3. ACCESS ROAD DEVELOPMENT

3.1 Present Situation of Road Transport Infrastructure

3.1.1 Present Road Network in Bangladesh

The RHD's road network consists of total of 21,302 km of National, Regional and Zila Roads, which makes up 6% of the total road network in Bangladesh. The road condition has been improved and over 90% of the roads are compared to a value of in 1991. The Asian Highways are the most important corridors not only for the domestic economic activities but also for multinational economic forum such as SAARC, SASEC, BIMSTEC and BCIM aiming to contribute to the multinational region functioning as a gateway to the hinterland countries and induce synergetic economic growth in Bangladesh.

At the site of the Matarbari Port Development Project, National Highway No.1 is the most important arterial road designated as the Asian Highway No.41, which functions as a port access from AH1 or AH2 to Chittagong and Mongla Ports.

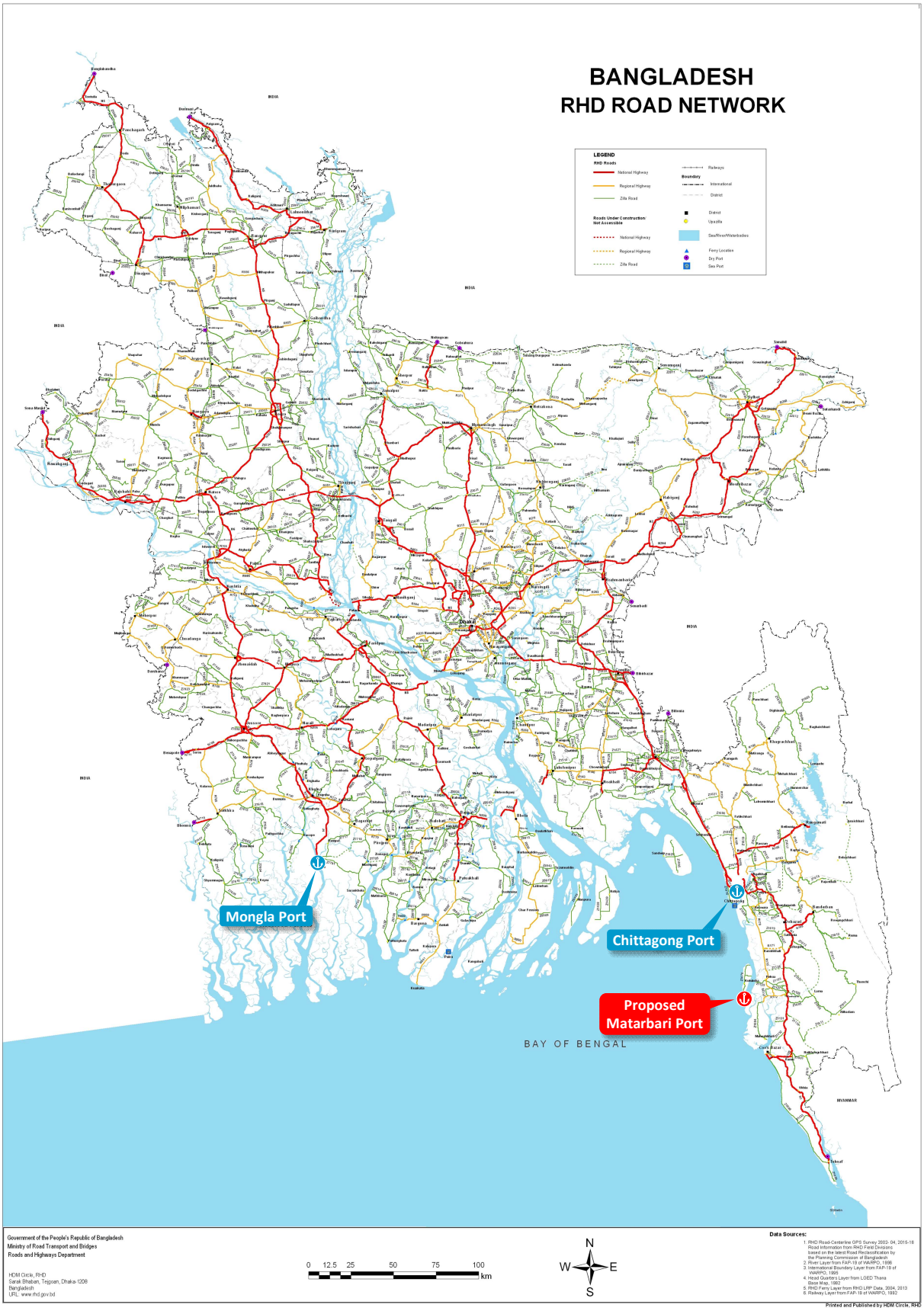
(1) Present Road Condition

The road network in Bangladesh consists of six road categories: National Highways, Regional Highways, Zila Roads, Upazila Roads, Union Roads and Village Roads. As summarized in the table below, a total of21,302 km of National, Regional and Zila Roads are under the jurisdiction of the Roads and Highways Department (RHD), under the Ministry of Road Transport and Bridges (MORTB) and a total of 333,589 km of Upazila, Union and Village Roads are under the jurisdiction of Local Government Engineering Department (LGED). The total road length managed by RHD makes up only 6.0% of the total road network in Bangladesh.

Table 3.1-1 Total Road Network in Bangladesh

Classification	Definition	Length (km)	Jurisdiction
National Highways	Highways connecting National capital with Divisional HQ's /sea ports / land ports / Asian Highway.	3,813	RHD
Regional Highways	Highways connecting District HQ's / main river / land ports / with each other not connected by National Highways.	4,247	RHD
Zila Roads	Roads connecting District HQ's with Upazila HQ's / connecting one Upazila HQ to another Upazila HQ by a single main connection with National/Regional Highway, through shortest distance/route.	13,242	RHD
