati and Chotohorina
- Each launch trip, on an average, carries 100 passengers
- On an average, these launches operate for 330 days/year
- Every day about 35 trucks, which carry fish, fruits, forest and agriculture product, etc that are collected from the study area (i.e. Rangamati – Barkal – Chotohorina – Thegamukh) by IWT, move out of Rangamati towards Chittagong and beyond.
- Similar number of trucks comes into Rangamati everyday and these goods are further transported by IWT for destinations in the study area.
- Each truck, on an average, carries 8 tonnes.
- On an average, each truck operates for 330 day/year

Based on the above information, base year (2015) traffic estimates have been worked for IWT and are presented in **Table 3.1.3.3.**

Table 3.1.3.3: Base Year (2015) IWT Traffic Estimate

O-D Pair	Traffic	Base Year 2015
Goods Traffic		
Rangamati-Chotohorina	Tonnes/day	280
	Tonnes/year	92,400
Chotohorina-Rangamati	Tonnes/day	280
	Tonnes/year	92,400
Total - Bothways	Tonnes/day	560
	Tonnes/year	184,800
Passenger Traffic		
Rangamati-Chotohorina	Passengers/day	600
	Passengers/year	198,00
Chotohorina-Rangamati	Passengers/day	600
	Passengers/year	198,00
Total – Both ways	Passengers/day	1,200
	Passengers/year	396,000

3.1.3.4 O-D Traffic Surveys

As indicated in **Table 3.1.3.2 A**, road O-D traffic surveys were conducted for a day at the three identified road side locations. The purpose of organizing these surveys was to identify the initial origin or final destination of the cargo flows that are originating from or terminating in the study area. Such information could not be collected due to lack awareness of the truck drivers. However, while attempting to elicit such information from the truck drivers, the following problems were encountered.

- ***Initial origin of the cargo if it is coming from the study area***: For instance, a truck carrying fruits and moving out of Rajosthali is intercepted at Rajosthali survey location and asked about its initial origin. The driver obviously tells that the origin is Rajosthali as the truck started from Rajosthali. But in fact the fruits may have been collected from various places in the study area and aggregated at Rajosthali from where it is loaded into the truck. This is because that driver does not really know the initial origin of the cargo. Such data does not provide correct information for developing O-D traffic flows.
- Similar problem also arose in case of cargo traffic coming into the study area after the truck is unloaded at say Rajosthali.

Because of the foregoing data lacunae, the information collected during the O-D survey could not be used.

3.2 Traffic Forecasts

3.2.1 Introduction

S.#	Details of Data/Reference	Source
1	District/upazilla level statistics covering area, population, agriculture, industry, socio-economic infrastructure, etc	Bangladesh Bureau of Statistics – website: www.bbs.gov.bd
2.	Bangladesh Economic Review - 2014	Ministry of Finance – website: mof.gov.bd
3.	Sector-wise GDP, its composition and growth at constant (Base: 2005-06) prices	Statistical Year Book, Bangladesh Bureau of Statistics – website: www.bbs.gov.bd
4.	Category-wise number of Motor Vehicles Registered in Bangladesh (2009 – 2015)	Bangladesh Road Transport Authority – website: www.brta.gov.bd
5.	Sale of MS and HSD during 2004-05 to 2013-14 in Metric Tons (M.T.)	Bangladesh Petroleum Corporation – website: www.bpc.gov.bd
6.	Import – Export Data, Bangladesh (2001-02 to 2013-14) in Billion USD	Ministry of Commerce – website: www.mincom.gov.bd
7.	Import and Export through Land Custom Check-posts, Bangladesh	Bangladesh Land Port Authority – website: www.bsbk.gov.bd
8.	Macro-economic indicators and allied data	Bangladesh Bank – website: www.bb.org.bd
9.	Traffic Count Data (AADT) on RHD Roads	HDM Division, Roads and Highway Department and website: www.rhd.gov.bd
10.	Vision – 2021 and Perspective Plan of Bangladesh 2010-2021	Ministry of Finance – website: mof.gov.bd
11.	The BCIM Economic Corridor: A Leap into the Unknown?, **Patricia Uberoi,** Working Paper, November 2014, Institute of Chinese Studies (ICS), Delhi	Institute of Chinese Studies (ICS), Delhi – website: www.icsin.org
12	Mizoram State Roads II – Regional Transport Connectivity Project, April 3, 2014, Report No: 83244-IN, World Bank	World Bank website: www.worldbank.org

3.2.1.1 This section presents data sources and traffic forecasting methodology, and results there-of. The Chittagong Hill Tracts Area Transport Connectivity project has two objectives i.e. i) to provide efficient and effective transport connectivity from Chittagong Port to remote areas of North-east districts of Bangladesh and ii) to develop cross-border transit corridors to North-eastern states of India. In other words, the proposed routes will need to cater for two streams of traffic i.e. local traffic and cross-border traffic.

3.2.2 Methodology and Approach

3.2.2.1 Transport is only an intermediate service and the extent of transport activity depends on the need for spatial movement of freight and passengers which in turn will be guided by the on-going and planned activities/ programs of different economic sectors. Based on the above criterion, the base year traffic will be projected taking into account some or all of the following aspects:

- Population growth trends
- M*otor* Vehicle Fleet growth trends
- Trends in fuel consumption
- Growth in GDP
- Economic Development Vs. traffic growth

3.2.2.2 ***Data Sources***: Relevant data have been gleaned from various secondary sources. Details of the data/references and their source are as under:

3.2.2.3 Using the data collected from the various above indicated sources, each of the aforementioned five aspects i.e. i) population trends, ii) Motor vehicle fleet growth, iii) trends in fuel consumption, iv) GDP growth and v) economic development vs traffic growth have been analysed as presented below:

3.2.2.3.1 *Population Growth Trends***:** Transport requirements of people mainly depend on their need for mobility for work, education, health, social activities, recreation, etc.Further, the level and composition of mobility needs, in turn, are determined by population size and structure (i.e. male & female, rural & urban, etc.). In this context, the type and composition of transport activity in a region/ area is guided by the existing and anticipated population sizes and structure of that region/ area. As per Census 2011, the total population of Rangamati district, which mainly constitutes the study area, was 5.96 million, with an inter-census growth rate of 1.66% per year. Of the total, male population was 3.13 million (52.5%) and female 2.83 million (47.5%). While there are no population forecasts at district level, national level forecasts are made up to the year 2035. Urban and rural and Population forecasts for Bangladesh as given in Statistical Hand Book – 2013 (Bangladesh Bureau of Statistics – BBS) are presented in **Table 3.2.2.3.1.**

Table 3.2.2.3.1: Population Forecasts - Bangladesh

(Million)

Year	Urban			Rural			Total Bangladesh			Share of Urban in the total (%)
	Male	Female	Total	Male	Female	Total	Male	Female	Total	
2011*	23.63	20.43	44.06	54.22	53.13	107.35	77.85	73.56	151.41	29.10%
2015	27.39	23.83	51.22	54.24	53.50	107.74	81.63	77.33	158.96	32.22%

Year	Urban			Rural			Total Bangladesh			Share of Urban in the total (%)
	Male	Female	Total	Male	Female	Total	Male	Female	Total	
2020	32.86	28.80	61.66	54.10	53.78	107.88	86.96	82.58	169.54	36.37%
2025	39.98	34.43	74.41	53.35	53.45	106.80	93.33	87.88	181.21	41.06%
2030	45.48	40.47	85.95	51.71	52.21	103.92	97.19	92.68	189.87	45.27%
2035	52.11	46.70	98.81	49.19	50.03	99.22	101.30	96.73	198.03	49.90%

Note ** Census 2011 figures*
Source*: Statistical Hand Book - 2013, Bangladesh Bureau of Statistics*

A quick look at the population forecasts brings out the following:

- The population has been projected to increase at a declining rate
- As expected the growth rate for urban segment is positive and that rural it is negative. This phenomenon is traceable to anticipated migration from rural to urban areas in search of better employment opportunities. The increasing urbanization would have significant impact on size, structure and quality of transport activities.
- Sex ratio remained more or less at the same level

Though no population forecasts are available for the study area, similar observations as above may be valid.

3.2.2.3.2 *Motor Vehicles – Growth Trend:* Road transport plays a significant role in Bangladesh and its share in carrying of freight and passenger traffic is more than 80 percent in tonne-km and more than 88 percent in passenger-km respectively. Given the importance of road transport, level and composition of motor vehicle population and its growth is expected to serve as a fairly reliable indicator of economic growth. In other words, vehicle fleet requirement and its extent of utilization are determined by the level of economic development of a region/ country. **Table 3.2.2.3.2** gives the total motor vehicle population and its growth during 2009-2014.

Table 3.2.2.3.2: Registered Motor Vehicles - Bangladesh

Year	Total Number of Motor Vehicles Registered	Growth (%)
2009	1,307,386	
2010	1,498,244	14.60%
2011	1,683,630	12.37%
2012	1,844,335	9.55%
2013	1,981,444	7.43%
2014	2,142,083	8.11%

Source*: BRTA, website*

During the period, the total vehicle fleet has increased from 1,307,386 in 2009 to 2,142,083 in 2014 indicating an average annual growth rate of 10.4%.

3.2.2.3.3 *Trends in Fuel Consumption/Sale:* Level of fuel consumption is another important indicator of traffic growth. Sale of MS and HSD during 2004-05 to 2013-14 in Bangladesh is presented in **Table 3.2.2.3.3.**

Table 3.2.2.3.3: Sale of MS and HSD during the Last Ten Years

Year	MS (Petroleum)		HSD	
	Quantity (M.T)	Growth (%)	Quantity (M.T)	Growth (%)
2004-05	143,965		2,264,843	
2005-06	153,340	6.51%	2,298,667	1.49%
2006-07	129,549	-15.52%	2,294,223	-0.19%
2007-08	124,823	-3.65%	2,333,597	1.72%
2008-09	115,381	-7.56%	2,301,269	-1.39%
2009-10	127,247	10.28%	2,568,208	11.60%
2010-11	141,491	11.19%	3,239,279	26.13%
2011-12	158,707	12.17%	3,240,349	0.03%
2012-13	169,710	6.93%	2,964,604	-8.51%
2013-14	178,674	5.28%	3,242,554	9.38%
Average Growth		**2.85%**		**4.47%**

***Source**: Bangladesh Petroleum Corporation (Website:www.bpc.gov.bd)*

During the period 2004-05 to 2013-14, the average growth in MS sale was 2.85% per year, the corresponding figure for HSD being 4.47%. These average growth rates are lower than the motor vehicle growth rate presented in Table 3.2, which may be attributable to: i) improved to road condition, ii) enhanced fuel efficiency of vehicles and iii) change from MS/HSD to CNG.

3.2.2.3.4 *Growth in GDP*: The extent of need for transport in a region/ country is determined by the level and composition of mobility requirements of different sectors of the economy which in turn depend on the spatial spread of production/ consumption areas and major marketing/ distribution centers. Demand for transport services at these areas/ centers is a function of the size and type of economic activity which is reflected by the economic development in terms of GDP. **Tables 3.2.2.3.4 A** and **3.2.2.3.4 B** present respectively GDP (at 2005-06 constant prices) of Bangladesh and the year-to-year growth rates for the period 2008-09 to 2013-14, respectively.

Tables 3.2.2.3.4 A: GDP at Constant Prices (Base: 2005-06) for Important Sectors and Total (Crore Taka)

Sector	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14*
Agriculture & Forestry	79,682	84,904	88,206	90,332	91,656	93,912
Fishing	22,793	24,601	28,482	31,827	36,995	42,669
Mining & Quarrying	8,841	9,561	9,907	10,593	11,584	12,188
Manufacturing	93,459	99,671	109,651	120,567	132,994	144,544
Electricity, Gas & Water Supply	7,012	8,346	11,589	14,189	16,381	17,900
Construction	44,180	49,474	57,072	68,304	82,432	97,538
Wholesale & Retail Trade	96,094	106,606	121,332	137,396	154,579	172,322
Hotel & Restaurants	5,790	7,028	8,228	9,755	11,263	13,033
Transport, Storage & commu.	67,185	80,454	94,571	112,702	124,281	136,470
Total GDP at Constant Prices	575,056	607,097	646,342	688,493	729,896	774,539

** Provisional*

***Source**: Appendix 1.1 - Bangladesh Economic Review 0 2014*

Table 3.2.2.3.4 B: Growth of GDP at Constant Prices (Base: 2005-06) for Important Sectors and Total

Sector	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14*
Agriculture & Forestry	3.09%	6.55%	3.89%	2.41%	1.47%	2.46%
Fishing	4.94%	7.93%	15.78%	11.74%	16.24%	15.34%
Mining & Quarrying	10.47%	8.14%	3.62%	6.92%	9.36%	5.21%
Manufacturing	6.69%	6.65%	10.01%	9.96%	10.31%	8.68%
Electricity, Gas & Water Supply	7.26%	19.02%	38.86%	22.44%	15.45%	9.27%
Construction	6.58%	11.98%	15.36%	19.68%	20.68%	18.33%
Wholesale & Retail Trade	5.86%	10.94%	13.81%	13.24%	12.51%	11.48%
Hotel & Restaurants	5.87%	21.38%	17.07%	18.56%	15.46%	15.72%
Transport, Storage & commu.	8.05%	19.75%	17.55%	19.17%	10.27%	9.81%
Total GDP at Constant Prices	**5.05%**	**5.57%**	**6.46%**	**6.52%**	**6.01%**	**6.12%**

During the period 2008-09 to 2013-14, the total GDP grew at an average rate of about 6% per year and varied in very narrow band i.e. 5.05% in 2008-09 to 6.52% in 2011-12. In other words Bangladesh economy maintained a study growth trajectory during the 6 years despite the resurgence of global recession during the first half of 2011-12.

3.2.2.3.5 *Economic Development vis-à-vis Traffic Growth*: It is widely recognized that the need for transport services in a region/ country increases with economic development which is normally measured in terms of GDP. At the initial stages of economic development, especially in developing countries, the demand for transport far exceeds the rate of economic growth. As the economy grows and reaches stability, the rate of growth for transport declines. Available empirical evidence suggests that transport demand tends to increase at a somewhat faster rate than the economic growth rate as measured by national and regional GDPs. In other words, for a given unit growth rate in GDP, the corresponding rate of increase in transport demand is expected to be more than unity. This relationship is called transport demand elasticity.

Transport demand elasticity estimates are not available for Bangladesh. However, considering the contribution of Land Transport in the total GDP as the proxy for transport output, the consultants have worked out transport demand elasticity. The same is presented in **Table 3.2.2.3.5**

Table 3.2.2.3.5: Bangladesh - Total and Land Transport GDP and Transport Demand Elasticity

Year	Total GDP		GDP from Land Transport			Elasticity of Land Transport w.r.t GDP
	Crore Taka	Growth (%)	Crore Taka	Share in Total GDP (%)	Growth (%)	
2008-09	575,056	5.05	39,296	6.83%	6.59	1.30
2009-10	607,097	5.57	42,169	6.95%	7.31	1.31
2010-11	646,342	6.46	45,198	6.99%	7.18	1.11
2011-12	688,493	6.52	48,283	7.01%	6.83	1.05
2012-13	729,896	6.01	51,136	7.01%	5.91	0.98
2013-14*	774,539	6.12	54,301	7.01%	6.19	1.01
Average						**1.13**

** Provisional*

***Source**: Appendix 1.1 - Bangladesh Economic Review - 2014*

The average transport demand elasticity during the period 2008-09 to 2013-14 works out to 1.13, the range being 0.98 to 1.31. A transport demand elasticity value of 1.13 indicates that for every one 1% increase GDP (i.e. economic development), the demand for transport will increase by 1.13%. This is line with transport demand elasticity values adopted in some developing countries.

3.2.3 Traffic Forecasts

3.2.3.1 ***All-Road Route***: The total all-road route between Chittagong and Thegamukh has two distinct sections namely, i) Rajosthali-Thegamukh (proposed new road section), and ii) Chittagong-Rajosthali (existing RHD road section). Details of these road sections are as under:

S. #	Name of the Road Section	Status	Length (Km)
I	**A. Rajosthali -Thegamukh**		
	A.1 Rajosthali - Bilaichari	Proposed New Road	47.066
	A.2 Bilaichari - Jurichari		28.091
	A.3 Jurichari - Thegamukh		34.518
	Total - A		109.675
II	**B. Chittagong - Rajosthali**		
	B.1 Chittagong - Chandraghona	Existing RHD Road	43.369
	B.2 Chandraghona - Rajosthali		31.933
	Total - B		75.302
	Total -(A+ B)		184.977

3.2.3.2 ***Traffic Forecasts – Proposed New Road***: The proposed new route, as mentioned earlier, will serve two broad streams of traffic:

i) Local traffic by providing improved accessibility for marginalized people of Chittagong Hill Tracts (CHT) area. This stream will have two components – a) diverted/normal traffic and b) induced or generated traffic.

Diverted traffic refers to that component of traffic which is currently coming into/going out of the study area (i.e. base year traffic) by other means of transport (IWT or head-loading) in the absence of the proposed route. When the proposed route becomes operational, all thistraffic will get diverted because of the overall cost advantage. In a way, this component may also be considered as '***normal traffic***' as no road currently exists in the study area.

Generated traffic connotes that element of traffic which will get generated/ induced due to better accessibility. This may emanate from suppressed demand or location of new economic and social activities in the study area.

ii) ***Cross-border/inter-regional*** traffic to North-eastern states of India, mainly adjoining Mizoram state.

3.2.3.2.1 Growth Rates and Forecasts for Local Traffic: From the foregoing analysis of various growth indicators, it emerges that transport demand elasticity would provide a meaningful basis for traffic forecasting. During the last 6 year period while total real GDP of Bangladesh was growing at about 6% per year, the GDP from Land transport grew at more

than 6% per year; yielding an average demand elasticity of 1.13. This statistic can be used to estimate future growth rates for forecasting, if GDP growth rates are given. In this context, Government of Bangladesh has prepared "Perspective Plan of Bangladesh (PPB) 2010-21: Making Vision 2021 A Reality". Vision 2021 envisions transformation of socio-economic environment of Bangladesh from a low income economy to the first stages of a middle income nation by 2021. To make the vision a reality, PPB 2010-21 stipulated the growth trajectory of real GDP of Bangladesh as under:

Year	FY 10	FY 15	FY 21
Real GDP Growth Rate (%) per year	6.1	8.0	10.0

In the present exercise, the foregoing real GDP growth rates have been used to work out relevant traffic growth rates for local traffic.

While adopting the GDP growth rates, the following approach has been used.

Though the PPB 2010-21 has envisaged a real GDP growth of 8.0% by 2014-15, the actual rate was 6%. Keeping this in view, the following 3 growth scenarios have been assumed.

Real GDP Growth Scenario	FY 15	FY 21	FY 26	FY 31	FY 36
Scenario 1 - Pessimistic	6.0%	6.0%	6.0%	6.0%	6.0%
Scenario 2 - Moderate	6.0%	7.0%	8.0%	9.0%	8.0%
Scenario 3 - Optimistic	6.0%	10.0%	10.0%	10.0%	8.0%

Applying, transport demand elasticity of 1.13 to the above assumed GDP growth rates, the corresponding traffic growth rates have been worked. However, since the traffic from/to the study area has been assumed to grow in proportion to the population growth in the area (refer paragraph 3.1.3.2.1), the traffic has been assumed to grow (irrespective of growth scenario) in line with population growth (i.e. 1.66% per year) till the 1st year of commencement of the new road i.e. year 2020. The growth rates adopted for traffic projection are presented in **Table 3.2.3.2.1 A**

Table 3.2.3.2.1A: Traffic Growth Rates for Local Traffic

Real GDP Growth Scenario	2013 to 2020	2020 to 2025	2025 to 2030	Beyond 2030
Scenario 1 - Pessimistic	1.66%	6.78%	6.78%	6.78%
Scenario 2 - Moderate	1.66%	9.04%	10.17%	9.04%
Scenario 3 - Optimistic	1.66%	11.30%	11.30%	9.04%

Local traffic forecasts worked using the above growth rate scenario are presented Table 3.8. These forecasts, as mentioned earlier, refer to diverted traffic. In studies of this nature, and where there is problem of paucity of relevant data, generated/induced traffic is assumed as percentage of estimated diverted/normal traffic. In the present case, to be on the conservative side, generated/induced traffic has been assumed as 20% of diverted traffic for all three scenarios. Forecasts for generated/induced traffic and total local traffic (diverted +generated/induced) are presented in **Tables 3.2.3.2.1B.**

Table 3.2.3.2.1B: Local Traffic Forecasts - Diverted (Vehicles/Day – Both-ways)

Section of the Road	Scenario 1 - Pessimistic					Scenario 2 - Moderate					Scenario 3 - Optimistic				
	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040	2020	2025	2030	2035	2040
i. Rajosthali to Bilaichari	530	735	1021	1417	1967	530	816	1325	2043	3148	530	905	1545	2382	3671
ii Bilaichari to Jurichhari	546	759	1053	1462	2029	546	842	1367	2107	3249	546	933	1594	2457	3788
iii. Jurichhari to Thegamukh	731	1014	1408	1954	2713	731	1126	1828	2817	4342	731	1248	2131	3285	5063
Local Traffic Forecasts - Generated/Induced															
i. Rajosthali to Bilaichari	106	147	204	283	393	106	163	265	409	630	106	181	309	476	734
ii Bilaichari to Jurichhari	109	152	211	292	406	109	168	273	421	650	109	187	319	491	758
iii. Jurichhari to Thegamukh	146	203	282	391	543	146	225	366	563	868	146	250	426	657	1013
Local Traffic Forecasts - Diverted and Generated/Induced															
i. Rajosthali to Bilaichari	636	882	1225	1700	2360	636	980	1590	2451	3778	636	1086	1854	2858	4405
ii Bilaichari to Jurichhari	656	910	1264	1754	2435	656	1011	1641	2529	3898	656	1120	1913	2949	4545
iii. Jurichhari to Thegamukh	877	1217	1689	2345	3255	877	1351	2193	3381	5211	877	1497	2557	3942	6076

When the project road i.e. two lane bitumen surfaced road commences operation, the above diverted/normal traffic will enjoy benefits traceable to reduced vehicle operating cost (VOC) and travel time and increased comfort. There will also be easy accessibility to medical centers, educational institutes (schools, colleges, etc.), social interaction, etc. At present, due to lack of proper transport facility, the potential of the area i.e. agriculture, horticulture, forestry, etc. remains mostly under/un-utilized. This is corroborated by the fact, as revealed during the discussions with concerned government agencies and local leaders in the project area, most of the agriculture and allied production in this area is mostly limited to meeting only the subsistence needs. This is because lack of proper transport and storage facilities has been hampering fruit production in this area and in some cases resulting in damage of millions taka worth of fruits. As such when the new road is available which in turn ensures easy accessibility to inputs and product markets, substantial quantum of traffic gets generated due to additional production. Further, this will also encourage setting up of related industries e.g. agro-processing, fruit canning and forest-based industries. This will in turn create employment to local population and result in additional income.

For the purpose of further analysis i.e. economic appraisal, moderate traffic projections i.e. Scenario 2, have been adopted. Detailed projections in this regard are presented in **Annexure 3.1**

3.2.3.3 ***Traffic Forecasts – Existing Chittagong – Rajosthali Road***: In the case of this existing road section, the RHD traffic count data as given in **Table 2.3.3** has been considered as the base year AADT. Using this as base and adopting RHD annual growth rate of 7% relevant for regional roads, traffic projections have been worked out and presented in **Table 3.2.3.3**

Table 3.2.3.3: Traffic Projections on Existing Chittagong-Chandraghona-Rajosthali Road Section - Normal Traffic

Road Section	Traffic Projections (AADT -Both Directions)				
	2020	2025	2030	2035	2040
Chandraghona-Rajosthali	1,657	2,324	3,260	4,572	6,413
Chandraghona-Chittagong	6,865	9,629	13,505	18,941	27,311

Detailed traffic projections for the existing road are presented in **Annexure 3.2**

Cross-border traffic i.e. traffic between CHT area and North-eastern states of India (mainly Mizoram State in this case), occupies important role on this Chittagong-Thegamukh road. Since this component is common for the entire stretch of the road, the component is discussed in the following section.

3.2.3.4 ***Cross-Border Traffic Forecasts***:
In Bangladesh land-based cross-border traffic is handled at custom check posts. Currently there are 9 operational land custom check posts – 5 under BOT and 4 directly operated by Bangladesh Land Ports Authority (BLPA) – Map3.2.3.4 A

Map -3.2.3.4 A Bangladesh Land Ports

Besides, there are a number of border land custom check posts that are under development or proposed **(Map 3.2.3.4 A).** As may be seen from the above map, a land custom post is under process of development at Thegamukh, which is the terminal point of the proposed routes and also bordering with Mizoram state of North-eastern region of India.

At present, there are no available cross-border moments through Thegamukh. Majority of cross-border traffic is moving through Benapole custom post. **Table 3.2.3.4 A** presents cross-border traffic (imports and exports) through land ports for period 2008-09 to 2013-14. As may be seen, this data does not provide any meaningful basis for forecast of cross-border traffic through Thegamukh.

Table 3.2.3.4 A: Imports - Exports through Land Ports: Bangladesh

(M.T.)

Year	Imports		Exports		Total		Exports as %age of Imports	Imports as %age of total
	Quantity (Tonnes)	Growth (%)	Quantity (Tonnes)	Growth (%)	Quantity (Tonnes)	Growth (%)		
2008-09	2,511,422		914,639		3,426,061		36.42%	73.30%
2009-10	2,834,003	12.84%	948,403	3.69%	3,782,406	10.40%	33.47%	74.93%
2010-11	3,539,251	24.89%	1,144,279	20.65%	4,683,530	23.82%	32.33%	75.57%
2011-12	4,631,403	30.86%	1,189,248	3.93%	5,820,651	24.28%	25.68%	79.57%
2012-13	4,990,898	7.76%	1,162,687	-2.23%	6,153,585	5.72%	23.30%	81.11%
2013-14	6,866,286	37.58%	731,433	-37.09%	7,597,719	23.47%	10.65%	90.37%
Average		22.79%		-2.21%		17.54%	26.97%	79.14%

***Source**: Bangladesh Land Port Authority, Website: www.bsbk.gov.bd*

However, some of the on-going regional initiatives like Bangladesh-China-India-Myanmar (BCIM) Economic Corridor and Mizoram State Roads II - Regional Transport Connectivity project, India (funded by World Bank) may provide a basis for broad assessment of cross-border traffic at Thegamukh.

BCIM Economic Corridor

The BCIM economic corridor is a sub-regional initiative for fostering cooperation among the four member countries. The proposed economic corridor originates from Kunming in China's Yunan province and pass through Yangon and Mandalay in Myanmar, Chittagong-Dhaka-Sylhet in Bangladesh before entering India's North Eastern states of Manipur and Assam and finally West Bengal and ending in Kolkata (**Map 3.2.3.4 B**). The hinterland region of BCIM corridor is one of the richest in the world in terms natural, mineral and other resources.

Map 3.2.3.4 B– BCIM Corridor

Enveloping about 9% of worlds area, the BCIM region accounts for 440 million people and 7.3% global GDP. The region has potential to generate enormous economic benefits in the area of trade, investment, energy, transportation and communications. For instance, intra-regional trade among BCIM member states amounted to 5 per cent of total BCIM trade in 2012, as opposed to ASEAN, where 35 per cent of total trade is intra-regional. The BCIM Corridor will allow all four countries to exploit existing complementarities in trade — in terms of both sectors and products. Myanmar is a primary goods exporter and has abundant cheap labour. India has an edge as a leading services exporter. China is the largest manufacturing exporter in the world; and Bangladesh, like many other South Asian countries, engages in both services export and low-end manufactured goods.

In view of the development potential, the four member countries have, of late, provided impetus for the development of BCIM Economic Corridor. Joint Study Groups (JSG) set up for the purpose are identifying various projects, infrastructure improvements, etc. to make the corridor operational. However, it is long way before some usable estimates of anticipated traffic levels are available.

One of the major beneficiaries of the BCIM corridor will be North-eastern state of India, which for all practical purposes are landlocked and far-removed from the main stream. Further, current BCIM corridor (**Map 3.2.3.4 B**) passes through Manipur and Assam, but does not link Mizoram and through it the biggest port of Bangladesh i.e. Chittagong Port. Provision of this link would benefit North-eastern region of India as well Bangladesh.

Given the above, no useable cross-border trade data could be drawn from the available BCIM references.

Mizoram State Roads II - Regional Transport Connectivity project, India (funded by World Bank): Taken up as part of the SAARC multi-modal transport initiative, this improved link to Bangladesh will facilitate greater bilateral trade as well as provide better access for Mizoram and

other North-eastern Indian states to Chittagong Port (which is the nearest shipping port for NER states of India).

Among others, the project comprises: widening and strengthening of three sections of (Group 1) road totaling 91 km including (i) a 22.0 km section of Lunglei –Tlabung – Kawrpuichhuah Road on the border with Bangladesh; (ii) the 27.5km Champhai-Zokhawthar Road on the border with Myanmar; and (iii) the 41.7km Chhumkhum-Chawngte North-South alignment connecting to the border roads with Bangladesh to the west and Myanmar to the south. The project implementation period is 2015-2015 and is found economically viable with an EIRR above the cut-off rate of 12%.

Base year estimates (2013) for cross-border traffic are based on the detailed review of regional trade prospects and its impacts on the project road. For the road linking Thegamukh, AADT of 657, with the following composition has been assumed.

Bus	Multi-axle Truck	Truck	LCV	Two wheeler	Car	Auto-rickshaw	Total
23	19	65	177	114	158	101	657

For the present study, only bus, multi-axle truck, truck, LCV and car traffic have been considered to constitute the cross-border traffic as these entail relatively long lead trips. Others like two-wheelers and auto-rickshaws mainly run for trips and are not relevant for the purpose. Based on the above assumption, the following traffic has been adopted as cross-border traffic for the present study.

Bus	Multi-axle Truck	Truck	LCV	Car	Total
23	19	65	177	158	442

The above cross-border traffic estimates are the only available information. Though all the proposed routes emanate from Thegamukh and diverge in three directions, since the proposed route constitutes the shortest road to Chittagong, it has been assumed that all the cross-border traffic considered above i.e. 442 vpd will follow this route. Assuming that the base cross-border traffic level for the 1st year of opening of the new road and further grow in line with the current average GDP growth of Bangladesh i.e. 6% per year, projections for this component of traffic have been made and presented in **Table 3.2.3.4 B**

Table 3.2.3.4 B: Cross-Border Traffic Projections – Vehicles Per Day (VPD)

Year	Heavy Truck	Medium Truck	Medium Bus	Utility	Car	Total - Motor Vehicles
2020	19	65	23	177	158	442
2025	25	87	31	237	211	591
2030	34	116	41	317	283	792
2035	46	156	55	424	379	1059
2040	61	208	74	568	507	1418

Detailed year-wise traffic projections including cross-border traffic for the proposed new road and existing road are presented in **Annexure 3.1** and **Annexure 3.2** respectively.

3.2.3.5 *IWT Traffic Projections*:

Using the base year traffic presented in Table **Table3.1.3.3** which are based on wide consultations with local government agencies and IWT vessel owners' association and adopting

current average GDP growth rate of Bangladesh (i.e. 6% per year), IWT traffic projections have been arrived at and presented in **Table 3.2.3.5**

Table 3.2.3.5: IWT Traffic Projections: Rangamati-Chotoharina

O-D Pair	Traffic	Base Year 2015	2020	2025	2030	2035	2040
Goods Traffic							
Rangamati-Chotohorina	Tonnes/day	280	375	501	671	898	1202
	Tonnes/year	92,400	123,652	165,474	221,442	296,339	396,569
Chotohorina-Rangamati	Tonnes/day	280	375	501	671	898	1202
	Tonnes/year	92,400	123,652	165,474	221,442	296,339	396,569
Total – Both-ways	Tonnes/day	560	749	1,003	1,342	1,796	2,403
	Tonnes/year	184,800	247,304	330,949	442,884	592,679	793,138
Passenger Traffic							
Rangamati-Chotohorina	Passengers/day	600	803	1,075	1,438	1,924	2,575
	Passengers/year	198,000	264,969	354,588	474,519	635,013	849,790
Chotohorina-Rangamati	Passengers/day	600	803	1,075	1,438	1,924	2,575
	Passengers/year	198,000	264,969	354,588	474,519	635,013	849,790
Total – Both-ways	Passengers/day	1,200	1,606	2,149	2,876	3,849	5,150
	Passengers/year	396,000	529,937	709,176	949,037	1,270,026	1,699,581

Note: Marginal difference in totals may be due to rounding-off.
Yearly figures worked out assuming 330 working days/year

The foregoing traffic projections along with capital cost of i) new road construction, ii) widening of the existing road and iii) deepening of water channel, terminals, etc., form the main inputs for assessing the economic viability of the proposed investment on the new road/IWT channel

3.2.3.6 Traffic Forecasts for Chittagong-Rangamati Road Section

Base year traffic (AADT) for this road section is given **Table 3.1.3.1**. This is a national road and RHD, Bangladesh recommends 10% traffic growth per year on these roads. Based on this traffic forecasts on different subsections of the road are presented in **Table 3.2.3.6**

Table 3.2.3.6: Traffic Forecasts on Chittagong-Rangamati Road (AADT)

Road Section	Year	Medium Truck	Small Truck	Large Bus	Medium Bus	Micro bus	Utility	Car	Auto Rickswa	Motor Cycle	Total Motor Vehicles
Chittagong – Munshihat	2020	906	422	230	257	328	253	345	6395	1258	10396
	2025	1458	680	370	413	528	408	556	10301	2026	16742
	2030	2349	1096	596	666	851	657	896	16590	3263	26964
	2035	3783	1765	960	1072	1370	1058	1443	26719	5255	43425
	2040	6092	2842	1547	1727	2206	1704	2324	43031	8463	69937
Munshihat-Ghagra	2020	666	368	361	234	359	815	201	1013	725	4741
	2025	1073	593	581	377	577	1312	323	1632	1167	7636
	2030	1729	955	935	607	930	2113	512	2628	1880	12298
	2035	2784	1539	1506	977	1498	3403	838	4233	3028	19805
	2040	4484	2478	2425	1573	2412	5480	1350	6817	4877	31897
Ghagra-Rangamati	2020	179	247	109	203	201	162	68	1762	918	3849
	2025	289	399	176	326	323	260	110	2837	1478	6198
	2030	465	642	283	526	521	420	177	4569	2381	9983
	2035	749	1034	456	847	838	676	285	7359	3834	16077
	2040	1206	1665	734	1363	1350	1088	459	11851	6175	25892

CHAPTER – 4

Design Standards for Road and Waterways

CHAPTER – 4

Design Standards for Road and Waterways

4 Design Standards for Road and Waterways

4.1 Introduction

Topographically Bangladesh can be divided into alluvial plains and hilly areas. More than 90 percent of total area of Bangladesh is low land, an alluvial plain formed by the sediments of several great rivers and their tributaries and distributaries which traverse the country. There are, however, some local variations in the nature and extent of the plain land.