	Total road length under RHD	21,302	6.0%
Upazila Roads	Roads connecting Upazila HQs with growth center with another growth center by a single main connection / connecting growth center to higher road system through shortest distance/route	39,756	LGED
Union Roads	Roads connecting Union HQs with Upazila HQs, growth centers / local markets / with each other	46,259	LGED
Village Roads	a) Roads connecting villages with Union HQs local markets, farms and ghats / with each other. b) Roads within a village	247,574	LGED
	Total road length under LGED	333,589	94.0%
	Grand total road length in Bangladesh	354,891	

Source: Road Master Plan, websites of RHD and LGED



Source: Bangladesh RHD Road Network

Figure 3.1-1 Bangladesh Road Network

RHD has developed the vast majority of the National, Regional and Zila Roads since independence in 1971. As shown in the table below, the paved road ratio of the RHD's road network has been improved to 91% (in 2015) from 62% (in 1991) and 80% (in 2007).

Table 3.1-2 Growth in RHD Road Network

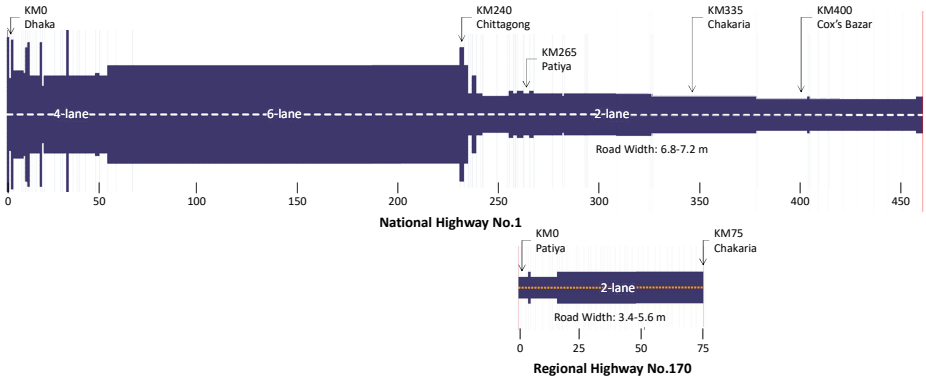
	1991		2007		2015	
	Paved	Unpaved	Paved	Unpaved	Paved	Unpaved
National Highway	3,002	161	3,485	85	3,759	54
Regional Highway	2,262	649	4,117	206	4,043	204
Zila Road	4,440	5,156	9,719	3,959	11,584	1,658
Total	9,704	5,966	17,321	4,250	19,387	1,915

Note: The unpaved road lengths in 2015 are calculated based on the total road length in Table 3.1 and the paved road length described in Annual Maintenance and Rehabilitation Needs Report 2015-16.
Source: RHD Road Master Plan, Annual Maintenance and Rehabilitation Needs Report 2015-16

The present road network in Bangladesh has been developed radially from Dhaka to the major regional centers. The proposed Matarbari Port is located in Southern Chittagong Region and is approximately 80 km south of Chittagong and 25 km north of Cox's Bazar. In this region, ladder-type road network is formed along with the coastal line comprising of National Highway No. 1 (N1) and Regional Highway No. 170 (R170). N1 and R170 are functioning as the north-south directional axes for both passenger and freight transport routes.

N1 (or called Dhaka (Jatrabari)-Comilla (Mainamati)-Chittagong-Teknaf Road) is a 462 km-long National Highway and is one of the most important arterial roads in Bangladesh. The section from Chittagong to Cox's Bazar has a distance of 160 km and is currently 2-lane. RHD has planned to improve/widen the road to a 4-lane or 6-lane carriageway in the future. The detailed design of the road widening project was completed under the financial support of Asian Development Bank (ADB). However, due to the envisaged large scale social environmental impacts, allocation of finances for the construction works has not yet been decided.

R170 (or called Patiya-Anowara-Banshkhali-Toitong-Pekua-Badarkhali-Chokoria (Eidmoni) Road) is a 75 km-long Regional Highway and has a better alignment than N1 but the widths of roadway and Right of Way (ROW) are narrow(according to the RHD's website, carriageway width is 3.4-5.6 m for 2-lane and ROW width would be 10 m especially at the town sections). Its improvement to 4 or 6 lanes would present more difficult due to the need for resettlement of houses and buildings to the outside of the RoW. Also, the elevation of R170 is lower than the flooding or storm surge levels, whereas that of N1 is higher.



Source: RHD Online Road Network

Figure 3.1-2 Present Road Details of N1 & R170

There are lateral roads in between N1 and R170, namely Z1040, 1036, 1019, 1037, 1124, 1125, 1127 and R172. Even though, the road network itself forms a ladder-type, lateral movability between N1 and R170 is weak because the said lateral roads are not regional highway-level roads and are narrow as shown in the table below, henceforth not suitable for comprising a freight transport network.

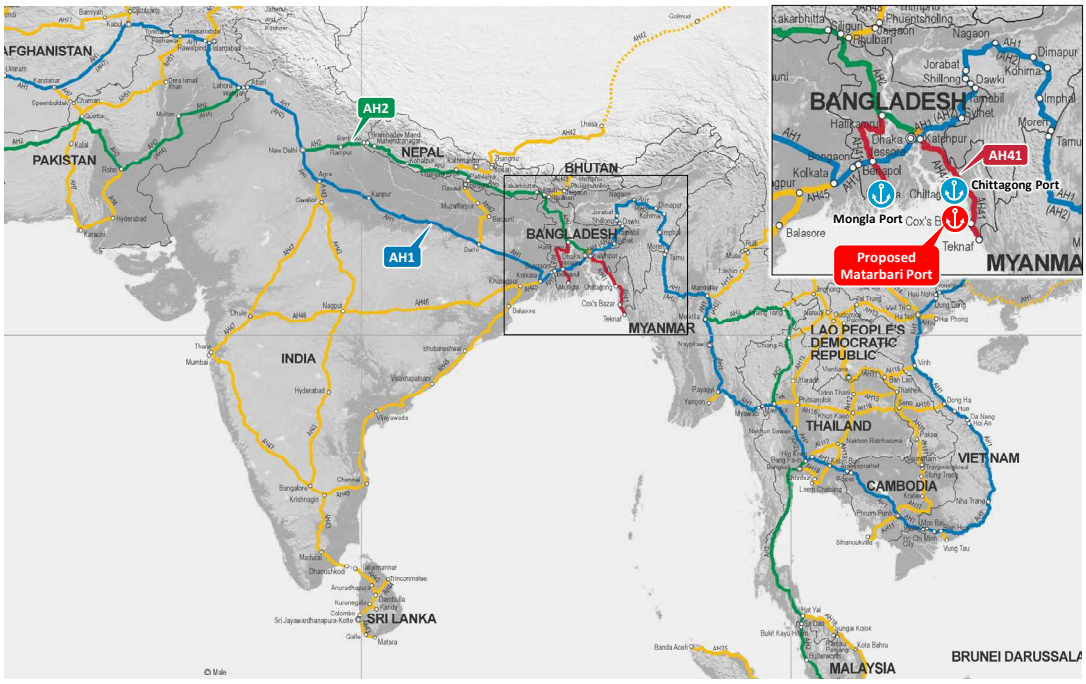
Table 3.1-3 Road Widths of Other Roads in the Region