Low hills are found in the north-eastern extremities of Bangladesh. These hills are part or extension of the Khasia-Garo-Jainta and the Tippera Hills of India. The more important hilly areas are concentrated in hill districts of Chittagong Division and are geologically the offshoots of the ArakanYoma running through Eastern India to Burma. The Chittagong hills are steep sloped parallel ranges, largely covered with tropical forests. These hills rise steeply to narrow ridge lines, generally no wider than 120 feet and no higher than 2000 to 3000 feet. The highest hill in Bangladesh is Keokradang (4034 feet) in south-east end of Bandarban district.

4.2 Design Standards for Project Roads and Waterways

The selection of design standards is related to function of road, volume of traffic and type of terrain, with additional procedures for the recognition and appropriate treatment of potential hazards.

Since the proposed road is going to be one of the major road corridor of category regional/national highway with 7.3 m width (two lane) principally RHD Geometric Design Standards Manual (Revised) 2005 has been followed for design parameters. Besides the following reference recommendations and standards have been consulted.

- AASHTO "A policy on Geometric Design of Highway and Streets" 2005
- IRC _SP_48_1998
- Overseas Road Note 6 "A Guide to Geometric Design" published by TRRL 1988
- Nepal Road Standards 2020(July 2013), Government of Nepal, Ministry of Physical Infrastructure and Transport. Department of Roads, Kathmandu, Nepal

Design Standards for waterways

Depth:

As per classification of rivers, the Kornafuli is class III routes. Designed depths of river routes are given below.

IWTA classification	Length (km)	Depth(m)
Class 1	683	3.66-3.96
Class 2	1000	2.10-2.44
Class 3	1885	1.52-1.83
Class 4	2400	Less than 1.52

Source: *BIWTA master plan study*

For class III routes, the recommended depth is1.52-1.83m. The route will be developed as waterway for comparative large passengers& cargo vessels. Its depth should be as per recommended depth of 2.10-2.44 m of class II river routes. In this case, the least available depth (LAD) is taken 3m.

Width:

The width of dredging of the channel depends on the traffic volume and size of the vessels plying. In case of the river Karnafuli width may be taken as 61 m (200') for easy, smooth & safe navigation & crossing of two vessels. After dredging, the side slope will be adjusted automatically by sliding the upper part & filling the lower formation bottom.Then the actual width of the bed will remain about 46 m (150').

4.3 General Design Considerations for Road and Waterways

Design consideration for Road

Sl.No.	Design Element	Unit	Plain				Rolling				Hilly		
			IRC	IRC With Same Speed As RHD	RHD 2005	Suggestedto Adopted	IRC	IRC With Same Speed As RHD	RHD 2005	Suggested To Adopted	IRC	RHD 2005	Suggested to Adopted
1	Design Speed	Km/h	100	80	80	80	80	65	65	65	50	50	50
2	Min. Stopping Sight Distance	m	180	120	120	120	120	90	90	90	60	60	60
3	Min. Intermediate Sight Distance	m	360	240	250	250	240	180	180	180	120	120	120
4	Min. Horizontal Radius	m	360	230	500	500	230	160	250	250	80	120	120
5	Transition Curve Required	-	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
6	Maximum Gradient	%	3.3	3.3	0-3	0-3	5	5	1-5.0	1-5.0	0-5.0	1-7.0	1-7.0
7	Maximum Super elevation	%	7	7	5	5	7	7	5	5	7	5	5
8	Min. Crest Vertical Radius	m			6000	6000			2500	2500		1500	1500
9	Min. Sag Vertical Radius	m			3000	3000			2000	2000		1000	1000
10	Traffic Lane Normal Cross fall	%	2.5	2.5	3	3	2.5	2.5	3	3	2.5	3	3
11	Shoulder Normal Cross fall	%	3	3	5	5	3	3	5	5	3	5	5
12	Right of Way	m	45	45	30	30	45	45	30	30	24	30	24

Design consideration for waterway:
In case of this water route, width of 61 m and LAD of 3 m has been considered. Considering the above width & depth dredging need has been calculated.

4.4 Geometric Design for Proposed Roads

4.4.1 Horizontal Curvature

Maximum Speed	80 kph.
Minimum Speed (Hill)	50 kph
Maximum Rate of Super elevation	5.00%
Minimum Radius without Super elevation, 80 kph	2,000 m
Minimum Radius without Super elevation, 50 kph (Hill)	500 m
Minimum Radius (Hill)	65 m

4.4.2 Longitudinal Gradient

Minimum K value, Crest Curve, 80 kph	35
Minimum K value, Crest Curve, 50 kph	9
Minimum K value, Sag Curve, 80 kph	25.3
Minimum K value, Sag Curve, 50 kph	10
Minimum Longitudinal Gradient	0.50 %
Maximum Longitudinal Gradient (Hill)	7.00 %

4.5 Safe Cut Slopes

Considering the heavy rainfall and poor maintenance of pavement in Bangladesh, a cross fall of 3% has been applied for carriageway and paved shoulder as recommended in RHD's Standard Design Manual. For the soft shoulder/verge a cross fall of 5.0% has been provided as per RHD's Standard.

For embankment construction the side slopes at 1V: 2H has been adopted as per RHD guideline. This has been adopted for both cut and fills section for the project road. The safe cut slope is 1V:1.5H (IRC recommendation) and berm 2m would be provided each 10m height.

Various types of soils occur along the alignment of hill roads. They include ordinary soils comprising colluviums, alluviums and completely decomposed rocks, disintegrated rocks, Soft rocks, medium rocks and hard rocks. The soils/rocks can stand safely at certain angles during cutting without any support. The safe stable angles are summarized in **Table 4.5** below.

Table 4.5: Safe Cut Slopes

SL No	Type of Soil	Side Slopes			Average Slope Angle in Degrees
1	Ordinary Soils	1:1	to	1.5:1	56
2	Disintegrated rock or Conglomerate	2 :1	to	4:1	71
3	Soft rock, Shale, Phyllite	4:1	to	8:1	80
4	Medium Rock	12:1	to	16:1	85
5	Hard Rock	Nearly vertical or half tunnelling if cut height exceeds 7.5 m			

4.6 Design standard for Bridges & culverts:

Introduction:
During the feasibility study phase, a comprehensive reconnaissance field survey was done to have an idea about the overall length of various options, approximate length of cross drainage structures, major or minor bridges and culverts etc. The Team also tried to collect the information from the local people regarding the hydrological data like flooding type, erosion of channel bed, low water & high water level etc for preliminary design of structures along the proposed alignment.

Preliminary Design of Bridge, Culverts & other drainage structures are based on Reconnaissance Survey :

4.6.1 Design Specifications :

AASHTO – Load & Resistance Factor Design (LRFD) method is used as Design Standard for Bridge and culvert design and other drainage structures.

The structure shall be analyzed for the following limit states:

Strength-1 :	Basic load combination relating to normal vehicular use of the Bridge with out wind.
Strength-2:	Load combination relating to special design vehicles with out wind.
Strength-3:	Load combination relating to wind velocity exceeding 90km / hr.
Strength-4:	Load combination relating to very high dead load to live load force effect ratios.
Strength-5:	Load combination relating to normal vehicular used with wind of 90km /hr velocity.
	Extreme event-1: Load combination including earthquake.
	Extreme event-2: Load combination relating to collision of vessels / barges, vehicles and certain hydraulic events.
Service-1:	Load combination relating to normal operational use with a 90km / hr wind.
Service-2:	Load combination intended to control yielding of steel structures.
Service-3:	Load combination relating only to tension in pre-stressed concrete superstructures for crack control.
Service-4:	Load combination relating only to tension in pre-stressed concrete substructures for crack control.
Fatigue:	Fatigue and fracture load combination. (Generally not critical for concrete bridges except in the case of pre-stressed cable stress range).

4.6.2 Analysis and Design :

Structural analysis and design of Bridge and culverts will be in accordance with American Association of State Highway and Transportation Officials (AASHTO). For vehicular loading, Standard specification for Highway bridges latest edition HL-93 is presently used in Bangladesh. The design method LFD (Load Factor Design) is adopted in design.

4.6.3 Vehicular Loading :

Vehicular Live load : AASHTO HL-93 Loading is used as vehicular live load for design of bridge.

4.6.4 Environmental Loading :

- Wind load analysis is done as per AASHTO-LRFD 2007 but wind speed is taken from latest approved BNBC 93.
- Seismic load analysis shall be done as per AASHTO-LRFD but seismic zone co-efficient will be taken from BNBC 93.

4.6.5 Other Loading :

Other loading shall be considered as per AASHTO-LRFD 2007.

4.6.6 Deck Geometry of Bridge and culverts :

Deck geometry is used following the guide line of "Bridge Design Standard for RHD & LGED, June' 2012 as approved by Planning Commission and considered Regional highway type 4.

- According to type 4, carriage-way width is 7.30m and 1.25m footpath including railing on each side. So total crest width for all bridges and culverts are 9.80m.

4.6.7 Railing Geometry :

Railing geometry like height of post, section of post and rail, rail numbers, c/c distance of post and rail etc. will be as per "Bridge Design standard for LGED, June' 2012".

4.6.8 Navigational Clearance :

The Navigational Clearance is considered in accordance with current BIWTA requirement. However, for waterways which is not been classified by BIWTA, consideration is given to the local requirements of river traffic movement like, engine boat, trawler, fishing boat etc.

Table for navigational clearance as per BIWTA requirements:

Sl. No.	Classification of waterways	Min. vertical clearance (m)	Min. horizontal clearance (m)	Remarks
1.	Class-I	18.30	76.22	
2.	Class-II	12.20	76.22	
3.	Class-III	7.62	30.48	
4.	Class-IV	5.0	20.00	

The vertical clearance should be measured from the Standard High Water Level (SHWL).

4.6.9 Girder type & Geometry :

Number of girder in each span of bridge for both RCC & PSC girder depending on the carriage-way width shall be as follows:

- For 3.70m carriage width nos. of girder shall be 2 (two)
- For 5.5m carriage width nos. of girder shall be 3 (three)
- For 7.3m carriage width nos. of girder shall be 5 (five)

For road type 4 of carriage way, 5 numbers of girder are provided for the bridges of both RCC and Pre-stressed.

4.6.10 Material Properties :

Concrete :

The concrete is to be produced from natural coarse aggregate, coarse sand, ordinary port land cement (OPC) and water without harmful chemical and suspended particles. Natural coarse sand is available from north zone of Sylhet district along the Indian border. Mechanically crushed stone aggregate to achieve proper gradient is proposed.

Cement :

Cement is produced in Bangladesh. This has to be comply with criteria for ordinary port land cement (OPC) and is considered to be suitable for the project.

Steel :

Reinforcing steel for both mild (276 Mpa) and high yield (410 Mpa) confirming to ASTM A615, A616, A617 or A706 is manufactured in Bangladesh. The maximum limiting bar size 32mm. The following bar size are available in Bangladesh :

8, 10, 12, 16, 20, 22, 25, 28 & 32mm diameter.

Pre-stressing Tendons :

Pre-stressing Tendons are not available in Bangladesh. Uncoated wire strand as required by the designer's shall confirm to the requirement of AASHTO M203 (ASTM A416) supplement SI (Low-relaxation).

Coarse and fine aggregate :

Coarse aggregate materials of boulder and gravel are available in the river beds of Sunamganj, Sylhet and other district which meets the standard requirement of Los Angles Abrasion value (LAAV) and Aggregate crushing value (ACV). Natural Sylhet sand usually meets the standard requirement of fineness modulus (FM 2.8) and specific gravity (≈ 2.6).

Construction water:

Water from streams and wells should be allowed to stand in settling basin and the impurities should be treated before use. Normally a deep tube well should be installed for use of water.

Stone chips / or Brick chips:

Mechanically crashed Stone chips or well burnt brick chips are available in local market.

4.6.11 Bridge Location And Approach Road Study :

Selection of a bridge alignment on a specified road network route depends mainly on river width, river geometry, navigational clearance requirements, and historical change in the water course. Before selecting the bridge alignment the above mentioned points are considered.

4.6.12 Preliminary Selection of Bridge Type :

As per site condition, construction facilities, material availability, type of river traffic, technical analysis and also from economic consideration, different type of girder like Pre-stressed concrete girder, RCC T-girder is considered after details bathymetric & topographical survey work. In ideal cases it is economical to construct RCC T-girder where the span is within the range of 25.0m but more than 25.0m, PSC girder is economical to construct. In the remote area where PS construction is difficult, then RCC box girder may be constructed for longer span more than 25.0m. Where the channel gap is within 6.0m and height is limited to 6.0m, RCC box culvert will be economical to construct.

CHAPTER - 5

Engineering Surveys and Investigations

CHAPTER - 5

Engineering Surveys and Investigations

5.1 Road and Bridge Inventory and Condition Survey

The River/Stream data and condition for existing structure has been collected. It has been found that most of the existing bridges are not suitable for the amount and type of the traffic expected on the proposed road hence all the existing bridges need to be replaced.The format for Inventory & Condition Survey of Existing Structures (Bridges & culverts) is provided in **Annexure 5.1**

It was decided that all the physical features, such as ponds, permanent structures, drains, hills, wells etcrelated to bridge should be demarcated properly. River/ channel/ khal cross section was exclusively taken along the center line of the proposed bridge alignment and other sections at distances of 0.50, 1, 2 and 4 times the channel widths at upstream and at distances of 0.50, 1 and 2 times channel widths at downstream. Spot levels on river cross section were taken at 3.0m intervals or as necessary.The length of each cross section covered the full channel width plus same length of left & right banks.Road cross section was taken along approach road at both ends of the proposed bridge. Four road sections at each end of the bridge @ 25m interval were taken. Bank line survey of the channel was proposed to be conducted by the following manner:

a) For less than 100m bridges, bank line survey of both sides shall be carried out minimum 300m towards the upstream and downstream of the river course way.
b) For bridges of proposed length 100~300m, the bank line survey of both side shall be carried out minimum 500m towards upstream and downstream of the river course way.
c) For bridges of the proposed length more than 300m, the bank line survey of both sides shall be carried out minimum 1 kM or as required towards upstream and downstream of the river course way.

It was decided to collect the information for HFL with reference to the PWD/ SOB Bench mark (BM).All RLs to be taken with respect to SOB/ PWD Bench mark available near by the bridge site and location of TBM to be clearly shown on the map.

The sub soil investigation was also carried out for bridge design. Following salient points were decided for this.

1. The borehole layout plan should be shown in the Digital Topographical survey map in x, y, z Co-ordinate.
2. Conduct sub-soil investigation work using 100mm exploratory boring for SPT test and soil sample collection.
3. For each bore-hole, minimum depth of boring shall be 20.0m, if poor quality soil encountered (say SPT value<20) the depth shall be extended upto 30.0m nor more.
4. Normally SPT is taken @ 1.50m interval, but SPT must be taken @ 1.0m interval upto top 6.0m depth.

5. If clayey soil encountered at any depth during boring, undisturbed soil samples must be collected with the help Shelby tubes.
6. Following laboratory test have been carried out :
   a) Unconfined compression for cohesive soil (C)
   b) Direct shear (φ)

5.2 Topographical Survey

The study approach includes collecting and analyzing information on topographic, cross section and longitudinal survey data, present scenario of the road. Basic idea of survey area for the whole project is defined as follows:

- The corridor of topographic survey measured 150m in average 75m left and 75m right from route center line.
- Special survey conducted for Bridge, Chhara/Canal/Khal and River

Study Area of selected road route alignment are presented in following

Datum Height and Coordinates

The horizontal and vertical control network derived from National Benchmark of Survey of Bangladesh (SOB). UTM Grid zone 46 used for horizontal datum or coordinate system. Mean Sea level MSL was used for vertical datum. The survey parameters are as follows:

Latitude of natural origin	0°
Central Meridian	93°
Scale factor	0.9996
False Easting	500000m
False Northing	0m
Linear Unit Metter	1m

Bench Mark Establishment

Primary benchmarks, secondary benchmarks points and associate/reference points set as suitable location along with the alignment.

Static GPS Survey

Static GPS survey designed considering the satellite position and availability on particular day and time. 2(two) nos. of Trimble 5700 GNSS Receiver, 1 (one) nos. of Trimble R9 GNSS permanent receiver (Chittagong Cantonment Officers Mess, Top of the Uttarayan Building) was used for establishment for this static survey. Observation time is depending on number of satellite and length of baseline. As 3 no of primary benchmarks established within 114.717 km for the feasibility survey works; with presence of 10 to 15 numbers of satellites, 1.5 hour observation in each control point is sufficient but for more confidence & safety, the observation has to be taken more than 1.45 hour.Three receivers used for establishing a single BM. The receiver states are given below.

a) SoB Chittagong Station (Permanent GNSS) used for reference Point. (Known)
b) R5700 receiver setup on SoB BM Pillarused as reference Point (Known)
c) R5700receiver setup on BM 01, 02, 03 used astarget Point (unknown)

Equipment and Software

Following equipment's was deployed for the static survey works:
RTK GPS (High Frequency GPS):

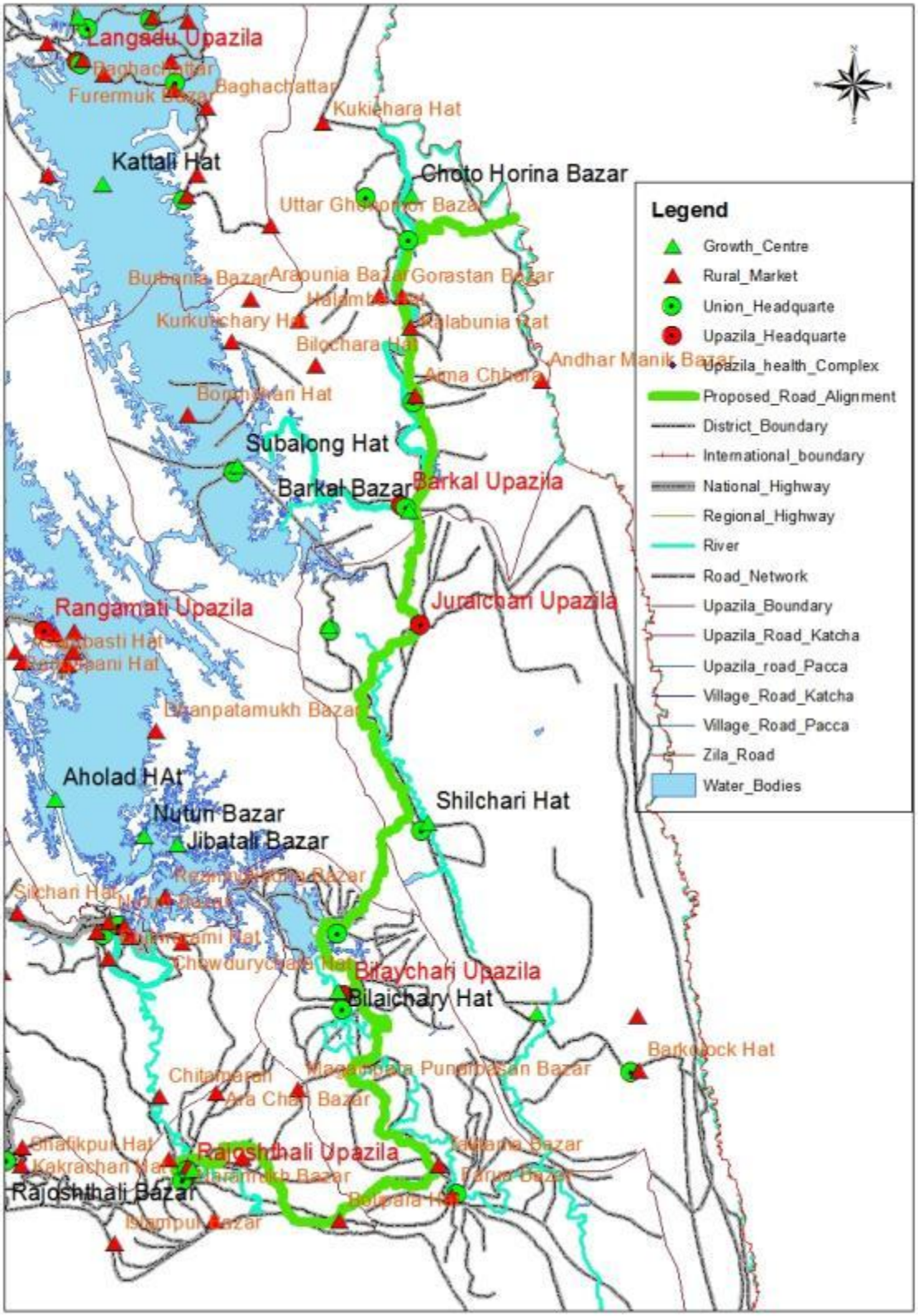


Figure 5.2 : Location Map of Proposed Road Route Alignment from Rajoshthali to Thegamukh

i) Trimble R9 GNSS (Chittagong reference station of SoB)

ii) Trimble 5700 GNSS (SL # 017561032263A6)
iii) Trimble 5700 GNSS (SL # 017561032263A6)

The following software was used for network adjustment
Data Processing Software: Trimble Business Centre 2.4 used for post processing
Network Adjustment Method: Least Square Adjustment

Equipment and Software
Following equipment's was deployed for the Topo survey works:

i) Leica TS 09 (SL # 1302071)
ii) Leica TS 06 (SL# 1360880)
iii) Leica TS 06 (SL# 1369139)
iv) Optical Level

Vertical Control Setup (Levelling Work)
Vertical control or level transfer to all primary and secondary control points double run using optical level from SOB BM.

Topographic Detail Survey (Planimetric)
Detail planimetric survey carried out using Total station and the measurement method by Radial Tachometric method.
The following mapping objects (but not limited) was recorded during topographic detail survey i.e.:

i. Edge of the road
ii. Ditch/Chhara/River
iii. Road components and Road furniture
iv. Boundaries of properties as indicated by existing landmarks or land use along the road. The name of the specific building also recorded such as office, market, hospital post office, mosque, church etc.
v. Building, shed, commercial etc
vi. Bridge, culvert, river, drainage, chharaetc

During survey a log sheet maintained to keep note of every object points and activities for further data processing and reference.

Cross Section & Longitudinal Profile
Cross section measurements
Cross section measurement performed at every interval of 100m along the centerline and at 5m intervals along cross section; with greater detail over all accessible position. The cross section survey performed by using total station and level device.

Long sections
The ground elevation of center line at every interval of 25m along the centerline measured to derive a long sectional profile.

Data Processing
Survey data collected at field at string of followings:

Point, easting, northing, elevation, point description/code, specialized survey software Trimble's Terramodel and Eagle points used to created AutoCAD 2D/3D mapping and prepare cross section and long sections as per specification.

Topographic Survey of Alignment Corridor

Accessibility and Limitations

The study area is hardly accessible and unsecured and is a restricted area also. It does not have motor able roads in any form. The topographical survey is very difficult and cumbersome. The physical features of all the land routes are rolling hills with limited plains, full of vegetation with some forests. People use waterway and foot trails to reach their settlements. Kaptai Lake is spreaded over the tributaries and small streams/ chharas. The water area is in the deep forests in upstream of the kaptai Dam, most of the area is mountainous valley with combination of hills.

Data collection

The survey team equipped with hand held GPS, camera and sketching accessories travelled physically all the proposed alignments.

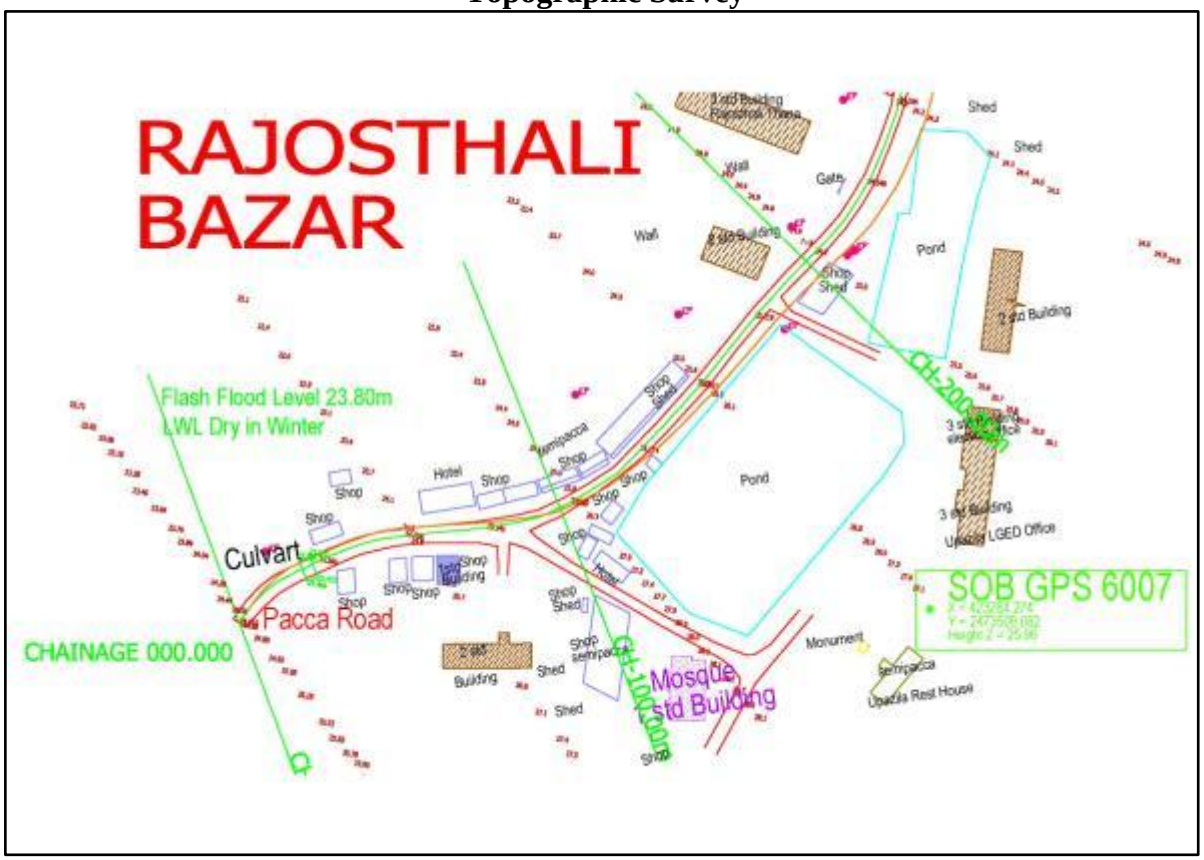
The surveyor collected the coordinated of road alignment by Total Station and records all possible important features like existing road width, existing bridge culverts, rivers,lakes ponds, chharas, hills, house, shed and important landmarks within the survey strips (150m).

1. The following observations are noticed during the topographic survey
    - I. Photographic identification information
    - II. Survey point coordinates recorded by Total Station
    - III. The land topography/ terrain of proposed route
    - IV. Edge of the road, Fence, Brick wall, Fence, Islands etc
    - V. Ditch, Pond, Chhara, River etc
    - VI. Electric Poles, Road components an Road Furniture'setc
    - VII. Boundaries of properties as indicated by existing landmarks or land use along the road such as fence, wall etc. The name of the specific building also recorded such as Office, market, hospital post office, mosque, church etc.
    - VIII. Building, Shed, Shop, Mosque, Temple, School, Madrashaetc
    - IX. Bridge, Culvert, Drainage etc
    - X. Accessibility of survey crew and inconvenience of survey works
    - XI. Fixed the locations of benchmarks and control points

Topographic Survey: The details measurement of Road Route Alignment corridor from Rajoshthali to Thegamukh as per survey corridor specification. All natural and manmade features within the survey corridor were measured accurately.

Detail topographic survey was conducted total length 114.717km from Rajoshthali to Thegamukh. A sample picture and drawing of topographic survey is given in following figure

Topographic Survey



Topographic survey map of road route alignment-01

Benchmarks (BM) /Control Point Establishment:

Some benchmarks along road route alignment were stablished. These are Primary Benchmark (PBM), Secondary Benchmark (SBM)and Temporary Benchmark (TBM). All survey activities of the project were carried out based on these benchmarks. In case of the location of the benchmark is concrete or hard surface, and then a survey nail is installed as a benchmark along

with appropriate marking. A sample picture of primary and secondary benchmarks are presented in following

Primary Benchmark at Barkal

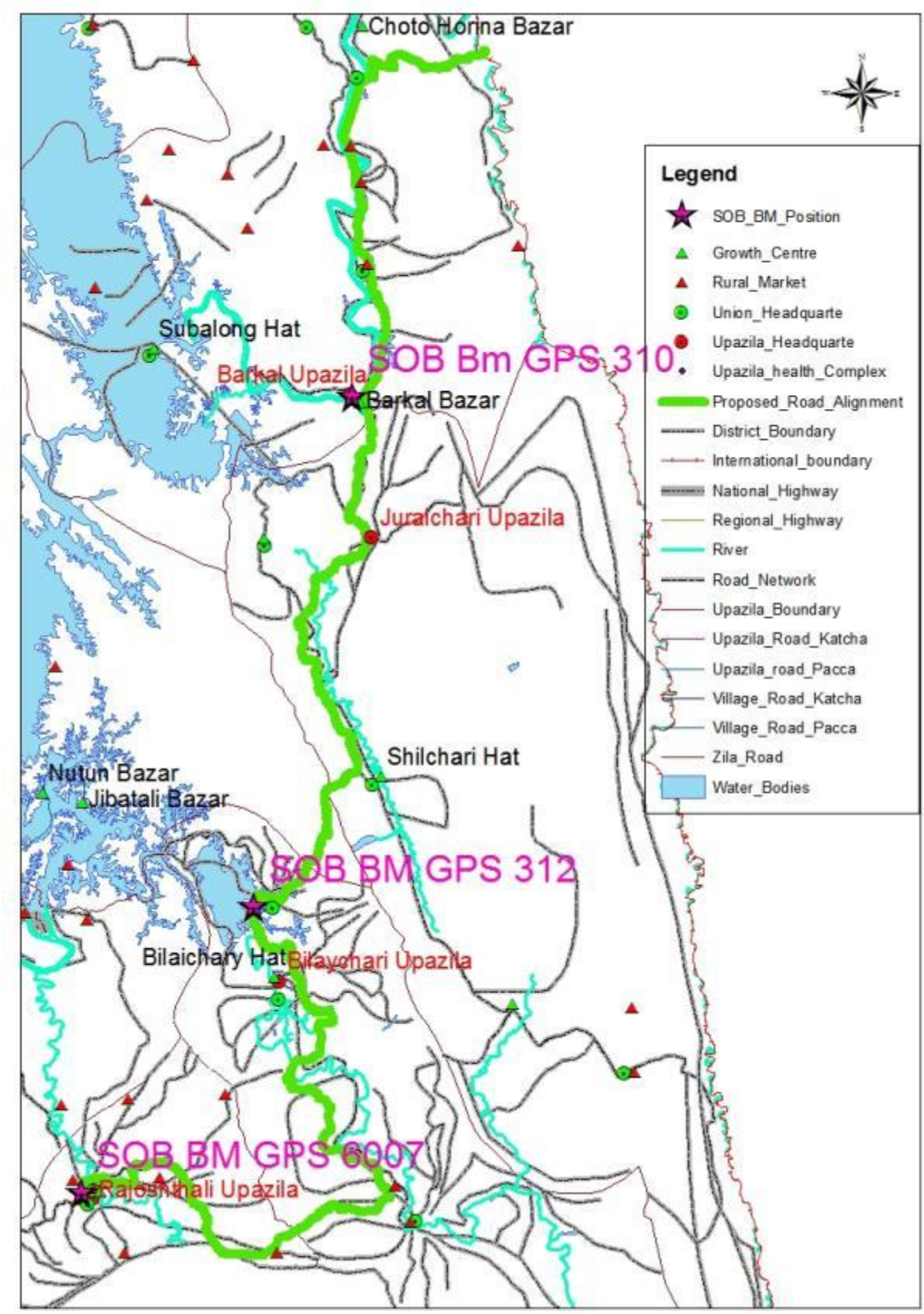
Secondary Benchmark

List of traverse points and Bench Marks for Road and Multimodal Alignment are given in Annexures 5.2

Horizontal Control Point Measurement

Identification of Reference/Datum Point

For the static GPS survey, Survey team used the SOB BM-GPS 6007, GPS 312, GPS 310 and SOB Chittagong reference point (top of the building) as reference points.The most important part of this survey to select the reference points that it has to give 15^{o} (fifteen degree) angle clear sky above and away from any element that interrupts electro-magnetic wave transmission, e.g. high-voltage electric tower. Detail of the reference points as shown in following Map-



SOB BM Reference Points

Table 5.2: SOB Benchmarks description

ID	Height m.MSL	Easting (m)	Northing (m)	Location	Description
GPS 6007	25.96	92°15'17.53"	22°21'56.96"	Rajoshthali, Rangamati	The pillar is situated at 50 feet south from Rajoshthali UpazilaBhoban and 15 feet north from Dhakbanglow
GPS 312	39.89	92°20'14.66670"	22°29'39.75676"	Bilaichari, Rangamati	The pillar is situated at BilaichariUpazilla compound. It is about 100m south from U.N.O's residence & south of Bilaichari Bazar.
GPS 310	32.84	92°23'02.61267"	22°43'24.23920"	Barkal,Rangamati	The pillar is situated north side of Karnafuly river. It is east of B.D.R camp and west of Family Planing Health Complex.
SOB GNSS		91°48'10.84914"	22°24'48.76380"	SOB Chittagong Station	Chittagong Cantonment Officers Mess, Top of the Uttarayan Building

*** mPWD = mMSL + 46 cm*

GPS Static Survey

After completing Primary Benchmarks (PBM) installation static survey works has beencompleted within January, 2016 with three SOB reference points. These are located at Rajoshthali (GPS 6007), Biliachhari (GPS 312), Barkal (GPS 310) and Chittagong reference station (GNSS point, Chittagong Cantonment Officers Mess, Top of the Uttarayan Building)).Static GPS Survey designed considering the satellite position and availability on particular day and time. 2(two) nos of Trimble R-5700 GNSS and SOB at Chittagong reference station (SOB Building Top), With presence of at least 10 numbers of satellites, 1 hour observation in each control point is sufficient but for more confidence & safety, the observation has been taken more than 1.45 hour. Static GPS Survey picture are presented in following

Bangalhalia

Rjoshthali SOB BM GPS 6007

Bilaichhari SOB BM GPS 312

Bilaichhari

Barkal SOB BM GPS 310

Barkal

Cross Section and Longitudinal Section Measurement

Cross Section Measurement

Cross section measurement performed at every interval 100m along the centerline and at 5m intervals along cross section line with greater detail. The width of the cross section 150 m depends on the location of the centerline. The detailed measurements on cross section survey performed by using Total Station which maintain same accuracy/quality. Near about 1400 cross section along the alignment, each and every Chhara/River location cross section has taken across the Chhara/River. With the help of cross sections and longitudinal sections the highway design has been carried out with the MXRoad software. The Plan and Profile of designed highway and road portiona of Multimodal is presented in Volume III.