Road No.	Road Name	Average Road Width (m)
Z1040	Gachbaria-Anowara Road	5.4
Z1036	Hashimpur Rail Station-Bagicharhat-Boroma Road	3.6
Z1019	Keranirhat-Gunagari Road	4.2
Z1037	Ghatiadanga-Monufakirhat Road (Shah Jabbaria Road)	3.7
Z1124	Harbang-Villagerpara-Toitong Road	3.7
Z1125	Ekatabazar-Paharchanda-Pekuabazar-Magnamaghat Road	5.5
Z1127	Lakkharchar-Betua Bazar-Bagguzzara Road	4.4
R172	Chokoria-Baderkhali Road	5.6

Source: RHD Online Road Network

(2) Strategic Development Corridors

Looking at the road network beyond the national borders, N1 (from Chittagong to Cox's Bazar) comprises a part of Asian Highway No. 41 (AH41), which starts from the border of Myanmar through Teknaf, Cox's Bazar, Chittagong, Katchpur, Dhaka, Hatikamrul, Jessore and ends at Mongla. As of now, AH41 runs only within Bangladesh and is not directly connected to India or Myanmar, but interconnects with AH1 and AH2 at Dhaka functioning as the feeder connectivity between the main corridor of Asian Highways and transport nodes such as Chittagong Port and Mongla Port. Through these Asian Highways network and major sea ports, Bangladesh would be able to function as the transport hub connecting with neighboring countries such as India, Bhutan and Nepal. Therefore, importance of N1 (from Chittagong to Cox's Bazar) would become higher if the proposed Matarbari Port is constructed.



Source: JICA Survey Team edited "Asian Highway Route Map" published by United Nations ESCAP

Figure 3.1-3 Asian Highway Route Map

The corridors in Bangladesh under the different programs are basically same and most of the sections consist of the Asian Highways. In connection with the Asian Highway network, the following corridors are recognized as the international strategic economic corridors in Bangladesh. South Asian Association for Regional Cooperation (SAARC) Highway Corridor

- South Asian Sub-regional Economic Cooperation (SASEC) Corridors
- The Bay of Bengal Initiative for Multi Sectoral Technical and Economic Cooperation (BIMSTEC) Road Corridor
- Bangladesh-China-India-Myanmar (BCIM) Economic Corridor

In a bid to observe such international agreement in relation to improvement of accessibility and mobility throughout the international economic corridors, the Government of Bangladesh has identified the following challenges that ought to be addressed to realize the aforementioned objective;

Table 3.1-4 Challenges for Improving International Economic Corridors

Item	Content
Restoring missing links and upgrading sub-standard sections	• Missing links on Asian Highway 1 & SAARC Road Corridor 1 need to be bridged • Sub-standard sections on the Asian Highways and SAARC Road Corridors need to be upgraded
Financing	• Financing will be needed for upgrading of highways • Where possible, PPP options should be explored • Support from development partners is needed • Regional Infrastructure Fund option can be explored
Infrastructure	• Road geometry needs to be improved to allow international traffic • Harmonization of design standards • Border facilities need to be developed • Multimodal integration

Source: Strengthening Transport Connectivity through Road Corridors in Bangladesh, Md. Moinuddin, Addl. Secretary (Roads Transport and Highways Division, Bangladesh)

South Asian Association for Regional Cooperation (SAARC)

SAARC is an association of 7 counties of the region consisting of Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. It was established in 1985 and has been working towards promoting regional cooperation among member states. SAARC is committed to intensify cooperation in a number of areas, including strengthening transport, transit and communication links across the region.