5.3 Geotechnical and Material Investigations for Roads

Ground investigation is a predominant feature in designing foundation of important structure in an intelligent, economic and satisfactory way. It provides the necessary information of strength and compressibility characteristics of the sub-soil to the design engineer for selection of Suitable

depth and type of foundation for the proposed structure. The investigation works including execution of 10 (Ten) borings up to31.0m depth from the existing ground level and execution of SPT test, collection of disturbed and undisturbed and bulk samples at specified depth under consideration, record of ground water level etc. All of these items of the field investigation have subsequently been followed by the performance of laboratory tests. The overall field investigation works includes the following sub items of works.

- **Extraction of Disturbed Soil Sample :**

Soil sample in the disturbed state have been extracted from the each 1.0m depth of each boring using split spoon sampler. These soil samples after extraction, have duly been classified in situ, in order to reconstruct a depth wise stratification chart of the each bore hole.

- **Extraction of Undisturbed Soil Sample :**

As both of the physical and the engineering properties of the soil are greatly affected by the disturbance of the soil sample, soil sample in the undisturbed state are generally preferred in collection in order to perform certain laboratory tests which eventually help to evaluate the bearing capacities as well as Geotechnical observations. Undisturbed soils are collected from cohesive strata.

- **Execution of Standard Penetration Test :**

Standard penetration tests were executed at each 1.0m interval in all the bore holes with the simultaneous collection of the disturbed soil samples. The tests were executed by using a split spoon sampler of 50mm outer dia. and 37.5mm inner dia. attached to the lower end of the drilling rod. 63.5 kg hammer was allowed to fall freely from a height of 760mm. The blows of the hammer drove the spoon into the soil up to 450mm. The nos. of blows required for each 150mm of penetration of the spoon was recorded. The number of blows required for last 300mm of penetration of the spoon was entered into the bore chart as being the standard penetration test results.

The standard blow count N_{70} can be computed from the measured N as follows:

$N'_{70} = C_N \times N \times \eta_1 \times \eta_2 \times \eta_3 \times \eta_4$

Where,

C_N= Adjustment for effective overburden pressure p'_o(kPa) computed [Liao and Whitman (1986)] CN= $(\frac{95.76}{p'o})$^0.5

N= Field SPT

η_i = adjustment factors

η_1 =0.79 energy ratio Er/70 for Er=55

η_2= 1.0 for Rod length > 10m

η_2= 0.95 for Rod length, 6-10m

η_2= 0.85 for Rod length, 4-6m

η_2= 0.75 for Rod length, 0-4m

η_3 = 1.0 for sampler correction without liner

η_4= 1.0 bore hole diameter correction for hole diameter of 60-120mm

- **Recording of Ground Water Table:**

After 24 hour completing the field investigations the level of ground water in each of the bore hole has been recorded by a measuring tape and found within a variable depth measured from the existing level of the ground. These are apparent level of ground water formed by the entrapped surface water.

Figure 5.3 shows the locations of bore holes**. Table 5.3** shows Existing ground level &Ground water table (stable) of investigated points

Table 5.3: Depth of Drilling, Existing ground level &Ground water table (stable) of investigated points

BOREHOLE ID	Depth of drilling (m)	Existing ground level (EGL) (m) PWD	Ground water table (GWT) (m)PWD
BH01	12.0	71	Not seen
BH02	15.0	41	38.1
BH03	15.0	34	30.95
BH04	24.0	45	42.5
BH05	15.0	31	28.6
BH06	31.0	33	30.65
BH07	26.0	30	27.05
BH08	15.0	32	29.8
BH09	15.0	35	33.9
BH10	15.0	101	Not seen

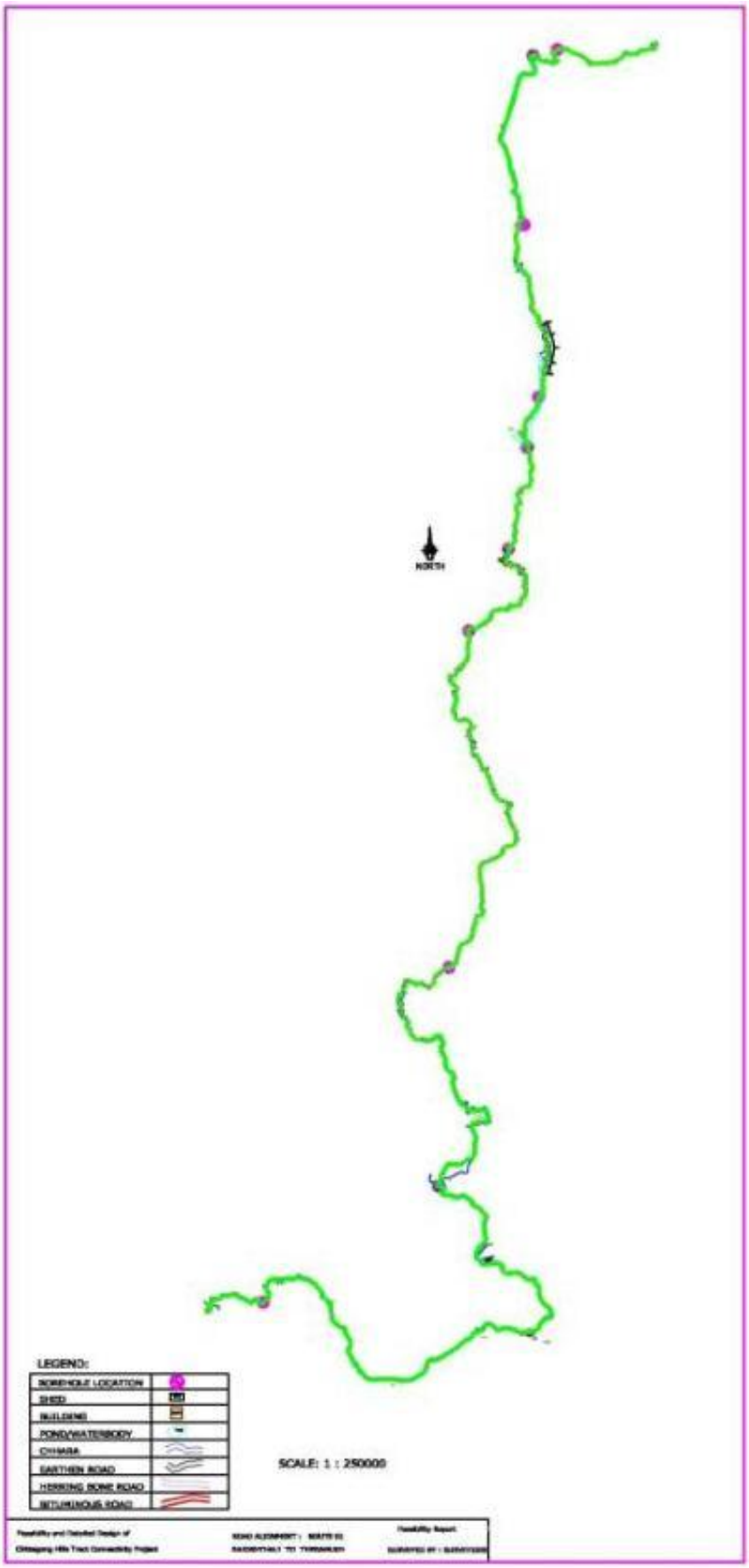


Figure 5.3: Locations of Bore Holes

5.3.1 Laboratory Testing

The following laboratory tests have been conducted on disturbed and undisturbed samples in the laboratory:

i) Grain Size Distribution (Mechanical)
ii) Grain Size Distribution (Hydrometer)
iii) Atterberg Limits (Liquid limit & Plastic limit)
iv) Moisture Content
v) Specific gravity
vi) Density test
vii) Unconfined Compression test
viii) Direct Shear test
ix) CBR test

The overall physical and engineering properties of the subsoil formation of the project area have been evaluated on the basis of 10 (Ten) boring 31.0m depth as per direction of the client.

The plasticity characteristics of the cohesive soils are found low to high and the consistency of the cohesive soils vary from soft to hard. The above classification has been made on the basis of ASTM procedure, according to unified soil classification systems, the cohesive formations fall in ML-CL Group and non-cohesive formations fall in SM Group. The detailed information of bore logs and summary sheet may be consulted in **Annexure 5.3.**

Description of the Geotechnical Units

The characteristics of the geotechnical units described based upon the test borings and the laboratory testing and other observation on site.

Stratification of soil:

The project area mainly comprises plastic CLAY, sandy SILT and silty fine SAND. Subsurface cohesive strata in nature consisting ofsoft to hard, Grey mixed brown to reddish brown low to high plastic CLAY and brown to yellowish brown low plastic sandy SILT. The non-cohesive layers consist of medium dense to dense, yellowish brown silty fine SAND with trace of mica.

Natural moisture content:

Natural moisture content of the investigated soil usually varies from 20% to 64%.

Specific gravity and Density:

Specific gravity of the investigated soil usually varies from 2.56 to 2.77

Atterberg limits:

The liquid limit of the cohesive soil varies from 18% to 46% and the plastic limit of the cohesive soil varies from 15% to 28%.

Shear Strength parameters: The shear strength parameters of various layers are described below:

Cohesion:

As reported from the performance of unconfined compression strength test, the values of cohesion vary from 17.25 kPa to 83.0 kPa.

Angle of internal friction:
As reported from the performance of direct shear test, the values of internal friction angle vary from 2 to 21 degrees. The value of Cohesion vary from 4.0 kPa to 6.0 kPa

5.3.1.1 Observations

On the basis of information available from geotechnical investigation and laboratory test report the allowable bearing capacity of different depths is given in the following **Table 5.3.1.1**

Table 5.3.1.1: Recommended allowable loads for 450mm and 600 mm diameter bored cast-in-situ pile

BH No.	Pile Penetration Depth (m)	Pile diameter (mm)	Pile Type	Compression Capacity (kN/pile)	Tension Capacity (kN/pile)
BH01	12.0	450	Bored pile	225.56	79.24
BH02	12.0	450	Bored pile	195.40	49.08
BH03	12.0	450	Bored pile	356.41	221.26
BH04	24.0	450	Bored pile	433.67	280.77
BH05	10.0	450	Bored pile	443.18	295.14
BH06	30.0	450	Bored pile	313.11	216.22
BH07	25.0	450	Bored pile	499.12	187.39
BH08	15.0	450	Bored pile	292.01	146.96
BH09	15.0	450	Bored pile	294.07	124.84
BH10	15.0	450	Bored pile	296.43	124.24
BH01	12.0	600	Bored pile	401.00	140.88
BH02	12.0	600	Bored pile	347.37	87.25
BH03	12.0	600	Bored pile	633.62	393.36
BH04	24.0	600	Bored pile	770.97	499.15
BH05	10.0	600	Bored pile	787.88	524.69
BH06	30.0	600	Bored pile	536.35	384.40
BH07	25.0	600	Bored pile	887.32	333.14
BH08	15.0	600	Bored pile	519.13	261.26
BH09	15.0	600	Bored pile	552.78	221.93
BH10	15.0	600	Bored pile	526.99	220.88

***Note**: Pile bearing capacity calculated according to BNBC-2012, by the use of static bearing capacity equations, 3.10.1.10 article.*

5.3.2 Interpretation of Test Result

1. The subsurface of the project area consists of three geological units. The top **Alluvium Formation** consisting of grey mixed brown to grey , very soft to soft, low to medium plastic unconsolidated silty Clay, Silt and fine Sand of Holocene/Recent age. Generally the thickness of this unit ranges between 0.0m to 14.0 m, in an average 6.0 m. The DihingSandstone / Siltstone Formation consist of moderately consolidated low to medium plastic yellowish brown highly oxidized Silty Clay of Late Piocene age. The thickness of this unit ranges between 0.0m to 19m with average thickness of about 8.0m. The **DupiTila Sandstone/ Claystone Formation** consists of over consolidated low to highly plastic reddish brown to yellowish brown highly oxidized mottled Silty Clay of Middle Pliocene age. The thickness of this unit ranges between 5.0 m to 31 m with an average thickness of about 9.0 m. The **Tipam Sandstone Formation** consists of yellowish brown to light brown, medium dense to very dense, fine to medium Sand with silt and race of mica of Middle

Miocene. The thickness of this unit ranges between 7.0m to 31.0m with an average thickness of about 8.0m.

2. The top Holocene Alluvium Formation has generally a low bearing capacity. The compaction of this unit is very loose to moderate. The SPT values ranges from 1 to 9 with an average of 3. The Dihing Siltstone / Sandstone Formation is mainly medium stiff to stiff with moderate bearing capacity. The SPT values ranges from 4 to 49 with an average of 21. The DupiTila Claystone/Sandstone Formation is mainly medium stiff to very stiff with moderate to high bearing capacity. The SPT values ranges from 5 to 53 with an average of 27. The Tipam Sandstone Formation is mainly medium dense to very dense. The SPT values ranges from 29 to 43 with an average of 35. This formation is very good for foundation layer; it is less vulnerable during the moderate to high earthquake.
3. According to observation regarding the sub soil condition of the proposed area Pile foundation is recommended, bearing capacity calculation of typical pile 450mm and 600mm foundation is attached in Appendix-4 of Annexure 5.3. The relevant Photographs are presented in Appendix-5 of Annexure 5.3.
4. The design engineer have to decide the type, depth and size of foundation depending on the load and he has to confirm the bearing capacity of the foundation. Hence the analysis may help in decision making.
5. Annexure 5.3 provides following details
   Appendix - 1: Borehole Location Map
   Appendix - 2: Borehole Logs
   Appendix - 3: Geological Profile
   Appendix - 4: Pile Bearing Capacity of Soil
   Appendix - 5: Photographs
6. The summary for results of Laboratory test have been provided in **Table 5.3.2**

Table 5.3.2: Summary for Results of Laboratory Tests

Type of Test														
SL No	Bbore Hole No.	Depth (m)	Moisture Content (%)	Specific gravity as per ASTM-854	Atterberg Limits			Density		Unconfined Compression strength		Direct shear test		CBR (%)
					Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (PI)	Wet Density (gm/cm^3)	Dry Density (gm/cm^3)	qu (kPa)	Cohesion soil (kPa)	Cohesion C (kPa)	Angle internal Friction Φd(deg)	
1	**BH NO-01**	2	19.89	2.67	33	19	14							13
		4	24.01	2.77	38	26	12							
		5	23											
		8	29.08											
2	**BH NO-02**	UD1	1.1											
		2	17.91	2.73										
		4		2.67										
		5	21.33		18	15	3							
		9						2.37	2.04			0	16	
		14						1.17	0.88			0	18	
3	**BH NO-03**	3	15.9	2.67	26	17	10							
		5		2.7										
		6	64		27	16	11							
		10										0	14	
4	**BH NO-04**	1	34.33											8
		2		2.67	35	21	14							
		3	24.54											
		4			33	25	8							
		UD2						1.8	1.32	44.5	22.25			
		8										3	12	
		14										0	21	
5	**BH NO-05**	UD2	32					1.77	1.28	41	21			11
		4	19.35		43	26	20							
		5		2.67										
6	**BH NO-06**	2	40.54	2.69										
		5		2.63	37	21	15							
		UD2						1.77	1.28	39	19.5			

Type of Test														
SL No	Bbore Hole No.	Depth (m)	Moisture Content (%)	Specific gravity as per ASTM-854	Atterberg Limits			Density		Unconfined Compression strength		Direct shear test		CBR (%)
					Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (PI)	Wet Density (gm/cm^3)	Dry Density (gm/cm^3)	qu (kPa)	Cohesion soil (kPa)	Cohesion C (kPa)	Angle internal Friction Φd(deg)	
		11										6	2	
		16	20.2		28	21	7							
		20										4	8	
		24										4	8	
		27			28	17	11							
		30	20.99											
7	**BH NO-07**	3	16.07											9.5
		8	22.7		28	17	10							
		12		2.63										
		UD1	25		40	16	24	1.97	1.58	166	83			
		17		2.63										
		22										6	6	
8	**BH NO-08**	UD1	21.61		29	20	9	2	1.64	73	36.5			
		6										6	6	
		10	21.59	2.56								4	6	
		15			46	28	18							
9	**BH NO-09**	1	28.69											
		UD1	35.18		31	21	10			34.5	17.25			
		3	33.62	2.69										
		4		2.64										
		5			32	18	14							
		UD1			31	21	10	1.85	1.37	34.5	17.3			
		10		2.65										
		12	29.63											
10	**BH NO-10**	1	18.31	2.65	41	27	15							10
		2	21.45	2.64										

5.4 Hydrological and Hydrographic Investigation:

The Karnafuli is a meandering river. During rainy season water level rises sharply facilitating plying of all types of vessels like passenger and cargo traffic. Sometimes damages the local cultivated crops. Though the river is a meandering one it does not create any problem of heavy erosion and siltation like other inland rivers the Padma, the Jamuna& the Meghnaetc. Which creates navigational hazards forming enormous shoals in their way to Bay of Bengal.

Water Level & Flow:

As per hydrographic survey, the water levels are found as below:

Highest water level of Kaptai reservoir is 33.69 m PWD and lowest water level is 23.63 m PWD from the graph of water level (**Fig 5.4 A and 5.4 B**) it is seen that water level dropped drastically in the month of April & May of 1998.Dredge Volumes for Multimodal RouteNo-1 is shown in **Annexure- 5.4** . Flow of the river is Karnafuli regulated by the barrage. Its flow is not directly connected to the sea. When upstream water level is high due to continuous rainfall and about to inundate the crops & households, the water is disposed off by opening the spillway of the barrage. If needed water is also disposed off by diversion tunnel.

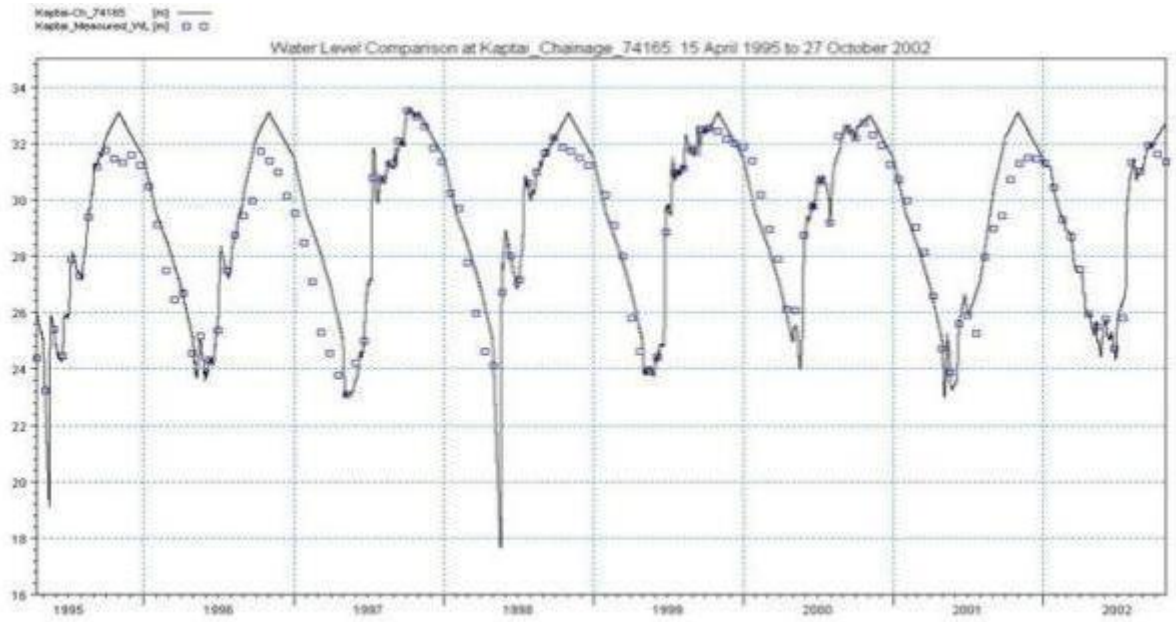


Figure 5.4 A: Graph of Water Levls in Kaptai Lake (1995 – 2002)

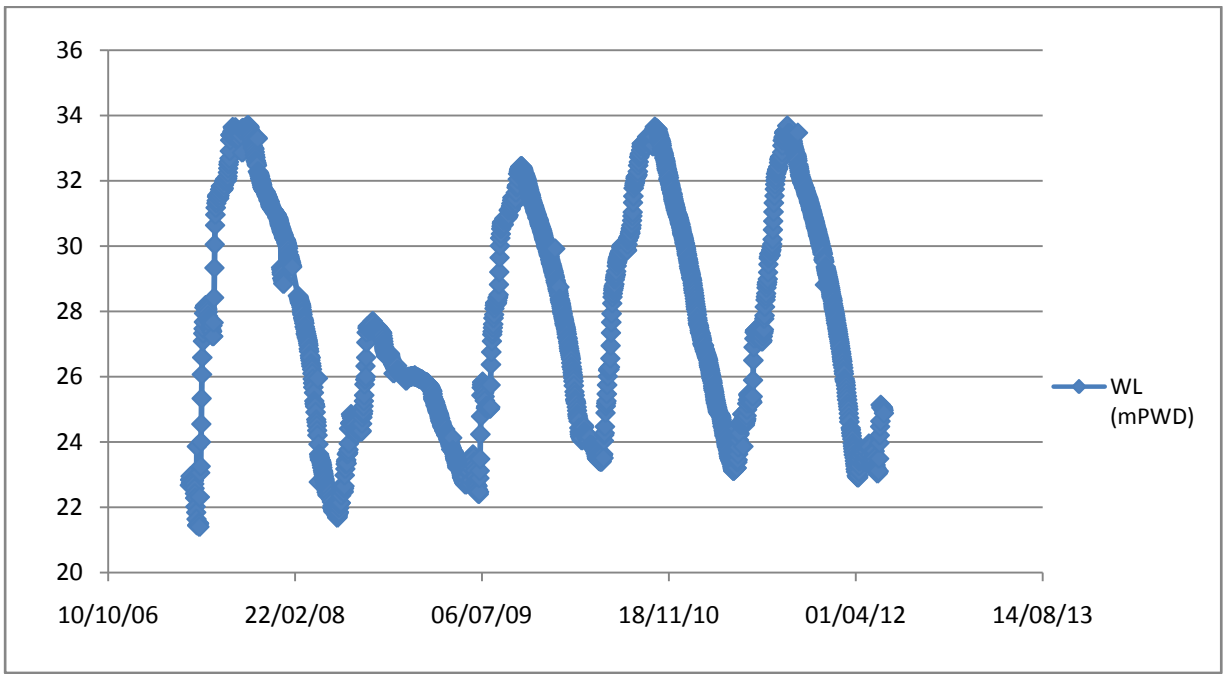
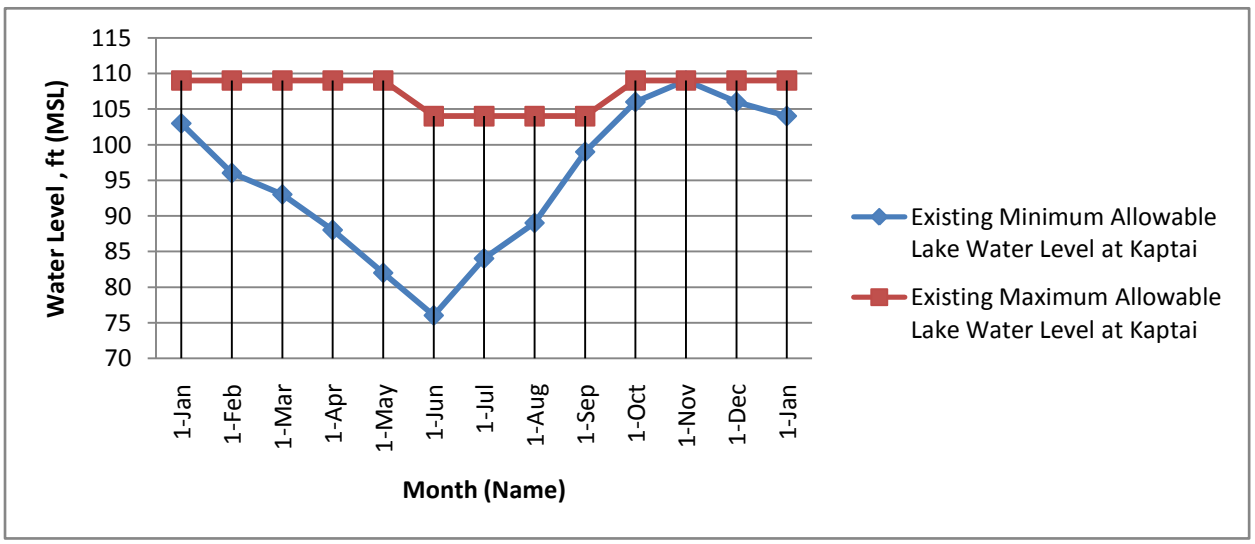


Figure 5.4 B: Graph of Water Levels in Kaptai Lake (2008 – 2012)

Operation policy of Kaptai reservoir is appended below:

The Reservoir is operated under a policy guided by a set of two rule curves. The upper rule curve gives the maximum allowable water level at the dam site. It is set at 33.23 m, MSL (109 ft, MSL) with a minimum flood cushioning between June and October of 1.52m (5 ft). The upper rule curve is the constraint to be maintained to ensure the safety of the dam. The lower rule curve has been constructed to maximize the power generation with the available water resources with 5 units. This rule curve allows storage of water during the months from June to October. The stored water is then utilized in the dry season for power generation. The lower rule curve varies from the lowest level of 23.17 m, MSL (76 ft, MSL) on the first day of June to maximum level of 33.23 m, MSL (109 ft, MSL) on the first day of November



Source: *Hydroelectric Power Plant atKaptai.*

- **Erosion:**

It is seen that from records of 2008-2011, no case of erosion was observed in this river. No storm occurredduring 2008-2011 (source Bangladesh meteorological Department).

- **Siltation & Re-siltation:**

The river is embraced by small hills & high lands. So its flow remains in the same path for years together. The river is assumed to be stable. It was not maintained any time by dredging or other river training works from its very creation. During the visit of SAI Expert team on 2.10.2015 in the month of October which is high water period, we observed the flowing water almost clean. Siltation is not prominent. Since dredging was not done previously, there is no previous record of re-siltation. So rate of re-siltation is not being possible to be reviewed and used for this assessment.

- **Rainfall / Precipitation**

It is seen from above statistics of 2008-2011 of Rangamati hill tract district that Annual rainfall varies from 1824 mm to 2535 mm/Annam

- **Temperature & Humidity:**

Temperature varies from 11.5 ºc – 36.2 ºc and humidity varies from 62.8 % to 76 %.