SAARC Regional Multimodal Transport Study identified 10 strategic road corridors of regional significance and the following 6 corridors connect Bangladesh:

- SAARC Road Corridor 1: Lahore–New Delhi–Kolkata–Petrapole/Benapole–Dhaka–Akhaura/ Agartala
- SAARC Road Corridor 4: Kathmandu–Kakarvitta–Phulbari–Banglabandha– Mongla or Chittagong
- SAARC Road Corridor 5: Sandrup Jongkhar–Shillong–Sylhet–Dhaka–Kolkata
- SAARC Road Corridor 6: Agartala–Akhaura–Chittagong
- SAARC Road Corridor 8: Thimphu–Phuentsholing–Jaigon–Chengrabandha–Burimari– Chittagong or Mongla
- SAARC Road Corridor 9: Malda-Shibgonj-Jamuna Bridge

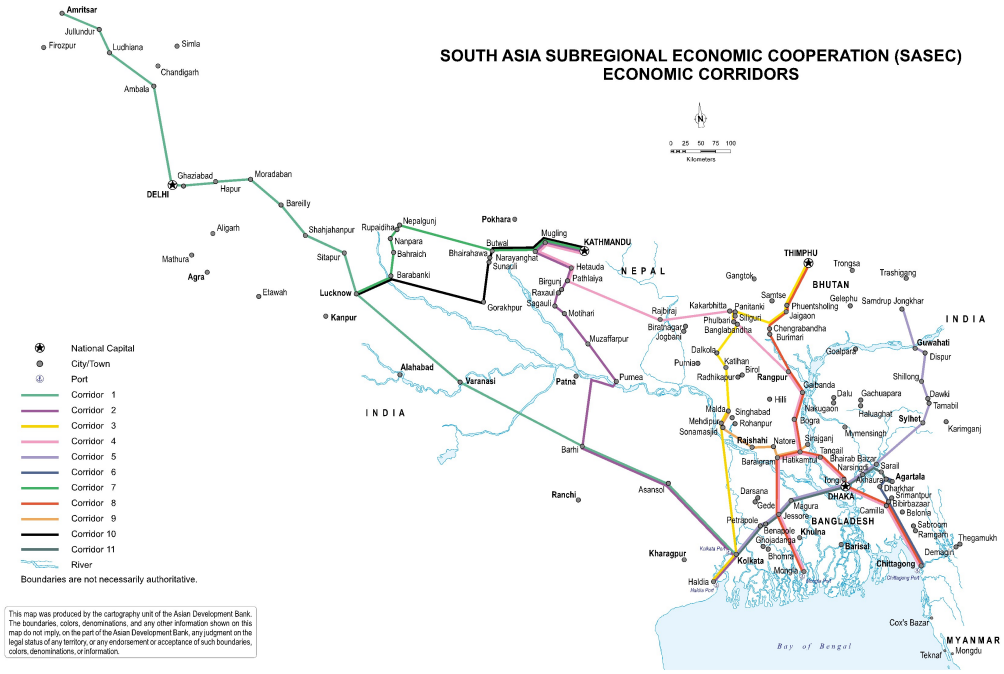
South Asian Sub-regional Economic Cooperation (SASEC)

SASEC includes Bangladesh, Bhutan, India, the Maldives, Nepal, Sri Lanka and Myanmar. Started in 2001,

SASEC has been helping members improve cross-border connectivity and increase trade using a pragmatic, results-oriented framework focused on transport, trade facilitation, and energy. Priority areas include (i) improving international corridors to expand trade and commerce; (ii) modernizing customs operations, improving border facilities, and facilitating trade through transport; and (iii) improving cross-border power transmission to boost energy security and reliability. There are 11 economic corridors under SASEC program and the following 3 corridors connect Bangladesh:

- SASEC Road Corridor 4: Thimphu-Phuentsholing- Jaigaon-Burimari-Mongla- Chittagong
- SASEC Road Corridor 9: Katmandu- Kakarvita-Phubari-Banglabandha- Mongla/ Chittagong
- SASEC Road Corridor 5A: Kolkata-Jessore-Khulna-Mongla Khulna-Jessore-Dhaka-Chittagong

As shown in the figure below, the major ports in Bangladesh function as a gateway to the economic corridors. Currently, the SASEC economic corridors start from Chittagong and Mongla Ports in Bangladesh and Haldia Port in India. In Bangladesh, the SASEC economic corridors have several bottlenecks such as existence of 2-lane sections and missing links across rivers. Therefore, improvement of the National Highways to 4-lane highways and construction of bridges are recognized as the major challenges under the SASEC program.