- **River bed material sampling**

The River bed material sampling analysis was done at Suvalong and Barkalof the river bed.The particle dia range and Locations of soil samples are given in the following **Table-5.4.A& 5.4 B**

Table 5.4A Particle dia Range

Class	Particle dia Range
Clay	<0.002 mm
Silt	0.002 mm to 0.06 mm
Sand	0.06 mm to 2 mm

Table 5.4B Locations of soil samples

Serial no.	Sample ID	From		River
		Latitude	Longitude	
1	SHU2015_01	22°44’25.183”	92°16’14.659”	Kasalong
2	BOR 2015_02	22°48’55.860”	92°23’31.035	Karnafuli

- **Hydrographic Chart:**

From the hydrographic chart it can be seen that the cross section of Kaptai Lake (Ch 33.00 – Ch 227.00) & Cross section at Karnafuly River (Ch 65.45 km – 68.75 km). (**Figure 5.4 C and 5.4 D**). The typical longitudinal profile is also drawn along the Thalweg from Kaptai to Chottohorina in **Figure 5.4 E**

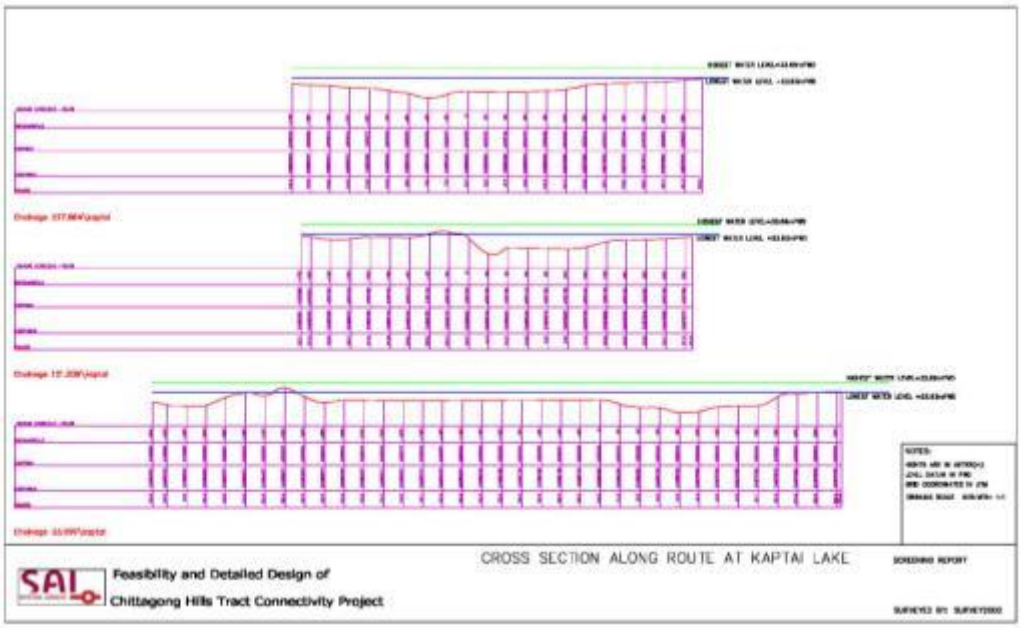


Figure 5.4 C: Typical Cross section at kaptai Lake (Ch 33.00 ~ Ch227.00)

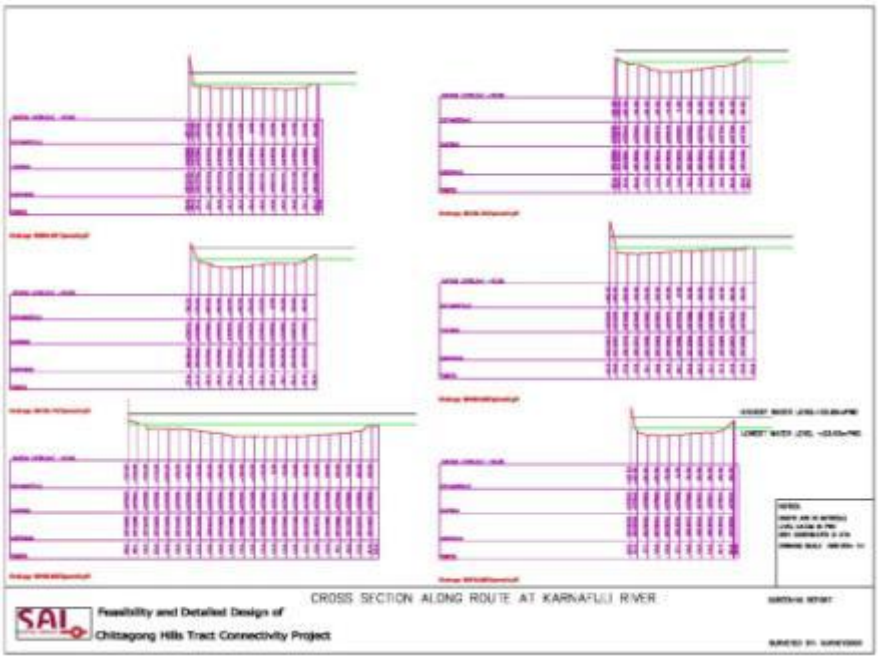


Figure 5.4 D: Typical Cross section at Karnafuly river (Ch 65.45km~Ch 68.75km)

Figure 5.4 E: Typical Longitudinal Profile in Kaptai Lake

5.5 Facilities Associated with Construction of Routes

5.5.1 Availability of construction material

Construction material such as Silty Soil/Soil for Sub-grade, Fine Sand/Sand, Bricks/Bricks aggregates, Stone/Stone aggregate, Bitumen, Road Marker Paint, Coarse Sand, Cement, and Reinforcement etc will be used for the proposed alignment. The availability of borrow and quarry sites are as follows:

5.5.1.1 Quarry Sites

Suitable sources for quarry sites have been identified along the project by local enquiry. However, Survey agency has carried out tests on selected sources to find their suitability for use. Sufficient number of quarries have been identified to verify availability of materials. The information on the materials sources was summarized in Geological Profile in Chapter 5 with the following number of quarries for stone, sand, gravel and quarry areas for the project area. The top Alluvium Formation consisting of plastic unconsolidated silty Clay, Silt and fine Sand of Holocene/Recent age. Generally the thickness of this unit ranges between 0.0m to 14.0m, in an average 6.0m. The **Dihing Sandstone/ Siltstone Formation** consists of moderately consolidated low to medium plastic Silty Clay of Late Pliocene age. The thickness of this unit ranges between 0.0m to 19.0m with an average thickness of about 8.0m.

Borrow and Quarry sites location maps are presented in following **Figure 5.5.1.1**

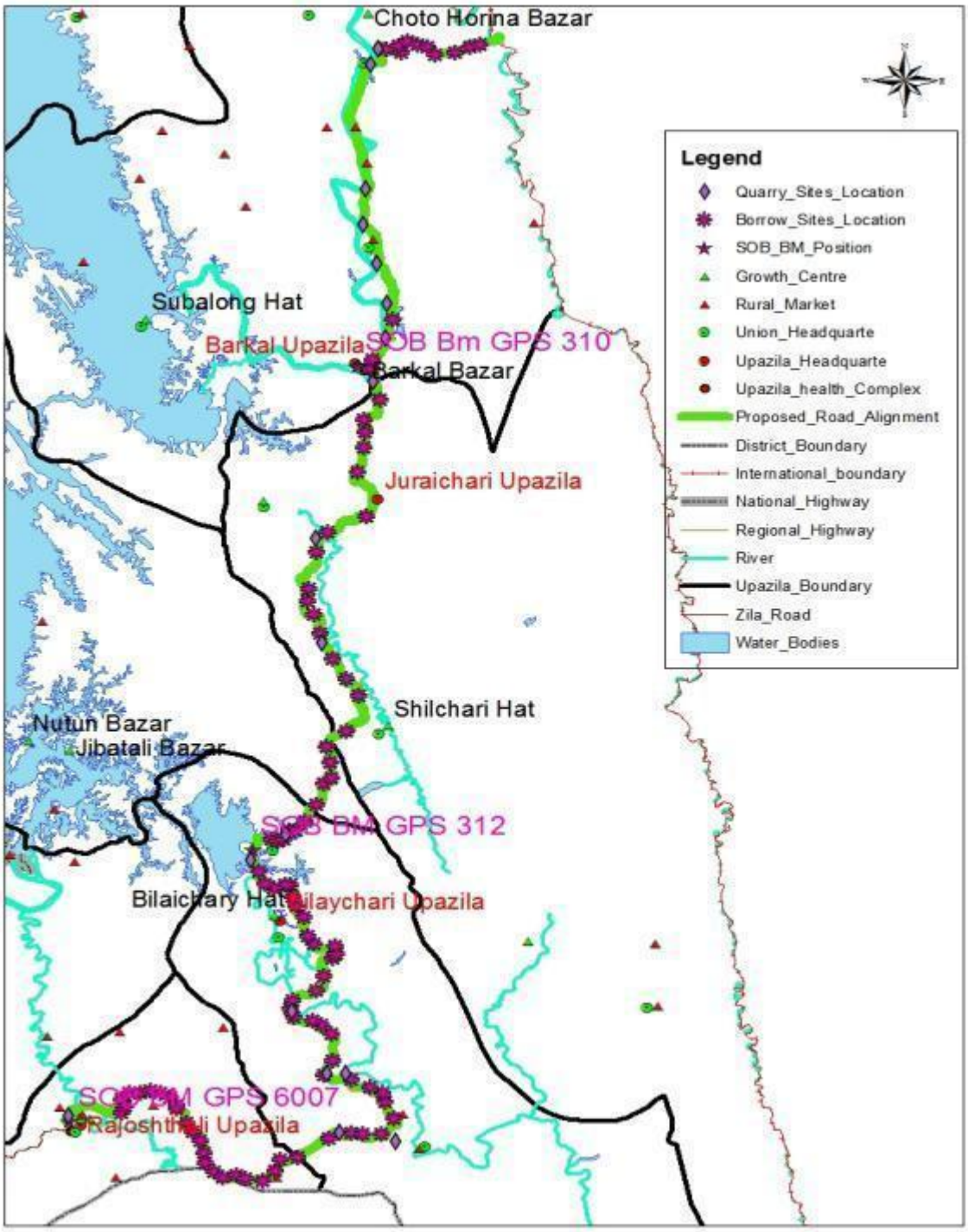


Figure 5.5.1.1:Possible Location Map of Borrow and Quarry Sites for Road Route

5.5.1.2 Borrow Sites

For the proposed route alignment borrow siteshas been identifiedwith material (soil, sand, stone, etc.) along with the alignment for use at other location.Only for soil and sand borrow siteswas found close to many location along the alignment. Soiland sand might be excavated to cut and fill for this project road route alignment. There is a need to provide acceptable resources to implement and maintain the environmental and safety management system including with labor and materials. For minimizing the amount of construction labor borrow sites location identified near to the alignment. Borrow sites location maps are presented in following **Figure 5.5.1.1**

5.5.1.3 Surveys of Construction Material

Table 5.5.1.3: List of Construction Materials & Sources

Route: 1			
Sl.N0	**Name of Construction Materials**	**Source**	**Remarks**
1	Silty Soil for Sub-grade	Rajoshthali, Farua, Bilaichari, Barkal, Chhotohorina. (Maximum area along with the alignment)	Available
2	Fine Sand (0.5 FM.) for ISG, Sub-base, etc.	Rajoshthali, Farua, Bilaichari, Barkal, Chhotohorina (Selected location along with the alignment up to Chhotohorina)	Available
3	Bricks/Bricksaggregates	Rangunia, Raowzan, Chhittagong	Available
4	Stone/Stone aggregate	Chittagong, Sylhet	Depends on volume of materials
5	Bitumen	Chittagong	Available
6	Road Marker Paint	Rangamati, Chittagong	Available
7	Coarse Sand	Chittagong, Sylhet	Depends on volume of materials
8	Cement	Rangamati, Chittagong	Available
9	Reinforcement	Rangamati, Chittagong	Available
10	Diesel, Petrol	Rangamati, Chittagong	Available

5.5.1.4 Construction Camps and Associated Services

Proper construction camps of the road maintenance provides many advantages to the project area. Construction camp locations based on current plans, this project covered 114.71km (Survey length) of the land-based road route alignment. Main objective to balance the number and location of camps to reduce distance from sources to destination for better and maximum productivity. By locating a camp near the proposed road routethat reduce travel time.

Safety of the workers in the camp and the nearby communities is considerable. Construction team will work with local police/BGB/Army to ensure that they are aware of project update/security and potential activity in the project area. Construction material camps location and associated services maps are presented in following **Figure 5.5.1.4**

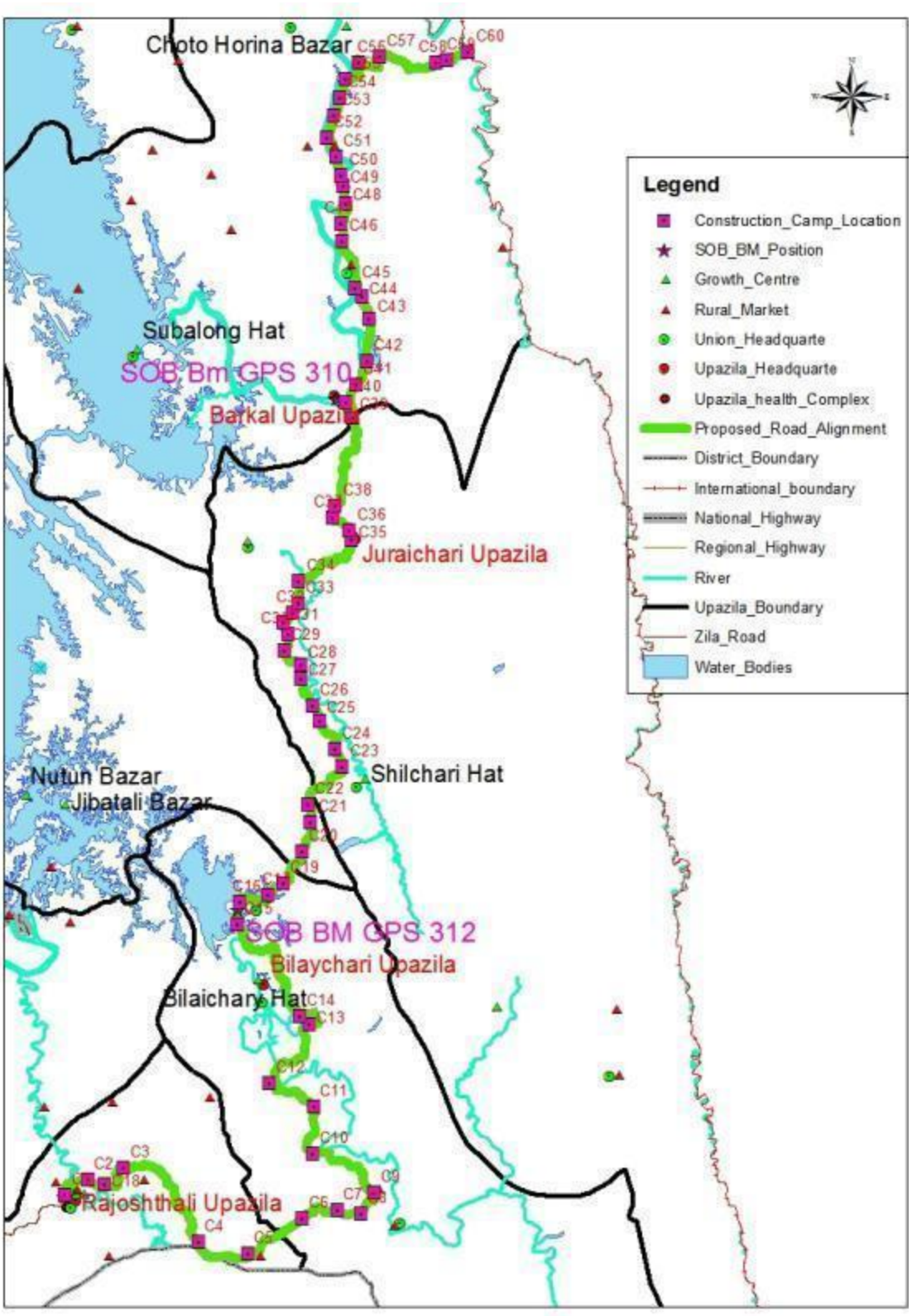


Figure 5.5.1.4: Possible Location Map of Construction Camps for Road Route

5.5.2 Soil and Dredged Material Disposal

Dredging Period

The dredging works can be started in early January when average water level is about +30 m.MSL and can be continued up to June. But early flash flood and monsoon may cause disruption of works in the months of March to June. Special measures are required to secure the dredgers and other equipment in these periods. On an average one month's work disruption may be estimated. As such, total of 5 (five) months working period would be available for each year's dredging in between January to June.

Dredge Material Management

The both banks along the dredging length of Karnafuli River and Kaptai Lake have been examined and found that the river banks are mostly flat in the fringe. At present only one crop of rice is being cultivated on most of the lands. The crop is being grown when the land is clear of water in the dry/low water period. The dredge material if placed on these cultivable lands would be useful for agriculture use.

By placing dredge material on the cultivable land, the height of the land would be raised. Some low lying areas will be filled up that will increase cultivable land. As the dredge material is suitable for agriculture use, this will be highly beneficial to the local farmers. Efforts should be made to fill up low lying areas as much as possible. When this would not be possible, the cultivable land should be raised within 1.0m meter. The dredge material is to be placed minimum 100 m beyond the river bank and within a distance of 1.5 Km. Crop compensation/land compensation to the farmers is to be arranged within the project cost.

Soil and Dredged material Disposal Site Management

The dredge material dumping reaches are selected at least 100 meter (if there is Space) away from bank line. The distance between outermost dredging point and the spoil dumping reach would not be more than 1.5 km. The sides of the dredging reaches should be developed in such a way so that dumped dredge material remains within the spoil reach, do not return back to the river. The low lying lands are preferred for development through spoil dumping. The center co-ordinates of spoil reach is presented in **Table 5.5.2** and location map is shown in **Figure-** (**5.5.2 a, b, c, d and e**). The dumping positions have been shown in the maps. The dimension of dredge material dumping reaches would be located with dimension during implementation of the project. During implementation of the project, the forest department, Kaptai Lake and local stakeholders might be contacted to finalize the dredge material dumping reach. The monitoring and quality control team would take necessary measure.

Table 5.5.2: Location of Centre Point of Proposed Spoil Dumping Zones at Kaptai Lake and Karnafuli River

ID	Easting	Northing
1	418982.585	2505258.510
2	419788.187	2506979.925
3	420756.618	2505618.768
4	422101.363	2507016.420
5	421996.177	2508163.087
6	421618.081	2509864.665
7	421252.912	2510883.921
8	422061.626	2511478.237

ID	Easting	Northing
9	424878.602	2512796.335
10	425277.792	2513517.394
11	426819.557	2514085.237
12	426517.565	2515070.023
13	426999.227	2515651.136
14	428010.735	2515749.670
15	427469.628	2516534.951
16	429150.274	2516669.661
17	429342.379	2517712.054
18	430522.968	2517850.175
19	431295.922	2516563.283
20	431382.215	2514729.955
21	431801.879	2514161.937
22	432135.873	2513360.452
23	433980.178	2513325.172
24	435451.112	2512861.514
25	437392.114	2512526.637
26	437721.549	2512259.868
27	437788.872	2512932.028
28	437635.630	2513712.067
29	437840.409	2514401.249
30	438295.216	2514951.203
31	437945.961	2515930.506
32	437414.814	2516275.948
33	437235.272	2516700.316
34	437311.474	2517437.807
35	437440.276	2518288.463
36	437103.329	2519180.209
37	436799.577	2519837.550
38	436733.476	2520581.253
39	436606.684	2521178.612
40	436033.713	2521900.073
41	436035.790	2522626.094
42	436640.771	2522271.896
43	437149.571	2522455.352
44	437493.722	2522978.840
45	437301.482	2524032.784
46	437587.469	2524325.448
47	437541.761	2524611.069
48	437680.926	2524984.618
49	436755.422	2526050.388
50	437061.800	2527407.135
51	437317.966	2528463.386
52	438165.463	2528985.719
53	437916.078	2529568.443

Location Map of spoil dumping reaches indicative (⊙) Alignment of Multimodal Route

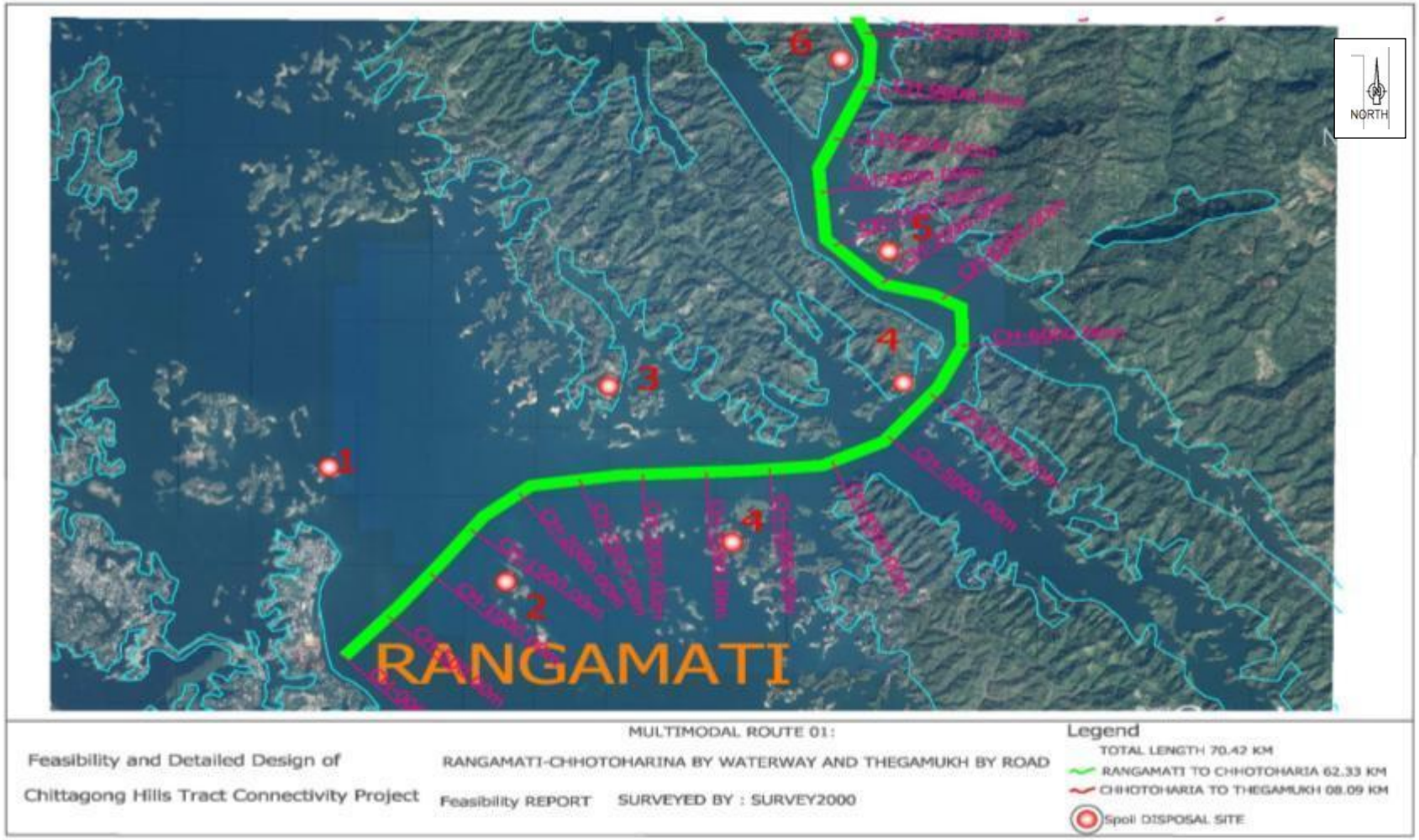


Figure 5.5.2 a: Location Map of Spoil Dumping Zoneof Multimodal Route-01 From Chainage 00.000m to 9500.00m

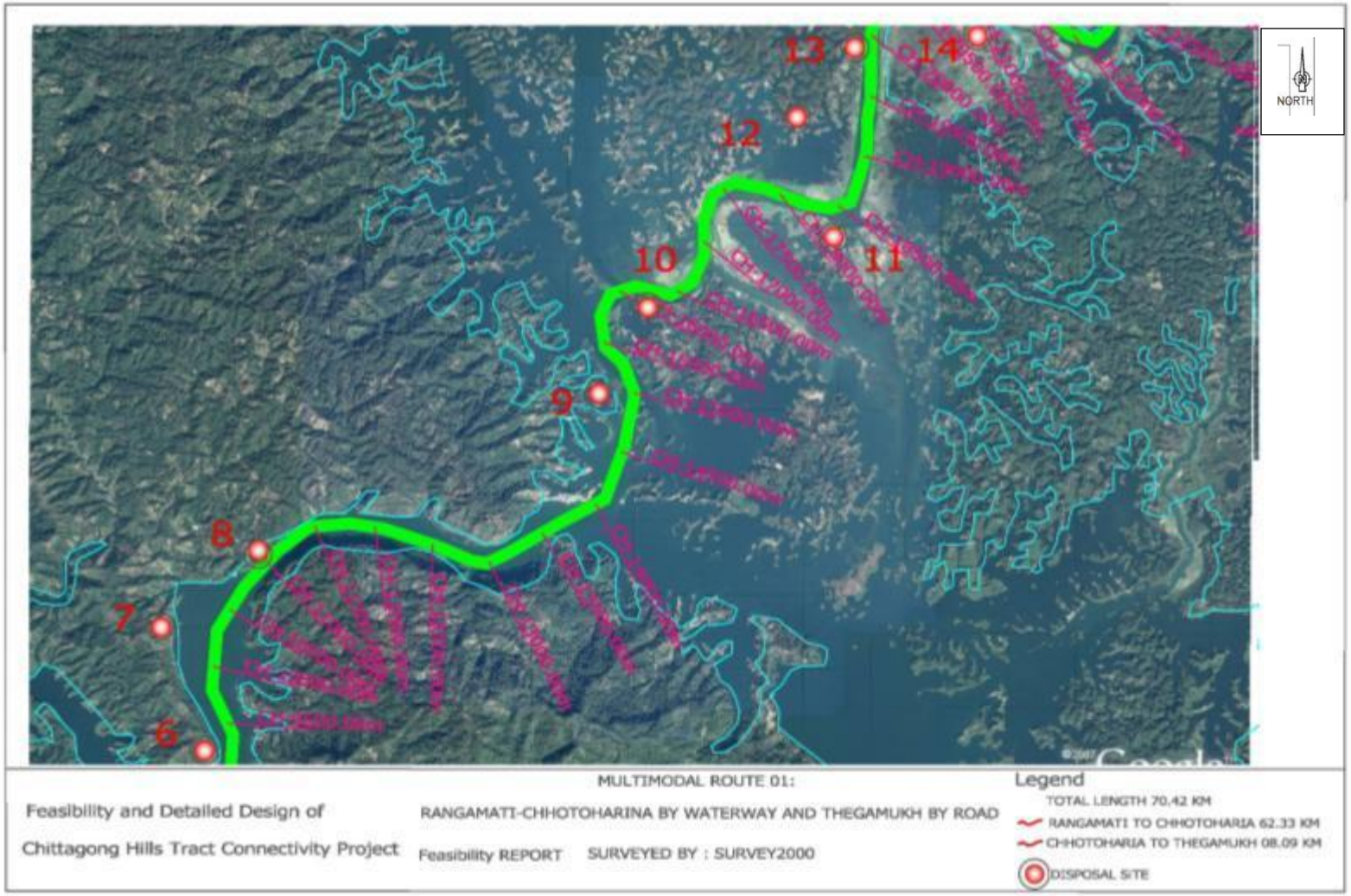


Figure 5.5.2 b: Location Map of Spoil Dumping Zone of Multimodal Route From Chainage From 9500.00m to 20000.00m

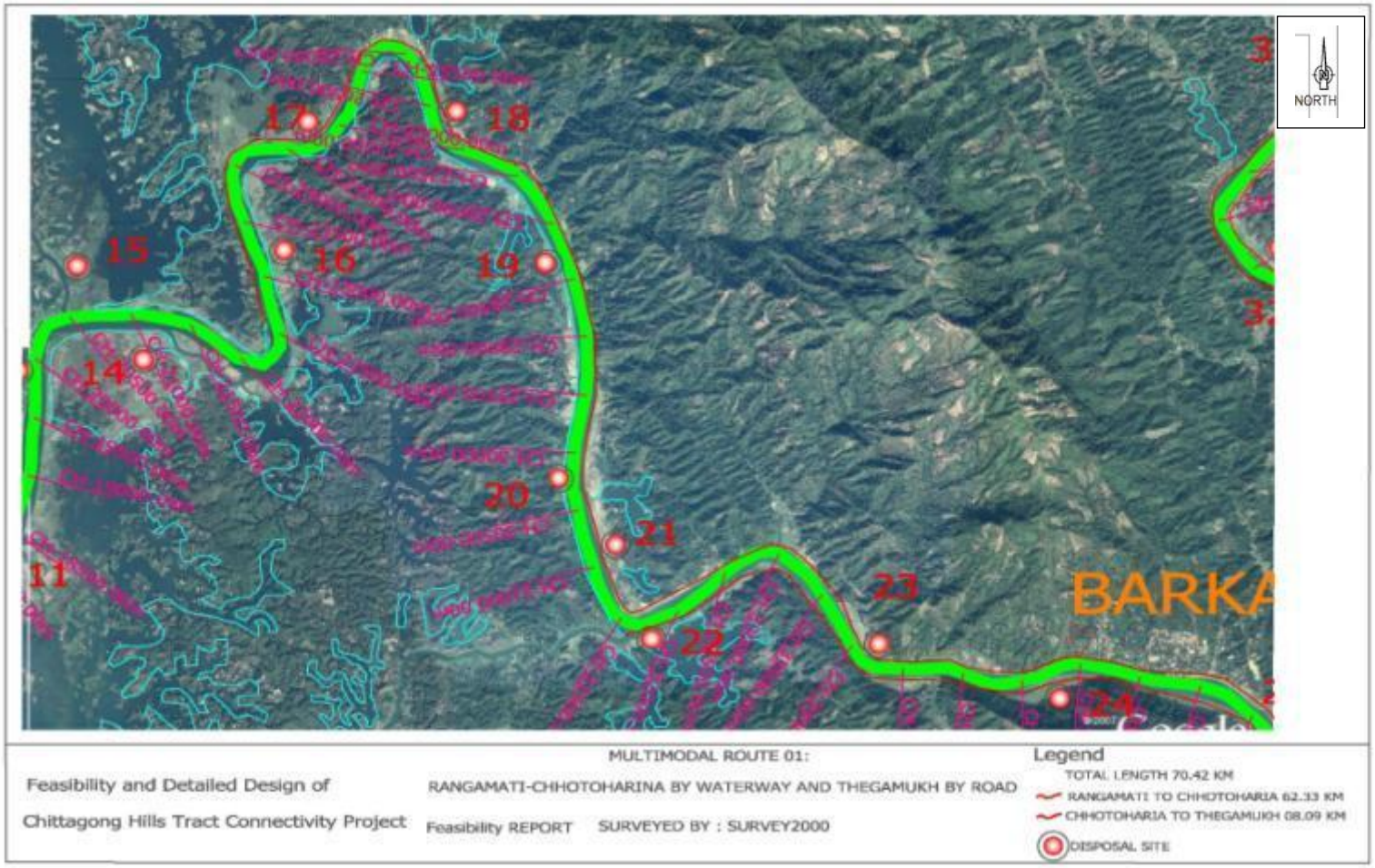


Figure 5.5.2 c: Location Map of Spoil Dumping Zone ofMultimodal Route From Chainage From 20000.00m to 34000.00m

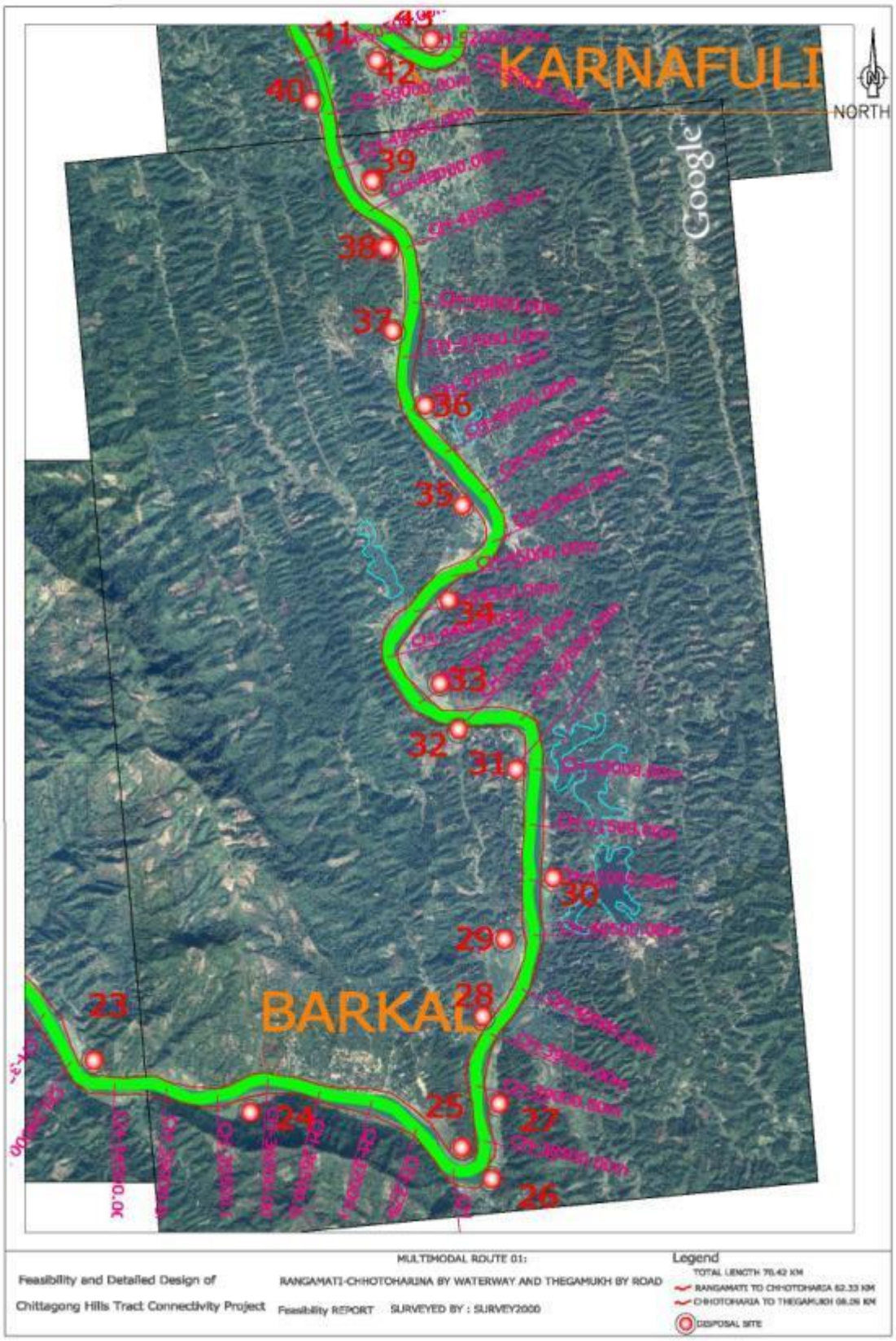


Figure 5.5.2 d: Location Map of Spoil Dumping Zone of Multimodal Route-01 From Chainage 34000.00m to 52500.00m

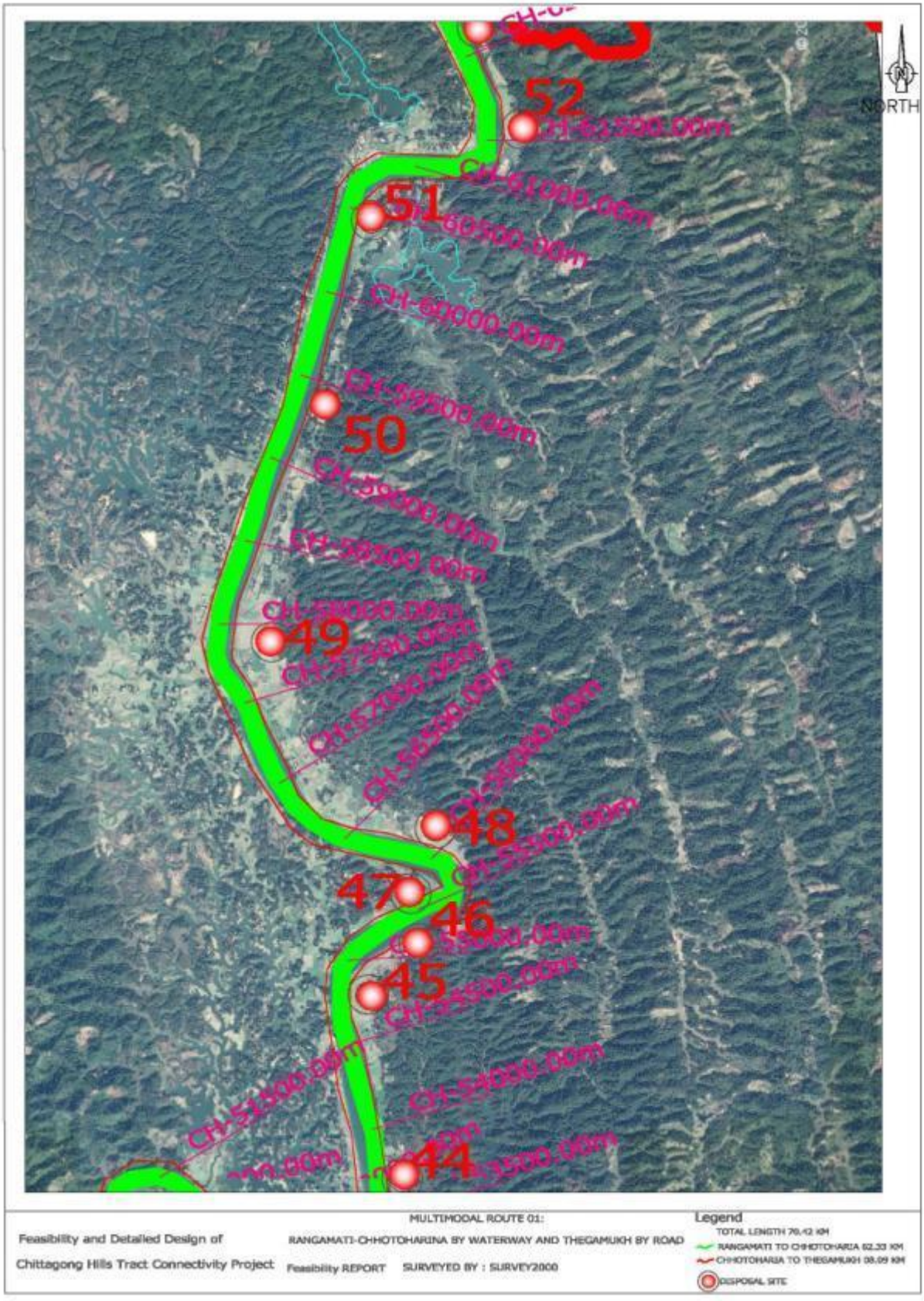


Figure 5.5.2 e: Location Map of Spoil Dumping Multimodal Route From Chainage 52500.00m to 62300.00m

CHAPTER - 6

Improvement Proposals for Proposed Road and Multimodal Routes

CHAPTER - 6

Improvement Proposals for Proposed Road and Multimodal Routes

6. 1 Design of Road Geometrics

6.1.1 Horizontal Alignment

The new road (horizontal) alignment has been designed to follow the existing one as much as possible with minor modifications like easing sharp bends and realigning short sections to connect some structures constructed or under construction and to avoid religious structures like mosques, temple, graveyards, etc. Alignment shifting has also been done to connect proposed bridges. Major deviation has been made at market/built-up areas to avoid demolishing multi storied residential and commercial buildings & structures. The details of horizontal curves used in the design have been given in the drawings.