Source: Trade Facilitation for a More Inclusive and Connected Asia and Pacific Region (ADB)

Figure 3.1-4 SASEC Economic Corridors

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

The BIMSTEC is an international organization of seven nations of South Asia and South East Asia comprising Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand aiming to accelerate economic growth and social progress in the sub-region by promoting free trade, increasing cross-border investment and tourism and technical cooperation. Bangladesh is expected to serve as a gateway to the large hinterland. Trade intensity and the transportation linkages are the two determinant regional integrations.

The region has 3 critical elements (i) missing- harmonization of railway network, (ii) all weather paved roads and (iii) modern port. This requires a sound infra-structure and transport base for movement of goods

and people in the region. BIMSTEC underlines seamless connectivity in 5 areas: transport connectivity, trade connectivity, investment connectivity, energy connectivity, and people-to-people connectivity.

BIMSTEC Transport Infrastructure and Logistic Study (BTILS) identified 14 corridors of regional significance and 7 of them connect Bangladesh:

- BIMSTEC Road Corridor 1: Kolkata-Petrapole/Benapole-Dhaka-Akhaura-Agartala
- BIMSTEC Road Corridor 8: Kathmandu-Kakarvita-Phulbari-Banglabandha- Mongla / Chittagong
- BIMSTEC Road Corridor 5: Samdrupjongkhar-Shillong-Sylhet-Dhaka-Kolkata
- BIMSTEC Road Corridor 6: Agartala-Akhaura-Chittagong
- BIMSTEC Road Corridor 4: Thimphu-Phuenthsholing-Jaigon-Chengrabandha-Burimari - / Mongla
- BIMSTEC Road Corridor 9: Maldha-Shibganj-Jamuna Bridge
- BIMSTEC Road Corridor 11: Chittagong-Ramu (Cox's Bazaar)-Teknaf-Maungdaw

Source: Preparatory Survey on The Cross-Border Road Network Improvement Project (Bangladesh), Final Report (JICA)

Figure 3.1-5 BIMSTEC Road Corridor in Bangladesh

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

The Bangladesh-China-India-Myanmar (BCIM) forum for regional cooperation aims to recapture the historic dynamism of the flows of goods, people and cultures over the famed "Southern Silk Route". The BCIM road corridor starts from Kolkata in India, through Dhaka and Sylhet in Bangladesh, Imphal in India and Lashio in Myanmar, and ends at Kunming in China.

3.1.2 Existing Road Development Plans and Proposals

National Land Transport Policy (NLTP) is the government's strategic development policy presenting the long-term vision for establishing a national land transport system, which is a safe, less expensive, modern, technologically dependable, environmental friendly and acceptable.

Road Master Plan was prepared in 2009 in response to the direction provided by the NLTP in order to materialize the necessary developments in road sector for achieving the goal set by NLTP. The major challenges under the Master Plan are i) improvement of important national highways, ii) enforcement of axle load control, improvement of traffic safety and mitigation of traffic congestion by reinforcing the road network in consideration of non-motorized traffic (NMT) and slow-moving vehicle traffic (SMVT).

(1) Strategy on Development of Regional and International Connectivity

Bangladesh is actively pursuing an open-door policy to international traffic by taking advantage of its strategic location in terms of easy access to the sea and being the gateway between the Eastern and Southern parts of Asia. Accordingly, the Government has been making efforts to improve the road connectivity with neighboring countries through various regional cooperation forums such as the South Asian Association for Regional Cooperation (SAARC), South Asia Sub-regional Economic Cooperation (SASEC), Bay of Bengal Institute for Multi-sectoral Technical and Economic Cooperation (BIMSTEC) and Bangladesh-China-India Myanmar (BCIM) as described earlier.

Bangladesh has acceded to the Asian Highway Network on 8 November 2009. The physical alignment of the Asian Highway Route in Bangladesh is more or less completed so far as the road connectivity is concerned. GOB has planned to upgrade almost the whole part of the AH Network in Bangladesh by phases in order to bring the same in harmony with such networks outside Bangladesh.

(2) National Land Transport Policy (2004)

The National Land Transport Policy has been formulated in the light of the Government pledge to establish a transport system, which is a safe, less expensive, modern, technologically dependable, environment friendly and acceptable in the light of globalization, with a long term vision of at least 30 years to make the role of transport in economic activities more significant and underpin continued economic and social development.

The strategic policy under the National Land Transport Policy is summarized as follows:

Table 3.1-5 Strategic Policy for National Land Transport

Subject	Policy
1. Greater private sector participation	• Private sector participation in the transport sector will be encouraged more. However, the ownership of road and rail infrastructure, being national assets, will remain with the Government. • Where the private sector is involved in infrastructure provision the Government will bring into practice long-term leases with appropriate terms to allow the private sector to recover its investment. • The private sector will be positively encouraged to participate in infrastructure development where it brings finance, efficient operating techniques and technological innovation. • Guidelines will be published setting out ways in which the above goals can be achieved. Further active participation of private sector in transport operations will be encouraged where it is beneficial for the public judging from financial or service standards.
2. Effective coordination in transport	• The Government will establish better coordination between the Ministries and Departments under its control. • Policy/rules & regulations will be formulated to achieve the goal of creating better working links between the Government and the public and private sectors. Discussion and consultation forums will be created for policy implementation. • The Government will promote clearer objectives and responsibilities for each sector in order to create more integrated working relationships.
3. Promoting the role of the transport users	• The Government will examine how best the interests of users can be represented within the existing national government and local authority system. • The Government will establish a user role within its transport planning process.
4. Transport users should pay for the cost of services	• The Government will gradually introduce necessary arrangements to realize cost of transport operation and road maintenance from road users. • The Government will move towards a taxation system for road users which ensures that users pay for the costs of transport operations and maintenance. • To protect public interest, the Government will regulate tariffs for passenger and goods both in road and rail transport.
5. Subsidies for transport services	• The Government will require transparent and fair assessment and appraisal methods to be developed and applied in the allocation of public funds for social and economic reasons. • The private sector may bid to provide those transport services which need a subsidy from Government so long as it competes openly and transparently, and that the cost of the subsidy is outweighed by economic or social benefits to the country. • Public and private sector operators seeking subsidies will be expected to participate under the same conditions.
6. Create public awareness for the policy	• The Government will keep the public aware regarding the aims and objectives of the policy. • Awareness will be created that the policy is being formulated to assist transport users and the whole of the society. • A sense of responsibility regarding safety and the environment will be created among transport users. • To implement the above policy Government will use a variety of media and techniques, ranging from seminars, conferences to mass media publicity.
7. Encourage proper utilization of transport resources	• Use of appropriate economic tools will be made to encourage proper utilization of resources. These will apply to transport operations, the management and construction of infrastructure and transport. • In rural areas, labor based contracting has proved very successful and will continue, as a means of assisting the rural poor. • The Government will also continue to foster the national contracting industry with a view to decreasing dependence on overseas contractors. • Proper employment standards will be encouraged throughout the transport industry in accordance with the International Labor Organization (ILO) core labor standards of employment.

Source: National Land Transport Policy, Ministry of Communications

Table 3.1-5 Strategic Policy for National Land Transport (Continuation)

Subject	Policy
8. Better integration with inland water transport policy	• Where tariff levels for passenger and freight are regulated, these will be reviewed across all modes of transport to ensure that costs to users are at a minimum consistent with other policy objectives. • The Government will take steps to ensure that investment decisions across all modes of transport are subject to the same financial and economic criteria. • Physical integration between water, road, and rail modes will be encouraged where there are benefits to users, costs reductions or environmental improvements. • Where integration is in the public and operators' interests, operators will be encouraged to publicize each other's services. • Financing systems for modal integration will be considered by Government so that schemes are not held back by the unwillingness of individual sectors to pay. The Government will establish a mechanism for aiding multi-modal schemes, and will publish advice on criteria for funding as early as possible. • Services and infrastructure in the water sector will be studied so that an analysis can be made of potential opportunities for integration, and competition where appropriate. Investment decisions in the road and rail sector should take account of the inland water transport strategy, and vice versa.
9. Increased access to transport and services in rural areas	• Paved connections between all the economic growth centers and the country's road network will be provided. The program of small bridge and culvert construction on the rural road network will be extended. • Concurrent with the development of the road network, it will be necessary to foster a higher level of rural mobility and access to basic transport facilities. In the medium-term future many of these may continue to be non-motorized. A high diversity of vehicles and technologies will be encouraged through removing inappropriate regulations. Transport and rural development policies will be more closely linked so as to improve economic conditions through improved local markets, labor based contracting on roads, transport hire facilities, and access to credit. • Improved human skills will be encouraged in machine maintenance, driving, business enterprise, and animal welfare. Government will work with NGO's to achieve this. • Needs of non-motorized transport will be considered in rural road design, including vehicle segregation and low gradient bridges.
10. To integrate transport policy, planning and appraisal across modes	• A Transport Co-ordination Wing will be created in the Planning Commission for the co-ordination of activities among the Ministries of Communications, Shipping, Civil Aviation and Tourism, and the Local Government Division which are involved in the transport sector of the country. • Scheme appraisal capabilities will be strengthened in those service departments which have a responsibility for transport. • The Government will treat long-term planning of transport as a priority. The Government's vision for transport needs to be translated into a long term Multimodal Transport Strategy.