6.1.2 Vertical Alignment

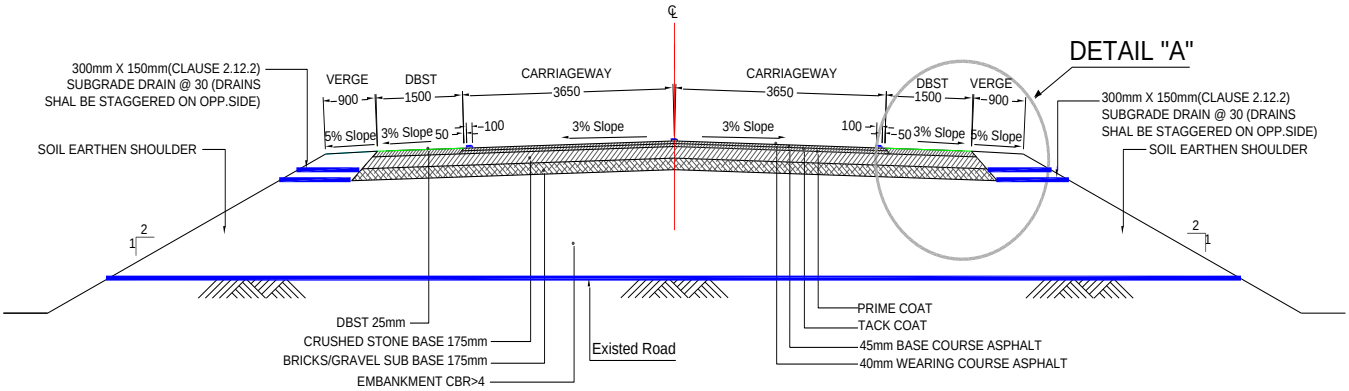
The design level of the sub grade has been fixed with minimum 1.0m above the Design Flood Level based on 30 years return flood as per RHD Standareds. The vertical alignments of the road have been designed for smooth transition. Standared longitudinal gradients have been provided for the road. For connecting the approach roads with design road profile and bridge ends vertical curves have been inserted. Navigational clearances for new Bridge have been provided as per requirements of Bangladesh Inland Water Transport Authority (BIWTA). The details of vertical curves used in the road design have been presented in the drawings.

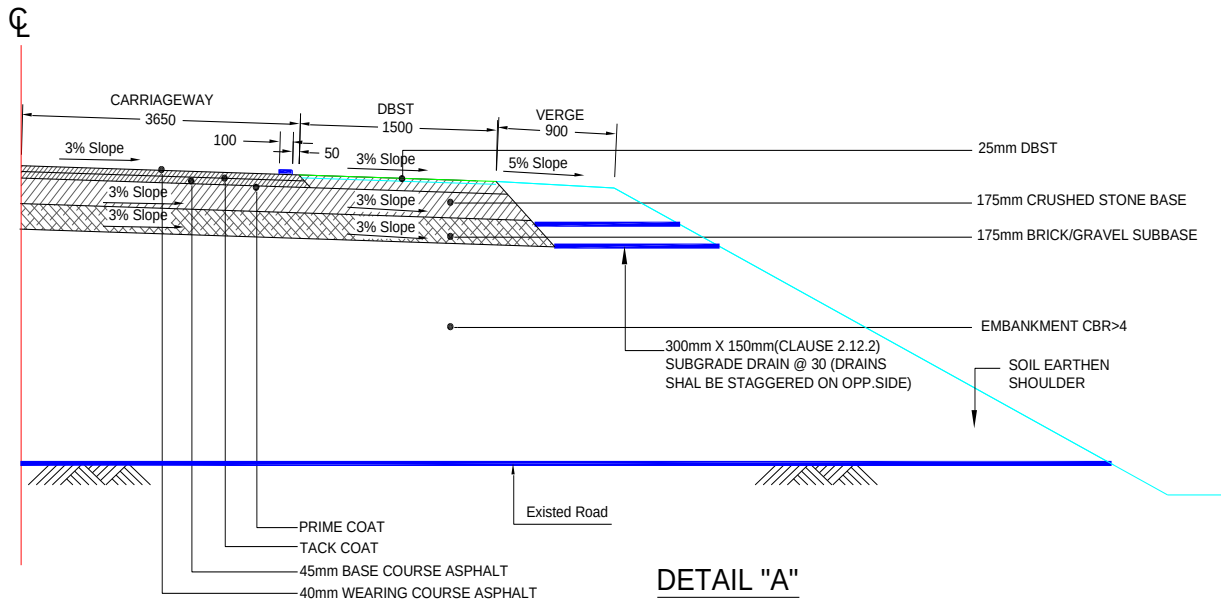
6.1.3 Road Cross-section

In the Cross section of the road has been considerded to be 12.10 m top (crest width). But modified cross sections have been taken for builtup areas and hilly areas. Adopted cross section carries 2 lane carriage way (each carriageway 3.65m wide), 1.50 m paved shoulder on each side. Alongside the paved shoulders there are verges of width 0.9m. Lane width and other parameters have been selected as per RHD & IRC standard but with appropriate modification. Typical cross sections of the road have been presented in **Figure 6.1.3 below**

Single Carriageway-	
Road Lane Width	2 x 3.65 m
Bridge Lane Width	2 x 3.65 m
Bridge Sidewalk Width	2 x 0.9 m
Railing width	2 x 0.2 m
Shoulder Width-	
Flat, Rolling (Hard Shoulder)	2 x 1.50 m
Hill (Hard Shoulder)	2 x 0.90 m
Flat and Rolling (Soft Shoulder)	2 x 0.90 m
Built-up Area	2 x 3.50 m
Shoulder Slope (Hard)	3.0%
Shoulder Slope (Soft)	5.0%
Normal Crossfall	3.0%

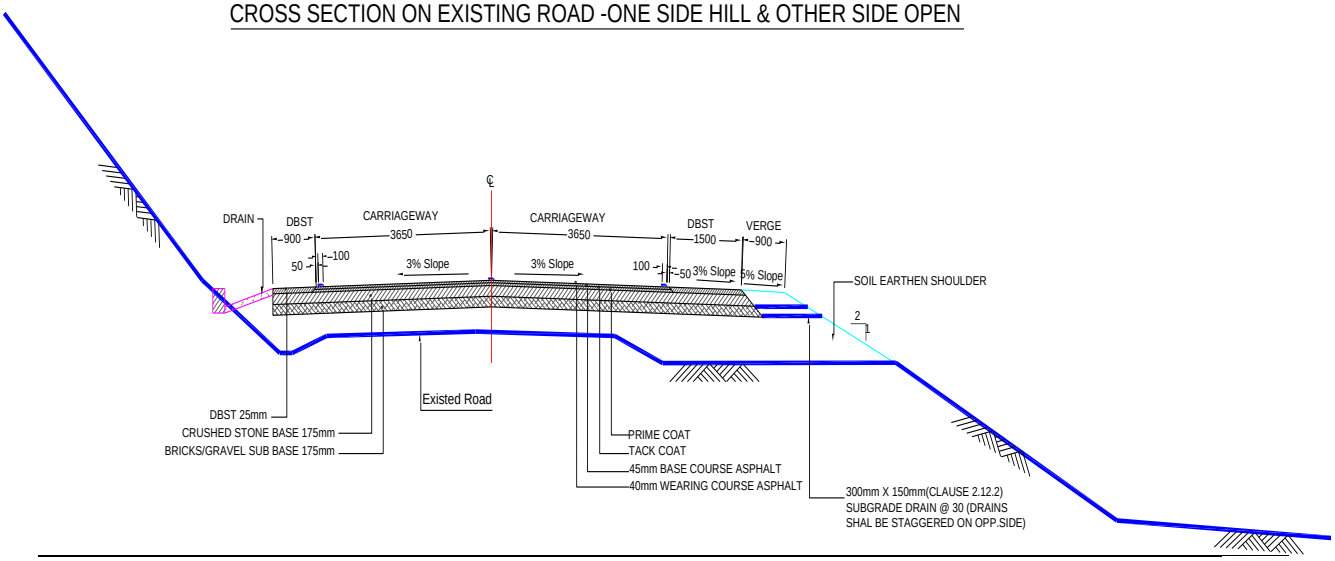
TYPICAL CROSS SECTION & DETAIL DRAWINGS (1)
CROSS SECTION OF ROAD OPEN AREA

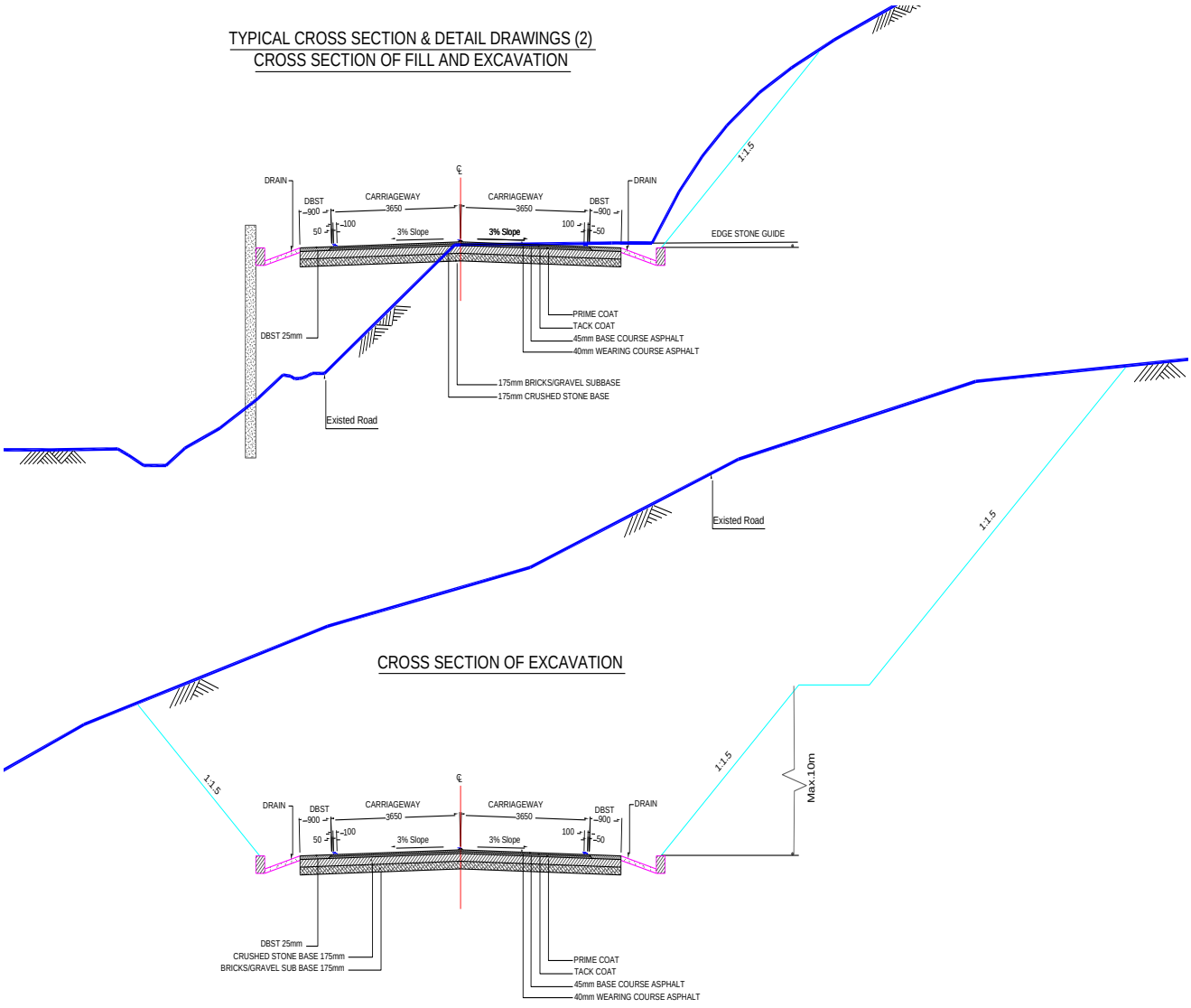




DETAIL "A"

CROSS SECTION ON EXISTING ROAD -ONE SIDE HILL & OTHER SIDE OPEN





TYPICAL CROSS SECTION & DETAIL DRAWINGS (3)

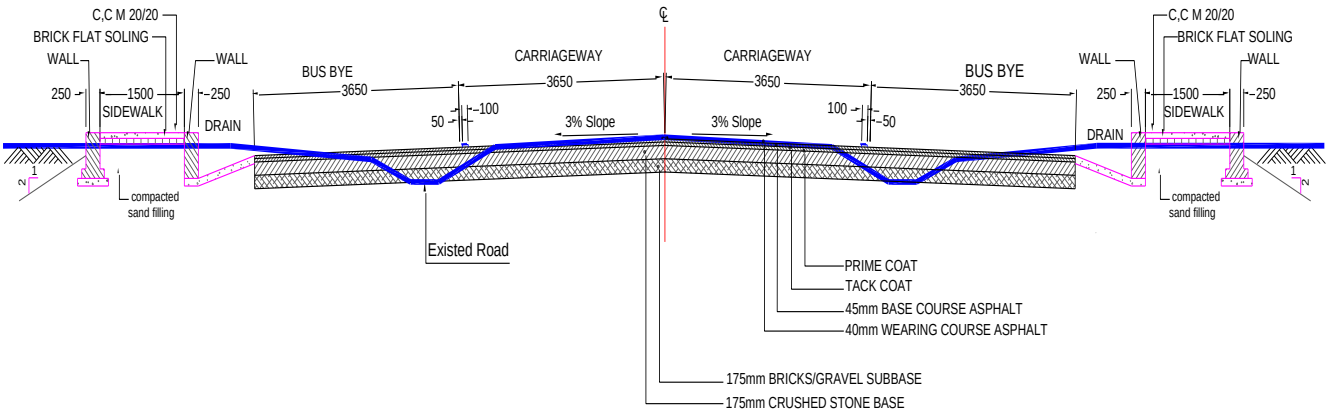


Figure 6.1.3: Typical cross sections of the road

6.2 Slope Stability of Proposed Road Routes and Road Portion of Multimodal Route

Slope stability conditions are studied along Rajosthali - Bilaichhari - Juraichhari - Barkal - Chhotoharina-ThegamukhRoad. In general the problems of slope stability are of small scale, localized and superficial. They include mostly of cut slope failure, soil erosion on cut slopes, improper water management and absence of side drains in these roads along most of the stretches.

6.2.1 General Review of Slope Stability Problems

The erosion of cut slopes causes the following harmful effects:

- Danger to stability of cut slope due to increased weight of the saturated soil and reduced shear strength.
- Seepage of water into the soil causing excess pressure on the slope.
- Loosening of soil and silting of side ditches and culverts.

The Extent of erosion depends on various factors such as soil type, slope of embankment, intensity of rainfall, height of embankment and various other factors. In general, the following situation call for close study:

- Approaches to bridges, especially in flood plains, where the height of embankment is high, and parallel flow is expected.
- High approaches to over-bridges.
- Embankments in loose sandy soils lacking in cohesion.
- Steep cuts specially in soil

A Variety of treatments is possible for slope protection, depending upon the severity of the erosion expected. Some of the well-known remedies are:

- Turfing
- Pitching with rip-rap, sand cement slabs, cement concrete slabs and bricks.
- Raised curbs, gutters and flumes
- Geotextiles and netlon
- Bituminous treatment.

Turfing is the most well-known and cheapest form of slope protection. The success of the measure depends upon the suitability of the soil to the development of turf culture.Purely sandy soils are unsuitable for growth of turf.In such cases, layer of clay soil (0.25-.03) m thick) from suitable borrow area can be laid to (i) confine the sand and (ii) foster growth of turf. Turf can be grown by planting sods or by seeding. Sods are preferred on steeper slopes, whereas seeding is resorted to on flatter slopes. The use of jute netting, coir netting and geo-grids helps the turf to grow by holding the soil firmly. After the turf grows, the jute and coir netting decomposes.

Pitching with rip-rap (boulders), sand-cement slabs, cement concrete slabs and bricks is very common when dealing with high embankments in flood zones and heavy rainfall areas. Open jointed pitching is to be preferred to joints with cement mortar because of the need to provide outlet for seepage water in the embankment. The pitching should be provided with a graded inverted filter bedding to prevent the soil particles from getting lost. The pitching must have a good stout toe wall.

Bituminous treatment (BT) is used for erosion control in a number of ways. The asphalt, sprayed as an emulsion at 0.7-1.0 kg/m^2 helps in a number of ways. It cuts down the susceptibility to erosion. It helps to retain the moisture content and it helps to raise the soil temperature by absorbing light rays and promoting the emergence of tiny saplings. The second type of treatment consists of laying and compacting asphalt mixes or spraying or spraying a low viscosity cut-back. The rate of application of asphalt is about 1 kg per m^2 so as to penetrate the soil to a depth of about 12 mm.

The following tentative locations have been identified where there is a need for Detailed Investigation (DI) during detailed design phase and appropriate measure need to be adopted as discussed above in the form of Bio- Engineering (BE), Turfing (TF), Water Management (WM), Trimming etc.

Sl. No.	Area Prone to Slope Stability		Remedial Measures
	From	To	
1	Ch. 8+150	Ch. 8+250	DI/BE/TF/WM/BT
2	Ch. 8+250	Ch. 8+350	DI/BE/TF/WM/BT
3	Ch. 8+350	Ch. 8+450	DI/BE/TF/WM/BT
4	Ch. 8+450	Ch. 8+550	DI/BE/TF/WM/BT
5	Ch. 8+550	Ch. 8+650	DI/BE/TF/WM/BT
6	Ch. 8+650	Ch. 8+750	DI/BE/TF/WM/BT
7	Ch. 8+750	Ch. 8+850	DI/BE/TF/WM/BT
8	Ch. 8+850	Ch. 8+950	DI/BE/TF/WM/BT
9	Ch. 8+950	Ch. 9+050	DI/BE/TF/WM/BT
10	Ch. 9+050	Ch. 9+150	DI/BE/TF/WM/BT
11	Ch. 9+650	Ch. 9+750	DI/BE/TF/WM/BT
12	Ch. 9+750	Ch. 9+850	DI/BE/TF/WM/BT
13	Ch. 9+850	Ch. 9+950	DI/BE/TF/WM/BT
14	Ch. 9+950	Ch. 10+050	DI/BE/TF/WM/BT
15	Ch. 10+05	Ch. 10+150	DI/BE/TF/WM/BT
16	Ch. 10+150	Ch. 10+250	DI/BE/TF/WM/BT
17	Ch. 10+250	Ch. 10+350	DI/BE/TF/WM/BT
18	Ch. 10+350	Ch. 10+450	DI/BE/TF/WM/BT
19	Ch. 10+450	Ch. 10+550	DI/BE/TF/WM/BT
20	Ch. 10+550	Ch. 10+650	DI/BE/TF/WM/BT
21	Ch. 10+650	Ch. 10+750	DI/BE/TF/WM/BT
22	Ch. 10+750	Ch. 10+850	DI/BE/TF/WM/BT
23	Ch. 10+850	Ch. 10+950	DI/BE/TF/WM/BT
24	Ch. 10+950	Ch. 11+050	DI/BE/TF/WM/BT
25	Ch. 11+050	Ch. 11+150	DI/BE/TF/WM/BT
26	Ch. 11+150	Ch. 11+250	DI/BE/TF/WM/BT
27	Ch. 11+450	Ch. 11+550	DI/BE/TF/WM/BT
28	Ch. 11+550	Ch. 11+650	DI/BE/TF/WM/BT
29	Ch. 11+650	Ch. 11+750	DI/BE/TF/WM/BT
30	Ch. 11+750	Ch. 11+850	DI/BE/TF/WM/BT
31	Ch. 11+850	Ch. 11+950	DI/BE/TF/WM/BT
32	Ch. 11+950	Ch. 12+050	DI/BE/TF/WM/BT
33	Ch. 12+050	Ch. 12+150	DI/BE/TF/WM/BT
34	Ch. 12+150	Ch. 12+250	DI/BE/TF/WM/BT
35	Ch. 12+550	Ch. 12+650	DI/BE/TF/WM/BT

Sl. No.	Area Prone to Slope Stability		Remedial Measures
	From	To	
36	Ch. 12+650	Ch. 12+750	DI/BE/TF/WM/BT
37	Ch. 12+750	Ch. 12+850	DI/BE/TF/WM/BT
38	Ch. 12+850	Ch. 12+950	DI/BE/TF/WM/BT
39	Ch. 12+950	Ch. 13+050	DI/BE/TF/WM/BT
40	Ch. 13+050	Ch. 13+150	DI/BE/TF/WM/BT
41	Ch. 13+150	Ch. 13+250	DI/BE/TF/WM/BT
42	Ch. 13+250	Ch. 13+350	DI/BE/TF/WM/BT
43	Ch. 13+350	Ch. 13+450	DI/BE/TF/WM/BT
44	Ch. 13+450	Ch. 13+550	DI/BE/TF/WM/BT
45	Ch. 13+750	Ch. 13+850	DI/BE/TF/WM/BT
46	Ch. 13+850	Ch. 13+950	DI/BE/TF/WM/BT
47	Ch. 13+950	Ch. 14+050	DI/BE/TF/WM/BT
48	Ch. 14+050	Ch. 14+150	DI/BE/TF/WM/BT
49	Ch. 14+150	Ch. 14+250	DI/BE/TF/WM/BT
50	Ch. 14+250	Ch. 14+350	DI/BE/TF/WM/BT
51	Ch. 14+350	Ch. 14+450	DI/BE/TF/WM/BT
52	Ch. 14+450	Ch. 14+550	DI/BE/TF/WM/BT
53	Ch. 14+550	Ch. 14+650	DI/BE/TF/WM/BT
54	Ch. 14+650	Ch. 14+750	DI/BE/TF/WM/BT
55	Ch. 14+750	Ch. 14+850	DI/BE/TF/WM/BT
56	Ch. 14+850	Ch. 14+950	DI/BE/TF/WM/BT
57	Ch. 14+950	Ch. 15+050	DI/BE/TF/WM/BT
58	Ch. 15+050	Ch. 15+150	DI/BE/TF/WM/BT
59	Ch. 15+150	Ch. 15+250	DI/BE/TF/WM/BT
60	Ch. 15+250	Ch. 15+350	DI/BE/TF/WM/BT
61	Ch. 15+350	Ch. 15+450	DI/BE/TF/WM/BT
62	Ch. 15+450	Ch. 15+550	DI/BE/TF/WM/BT
63	Ch. 15+550	Ch. 15+650	DI/BE/TF/WM/BT
64	Ch. 15+650	Ch. 15+750	DI/BE/TF/WM/BT
65	Ch. 15+750	Ch. 15+850	DI/BE/TF/WM/BT
66	Ch. 15+850	Ch. 15+950	DI/BE/TF/WM/BT
67	Ch. 15+950	Ch. 16+050	DI/BE/TF/WM/BT
68	Ch. 16+050	Ch. 16+150	DI/BE/TF/WM/BT
69	Ch. 16+150	Ch. 16+250	DI/BE/TF/WM/BT
70	Ch. 16+250	Ch. 16+350	DI/BE/TF/WM/BT
71	Ch. 16+350	Ch. 16+450	DI/BE/TF/WM/BT
72	Ch. 16+450	Ch. 16+550	DI/BE/TF/WM/BT
73	Ch. 16+550	Ch. 16+650	DI/BE/TF/WM/BT
74	Ch. 16+650	Ch. 16+750	DI/BE/TF/WM/BT
75	Ch. 16+750	Ch. 16+850	DI/BE/TF/WM/BT
76	Ch. 16+850	Ch. 16+950	DI/BE/TF/WM/BT
77	Ch. 16+950	Ch. 17+050	DI/BE/TF/WM/BT
78	Ch. 17+050	Ch. 17+150	DI/BE/TF/WM/BT
79	Ch. 17+150	Ch. 17+250	DI/BE/TF/WM/BT
80	Ch. 36+700	Ch. 37+950	DI/BE/TF/WM/BT
81	Ch. 51+000	Ch. 56+400	DI/BE/TF/WM/BT
82	Ch. 78+950	Ch. 80+800	DI/BE/TF/WM/BT

6.3 Road Safety Aspects

6.3.1 Safety-Barriers/Crash Barrier& Delineators

The accident prone areas are sharp curves, approaches to roadway bridges, and high embankment sections. Crash barriers are provisioned on the bridges also safety barriers are proposed on high embankments, sharp curveys. On bridge approaches Guard posts are proposed. Delineators are also proposed as light – retro – reflecting devices by the side of roadway alignment, specially for night driving. It is proposed to provide delinators on the curves, guard rails , bridges, abutments etc.

6. 3.2 Signs and Road Markings

For traffic signs and road markings, Bangladesh Road Transport Authority (BRTA) Traffic Signs Manuel 2000 has been followed. In the hilly area as given in geometric standards 50 Kmph speed is followed but on the curves where it was found difficult to maintain the speed is reduced and speed control sign posts are indicated at appropriate locations. Similarly as per the Manual Regulatory, Warning and Informatorysignes are also proposed.

Other Safety Measures

- It is decided to provide Sidewalk/ footpath (1.5m desirable, 1 m minimum) on both sides of the carriageway passing through major settlements. Ensure that the footpaths are installed at a higher level than the carriageway to separate out the carriageway and footpaths at the same time enhance the visibility of pedestrians.
- Separate provisions are made for bus bays at the locations of bus stops in order not to create hindrance to moving traffic.
- Various types of soils can occur along the alignment of the roadway segments. They can include ordinary soils comprising colluviums, alluviums and completely decomposed rocks, disintegrated rocks, Soft rocks, medium rocks and hard rocks. The soils/rocks can stand safely at certain angles during cutting without any support. The safe stable angles are summarized in **Table 6.3.2** below and the roadway segments should be designed to provide safe stable slopes.

Table 6.3.2 Indicates Tentative Safe Cut Slopes Recommended

SL. No	Type of Soil	Side Slopes (V:H)			Average Slope Angle in Degrees
1	Ordinary Soils	1:1	to	1.5:1	56
2	Disintegrated rock or Conglomerate	2 :1	to	4:1	71
3	Soft rock, Shale, Phyllite	4:1	to	8:1	80
4	Medium Rock	12:1	to	16:1	85
5	Hard Rock	Nearly vertical or half tunneling if cut height exceeds 7.5 m			

- Traffic-calming is necessary to safeguard the pedestrians at major settlements and bazar this road passes through and it should be considered in the design process.
- Cover all open side drains proposed in the market areas to be forgiving to the pedestrians and facilitate them to access the adjacent properties.
- Cover slabs of the side drains should be installed at a higher level than the carriageway in order to separate them from the carriageway to protect the pedestrians.
- Warning signs are recommended to warn of the settlements along the road this roadway passes through.
- Explore the feasibility of providing safe side slope (1:4) at the valley side or

embankment. If this is not feasible and the valley side does not warrant safety barriers, provide concrete post delineators at closer intervals to improve delineation.

- For pipe culverts Install sign to warn about shoulder obstruction due to modification for both directions.
- If the culvert is located along a sharp horizontal or steep vertical curve, extend the parapet recommended above up to the length of the approach curve. Install delineator posts (reflective) at 2 m interval at both sides of the roadway over these parapets as well as the approach curves, to improve delineation.
- Design barriers on both sides of slab culverts to be 0.9 m in order to effectively prevent vehicles from running over the roadway in the vicinity of these structures.
- For slab culverts located along a sharp horizontal or steep vertical curve, extend the RCC barriers recommended above up to the length of the approach curve and supplement it with delineator posts (reflective) at 2 m interval over approach and the barrier on both sides.
- Explore the feasibility of extending a 1 m wide cantilever slab or steel fabricated assembly on both sides or at a minimum on one side of the bridges to provide side-walks. If this is feasible ensure that the side-walks are 0.5 m above the carriageway by means of kerbs and paving blocks or other appropriate means to separate pedestrian from vehicular traffic and enhance pedestrian visibility. To facilitate easy access for the pedestrians along the bridges either adjust the grades of the approach shoulder to ramp to the level of side-walks or construct steps.
- If provision of side-walks is not feasible, install necessary signs at both ends of the bridge-parapets to caution drivers about lateral constraints across the bridge as an intermediate measure.

6. 4 Design of Pavements for Road Route and Road Portion of Multimodal Route.

RHDpavement design manual,2005 has been used for the road portion. The RHD Pavement Design Guide has been prepared based on two internationally recognized design standards, namely the AASHTO Pavement Design Manual and the TRL Overseas Road Note 31, with a view to making the design of road pavements as straightforward as possible. The strength of each layer is expressed in terms of the California Bearing Ratio (CBR) and it is essential that the materials used, and compaction obtained, for each layer achieves the required CBR for that layer. If the underlying layers do not have the required CBR then the upper layers of a road pavement will fail even if they have been correctly constructed.All road pavements require to be designed with the thickness of the various pavement layers, including the bituminous surfacing, being determined by estimating the cumulative number of Equivalent Standard Axles (ESAs) that the road will be subjected to over its design life, and then reading off the required thickness for each layer from the design chart.

For the design of road pavements, an estimate must be made of the cumulative number of heavy axle loads that the road pavement will be subjected to over its design life. In this cars, rickshaws and other light traffic may be ignored with only trucks and other commercial vehicles being considered.For single carriageway roads the average truck and commercial vehicle flow in both directions is adopted for design purposes i.e. 0.5 x the sum of both directions. For dual carriageways, where trucks may be more heavily loaded in one direction than the other, the pavement for each carriageway should be subject to a separate design based on the forecast commercial traffic for that carriageway (heaviest loaded lane). Thus all the commercial vehicles

are converted in to Equivalent Standard Axles (ESA) and finally million standard axle (msa) values are derived.

The cumulative ESA values have been estimated from the traffic data using RHD Pavement Design Guide 2005 with annual traffic growth rate for Regional roads 'r' = 7%. The Traffic (ESA in million) has been adopted in the range of 3 – 4. Following are the estimated CBR values which have been adopted for pavement design at different locations:

Rajosthali : 13%
Bilaichhari : 8%
Juraichhari : 11%
Barkal : 9.5%
Chhotoharina : 10%

Based on the above CBR values and MSA (Million Standard Axles) following complosition of Pavement is adopted based on above manual:

Asphalt Wearing course : 40 mm
Asphalt Base Course : 45 mm
Granular Base (Type I) : 175 mm
Sub – Base : 175 mm
Total Pavement thickness : 435 mm

Since the CBR of Subgrade is more than 5% Improved Subgrade is not required. Moreover the MSA values are also on lower side the above pavment composition seems to be adequate.

6.5 Drainage and Cross Drainage Structures for Road Route and Road Portion of Multimodal Route.

Discharge in the drainage structure is the function of basin characteristics (size, shape, slope, vegetation cover, land use practices etc.) and rainfall (intensity, forms, amount, distribution etc.) over the catchments. To estimate the rainfall over the catchment for different durations, extremerainfall data recorded by department of Hydrology and Meteorology (DHM) inside the catchment and/ or nearby stations are collected.

Catchment Characteristics

Discharge through a particular catchment is a function of its catchment size and associated parameters like shape, slope, channel length, roughness coefficient, runoff coefficient, soil type and land use type. So it is more important to delineate the corresponding catchment area of crossdrainages (streams/ Rivers) crossing the road alignment precisely.

Drainage Area

Catchment area of cross drainages directly reflects the size of that river streams and vice versa so precise calculation of catchment area is more important to calculate the more reliable design discharge. Large rivers have the larger catchments and it requires a number of topography maps even to delineate catchment of single cross drainage. This process is not only tedious but also has more chances of mistakes during delineation of watershed. To minimise these things catchment area of each cross drainage are calculated by different computer software like Google Earth Pro and Arc GIS V10 using ASTR data.

Runoff Coefficient

The runoff coefficient depends on catchment characteristics such as slope, vegetation, shape and size of the catchment. These characteristics are different even in a single watershed. It is very difficult to define the accurate value of runoff coefficient. However standard tables are available to select this coefficient roughly for different cases.

In present study it is impossible to establish this coefficient for individual catchments as they are in plenty. However it is very clear from topographical maps and field visit that the catchments are more or less homogeneous. Hence the single value of runoff coefficient may be used for all the catchments in the project area.

Slope of these catchments are not so steep, most of the catchments are well vegetated and forested. It seems that more than 50% of rainfall will be retained by catchments due to dense vegetation and forests as well as by infiltration. Considering all these factors an average value of 0.35 to 0.4 is used for catchments of the study road.

Design Flood Estimation

Rational Method

Rational formula is well applicable to small catchments. Hence it is used to calculate the design floods for cross and side drains using maximum hourly rainfall intensity for determined duration and adopted frequency. The average runoff coefficient is assumed equal to 0.35 to 0.4 for catchments. The formula is as follows:

$$Q_P = \frac{C * I * A}{3.6}$$

Where, Q_p = Maximum flood discharge in m^3/s

I = Rainfall intensity within the time of concentration in mm/hr

A = Catchment area in km^2

C = Dimensionless run-off coefficient

Following formula has been used for rainfall intensity.

$$R_{t_c} = \frac{R_{24}}{24}\left(\frac{24}{t_c}\right)^{\frac{2}{3}} \qquad (1)$$

Where,

R_{tc} = Rainfall intensity in tc hours (mm/hr)

R_{24} = 24 hours maximum rainfall (mm)

t_c = Time of concentration in hr, calculated by equation 2.

$$t_c = \left(\frac{0.87L^3}{h}\right)^{0.385} \qquad (2)$$

L = Stream length in km

h = Difference of the maximum and minimum elevations in m.

If the time of concentration is less than 15 minutes then it is assumed to be 15 minutes as recommended by ASCE (American Society of Civil Engineers).

Design of Cross Drainage:

The cross-drainages are constructed in the form of Bridges, Culverts (**box/slab/pipe**) and Causeways etc. The choice of the structures depends on the design discharge, anticipatedsediment loads, configuration of flow, foundation condition, ease of construction

and cost of structures etc. Out of many types of the culverts, the choice depends on the local topography, sediment load, availability of material and costs. Mainly masonry slab culverts, concrete pipe culverts, concrete box culverts and concrete or masonry causeways/floodways are considered for the design of the cross drainages.

Locations of the cross drainages have to be chosen from the plan and profile of the road. Care has been taken that as far as possible the natural channel/gullies are maintained. Culverts are also provided at the valley curves /lowest point of the road to allow the side drain water to cross the road. Adequate sized inlet and out let structures are designed for each of the culverts considering the topography and probability of siltation, debris flow and mud flow.

The **Table 6.5A** shows the data for maximum discharge for each of the group of gullies or drainage system and the recommended size of the culverts to accommodate the discharge of streams. The culverts are designed to accommodate the design discharge as a grouped together in each of the groups given in the **Table 6.5A**. The maximum value is considered for the design of the cross drainages for each group.

The slope provided for pipe culverts is 3% which causes water to flow with a velocity of 4.27 m/sec through it. This velocity is expected to self-flush the culvert, although, it may cause erosion at the outlet of the cross drain. To encounter this problem aprons of appropriate sizes along with the cascades are provided at the out lets. The standard inlets are also designed to accommodate and channelized the flow from the gullies and the side drains. For the purpose of cross drain design, discharge values are extracted from the hydrology part and group is separated. Each group is provided with different sized culverts as per the discharges.

Table 6.5A: Maximum Values for Design of Cross Drains

Description	Design Discharge (20 year return period) cum/sec	Size of culverts recommended
Group I	Up to 2.00	900 mm dia. pipe culverts
Group II	2.00 – 5.00	2*900 mm dia. pipe or 1.5m*1.5m slab culvert.
Group III	5.00 - 15.00	2m*2m Slab culvert
Group IV	15.00 – 50.00	3m*3m Slab culvert
Group V	50.00 – 100.00	4m*4m Slab culvert
Group VI	Above 100	5m*5m Slab culvert

Hydraulic Design

For the design of cross drainages over watercourses, the design discharge for return period of 20 years is taken into consideration. The hydrological study requires the discharges of 20 years return period, for all significant watercourses along the road. Other streams or watercourse also need to be bridged to allow the water to flow through even if the discharge is insignificant. The objective of the hydraulic design is to determine the opening of the culvert over the watercourse, so that the estimated discharge flow freely through it.To determine the size of opening for pipe, slab or box culverts, side drains and causeways, to allow the design discharge of a stream to flow freely through it, Manning's formula is used. For this purpose allowable discharge capacity of different sized culverts and side drains are determined using the formula.
The Manning's formula is as follows:

$V = 1/n*R^{2/3}*S^{1/2}$, Where,V = velocity in m/sec
n = coefficient of surface roughness which depends in the roughness of the surfaces. It is generally taken as 0.02 for slab culverts having random stone masonry in cement mortar concrete bottom and it is 0.017 for rubble stone masonry side drains. For pipe culverts it could be taken as that for trowel finished concrete which has a value for n as 0.014.

Hydraulic Radius in meters, R = Aw/Pw
Where, Aw = Area of flow cross section in m^2, Pw = Wetted Perimeter in m, S = Bed slope of channel, which is roughly taken as a slope of culvert bed in % . Finally, the discharge is calculated using the formula,

Q = V*Aw, Where, Q = discharge in m3/sec.
For calculating the discharge capacity of the open or covered trapezoidal and right triangular or tick drains, same formula as above is applied.

Using above formula, allowable discharge capacity of the standard size pipe, slab and box culverts and different section of road side drains with different bed slopes, are determined and provided in **Annexure 6.5A**. Generally, a freeboard of 0.6 m is provided for slab and box culverts while determining the discharge capacity. The size of the slab or box culverts and its freeboard depends upon the topography of the stream, expected sedimentation load, debris flow, design profile of road and locations like in valleys, mid-hill and ridges. The bed slope of the culvert is limited to maximum of 3% because higher the bed slope increases the velocity of flow consequently cause erosion at outlets, requiring additional preventive measures. Hence bed slope is considered as 3% in all and allowable discharges are taken for all types of culverts. However, the road side drain slopes are determined as per road profile gradient. Generally the drains will have the same slope as the road gradient. Higher the velocity of the flow, higher the discharge capacity of the drain and higher the probability of erosion. Therefore to encounter the erosion, concrete bedding is recommended for side drains. The capacities of 600 mm, 900 mm and 1200 mm diameter pipes are calculated using the Manning's formula. For the calculation of the discharge capacity of the pipes, Manning's formula is used. The roughness value ("n") for concrete is taken as 0.014.

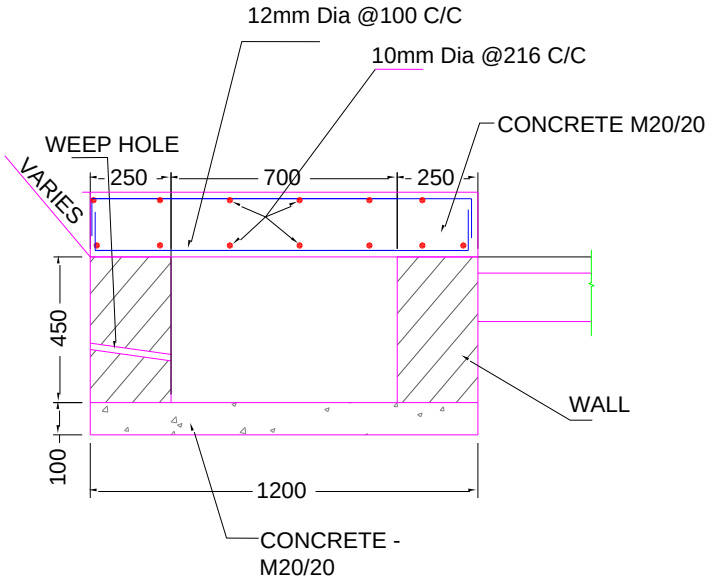
Design of Side Drains

Conservation of the natural drainage system around the roads and highways is one of the most important concerns during design and construction period. For this purposes network of side drains and cross drains along with other related structures are proposed for the project as per hydrological data obtain from the report provided above.The side drain is the most important component of roads to intercept water coming from seepages, surface runoff and pavement surfaces and lead to the safe discharge point. It is constructed mainly as open channels, however, covered drains are also constructed in the built up areas. The side drains are generally constructed throughout the length of hilly road on foot hill side whereas drains are also provided on either side of the road at box cutting gullies/wide plain land and developed area. Side drains are constructed at the same level or below the shoulder level/ pavement surfaces, so that water from the surfaces can be drained out quickest possible.

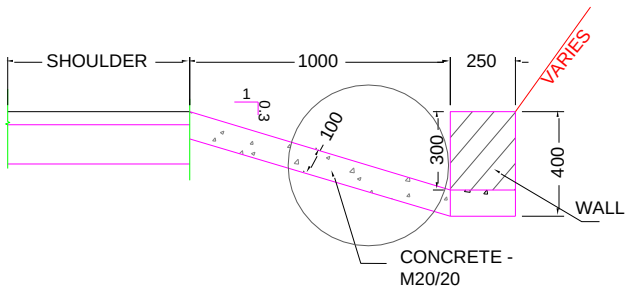
The side drains are designed to collect and remove surface water from the immediate vicinity of the road and to prevent any sub-surface water adversely affecting the road pavement structures. The cross- sections of side drain were selected considering hydraulic capacity, ease of

maintenance, space restriction and traffic safety etc. Design volumes of runoff are adopted to comply with the cross section proposed for side drains. The rainfall intensity for duration of 15 minutes (0.25 hrs.) for a returned period of 5 years and design discharge of 5 years returned period is normally taken into account.

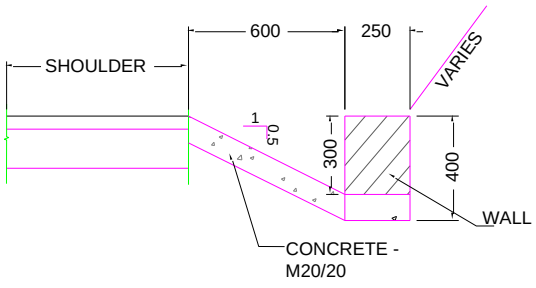
The hydraulic design of side drain sections are carried out with the help of Manning's equation and checked for non-eroding velocity of 4 m/sec. For this value of Manning's roughness coefficient (n), for masonry is taken as 0.017. The longitudinal slope (S) of the side drain conform the longitudinal slope of the road profile. Wherever longitudinal gradient exceeds 7 %, the side drain longitudinal slopes (S) are cascaded to maintain the slope not beyond 5 %. The flow capacities and velocities for different longitudinal slopes (S) of various side drain types adopted. The cross sectional dimensions of drains types adopted in design are given in **Fig 6.5** and **Annexure 6.5 B** gives details of locations of different types of side drains.



ROAD SIDE DRAIN (TYPE -U WITH SLAB)



ROAD SIDE DRAIN (TYPE -V) END



ROAD SIDE DRAIN (TYPE -V) START

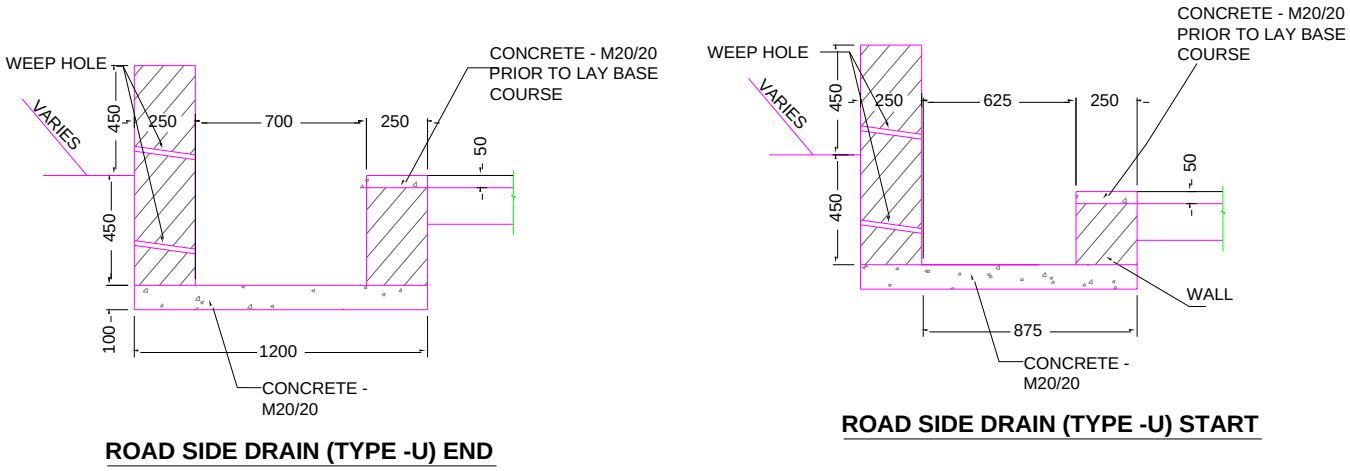


Fig 6.5: Road Side Drain

6.6 Bridges, Culverts and cross drainage structures: Improvement proposal for Road Route and Road Portion of Multimodal Route

For improvement of the existing road structures along the proposed alignment, an inventory survey was carried out for assessment of structural soundness, stability and adequacy for future traffic movement. Maximum of the structures were found as pedestrian and a few numbers were 2.50m to 3.0m carriage width. According to Bridge design specification AASHTO LRFD 2007 &for two lane road, width of all the existing structures is sub-standard and constructed a few years before. So as per Bridge design standard specification AASHTO LRFD 2007, all the existing structures are to be replaced by new construction. Following **Table 6.6 A, 6.6 B** indicates proposed culverts and bridges for Road Route & **Table 6.6 C** indicates proposed bridges for road portion of Multimodal Route. **Discharge & Catchment area calculation are shown in Annexure 6.6**

Table 6.6A: Proposed Culverts

Culvert No.	Existing Chainage No.	Road Design Chainage No.	Size of Culvert Vent x b x h, (m)	Slab top finished Level (FL), m (PWD)	Invert Level (IL), m (PWD)	Remarks
From Ch.00+000-47+066= 47.066 Km						
CUL-01	Ch 0+025	Ch 0+025	1x4.0x3.0	24.70	21.30	Existing to be replaced
CUL-02	Ch 19+340	Ch 18+533	2x6.0x3.0	51.45	48.00	New
CUL-03	Ch 20+970	Ch 20+119	2x5.0x5.0	56.45	51.45	Existing to be replaced
CUL-04	Ch 21+030	Ch 20+175	1x6.0x4.0	58.00	53.55	Existing to be replaced
CUL-05	Ch 21+215	Ch 20+353	1x6.0x4.5	69.95	65.45	Existing to be replaced
CUL-06	Ch 22+955	Ch 22+079	1x4.0x3.0	36.00	32.60	New
From Ch.47+066-75+157=28.091km						
CUL-07	Ch 50+850	Ch 48+705	1x6.0x5.0	46.50	53.00	New, Shifted from Ch. 50+900 as per site cond.
CUL-08	Ch 59+900	Ch 57+321	2x4.0x6.0	59.40	53.00	New
CUL-09	Ch 62+205	Ch 59+560	2x4.0x3.0	51.90	48.50	New
CUL-10	Ch 62+975	Ch 60+290	2x3.5x4.0	55.40	51.00	New

CUL-11	Ch 64+100	Ch 61+373	2x3.0x4.0	43.35	39.00	Existing to be replaced
CUL-12	Ch 65+610	Ch 62+864	2x4.5x3.0	48.40	45.00	Existing to be replaced
CUL-13	Ch 66+850	Ch 64+042	1x6.0x4.5	60.90	56.45	New
CUL-14	Ch 70+180	Ch 67+183	2x4.5x4.0	34.90	30.50	New
CUL-15	Ch 77+085	Ch 73+730	2x4.5x4.0	32.25	27.85	New
CUL-16	Ch 77+940	Ch 74+567	2x3.5x3.0	36.65	33.25	Existing to be replaced
From Ch.75+157-81+600=6.443km						
CUL-17	Ch 79+000	Ch 75+615	1x6.0x6.0	45.00	38.50	Existing to be replaced
From Ch.81+600-102+098=20.498km						
CUL-18	Ch 86+920	Ch 82+980	2x4.0x5.0	34.70	28.30	New
CUL-19	Ch 89+602	Ch 85+638	2x5.0x4.0	34.68	30.23	New
CUL-20	Ch 91+115	Ch 87+059	2x4.0x3.0	37.00	33.60	Marcy Land
CUL-21	Ch 104+850	Ch 100+306	3.0x5.0x5.0	56.45	51.45	Existing to be replaced

Table 6.6 B: Proposed Bridges for Road Route

Bridge No.	Existing Chainage No	Road Design Chainage	Missing Length (m)	Proposed Structural Deck Length(m)	Existing Ground Level (m)	Pile Cap Level (m)	Finish Level/Deck Level(m)	Type of Bridge	HFL (m)	LFL(m)	Remarks
From Ch.00+000-47+066= 47.066 Km											
1	Ch 0+0380	Ch 0+378	61.894	(3x21.0)	18.4	20.55	26.02	RCC Bridge	22.30	Dry in winter	Existing to be replaced
2	Ch 5+145	Ch 4+932	32.116	(1x35.0)	27.93	25.26	32.52	PCC Bridge	28.50	Dry in winter	New
3	Ch 8+385	Ch 8+040	28.004	(1x30.0)	51.05	44.80	56.02	PCC Bridge	52.20	Dry in winter	New
4	Ch 11+850	Ch 11+268	30.378	(1x35.0)	57.12	60.21	67.47	PCC Bridge	62.96	Dry in winter	New
5	Ch 33+490	Ch 32+251	41.129	(3x15.0)	32.34	34.08	39.42	RCC Bridge	35.00	Dry in winter	New
6	Ch 39+960	Ch 38+543	286.628	(9x32.0)	36.01	38.22	48.82	PCC Bridge	44.00	38	Existing to be replaced
7	Ch 47+850	Ch 45+862	131.687	(5x26.0)	20.55	26.69	35.32	PCC Bridge	30.50	22	Existing to be replaced
8	Ch 48+240	Ch 46+262	112.074	(3x38.0)	19.69	27.99	35.92	PCC Bridge	30.50	22	Existing to be replaced
From Ch.47+066-75+157=28.091km											
9	Ch 51+840	Ch 49+645	16.891	(1x20.0)	33.13	34.37	39.52	RCC Bridge	35.00	Dry in winter	New
10	Ch 65+340	Ch 62+607	33.989	(1x35.0)	45.56	43.80	52.02	PCC Bridge	47.00	Dry in winter	Existing to be replaced
11	Ch 68+985	Ch 66+047	18.967	(1x20.0)	41.56	41.00	46.52	RCC Bridge	44.00	Dry in winter	New
12	Ch 72+250	Ch 69+197	34.896	(1x35.0)	30.77	28.80	37.52	PCC Bridge	33.02	Dry in winter	New
13	Ch 77+275	Ch 73+925	86.631	(3x30)	27.9	28.00	36.32	PCC Bridge	31.50	Dry in winter	Existing to be replaced
From Ch.75+157-81+600=6.443km											
14	Ch 78+890	Ch 75+507	11.643	(1x15.0)	43.69	39.68	45.77	RCC Bridge	41.00	Dry in winter	Existing to be replaced
15	Ch 79+315	Ch 75+870	18.593	(1x20.0)	26.35	33.00	38.52	RCC Bridge	34.50	Dry in winter	Existing to be replaced
16	Ch 80+115	Ch 76+660	30.907	(1x35.0)	34.39	34.76	41.02	PCC Bridge	36.00	Dry in winter	New
17	Ch 83+340	Ch 79+700	11.685	(1x15.0)	163.88	164.96	171.07	RCC Bridge	166.65	Dry in winter	New
18	Ch 84+595	Ch 80+842	11.197	(1x15.0)	37.75	37.67	42.67	RCC Bridge	39.25	Dry in winter	New
19	Ch 85+270	Ch 81+480	227.194	(7x33.0)	12.2	22.00	42.76	PCC Bridge	33.23	23.17	New

From Ch.81+600-102+098=20.498km											
20	Ch 88+215	Ch 84+250	153.816	(5x32.0)	19.2	27.00	42.67	PCC Bridge	33.23	23.17	New
21	Ch 89+530	Ch 85+570	11.123	(1x15.0)	31.51	31.54	36.65	RCC Bridge		Dry in winter	New
22	Ch 90+075	Ch 86+104	28.512	(1x30.0)	30.1	29.67	37.05	PCC Bridge		Dry in winter	New
23	Ch 90+690	Ch 86+685	22.422	(1x25.0)	29.37	31.86	37.05	RCC Bridge		Dry in winter	New
24	Ch 91+030	Ch 86+972	14.307	(1x15.0)	35.59	31.54	36.65	RCC Bridge		Dry in winter	New
25	Ch 91+440	Ch 87+379	11.53	(1x15.0)	36.8	31.54	36.65	RCC Bridge		Dry in winter	New
26	Ch 95+040	Ch 90+825	43.842	(3x15.0)	33.64	31.31	36.65	RCC Bridge	33.23	Dry in winter	Existing to be replaced
27	Ch 95+530	Ch 91+327	39.001	(3x15.0)	30.64	31.31	36.65	RCC Bridge	33.23	Dry in winter	Existing to be replaced
28	Ch 95+985	Ch 91+770	23.394	(1x30.0)	27.5	29.68	37.05	PCC Bridge	29.90	Dry in winter	Existing to be replaced
29	Ch 97+400	Ch 93+082	130.426	(3x30.0-2x26.0)	12.2	18.00	42.67	PCC Bridge	33.23	23.17	New
30	Ch 100+190	Ch 95+687	11.777	(1x15.0)	30.3	31.54	36.65	RCC Bridge	33.23	Dry in winter	Existing to be replaced
31	Ch 101+740	Ch 97+200	29.676	(1x30.0)	31.8	30.87	37.25	PCC Bridge	33.23	Dry in winter	Existing to be replaced
32	Ch 103+360	Ch 98+802	23.461	(1x25.0)	31.8	31.86	37.05	RCC Bridge	33.23	Dry in winter	Existing to be replaced
33	Ch 103+725	Ch 99+175	36.574	(1x30.0)	31.9	30.82	37.05	PCC Bridge	33.23	Dry in winter	Existing to be replaced
34	Ch 103+975	Ch 99+425	26.466	(1x30.0)	31.5	30.82	37.05	PCC Bridge	33.23	Dry in winter	Existing to be replaced
35	Ch 104+085	Ch 99+527	11.883	(1x15.0)	32.5	31.54	36.65	RCC Bridge	33.23	Dry in winter	Existing to be replaced
36	Ch 105+395	Ch 100+837	31.63	(1x35.0)	32.2	29.98	37.25	PCC Bridge	33.23	Dry in winter	Existing to be replaced
37	Ch 106+580	Ch 101+997	167.496	(5x35.0)	12.2	31.00	42.87	PCC Bridge	33.23	23.17	New
From Ch.102+098-109.675=7.577km											
38	Ch 106+840	Ch 102+265	27.541	(1x30.0)	13.5	30.80	37.05	PCC Bridge	33.23	Dry in winter	Existing to be replaced
39	Ch 113+145	Ch 108+152	29.36	(1x35.0)	41.34	39.58	47.02	PCC Bridge	43.00	Dry in winter	New
40	Ch 114+150	Ch 109+105	18.145	(1x20.0)	35.1	36.37	41.52	RCC Bridge	38.01	Dry in winter	Existing to be replaced

Size	No.	Type of Bridge
1x15	8	RCC Bridge
1x20	4	RCC Bridge
1x25	2	RCC Bridge
1x30	7	PCC Bridge
1x35	7	PCC Bridge
3x15	3	RCC Bridge
3x21	1	RCC Bridge
3x30	1	PCC Bridge
3x38	1	PCC Bridge
5x26	1	PCC Bridge
9x32	1	PCC Bridge
5x32.0	1	PCC Bridge
5x35.0	1	PCC Bridge
7x33.0	1	PCC Bridge
3x30.0-2x26	1	PCC Bridge

RCC Bridge	18
PCC Bridges	22
TOTAL=	**40**

Table 6.6 C: Proposed bridges for road portion of Multimodal Route

Bridge No.	Existing Chainage No	Road Design Chainage	Missing Length (m)	Proposed Structural Deck Length (m)	Existing Ground Level (m)	Pile Cap Level (m)	Finish Level/Deck Level(m)	Type of Bridge	HFL (m)	LFL (m)	Remarks
From Ch.00+000-7+370=7.370 Km											
1	Ch 6+280	Ch 5+855	29.36	(1x35.0)	41.34	39.58	47.02	PCC Bridge	43.00	Dry in winter	New
2	Ch 7+495	Ch 6+805	18.145	(1x20.0)	35.1	36.37	41.52	RCC Bridge	38.01	Dry in winter	Existing to be replaced

Size	No.	Type of Bridge
1x20	1	RCC Bridge
1x35	1	PCC Bridge
Total	2	

6.7 Design of Earth Retaining structures for Road Route and Road portion of Multimodal Route

Earth retaining wall is a structure that retains (holds back) any material (usually earth) and prevents it from sliding or eroding away. It is designed so that to resist the pressure of the material that it is holding back.

Types of Retaining Walls
An earth retaining structure can be considered to have the following types:

1. Gravity Walls
    - Reinforced Gravity Walls
        1. Concrete Cantilever retaining wall
        2. Counter-fort / Buttressed retaining wall
        3. Precast concrete retaining wall
        4. Prestressed retaining wall

    Brick
    Brick Masonry retaining wall
    Stone
    Reinforced Soil Walls
    - Reinforced Soil
    - Soil Nailing

    Hybrid System
    - Anchored Earth
    - Tailed Gabion
    - Tailed Concrete Block

As per site condition where the hilly area exist, there may be required some earth retainingstructures to protect the soil or sliding materials from the hill nearby the proposed road. Due to economic consideration, availability of materials and stability of the structure, RCC gravity type retaining wall is proposed. In some cases where the retaining wall to be constructed near the river bank or canal side and there is a possibility of soil erosion or scouring, pile foundation below the retaining wall base to be provided to protect from sliding, overturning and stability of the structure.Locations where these structures are required are given in following **Table 6.7 A & 6.7 B** for road route and multimodal route.

Table 6.7A: Locations of Retaining Walls for Road Route (Rajosthali to Thegamukh)

Sl No	Chainage	Left Side/Right Side	Length of Road Side (m)	Proposed Retaining Wall Height (m)	Remark
1	Ch.3+250-3+350	Right side	100	5	
2	Ch.6+050-12+150	Right side	100	4	
3	Ch.12+350-12+450	Right side	100	9	
4	Ch.17+950-18+050	Left Side	100	4	
5	Ch.18+350-18+450	Left Side	100	4	
6	Ch.18+450-18+550	Left Side	100	7	
7	Ch.20+950-21+050	Right side	100	10	
8	Ch.21+050-21+150	Right side	100	4	
9	Ch.21+150-21+250	Right side	100	4	
10	Ch.21+350-21+450	Right side	100	4	
11	Ch.21+450-21+550	Right side	100	4	

Sl No	Chainage	Left Side/Right Side	Length of Road Side (m)	Proposed Retaining Wall Height (m)	Remark
12	Ch.24+425-24+475	Left Side	50	6	
13	Ch.24+475-24+525	Left Side	50	7	
14	Ch.24+525-24+575	Left Side	50	4	
15	Ch.24+875-24+925	Left Side	50	5	
16	Ch.25+275-25+325	Left Side	50	9	
17	Ch.25+325-25+375	Left Side	50	7	
18	Ch.25+975-26+025	Right side	50	5	
19	Ch.26+825-26+875	Right side	50	10	
20	Ch.26+875-26+925	Right side	50	10	
21	Ch.26+925-26+975	Right side	50	6	
22	Ch.28+225-28+275	Left Side	50	6	
23	Ch.28+375-28+425	Right side	50	8	
24	Ch.28+425-28+475	Right side	50	6	
25	Ch.34+550-34+600	Right side	50	7	
26	Ch.34+600-34+650	Right side	50	10	
27	Ch.34+650-34+700	Right side	50	8	
28	Ch.34+700-34+750	Right side	50	6	
29	Ch.35+050-35+100	Right side	50	5	
30	Ch.35+100-35+150	Right side	50	4	
31	Ch.35+550-35+600	Right side	50	6	
32	Ch.35+600-35+650	Right side	50	4	
33	Ch.35+800-35+850	Right side	50	6	
34	Ch.35+850-35+900	Right side	50	4	
35	Ch.36+600-36+650	Left Side	50	9	
36	Ch.38+100-38+150	Left Side	50	9	
37	Ch.38+350-38+400	Left Side	50	9	
38	Ch.38+500-38+550	Both Side	100	9	
39	Ch.40+200-40+250	Right side	50	9	
40	Ch.42+200-42+250	Right side	50	9	
41	Ch.42+250-42+300	Right side	50	8	
42	Ch.42+550-42+600	Right side	50	6	
43	Ch.42+700-42+750	Right side	50	9	
44	Ch.50+600-50+700	Right Side	100	5	
45	Ch.50+800-50+900	Both Side	200	10	
46	Ch.56+500-56+600	Right Side	100	10	
47	Ch.57+400-57+500	Right Side	100	7	
48	Ch.58+300-58+400	Left Side	100	4	
49	Ch.58+600-58+700	Left Side	100	7	
50	Ch.59+100-59+200	Right Side	100	8	
51	Ch.60+200-60+300	Right Side	100	4	
52	Ch.61+400-61+500	Right Side	100	7	
53	Ch.60+200-60+250	Right Side	50	4	
54	Ch.60+300-60+350	Right Side	50	4	
55	Ch.60+350-60+400	Right Side	50	3	
56	Ch.61+400-61+450	Right Side	50	6	
57	Ch.61+750-61+800	Right Side	50	3	
58	Ch.75+100-75+150	Both Side	100	10	

Sl No	Chainage	Left Side/Right Side	Length of Road Side (m)	Proposed Retaining Wall Height (m)	Remark
59	Ch.75+150-75+200	Both Side	100	10	
60	Ch.75+200-75+250	Both Side	100	10	
61	Ch.75+250-75+300	Both Side	100	10	
62	Ch.75+300-75+450	Both Side	300	9	
63	Ch.81+350-81+450	Both Side	200	9	
64	Ch.97+200-97+300	Both Side	200	6	
65	Ch.101+700-102+000	Right Side	300	7	
66	Ch.102+300-102+500	Both Side	400	9	
67	Ch.103+200-103+300	Both Side	200	9	
Total Length=			**6000**		

Hight of Walls (m)	Nos. of Walls	Remarks
3	2	
4	15	
5	5	
6	10	
7	8	
8	4	
9	13	
10	10	
Total No=	**67**	

Table 6.7 B: Locations of Retaining Walls for Multimodal Route (Chotohorina to Thegamukh)

Sl No	Chainage	Left Side/Right Side	Length of Road Side (m)	Proposed Retaining Wall Height(m)	Remark
1	Ch.102+300-102+500	Both Side	400	9	
2	Ch.103+200-103+300	Both Side	200	9	
Total Length=			**600**		

Hight of Walls (m)	Nos. of Walls	Remarks
9	13	
Total No=	**13**	

6.8 Improvement of Waterway for Multimodal Route

6.8.1 Improvement of draft by dredging:

The route will be improved as class II route. As per recommendation of depth of class II routes the route will be dredged upto the formation level where 3 m depth will be ensured round the year.

6.8.1.1 Maintenance Dredging:

Rate of re-siltation is not being possible to be reviewed and esed for this assessment accurately.Maintenance dredging wil be required.During project implementation period (3

years) maintenance dredging may be taken as 1% of the Capital dredging per year for 3 years time the maintenance will come to 8260000x1%x3 years=2478000 m^3 and cost will be = 247800 m^3 x250 Tk/m^3= 61950000 Tk

This cost is provided in the cost estimate.

Repair & Maintenance of structure will not be required with project implementation period of 3 years.If needed cost may be met from the item of other ancilliary works.

Capital & Maintenance dredging should be closely monitored through Engineering and Post dredging hydrographic survey to ensure dredging according to the designed formation level and width of the channel.

6.8.2 Provision of additional structures for waterway:

Structure like R.C.C,jetty, spud, Pontoon passengers waiting shed have been provide in the estimate for each major landing station. In addition a transit shed may be provided at Rangamati and Chottohorina for cargo transit storage and cargo yard.Accordingly about 3 acres of land will be needed for each of the above landing station. Arrangements are to be made for providing this land either by acquisition or by the Government. The details can be worked out during details design phage. Besides, bank protection work may be required. This cost is also provided in the cost estimate as lump-sum.

Landing Facilities

From Rangamati to Chottohorina via Barkal the places of traffic importance are:

(i) Rangamatisadar
(ii) Shovolong
(iii) Barkal
(iv) Chottohorina
(v)Thagamukh

(I)Rangamatisadar	(i) One R.C.C Jetty (straight 30 m+ sloping 43.55 m) (ii) One 19.50 m Pontoon (iii) 2 Steel spuds (iv) One Terminal Building (v) One Transit shed of 10m * 5 m (vi)Tube-well (vii) Electric Connection
(II) Shovolong	(i) One14.60 m Pontoon including 2 wooden planks
(III) Barkal	(i) One R.C.C Jetty (straight 30 m+ sloping 43.55 m) (ii) One 19.50 m Pontoon (iii) 2 Steel spuds (iv) One Terminal Building. (v) One Transit shed of 10m * 5 m (vi) Tube-well vii) Electric Connection
(IV) Chottohorina	(i) One R.C.C Jetty (straight 30 m+ sloping 43.55 m) (ii) One 19.50 m Pontoon (iii) 2 Steel spuds

(iv) One Terminal Building
(v) One Transit shed of 10m * 5 m
(vi) Tube-well
vii) Electric Connection

(V) Thegamukh Land customs will build the necessary structures under their project

Besides the above important launch stations, there are also some launch stations namely:
1. Bhushionchara, 2. Arabunia, 3. Bamland, 4. Kala bunia,
5.SouthKalabunia, 6. Bhutchara, 7. Baraitala, 8. Nutun Bazar.

In each of the landing stations, at least one 14.63 m pontoon may be provided with supply of two wooden planks as shore connection from pontoon to shore.
Other 8 Stations: (i) 8 pontoons

Typical drawing of R.C.C jetty, Pontoon, Spud, Terminal are provided in volume III. Details will be worked out during detailed design phase.

Cost of landing facilities:

Rangamati:	
(i) One R.C.C Jetty (straight 30 m+ sloping 43.55 m) (ii) One 19.52 m Pontoon (iii) 2 Steel spuds 17m and 10m (iv) One Terminal Building (v) One semi puccaTransit shed of 10m * 5 m @Tk. 12000/m^2 (vi)Tube-well (Shalow) (vii) Electric Connection	=Tk.90.60 Lac =Tk.74.90 Lac =Tk.15.15 Lac =Tk.149.50 Lac =Tk.6.00 Lac =Tk.0.80 Lac =Tk.0.20 Lac
Sub Total	**=Tk. 337.15 Lac**
Shovolong: 14.60 m Pontoon including 2 wooden planks@ Tk 50 lac	**=Tk. 54.98 Lac**
Barkal:	
(i) One R.C.C Jetty (straight 30 m+ sloping 43.55 m) (ii) One 19.52 m Pontoon (iii) 2 Steel spuds 17m and 10m (iv) One Terminaal Building (v) One semi puccaTransit shed of 10m * 5 m @Tk. 12000/m^2 (vi)Tube-well (Shalow) (vii) Electric Connection	=Tk.90.60 Lac =Tk. 74.90 Lac =Tk. 15.15 Lac =Tk. 149.50 Lac =Tk. 6.00 Lac = Tk. 0.80 Lac =Tk.0 .20 Lac
Sub Total	**=Tk. 337.15Lac**

Chottohorina:	
(i) One R.C.C Jetty (straight 30 m+ sloping 43.55 m) (ii) One 19.52 m Pontoon (iii) 2 Steel spuds 17m and 10m (iv) One Terminaal Building (v) One semi puccaTransit shed of 10m * 5 m @Tk. 12000/m^2 (vi)Tube-well (Shalow) (vii) Electric Connection	=Tk.90.60 Lac =Tk. 74.90 Lac =Tk. 15.15 Lac =Tk. 149.50 Lac =Tk. 6.00 Lac = Tk. 0.80 Lac =Tk.0 .20 Lac
Sub Total	**=Tk. 337.15 Lac**

Other 8 Launce Stations:

(i) One 14.63 m (48') pontoon in each station with supply of two wooden planks @ Tk.54.98lac each.	**=Tk. 439.84 Lac**
Cost of Landing Facilities	**=Tk. 1506.27 Lac**
	Say =Tk. 150.63 million

Source: Rates are collected from BIWTA.

	Total Cost (TK)
a) Cost of Capital dredging	= Tk. 2065 million
b) Cost of Maintenance Dredging	= Tk. 61.95 million
c) Cost of Landing Facilities	= Tk. 150.63 million
d) Cost of Bank Protection L. S	= Tk. 7.00 million
e) Cost of Other ancillary works	= Tk. 7.00 million
Grand Total	**=Tk. 2291.58 million**

Calculation sheets showing quantity & cost of R. C. C. jetty, steel pontoon & steel spuds are given in volume II (Cost Estimate) part item (II B) Table 6.8.2 A, 6.8.2 B, 6.8.2 C, 6.8.2 D.

6.9 Improvement in Existing Road Connecting Chittagong Port for Road Route and Multimodal Route

It is investigated that existing land route from Chittagong Port to Rajoshthali already constructed long time before in which first 10.923 km i.e, Chittagong Port to Mohora/Raster Matha constructed & maintained by Chittagong City Corporation and does not require any further development right now.

From Mohora/Raster Matha to Chandraghona 32.446 km regional road (R163) is constructed and maintained by RHD. But insufficent carriageway width 6.20m has to be extended to 7.3m by proper rehabilitation works. The aggregated rehabilitation works is 35690.60 sqm of carriageway From Chandraghona to Bangalhalia 12.310 km regional road (R161) is constructed and maintained by RHD. But here also insufficent carriageway width 5.43m has to be extended to 7.3m width by proper rehabilitation works. The aggregated rehabilitation works is 23019.70 sqm of carriageway. In this portion also 315m long Bridge is required on the Karnafully River to eleminate the Chandraghona Ferry Ghat. In other two locations of this portion two RCC Bridges are required by replacing the existing Baily Bridges of 21.5m & 18.4m length.

From Bangalhalia to Rajoshtholi 19.623 km Zilla road (Z1814) is already constructed & maintained by RHD. But the insufficient road width 4.34m has to be extended to 7.3m width by proper rehabilitation works. The aggregated rehabilitation works is 58084.08 sqm of carriageway. The existing two Baily Bridges of 25m & 61.6m length have to be replaced by RCC Bridges.

The existing land route from Chittagong Port to Rangamati for multimodal route option the investigation and inventory have been done. It is seen that Chittagong Port to Oxygen More 15.368 km bituminous carpeting road with 19.33m width of carriageway already constructed and

maintained by CDA/CCC (Chittagong Development Authority/Chittagong City Corporation) and it does not require any development right now.

From Oxygen More to Hathazari 16.191 km. bituminous carpeting road with 7.45m width of carriageway already constructed and maintained by RHD as National Highway (N106). It does not require any development now but one boxculvert of 16.9m length has to be replaced by a RCC Bridge.

From Hathazari to Ghagra 33.426 km bituminous carpeting road with 6.80m width of carriageway is constructed and maintained by RHD as National Highway (N106). But the insufficient road width 6.80m has to be extended to 7.3m width by proper rehabilitation works. The aggregated rehabilitation works is 16713 sqm of carriageway. The existing one Bailey Bridge of 15m length has to be replaced by RCC Bridge and one old & small Box culvert of 2.9m length has to be replaced by a new Box culvert.

From Ghagra to Rangamati 7.525 km bituminous carpeting road with 7.04m width of carriageway is constructed and maintained by RHD as National Highway (N106). The shortage carriage way width (7.04m) has to be rehabilitated for 7.3m width of carriageway and aggregated rehabilitation works is 1956.5 sqm of carriageway.

The various improvement required on this route are tabulated as below in Table 6.9A. **Annexure 6.9 A gives details of Existing road from Cittagong to Rajosthali.**

Table 6.9A: Improvements required on Existing Land Route from Chittagong-Rajoshthali

Section of the Road	Owner of the Road	Location	Length (km)	Avg. Carriage way (m)	Pavement Type	Widening of carriageway to 7.3m	Total No of existing Bridge	Existing Total length of Bridge (m)	Existing total no of culvert	Existing Total length of Culvert (m)	Missing Link (m)	Improvements
a.Chittagong Port to Mohora/Raster Matha (Ch.0+000-10.923)	CDA	Chittagong City Corporation	10.923	17.95	BC Road	N/A	2	343	8	40.7	N/A	N/A
b. Mohora/Raster Matha to Chandraghona (Ch.0+000-32.446)	RHD (R163)	**Upozila**: Boalkhali,Rangunia Kaptai **District:** Chittagong, Rangamati	32.446	6.20	BC Road	35690.60	8	411.40	33	154	N/A	**35690.60 sqm** Carriage way widening
c.Chandraghona to Bangalhalia (Ch.19+775-32+085	RHD (R161)	**Upozila**: Kaptai **District:**Rangamat	12.310	5.43	BC Road	23019.70	2	39.90	4	6.6	315	**315 m** bridge should be constructed on the karnafuly river at chandraghona ferry ghat ,**21.5 m,18.4 m** existing Baily Bridge should be replace by RCC or PC Girder bridge &**23019.70 sqm** Carriage way wideningrequired
d.Bangalhalia to Rajosthali (Ch.0+000-19+623)	RHD (Z1814)	**Upozila:** Rajosthol **District:**Rangamat	19.623	4.34	BC Road	58084.08	3	129.40	4	12	N/A	**25 m ,61.6 m** existing Baily Bridge should be replace by RCC or PC Girder bridge &**58084.08 sqm** Carriage way widening
Total=			**75.302**			**116794.38**	**15**	**923.70**	**49**	**213**		

The road which is connecting Chittagong Port to Multimodal Route at Rangamati passes through Oxygen more. The total length of existing road is 72.51 Km with 21 bridges and 107 culverts. The existing road is Bituminous concrete with an average width of 7.1 m. The **Annexure 6.9Bgives details of existing road from Chittagong to Rangamati.**

Table 6.9B: Improvements required on Existing Land Route from Chittagong-Rangamati

Section of the Road	Owner of the Road	Location	Length (km)	Avg. Carriage way (m)	Pavement Type	Widening of arriageway to 7.3m	Total No of existing Bridge	Existing Total length of Bridge (m)	Existing total no of culvert	Existing Total length of Culvert (m)	Missing Link (m)	Improvements
a. Chittagong Port to Oxygen more (Ch.0+000-15+368)	CDA	Chittagong City Corporation	15.368	19.33	BC Road	N/A	2	337.1	7	36.4	N/A	N/A
b.Oxygen more to Hathazari (Ch.0+000-19+191)	RHD (N 106)	**Upozila**:Hathazari Manikchhari **District:** Chittagong, Rangamati	16.191	7.45	BC Road	N/A	5	156.5	23	177	N/A	**16.9m** Box Culvert should be replace by RCC Bridge
c.Hatgazari to Ghagra (Ch.16+191-49+617)			33.426	6.80		16713	13	478.9	59	292.3	N/A	**2.9m** Box culvert should be replace by another Box culvert &**15 m** baily Bridge will be replace by RCC bridge &**16713**sqm Carriage way widening
d.Ghagra to Rangamati (Ch.49+617-57+142)			7.525	7.04		1956.5	1	75.8	18	70.2	N/A	**1956.5 sqm** Carriage way widening
Total =			**72.51**			**18669.5**	**21**	**1048.3**	**107**	**575.9**		

6.10 Cost Estimates forRoad Route and Multimodal routes:

The detailed construction Cost for all concerned components of the proposed road route i.e, Rajostholi to Thegamukh, 109.670 km and development works of existing portion i.e, Chittagong to Rajostholi are computed item-wise on the basis of detailed bills of quantities. Unit rates for all items of works are considered according to RHD Schedule of Rates, August 2015 and some of rates which are not available or does not match in RHD Schedule of rates have been taken from LGED Schedule of Rates, July 2014.**Unit rates and quantity estimates for major activities are shown in Annex 6.10**. The construction cost is summarized as follows:

1.ROAD ROUTE:

A) Cost Estimate for all items of Proposed Road Route (Rajoshtholi to Thegamukh=109.670 km)

SL. No	Name of Component	Division as per RHD & LGED	Total Taka (Including VAT & TAX)
1	General & Site facilities	Division-1	23038941.00
2	Earth work & Pavement works	Division-2	12822660852.20
		Division-3	4574709695.42
3	Bridges (PCC & RCC), Structures, Foundation works, etc.	Division-2	25950037.50
		Division-4	591471751.50
		Division-5	1422988043.69
5	Box Culverts, Backfilling earth works,etc.	Division-2	3388589.70
		Division-5	147101221.92
6	RCC Retaining wall, Back filling, etc.	Division-2,3,5 & 6	1435825378.10
7	Drains, backfilling earth works, etc.	Division-2 & 5	307070451.35
8	Incidental	Division-6	44456650.00
	Total Tk.		21,398,661,612.38

21398.66 Million Taka

277.19 Million US$

B) Cost Estimate for all items of Existing Road Development (Chittagong Port to Rajoshtholi=75.302 km)

SL. No	Name of Component	Division as per RHD & LGED	Total Taka (Including VAT & TAX)
1	General & Site facilities	Division-1	0.00
2	Earth work & Pavement works	Division-2	84403936.75
		Division-3	838946249.00
3	Bridges (PCC & RCC), Structures, Foundation works, etc.	Division-2	2254500.00
		Division-4	73195440.50
		Division-5	252355837.30
	Total Tk.		1,251,155,963.55

1251.156 Million Taka

16.207 Million US$

C). Cost Of Environmental Mitigation Measures For Road Route =1050 Million Taka

TOTAL COST (A+B+C) FOR ROAD ROUTE = 23699.82 MILLION TAKA
=307 MILLION US$

2. Multimodal Route:

A) Cost for Multimodal Route from Rangamati to Chotohorina (Waterway) & Chotohorina Thegamukh by Road					
Dredging Cost					
SL. No.	**Description**	**Unit**	**Quantity**	**Rate (Taka) (Including VAT & TAX)**	**Amount (Taka)**
1	Dredging from Rangamati to Barkal	m^3	1180000	250	295000000.00
2	Dredging from Barkal to Chotohorina	m^3	7080000	250	1770000000.00
3	Cost of Maintenance Dredging	m^3	247800	250	61950000.00
				Sub Total	2126950000.00
Cost of Landing Facilities					
1	R.C.C Jetty	No	3	9060000	27180000.00
2	Pontoon (Big)	No	3	7490000	22470000.00
3	Pontoon(Small)	No	9	5498000	49482000.00
4	Spud	No	6	757550	4545300.00
5	One Terminal Building	No	3	14949834	44849502
6	One Semi Pucca Transit shed	No	3	600000	1800000.00
7	Tube-well(shallow)	No	3	80000	240000.00
8	Electric Connection	No	3	20000	60000.00
				Sub Total	150626802.00
1	Bank protection work		L.S		7000000.00
2	Other ancillary work		L.S		7000000.00
				Total	**2291576802.00**
Cost of Road (From Chotohorina to Thegamukh) Road Portion					
1	General				21058941.00
2	Road Pavement				789628180.85
					312618255.29
3	Bridges (PCC & RCC)				1955857.50
					34362497.50
					61810356.69
4	RCC Retaining wall				219924966.00
5	Drain				31330639.92
6	Incidental				3063339.99
				Sub Total	**1,475,753,034.74**
				Grand Total(Including 15% VAT)	**3767329836.74**
				Million Tk	**3767.33**
				Million US$	**48.79**

B) Cost Estimate for all items of Development/Rehabilitation works required on existing roads (Multimodal route) i,e,Chittagong port to Rangamati (72.51km)			
SL. No	**Name of Component**	**Divisions**	**Total Taka (Including VAT & TAX)**
1	General	Division-1	0.00
2	Road Pavement	Division-2	11443992.75
		Division-3	107501638.00

3	Bridges (PCC & RCC)	Division-2	529449.50
		Division-4	6352496.50
		Division-5	16574266.42
	Grand total		142,401,843.17

142.40 Million Taka
1.845 Million US$

C) Cost of Environmental Mitigation Measures for Multimodal Route =161 MillionTaka

TOTAL COST FOR MULTIMODAL ROUTE (A+B+C) = 4070.73 MILLION TAKA.
= 52.74 MILLION US$

6.11 Implementation Plan for Road Route and Multimodal Route:

Implementation Plan For Road Route Chittagong Port To Thegamukh

			1st Year		2nd Year		3rd Year	
Sr. No.	**Items of Work**	**Unit**	**Quantity**	**Amount(Tk)**	**Quantity**	**Amount(Tk)**	**Quantity**	**Amount(Tk)**
1	**Earthwork**	cu. meter	33,420,371.57	5,781,657,723.84	33,420,371.57	5,781,657,723.84	7,426,749.24	1,284,812,827.52
2	**Road Pavement**	cu. meter			186,971.63	1,264,261,478.33	436,267.13	3,792,784,434.99
3	**RCC Work s**	cu. meter	8,522.06	335,296,793.12	34,088.22	1,005,890,379.35	14,203.43	894,124,781.64
4	**Drain**	lin. Metre	5,227.50	15,353,522.57	31,365.00	76,767,612.84	6,795.75	214,949,315.95
5	**Enviroment/Social**	Lump sum		315,000,000.00		420,000,000.00		315,000,000.00
6	**Road Furniture**	Lump sum						44,456,650.00
7	**General**	Lump sum		577,552,856.69		817,904,000.60		478,732,886.12
	Total			6,709,860,896.21		8,946,481,194.95		6,709,860,896.21

Implementation Plan For Multimodal Route Chittagong Port To Thegamukh

			1st Year		2nd Year		3rd Year	
Sr. No.	**Items of Work**	**Unit**	**Quantity**	**Amount(Tk)**	**Quantity**	**Amount(Tk)**	**Quantity**	**Amount(Tk)**
1	**Earthwork**	cu. meter	2,308,533.79	399,050,483.81	1,846,827.03	319,240,387.04	1,846,827.03	79,810,096.76
2	**Road Pavement**	cu. meter			20,749.34	137,851,290.92	33,717.68	256,009,540.27
3	**RCC Work s**	cu. meter	0,342.02	38,211,868.32	0,684.03	127,372,894.40	0,912.04	89,161,026.08
4	**Drain**	lin. Metre	0,430.00	1,566,532.00	2,580.00	12,532,255.97	3,440.00	17,231,851.96
5	**Enviroment/Social**	Lump sum		48,300,000.00		64,400,000.00		48,300,000.00
6	**Road Furniture**	Lump sum						3,063,339.99
7	**dredging**	cu. meter	2,478,000.00	619,500,000.00	3,304,000.00	826,000,000.00	2,478,000.00	619,500,000.00
8	**R.C.C Jetty**	NO.	1	9,060,000.00	1	9,060,000.00	1	9,060,000.00
9	**Cost of Maintenance dredging**	cu. meter	74,340.00	18,585,000.00	99,120.00	24,780,000.00	74,340.00	18,585,000.00
10	**pontoon**	NO.	4	17,988,000.00	4	29,980,000.00	4	23,984,000.00
11	**Bank protection work**	Lump sum		2,100,000.00		2,800,000.00		2,100,000.00
12	**Other ancillay work**	Lump sum		2,100,000.00		2,800,000.00		2,100,000.00
13	**General**	Lump sum		64,757,619.85		71,475,843.64		52,314,648.91
	Total			1,221,219,503.97		1,628,292,671.96		1,221,219,503.97

Remark: Detailed Implementation plan with construction schedule and activities would be provided in the detailed design phase with No. of packages in consultation with client, availability of finances, actual date of start of activities etc.

CHAPTER – 7

Economic Appraisal of Road and Multimodal Route

CHAPTER – 7

Economic Appraisal of Road and Multimodal Route

7.1 Introduction

Economic appraisal is carried out to assess the viability of the proposed investment in the transport infrastructure (i.e. road and IWT) duly taking into account various benefits (positive as well as negative) that are likely to accrue to the users of the facility as well as the different types of stakeholders in the project influence area (PIA). Further, in economic analysis project costs and benefits are assessed from the point of view of the economy. Given the base year traffic estimates (Section 2.3), traffic forecasts during the design life of the project (Chapter 3), this chapter presents methodology, inputs and results of economic appraisal. As mentioned in Section 2.3 and Chapter 3, two routes namely, i) all-road route: ***Chittagong-Rajosthali-Thegamukh*** and ii) multi-modal route: ***Chittagong-Rangamati by road***, ***Rangamati-Chotohorina (by waterway) and Chotohorina-Thegamukh by road***. For the sake of convenience and clarity, appraisal methodology and results are presented first for all-road route and then for multi-modal-route.

7.2 Appraisal Methodology

7.2.1 *All-Road Route: Chittagong-Rajosthali-Thegamukh*

In the case of road widening/construction projects like the current one, major benefit emanates from reduction in vehicle operating cost (VOC) which in turn translates to reduced transport cost for passengers and goods traffic. Further, improved road condition will facilitate comfortable travel at higher speeds on the one hand and contribute to better environment in the project area in terms of reduction of dust pollution, etc. on the other. In other words, improved/new project road would result in savings to road users as well as to the society in terms of reduced transport costs and travel time, and improved environmental conditions. Since, the road projects normally entail lengthy operational (or design) lives, all the relevant costs and benefits of the project need to be estimated for each year of the project life (including construction period) and appropriately compared to arrive at the overall viability of the proposed investment on road improvement works. To this end, the HDM IV model which allows life cycle costing has been used for assessing the costs and benefits traceable to the road upgrading project during its entire design life period. Within this framework, two mutually exclusive project alternatives viz. i) with the project and ii) without the project, have been considered for assessing the economic viability of proposed road project.

In economic appraisal, all the project costs and benefits are required to be expressed in their economic terms (or in terms true cost of resource consumption) rather than financial / market prices which are used in financial appraisal. This is because the market/ financial prices of a commodity/ services do not reflect their true value to the economy due to market distortions traceable to administered prices, taxes, subsidies, etc. Another important factor in economic appraisal is the ***discount rate*** (***or cut-off rate***) used for discounting future economic costs and benefits of the project to their present values. The discount rate represents *opportunity cost of capital* in economic appraisal. Since the information on cost of various items collected from the

market and other sources are in financial terms, the same have been converted into economic costs by using standard methods.

The HDM-IV model is a life-cycle costing model in as much as it computes costs and benefits traceable to the road investment project for each year of its design life. Given the inputs relating to i) road improvement/construction and maintenance costs, ii) base year traffic levels by vehicle category and their corresponding growth rates, iii) physical characteristics and utilization data of various types of vehicles and their cost, iv) cost of fuel, v) cost of tyre, vi) cost of vehicle crew and maintenance labour, vii) value of time for passenger and freight traffic, etc., the HDM-IV model output yields, among others, the following project viability parameters:

- Net Present Value (NPV)
- Economic Internal Rate of Return (EIRR)

Various inputs that are required for calibration of the HDM-IV model are presented in the ensuing sections.

As mentioned earlier, for the purpose economic appraisal, financial/ market prices of all the inputs for HDM-IV are required to converted in to their economic terms. To this end, the information contained in the report on *"RHD Road User Cost Annual Report 2004-05"* and *latest updates on VOC from RHD* coupled with data on vehicle related data collected by the Consultants have been used to arrive at the economic costs. Details in this regard are presented in the following paragraphs.

7.2.1.1 HDM-IV Model Inputs

a) Vehicle Related Inputs

Various inputs/ parameter-estimates that are required for calibrating the vehicle operating cost and other user costs sub-routines within the HDM 4 include market prices of different types of motor vehicles, tyres, fuels (petrol, diesel and lube oil), vehicle characteristics and their utilization, cost of vehicles crew and maintenance labour per hour, value of passenger time per hour and cost cargo delay per hour relevant for the project area.

Information on vehicle prices and their physical characteristics has been collected from the major auto dealers in Dhaka. As to vehicle utilization, cost of crew and maintenance labour, the relevant information was gathered from major truck/ bus companies, travel agencies and auto garages (repair/ service stations). In the case of tyres, relevant market prices have been collected from tyre dealers in Dhaka. All these market prices relate to October 2015. Latest fuel prices have been collected from the website of Bangladesh Petroleum Corporation (BPC). Broadly speaking, the consultants collected all the relevant information on input prices through market surveys. In certain cases such as vehicle utilization data, value of passenger travel time and cargo delay time, the information contained in the *"RHD Road User Cost Annual Report 2004-05"*. Further, as mentioned above, latest vehicle related input data for the year 2011 used in the RHD's HDM database has been collected. Using latest market/financial data collected by the Consultants, RHD's vehicle-related HDM input data has been updated and the resultant estimates form the inputs in the present analysis. The vehicle-related HDM-IV inputs are presented in Table 7.1

Table 7.1: Vehicle Related HDM-IV Inputs (2015 Prices)

Cost Item	Unit	Type of Vehicle									
		Heavy Truck		Medium Truck		Small Truck		Large Bus		Mini Bus	
		Fin	Eco	Fin	Eco	Fin	Eco	Fin	Eco	Fin	Eco
New Vehicle	Tk' 1000/Veh	7540	5608	2467	1835	1750	1291	4817	4088	2967	2144
New Tyre	Tk' per Tyre	39242	27626	33000	23232	17300	12181	31000	21824	16400	11545
Maint. Labour	Tk' per Hour	125	101	125	101	125	101	125	101	125	101
Overheads	Tk' 000/annum	514	412	514	412	230	186	2798	2239	156	125
Crew Wages	Tk' per Hour	76	61	76	61	44	35	76	61	52	43
Fuel - Diesel	Tk' per litre	68	56	68	56	68	56	68	56	68	56
Fuel - Petrol	Tk' per litre	99	81	99	81	99	81	99	81	99	81
Lubricants	Tk' per litre	450	360	450	360	450	360	450	360	450	360
Utilization											
Auual Km Driven	Kms/year	86000		80700		74000		129800		66700	
Annual Hrs. Working	Hrs./year	3110		3100		3600		3450		3060	
Annual Hrs. Driven	Hrs./year	2050		2036		1748		2864		2131	
Average Service Life	Years	14		9		8		5		5	
Travel Time Cost											
Passenger	per Pass Hr. (Tk)							59	47	59	47
Cargo	per Veh. Hr. (Tk)	27.76	22.21	27.76	22.21	27.76	22.21				
Average Payload											
Passenger Vehicles	No. of Passengers							39		32	
Cargo Vehicles	Tonnes	13		9.5		2.5					

Cost Item	Unit	Type of Vehicle									
		Micro Bus		Utility		Car		Motor Cycle		Auto Rickshaw	
		Fin	Eco	Fin	Eco	Fin	Eco	Fin	Eco	Fin	Eco
New Vehicle	Tk' 1000/Veh	2500	1682	5117	2365	3039	1855	215	128	375	224
New Tyre	Tk' per Tyre	11500	8096	13600	9581	8800	6198	3085	2171	3033	2131
Maint. Labour	Tk' per Hour	125	101	125	101	125	101	125	101	125	101
Overheads	Tk' 000/annum	268	215	275	220	73	59	32	26	35	29
Crew Wages	Tk' per Hour	44	35	46	37	50	43	0	0	40	34
Fuel - Diesel	Tk' per litre	68	56	68	56	68	56	68	56	68	56
Fuel - Petrol	Tk' per litre	99	81	99	81	99	81	99	81	99	81
Lubricants	Tk' per litre	450	360	450	360	450	360	450	360	450	360
Utilization											
Auual Km Driven	Kms/year	56800		22800		50000		46000		13000	
Annual Hrs. Working	Hrs./year	3200		4700		2850		3950		3850	
Annual Hrs. Driven	Hrs./year	1171		863		1276		588		2126	
Average Service Life	Years	6		7		5		5		5	
Travel Time Cost											
Passenger	per Pass Hr. (Tk)	84	67	104	83	104	83	77	62	56	44
Cargo	per Veh. Hr. (Tk)										
Average Payload											
Passenger Vehicles	No. of Passengers	6		3		3		1		4	
Cargo Vehicles	Tonnes										

***Source**: Consultant's Market Survey Data and RHD's HDM-IV Database*

b) Traffic Related Inputs

As mentioned in Chapter 3, the total all-road route between Chittagong and Thegamukh has two distinct sections namely, i) Rajosthali-Thegamukh (proposed new road section), and ii) Chittagong-Rajosthali (existing RHD road section). Details of these road sections are as under:

S. #	Name of the Road Section	Status	Length (Km)
A. Rajosthali -Thegamukh			
	A.1 Rajosthali - Bilaichari	Proposed New Road	47.066
	A.2 Bilaichari - Jurichari		28.091
	A.3 Jurichari - Thegamukh		34.518
		Total - A	109.67
B. Chittagong - Rajosthali			
	B.1 Chittagong - Chandraghona	Existing RHD Road	43.369
	B.2 Chandraghona - Rajosthali		31.933
		Total - B	79.07
		Total -(A+ B)	188.74

Viability or otherwise of road upgrading/construction projects mainly depends on the savings in motor vehicle operating cost (VOC) that is likely to accrue to the road users. Further, the pavement design and road geometry are also determined by the level and composition of base year traffic and their projections. Based on the field studies and detailed analysis of the available primary and secondary sources of information, the consultants have estimated base year (2013) traffic level and composition (Section 2.3) and their projections till the end of the design life (Chapter 3) for the project road. For ease of referencing summary of traffic projections are presented in Tables 7.2 and 7.3 for the proposed road and existing road espectively.

Table 7.2: Traffic Projections on New Road Section : Rajosthali-Theghamukh (Moderate Scenario)

Road Section	Traffic Projections (AADT -Both Directions)				
	2020 - 1st Year	2025	2030	2035	2040
Normal/Diverted Traffic					
Rajosthali - Bilaichari	530	816	1,325	2,043	3,148
Bilaichari - Juraichari	546	842	1,367	2,107	3,249
Juraichari - Theghamukh	731	1,126	1,828	2,817	4,342
Including Generated Traffic (20% of Normal Traffic)					
Rajosthali - Bilaichari	636	980	1,590	2,451	3,778
Bilaichari - Juraichari	656	1,011	1,640	2,529	3,898
Juraichari - Theghamukh	877	1,351	2,194	3,381	5,211
Cross-border Traffic					
Rajosthali - Theghamukh	442	591	792	1,059	1,418
Total Traffic Projections including Cross-Border Traffic					
Rajosthali - Bilaichari	1,078	1,571	2,382	3,510	5,196
Bilaichari - Juraichari	1,098	1,602	2,432	3,588	5,316
Juraichari - Theghamukh	1,319	1,943	2,985	4,440	6,629

Table 7.3: Traffic Projections on Existing Road

Traffic Projections on Existing Chittagong-Chandraghona-Rajosthali Road Section - Normal Traffic					
Road Section	Traffic Projections (AADT -Both Directions)				
	2020 - 1st Year	2025	2030	2035	2040
Chandraghona-Rajosthali	1,657	2,324	3,260	4,572	6,413
Chandraghona-Chittagong	6,865	9,629	13,505	18,941	27,311
Cross-border Traffic Bothways - AADT from the year					
Chittagong - Rajosthali	8,522	591	792	1,059	1,418
Traffic Projections on Existing Chittagong-Chandraghona-Rajosthali Road Section - Normal Traffic and Cross-border traffic					
Chandraghona-Rajosthali	2,099	2,916	4,051	5,631	7,830
Chandraghona-Chittagong	7,307	10,220	14,296	20,000	28,728

c) Infrastructure Related Inputs

Infrastructure related inputs include i) capital cost of the road improvement/construction works and cost of maintenance (routine as well as periodic) for each of the alternatives considered for the road works under the project and ii) design parameters for each alternative.

i) Capital Cost of Road Widening/Construction Works

For the purpose of economic appraisal two mutually exclusive project scenarios have been considered, namely "*without the project*" and "*with the project*". Under *without the project* scenario only do-minimum situation (i.e. maintaining the existing road in its present condition) has been assumed and it is termed as **Alternative 0** (**Alt-0**). In the case of *with the project* scenario, alternative only one below:

Alternative 0: Do-minimum **(Alt-0):** To maintain current roughness and service levels. Since there is no existing road between Rajosthali and Thegamukh, a two-lane very badly deteriorated (> IRI 12) all-weather road has been assumed for HDM analysis.

Alternative 1: Proposed:(Rajosthali to Thegamukh) 7.3m wide road with 0.9 m shoulder on either side in hilly area and 7.3 m wide road with 1.5 m shoulder and 0.9 m verge on either side in open area.

Existing: (Chittagong to Rajosthali) 7.3 m wide road with 1.5 m shoulder and 0.9m verge on either side of road

Under alternative 1, the capital cost of construction of the new road from Rajosthali to Thegamukh and of widening of the existing road from Chittagong to Rajosthali is given in Table 7.4.

Table 7.4: Capital Cost of Construction/Widening

Road Section	Status	Type of Work	Length (Km)	Capital Cost (mill. Taka)	
				Financial	Economic*
Chittagong – Rajosthali	Existing Road	Widening	75.30	1,251.16	1,000.93
Rajosthali – Thegamukh	New Road	New Construction	109.67	21,398.66	17,118.93
Total			**184.97**	**22,649.82**	**18,119.86**

*Economic costs are calculated by applying conversion factor of 0.8 to financial cost.

For all road route, environmental mitigation cost has been estimated at 1,050 million taka.

ii) Maintenance cost

The following two maintenance types are considered in the analysis:

i) Routine Maintenance: Includes grass cutting, drain clearing, re-cutting ditches to the proper shape, culvert maintenance, road sign maintenance etc.

ii) Periodic Maintenance: Includes repairing of potholes, repair edge, sealing cracks, resealing (surface dressing, slurry sealing etc.), re-gravelling road and shoulders etc.

The estimates for maintenance works have been estimated within the framework of RHD's Pavement Design Guide (2005) using the information on unit rates for maintenance works and standards collected from the relevant divisions of RHD. The unit costs adopted for maintenance operation are given in Table 7.5. Economic costs presented in the table are calculated by applying conversion factor of 0.8 to financial cost.

Table 7.5: Unit Costs of Work for Maintenance

Work Class	Work Type	Predominant Activity	Unit	Maintenance Cost (Taka)	
				Fin. (1)	Econ
Routine	Routine Maintenance	Maintenance Outside Carriageway	Per Km	66,290	53,032
		Patching Potholes 1,272	Per Sq. m	1,686	1,349
		Crack Sealing	Per Sq. m	251	201
		Edge Repair	Per Sq. m	1,686	1,349
Periodic	Resurfacing	Seal Coat 15 mm	Per Sq. m	251	201
		DBST	Per Sq. m	398	318
	Asphalt Mix	Bituminous Carpeting 40mm	Per Sq. m	850	680
	Resurfacing	Overlay 40 mm	Per Sq. m	793	634
		Overlay 50 mm	Per Sq. m	981	784
		Overlay 60 mm	Per Sq. m	1,171	937
		Overlay 80 mm	Per Sq. m	1,549	1,239
		Overlay 100 mm	Per Sq. m	1,928	1,542
		Overlay 120 mm	Per Sq. m	2,306	1,845

Source: **Maintenance & Rehabilitation Needs Report of 2012-2013 for Paved Roads, RHD**
Table 3.3, pages 13 and 14.

Note (1) **Updated using average CPI from 2011 to 2015**

iii) Other Inputs and Assumptions

The following assumptions and parameter-estimates have been considered for HDM-IV model calibration.

a) Design life of the project (or period of analysis) has been taken as 20 years.

b) Opportunity cost of capital is 12%.

c) Base Alternative is "do-minimum" scenario (**Alt-0**)

d) Salvage or residual value of the road upgrading/ improvement works is assumed as 10% of the initial value.

e) Construction period as 3 years (2017-2019)

f) The spread of road widening/ construction cost over the 3 years has been assumed as 30% (1st year), 40% (2nd year) and 30% (3rd year).

g) Medium Traffic Forecast Scenario has been considered for economic appraisal

7.3 Economic Appraisal Analysis and Results

Within the methodological framework described above, the economic appraisal has been carried out by comparing the costs and benefits of the road upgrading project throughout its design life under two mutually exclusive scenarios namely: ***without the project*** and ***with the project***. Under *the with the project* scenario, the project costs include capital cost of road widening/ construction works including project supervision, cost of environmental mitigation measures and cost of relocation of /compensation to project affected people (PAP). Further, recurrent expenditures on routine and periodic maintenance to maintain the road at the specified service levels form part of the project cost.

As to the project benefits, savings in vehicle operating cost that is expected due to the proposed road improvement works constitute major quantifiable benefit for the project. Other quantifiable project benefits include: user savings, (travel time saving), residual value of capital works at the end of economic life of the road, arising due to 'the with the project scenario' as against the 'without the project scenario'. Costs and benefits traceable to possible reduction in accidents were not considered due to unavailability of reliable sources of data.

The project cost and benefit streams under *with the project* scenario have been computed for each year of the project life. Each of these cost/benefit streams were compared with the corresponding streams of Base Case Alternative (*without the project* scenario) and economic internal rate of returns (EIRRs) have been worked out using discounting technique. In addition, net present value (NPV) has been computed at 12% rate of discount; opportunity cost of capital used for public project appraisal in Bangladesh.

The economic appraisal has been carried out separately for the following two distinct road situations.

- **Situation 1**: For the entire road stretch from Chittagong to Thegamukh i.e. Chittagong-Rajosthali-Chotohorina-Thegamukh. This includes the existing road from Chittagong to Rajosthali and new road from Rajosthali to Thegamukh.
- **Situation 2**: For the new road from Rajosthali to Thegamukh.

HDM-4 model output containing summary results of economic appraisal are presented in Annex 7.1. Brief summary results of the economic appraisal are presented in Table 7.6.

Table 7.6: Economic Appraisal: Summary Results

(Do-minimum versus With the Project Alternatives)

With the Project Alternative	Status of the Road Section	EIRR (%)	NPV @10% (Taka Million)
1. Chittagong-Rajosthali-Thegamukh	Situation 1	21.8	16,004
2. Rajosthali - Thegamukh	Situation 2	13.3	1,735

From the economic appraisal indicators set out in Table 7.6, both the Situations 1 and 2 are economically viable; the EIRRs being higher than the cut-off rate of 12%. As expected, Situation 1 has yielded a higher EIRR (21.8%) as the investment is relatively low with higher traffic levels. In case of Situation 2, the EIRR is marginally higher (i.e. 13.3%) than the cut-off rate. In this context it may be mentioned that Situation 2 represents all new road construction (i.e. green field project) in a very difficult terrain which entailed very high construction cost. Further, only quantifiable savings arising from reduction in vehicle operating cost (VOC) and travel time have only been considered. Since this road provides all-weather accessibility to project area which hitherto was practically inaccessible, a number of benefits accrue because of this new road. These include a) easy accessibility to education and health facilities, markets for agriculture/horticulture inputs and outputs, etc., b) establishment of new industries and creation of employment, and c) additional employment to local population due to construction of new road, etc. If all these all factored in, the EIRR for the new road (Situation 2) will be much higher.

7.3.1 Sensitivity Analysis

Economic viability of the road widening/construction project crucially depends on robustness of the project cost estimates and traffic forecasts. In reality, these estimates are likely to vary from their actual values. It is in this context, an attempt has been made to gauge the extent of impact of variations in project costs and benefits on the economic viability of the project. To this end, the following sensitivity scenarios have been considered.

a) 15% increase in the capital cost of the project (Scenario I)

b) 15% decrease in project benefits (Scenario II)

c) Scenario I and Scenario II taken together (Scenario III)

Results of the sensitivity analysis are presented in Table 7.7.

Table 7.7: Results of Sensitivity Analysis – All Road Route

Sensitivity Analysis Scenario	Economic Internal Rate of Return (%)	
	Situation 1	Situation 2
Base Case	21.8	13.3
1. 15% increase in Capital Cost (Scenario I)	19.2	11.5
2. 15% decrease in Project Benefits (Scenario II)	19.3	11.2
3. Scenarios I and II combined (Scenario III)	17.0	9.6

As expected, the results of sensitivity analysis indicate that the project under Situation 1 is economically viable even if the project cost increases by 15% or project benefits decrease by 15% or both taken together. In case of Situation 2, the EIRRs are close to the cut-off rate of 12%

indicating economic viability. These EIRR values should not be taken at their face value. This is because influence area of Rajosthali-Thegamukh road has vast traffic potential and due to lack of accessibility there is a huge latent/suppressed demand for traffic. Again, with the new road there will be exponential development. If all these things are considered, the traffic levels will be much more than the Moderate Scenario considered for economic analysis. Thus, considering all these additional aspects including benefits attributable to this new road mentioned earlier, the EIRRs will be higher than 12% indicating economic viability. Further, for fulfilling the objectives of the study i.e. to connect Chittagong port to CHT area as well as to promote border trade with North-east India, the entire road stretch i.e. Chittagong-Rajosthali-Thegamukh need to be improved/developed as a whole and as such it is not rational to develop only one stretch i.e. Chittagong-Rajosthali and ignoring the rest.

It may be pertinent to add here that results of the economic appraisal are valid subject to the realisation of the following assumptions.

- The road widening/ construction works have been assumed to commence from 1st Quarter 2017, implying that all the pre-construction process – securing adequate funds, selection of supervision consultant and civil works contractor and award of contracts – should be completed before the end of 2016.
- The construction work is assumed to spread over a 3 year period (2017-2019).
- Timely completion of the widening/ construction works within the planned budget (i.e. no time and cost over-runs)
- Adequate funds will be available for attending to routine and periodic maintenance of the upgraded road so as to ensure sustainability of its condition at the required service levels.
- Various developmental and allied projects will be taken up in the project area to ensure materialization of the GDP growth profile projected Perspective Plan of Bangladesh (2010-21) which formed the basis for traffic projections.
- Adequate feeder roads will be provided to the villages/ population settlements which are away from the project road so as to ensure that benefits of the improved road reach rural poor in remote areas.
- Strict enforcement of traffic and axle load regulations. This would check overloading and reduce accident rates.

Socio-economic Benefits

Apart from the quantifiable benefits like reduction in the vehicle operating cost (VOC), value of time, etc. a number of socio-economic benefits are likely to be enjoyed by the population in the project area. Some of these benefits are illustrated below.

Accessibility to Markets: Reduction in transport cost will facilitate access to bigger markets and in turn ensure better prices for agriculture and related produce of the project area.

Agricultural Inputs: Availability of better transport facilities at lower tariffs would facilitate timely availability of required agricultural inputs at reasonable prices. This in turn would enhance production levels.

Employment Opportunities: Large construction works like the present road construction project provide better employment opportunity for local poor during the construction period. The extent of employment and its impact on poverty reductions depends on the technology adopted for construction. The experience in the case of many developing countries indicates higher employment opportunities for labour if labour-based techniques are used for construction and maintenance of roads.

7.4 Economic Appraisal of Multi-modal Route: Chittagong-Rangamati-Thegamukh

The multi-modal route involves travel/transport by road and waterway. In the present route, transport on Chittagong-Rangamati is by road, Rangamati-Chotohorina by waterway and Chotohorina-Thegamukh by road. Details of distance and mode of transport on these stretches are given below:

Table 7.8: Multi-modal Route Distances

Section	Mode of Transport	Distance (Km)
Chittagong-Rangamati	Road	72.5
Rangamati-Chotohorina	Waterway	63.0
Chotohorina-Thegamukh	Road	7.4
Total Distance (Km)		142.9

In the case of the multi-modal route also, the economic appraisal has been done within the similar frame work as mentioned earlier i.e. using "with the project" and "without the project" approach. For the two road sections, HDM-IV model formed the basis for economic analysis, the vehicle related and other inputs being the same. Traffic forecast details for these two road sections are given in Chapter 3. The following paragraphs present relevant inputs for economic analysis for the waterway section i.e. Rangamati-Chotohorina.

a) **Traffic Forecast**: For easy referencing, traffic forecasts presented in **Chapter 3** are given below.

Table 7.9: IWT Traffic Forecasts

O-D Pair	Traffic	Base Year 2015	2020	2025	2030	2035	2040
Goods Traffic							
Rangamati-Chotohorina	Tonnes/day	280	375	501	671	898	1202
	Tonnes/year	92,400	123,652	165,474	221,442	296,339	396,569
Chotohorina-Rangamati	Tonnes/day	280	375	501	671	898	1202
	Tonnes/year	92,400	123,652	165,474	221,442	296,339	396,569
Total – Both-ways	Tonnes/day	560	749	1,003	1,342	1,796	2,403
	Tonnes/year	184,800	247,304	330,949	442,884	592,679	793,138
Passenger Traffic							
Rangamati-Chotohorina	Passengers/day	600	803	1,075	1,438	1,924	2,575
	Passengers/year	198,000	264,969	354,588	474,519	635,013	849,790
Chotohorina-Rangamati	Passengers/day	600	803	1,075	1,438	1,924	2,575
	Passengers/year	198,000	264,969	354,588	474,519	635,013	849,790
Total – Both-ways	Passengers/day	1,200	1,606	2,149	2,876	3,849	5,150
	Passengers/year	396,000	529,937	709,176	949,037	1,270,026	1,699,581

b) **Capital Cost of Infrastructure**: Improved IWT services for providing faster, better, comfortable and competitive services would require deeper channel for plying bigger and faster vessels, fully equipped terminals for handling different types of cargo and passengers, etc. The total investment required on these infrastructure facilities to handle the projected traffic is presented in Table 7.10.

Table 7.10: Capital Cost (Million Taka)

Cost Item	Financial	Economic*
Dredging	2126.95	1701.56
Terminals/Landing Facilities	150.63	120.50
Bank Protection	7.00	5.60
Other Ancillary works	7.00	5.60
Grand Total	2291.58	1833.26

* Calculated by multiplying financial cost with 0.8.

For the multi-modal route, the environmental mitigation cost has been estimated as 185 million taka.

c) **Vessel Cost and Speed**: The type of vessels required under the existing and improved situations, their unit costs, O& M cost and operational speeds are given in Table 7.11.

Table 7.11: Vessel Cost and Speed

S.no.	Type of Vessel/Cost Item	Unit	Existing Situation	After Improvement
1	**Cargo Vessels**			
	i) Capital Cost of Vessel	Million Taka	0.70	29.32
	ii) O & M cost per Vessel*	Million Taka	0.07	0.29
	iii) Travel Speeds	Km/hour	5-10, Average 7.5	15
2	**Passenger Vessels**			
	i) Capital Cost of Vessel	Million Taka	1.50	34.3
	ii) O & M cost per Vessel*	Million Taka	0.015	0.343
	iii) Travel Speeds	Km/hour	5-10, Average 7.5	15-20, 17.5Aaverage

* 1% of capital cost

d). Other inputs/Assumptions: Various other inputs that go into the economic analysis like vessel life, handling time and cost, salvage value, etc under the exiting and improved situations are presented in Table 7.12.

Table 7.12: Other Inputs and Assumptions

S.#	Description	Exiting Situation	Improved Situation
1	Working Days/Year	330	330
2	Working hours/Day	12	12
3	Handling Time at Terminal (hr/tonne)	5	4
4.	Handling Costs (taka/tonne)	5000	4000
6	O& Cost		
	- Vessel	10% of Capital	1% of Capital
	- Terminal	10% improved situation	1% of Capital
7	Vessel life (Cargo/Passenger)	7 Years	20 Years
8	Carrying Capacity		
	- Cargo Vessel	20 Tonne	300 Tonne
	- Passenger Vessel	100 Passengers	400 Passengers
9	Average Utilization		

S.#	Description	Exiting Situation	Improved Situation
	- Cargo Vessel	80%	80%
	- Passenger Vessel	100%	100%
10	Empty Haulage – Cargo Vessel	25%	25%
11	Salvage Value of Vessel	20%	20%
12	Construction Period		3 years (2017-2019)

Based on the traffic forecasts and cost and allied inputs, the cost of moving passenger and cargo traffic by IWT has been worked out separately under the existing (Without the Project) and improved (With the Project) situations for each of the year. The cash flows thus worked out under each situation have been compared and the economic internal rate of return (EIRR) and net present value (NPV) have been worked out for the project.

7.4.1 Results of Economic Appraisal for Multimodal:

The results of the economic analysis for multi-modal route comprising three sections are presented in Table 7.13. Details regarding economic appraisal are given in Annexure 7.2.

Table 7.13: Results of Economic Analysis – Multi-modal Route

Section	Mode of Transport	EIRR (%)	NPV (Million Taka)
Chittagong-Rangamati	Road	23.8	2,124.2
Rangamati-Chotohorina	Waterway	20.1	1,476.7
Chotohorina-Thegamukh	Road	14.8	281.9

It may be seen from Table 7.13 that the EIRR for each of the three constituent sections of the multi-modal route has an EIRR much above the cut-off rate of 12% implying that each of the sections is economically viable. Since each constituent section is economically viable, the entire multi-modal route is viable. Similar sensitivity analysis as for the all-road route has also been carried in this case also. The results are as under.

Table 7.14: Results of Sensitivity Analysis – Multi-Modal Route

Sensitivity Analysis Scenario	Economic Internal Rate of Return (%)		
	Chittagong-Rangamati (Road Section)	Rangamati-Chotohorina (Waterway)	Chotohorina-Thegamukh (Road Section)
Base Case	23.8	20.1	14.8
1. 15% increase in Capital Cost (Scenario I)	23.7	18.2	13.0
2. 15% decrease in Project Benefits (Scenario II)	18.9	4.4	12.7
3. Scenarios I and II combined (Scenario III)	18.8	3.4	10.9

Sensitivity analysis results in Table 7.14 reveal that both the road sections stand economically viable in all three sensitivity scenarios. In the case of waterway route, while increase in cost by 15% would not affect the viability, 15% decline in benefits will adversely impact the project viability bringing down the EIRR to 4.4%. However, in view of the huge latent/ unsatisfied demand for transport in the hitherto inaccessible area, such decline in demand for transport is a very distant possibility and may be ruled out. As such, the multi-modal route as a whole is economical under all the sensitivity scenarios.

It may be pertinent to add here that results of the economic appraisal are valid subject to the realisation of the following assumptions.

- The channel deepening and terminal construction works have been assumed to commence from 1st Quarter 2017, implying that all the pre-construction process – securing adequate funds, selection of supervision consultant and civil works contractor and award of contracts – should be completed before the end of 2016.
- The construction work is assumed to spread over a 3 year period (2017-2019).
- Timely completion of the works within the planned budget (i.e. no time and cost over-runs)
- Adequate funds will be available for attending to maintenance of the facilities to ensure sustainability of their condition at the required service levels.

7.5 Conclusion and Recommendation for the Preferred Option

All-Road Route: Considering the results of the economic appraisal and sensitivity analysis, widening of the existing road and construction of the new project road to paved standard alternative is imperative. As stated above, the new project road would lead to reduction in Road User Cost (RUC), including VOC, travel time for road users. The benefits could be higher if factors such as improved access to public service deliveries, the horizontal integration of markets and others could be considered.

Multi-Modal Route: Based on the results of the economic appraisal and sensitivity analysis, investment on multi-modal route is economically viable. The benefit would be higher if aspects such as enhanced income levels due to additional production of agricultural products traceable to better market access, better employment opportunities due to establishment of agro-based industry, etc. could be considered.

CHAPTER - 8
Conclusions and Recommendations

CHAPTER - 8
Conclusions and Recommendations

1. Road Alignment Rajostholi – Billaichhari –Juraichhari – Barakal – Thegamukh (109.67 Km) will be the most feasible one considering Technical and Engineering parameters and also with different social parameters which include: land acquisition (per km), number of households to be rehabilitated (per km.), impacts on economic structures (per km.), impacts on cultural properties (per km.), loss of agricultural land (per km.), loss of commercial land (per km.), impacts on tribal people (per km.), positive impact on population, poverty level, population to be influenced per km, and People's perception of the proposed project. That road has much potential, such as, it has highest area of hinterland to be covered, in case of non-operation of Chittagong-Cox's Bazaar road it can be used for traffic diversion, in future when the deep sea port will be developed, it would be used for trade facilities. Moreover, it would strengthen connectivity to all areas of CHT district.
   Among the Multimodal routes the alignment: Rangamati – Chhotoharina – connected by waterway (63 Km) and Thegamukh by road (about 7.37 km) have the highest scores. Thus these two alignments have been proposed for detailed feasibility study.
2. The connectivity with Chittagong port will enhance the economic activities in the hill region for which the people of the area were deprived so long. The area has very negligible number of road infrastructure except in the urban area of Rangamati, Bandarbon, and Khagrachari. Most roads are stopped while entering the hills. Though some roads are available in the western fringe of the CHT but the eastern fringe running north to south devoid of any communication. This lead to the marginalization of agricultural producer in the area. This road connectivity can change the socio economic scenario of the area. During Public Consultation it is revealed that the farmers can't take products to market due to non-availability of motorized transport. The health care facility cannot reach to the marginalized farmers due to lack of communication. Thus people of the area are deprived from the access to basic needs and services of the country.
3. The CHT areas also have presence of tribal peoples in their ancestral territories with distinct culture, language and livelihood practices. These peoples will be socially impacted by the growth in transportation and commerce in that region which are among the goals of the eventual investments. The strategic framework for sustainable development in CHT has been launched. 25 action points to support Sustainable Development Goals in CHT has been incorporated in the 7th five year plan of Bangladesh.
4. Road only connectivity may not be compared with multimodal one. Carrying cargo by vessel along the river/ lake route will not help in improvement of socio economic condition of the indigenous people (IP) of hill population. The people living along the lake or river may not improve much in transporting their produce what they are doing now with passenger/cargo launches. Most benefit will go to the bulk carrier from Chittagong port to transboundary destination (negligible cargo traffic between Chittagong port to Barkal/Chotohorina/Thegamukh). The planned road connectivity is must for the 'sustainable development goal' what government has out lined 25 points of action in the 7th five year plan in consultation with the ICIMOD.
5. The Kaptai Lake is the hot spot of biological diversity. Most families lost their land due to Kaptai reservoir and are living along the shore line of Kaptai lake and heavily dependent on the lake for water for drinking, household use, irrigation and fishing. It facilitates local

transportation to connect between the hills around the lake. The dredging of Lake Route has high risk of damaging flora and fauna population particularly of fish habitat. If the lake is left without dredging (between Kaptai-Rangamati-Barkal along the Karnafuli channel in the lake) part of the year the vessel can't ply because of draft problem. The constraint of lost draft during dry season will have to be accepted. This need detail hydrological study and hydrographic survey. Moreover maintenance of dredger fleet, cargo vessel inside the lake is another impediment in protecting the habitat.

6. However the draft between Barkal and Chhothorina can be increased by dredging. This portion of the channel is out of the Kaptai reservoir. Depending on the quality of dredged material it can be used to close the gaps of charas for road construction. The water control structure at the bottom may be needed. The careful dredging in this part of the multimodal route can avoid destruction/ upsetting fish habitat in the Kaptai lake. Chhotoharina-Theghamuk is connected by road. But it is the same Karnafuli river which has made loop between Chhotoharina and Theghamuk. Chhotoharina can be connected to Theghamuk by dredging the Karnafuli river which likely to be about 18 km or cutting a loop of 1 km a bit upstream of Chhotoharina and Theghamuk.
7. In future Rajostholi can be connected to the Karnafuli left bank if further port facilities are developed. On the left bank there are small port activity like KAFCO has one jetty for their own use. Moreover, in future, Rajostholi can be connected to the Cox's Bazar highway which may lead to another connectivity with deep sea port at Kutubdia/Moheshkhali. Tunnel at the outfall of Karnafuli has been planned that will effectively connect the eastern part of Chittagong with west. One bypass along the coastal embankment is under construction to connect western part of the country (Dhaka, Sylhet etc.) avoiding city traffic congestion of Chittagong.

Potential Expansion of Trade and Benefits

8. During the last 6 year period while total real GDP of Bangladesh was growing at about 6% per year, the GDP from Land transport grew at more than 6% per year; yielding an average demand elasticity of 1.13. Government of Bangladesh has prepared "Perspective Plan of Bangladesh (PPB) 2010-21: Making Vision 2021 A Reality". Vision 2021 envisions transformation of socio-economic environment of Bangladesh from a low income economy to the first stages of a middle income nation by 2021. To make the vision a reality, PPB 2010-21 stipulated the growth trajectory of real GDP of Bangladesh as 6.1%, 8% and 10% during the years 2010, 2015 and 2021. Using appropriate GDP growths in pessimistic, moderate and optimistic scenarios the following traffic growth rates have been worked out

Real GDP Growth Scenario	FY 15	FY 21	FY 26	FY 31	FY 36
Scenario 1 - Pessimistic	6.0%	6.0%	6.0%	6.0%	6.0%
Scenario 2 - Moderate	6.0%	7.0%	8.0%	9.0%	8.0%
Scenario 3 - Optimistic	6.0%	10.0%	10.0%	10.0%	8.0%

These growth rates will decide the future traffic forecasts which are quite encouraging.

9. In Bangladesh land-based cross-border traffic is handled at custom check posts. Currently there are 9 operational land custom check posts – 5 under BOT and 4 directly operated by Bangladesh Land Ports Authority. Besides, there are a number of border land custom check posts that are under development or proposed. A land custom post is under process of development at Thegamukh, which is the terminal point of the proposed routes and also

bordering with Mizoram state of North-eastern region of India. At present, there are no available cross-border movements through Thegamukh. Majority of cross-border traffic is moving through Benapole custom post.
However, some of the on-going regional initiatives like Bangladesh-China-India-Myanmar (BCIM) Economic Corridor and Mizoram State Roads II - Regional Transport Connectivity project, India (funded by World Bank) may provide a basis for broad assessment of cross-border traffic at Thegamukh.

The BCIM economic corridor is a sub-regional initiative for fostering cooperation among the four member countries. The proposed economic corridor originates from Kunming in China's Yunan province and pass through Yangon and Mandalay in Myanmar, Chittagong-Dhaka-Sylhet in Bangladesh before entering India's North Eastern states of Manipur and Assam and finally West Bengal and ending in Kolkata. The hinterland region of BCIM corridor is one of the richest in the world in terms of natural, mineral and other resources. Enveloping about 9% of worlds area, the BCIM region accounts for 440 million people and 7.3% global GDP. The region has potential to generate enormous economic benefits in the area of trade, investment, energy, transportation and communications. The BCIM Corridor will allow all four countries to exploit existing complementarities in trade — in terms of both sectors and products. Myanmar is a primary goods exporter and has abundant cheap labor. India has an edge as a leading services exporter. China is the largest manufacturing exporter in the world; and Bangladesh, like many other South Asian countries, engages in both services export and low-end manufactured goods. Provision of this link would benefit North-eastern region of India as well Bangladesh.

Mizoram State Roads II - Regional Transport Connectivity project, India (funded by World Bank): Taken up as part of the SAARC multi-modal transport initiative, this improved link to Bangladesh will facilitate greater bilateral trade as well as provide better access for Mizoram and other North-eastern Indian states to Chittagong Port (which is the nearest shipping port for NER states of India). Among others, the project comprises: widening and strengthening of three sections of (Group 1) road totaling 91 km including (i) a 22.0 km section of Lunglei –Tlabung – Kawrpuichhuah Road on the border with Bangladesh; (ii) the 27.5km Champhai-Zokhawthar Road on the border with Myanmar; and (iii) the 41.7km Chhumkhum-Chawngte North-South alignment connecting to the border roads with Bangladesh to the west and Myanmar to the south.

Thus the above discussion indicates a great potential for cross border traffic and the possibility to generate / divert traffic on the proposed corridors of this study. However it requires some more detailed data and in-depth analysis for appropriately allocating this traffic to relevant routes

10. When the project road i.e. two lane bitumen surfaced road commences operation, the above diverted/normal traffic will enjoy benefits traceable to reduced vehicle operating cost (VOC) and travel time and increased comfort. There will also be easy accessibility to medical centers, educational institutes (schools, colleges, etc.), social interaction, etc. At present, due to lack of proper transport facility, the potential of the area i.e. agriculture, horticulture, forestry, etc. remains mostly under/un-utilized. This is corroborated by the fact, as revealed during the discussions with concerned government agencies and local leaders in the project area, most of the agriculture and allied production in this area is mostly limited to meeting only the subsistence needs. This is because lack of proper transport and storage facilities has been hampering fruit production in this area and in some cases resulting in damage of

millions taka worth of fruits. As such when the new road is available which in turn ensures easy accessibility to inputs and product markets, substantial quantum of traffic gets generated due to additional production. Further, this will also encourage setting up of related industries e.g. agro-processing, fruit canning and forest-based industries. This will in turn create employment to local population and result in additional income.

11. Economic Appraisal : All Road Project: Chittagong-Rajosthali-Thegamukh

Major benefit of road improvement/construction is reduction in vehicle operating cost (VOC) which in turn translates to reduced transport costs for passengers and goods traffic. Upgrading of the project road would result in savings to road users as well as to the society in terms of reduced transport costs and travel time, and improved environmental conditions. Since, the road projects have lengthy operational (or design) lives, the HDM IV model which allows life cycle costing has been used for assessing the costs and benefits traceable to the road upgrading project during its entire economic (design) life period. Within this framework, two mutually exclusive project alternatives viz. i) with the project and ii) without the project, have been considered for assessing the economic viability of proposed road project.

Economic analysis has been carried out based on medium traffic forecast. While the project cost included capital cost of road upgrading/construction work and maintenance cost (routine and periodic), the quantifiable project benefits were savings in vehicle operating costs. Economic analysis results indicate that all the project options have a high economic rate of return.

Based on the economic analysis of the proposed project, as well as overall engineering and traffic assessment, construction of the new road between Rajosthali and Thegamukh along with widening of the existing road between Chittagong and Rajosthali with an EIRR of 21.8%, is preferable for the entire project road. Even under the most pessimistic scenario of 15% increase capital cost and 15% decrease in project benefits, the project yields an EIRR of 17.0 % which is much higher than the cut-off rate of 12% applicable in Bangladesh.
Thus considering the results of the economic appraisal and sensitivity analysis, widening of the existing road and construction of the new project road to paved standard alternative is imperative. As stated above, the new project road would lead to reduction in Road User Cost (RUC), including VOC, travel time for road users. The benefits could be higher if factors such as improved access to public service deliveries, the horizontal integration of markets and others could be considered.

Economic Appraisal: Multi-Modal Route - Chittagong-Rangamati-Chotohorina-Thegamukh
Under this, movement between Rangamati and Chotohorina is by water transport and that between i) Chittagong and Rangamati and ii) Chotohorina and Thegamukh is by road. For each of these three constituent sections of the multi-modal route, the investments are economically viable with EIRR more than 12%, the cut-off rate.

Based on the results of the economic appraisal and sensitivity analysis, investment on multi-modal route is economically viable. The benefit would be higher if aspects such as enhanced income levels due to additional production of agricultural products traceable to better market access, better employment opportunities due to establishment of agro-based industry, etc. could be considered.

Recommendations

1.The detailed design of the selected routes is very much essential because being hilly terrain more detailed and extensive data collection is required. In order to maintain desired speed the desirable geometric standards need to be maintained and many places the alignment may get shifted which requires availability of more data. If more data is available the possibility of further refinement of alignment can be explored.

2.During the detailed design there is a need for more detailed investigations in certain areas like the present proposed Road alignment is supposed to pass through Jurachuri Sadar, and then it would need to remove all establishments of Upazila and other buildings. The possibility should be explored for modifying the alignment to save those establishments. If the route passes by the Upazila Police station-Labour Para –Kalika Para-Barkal then the upazila establishments will be saved and road length would be shortened by 4-5 km. This possibility should be explored. Similarly if the Road Alignment follows the old KPM road that passes through Farua, Akuzzapara,Taktanala, Alikhong to down bridge, then it would prove to be cost effective and a lot of houses and buildings would be saved from acquisition. There is a need to look for these options during detailed design phase.

3.During the detailed design phase for preparing Road Alignment Maps, important locations should be demarcated on the mouza maps. And at the same time during consultation, surveyors should be advised to use Mouza Maps to find out the exact alignment locations. It would be very much fruitful, if there would be one day small workshop for review of the design and alignment in each of the four Upazilas, through which the road alignment has been passing with the presence of Headman, Karbari, UNO, UP Chairmen, UP members, Upazila Chairman, Vice-Chairman, etc. These workshops would help the project to do re-settlement works easily.