Source: National Land Transport Policy, Ministry of Communications

(3) Road Master Plan (2009)

This plan was developed in response to the direction provided by the National Land Transport Policy, which committed the government of Bangladesh to develop a long term road master plan. The Road Master Plan for Bangladesh is expected to guide the development and maintenance of RHD's road infrastructure over the 20 years from 2009. The identified challenges under the Master Plan are the following:

- Roads and bridges are continuously damaged from a lack of adequate maintenance and vehicle overloading;
- Continuing traffic growth that will exceed the capacity of many National Highways in the next 20 years. The major national highways (N1 through N8) are the backbone of the nation's road network, but their efficiency is hampered by traffic congestion at a large number of small towns, hats and bazaars caused by poor local traffic management and encroachment;
- A mix of motorized and non-motorized traffic, and encroachment onto roads, leading to high accidents rates and road safety is not properly addressed in design or enforcement;
- The country's rural centers are not fully connected with the main road network because the Zila Road network is not fulfilling its full role in rural connectivity because it is partly incomplete, and has suffered from a lack of maintenance; and
- The large number of rivers that are still crossed by ferries hampers smooth movement of traffic.

The objectives of the Master Plan were to set out a comprehensive investment program that will:

- Protect the value of RHD's road and bridge assets;
- Improve the connectivity of the road network;
- Enhance and develop the strategic road network to meet economic and traffic growth targets;
- Improve the Zila Road network to enhance connectivity to the county's growth centers;
- Improve road safety and reduce road accidents;
- Provide environmental and social protection; and
- Outline the institutional improvements required for RHD to deliver the above.

Table 3.1-6 Road Sector Policy

Subject	Government Policy
Integrated planning should be improved	• Development of the strategic road corridors will be planned in coordination with the development of the railway and inland waterway networks to ensure that the most appropriate mode is used for the movement of people and goods.
Insufficient attention has been paid in the past to road maintenance. Road maintenance must be given a higher priority, and enough resources allocated. Road maintenance must be performed in a transparent and accountable way.	• Government to establish a "**Road Maintenance Initiative**" to direct development partners to focus their assistance on a single program for road maintenance and rehabilitation. • Government to create a High Level Committee (headed by Minister) to oversee Road Maintenance Initiative, to ensure that targets are being met and adequate resources are provided. • Government will create Road Fund and autonomous Board to manage it. • Board may create a Technical Advisory Committee on the Road maintenance Initiative, comprising all stakeholders, including government, transport industry, road users, industry and commerce, agricultural sector, and construction industry. Technical Advisory Committee to ensure that initiatives are taken to improve road maintenance quality and to meet the agreed standards.
There are no agreed standards and targets for the condition of the road network. By setting targets the Government can expect road agencies to improve performance.	• Road network to be maintained to a set of agreed standards. Government will set standards for the quality of the road network and ensure that resources are made available to road agencies for targets to be met.
Routine maintenance is not done properly in Bangladesh. It must have a higher priority.	• All roads under RHD to be placed under routine maintenance contracts. • Contractors will be asked to tender for 3-year contracts to provide all routine maintenance activities; vegetation control, culvert cleaning, slope protection, pothole filling and crack repairing, signage, lines etc. • Pilot schemes will be used to develop the most appropriate form of contract. • RHD to set performance standards for these contracts.
Overloaded trucks and buses cause excessive damage to roads and cost the country around BDT 3 billion per year in additional maintenance needs. Axle loads need to be controlled.	• The Government will confer powers on, and allocate resources to road agencies to set and enforce limits on the weights of vehicles so as to protect the road network from damage caused by overloading. • Government to consult stakeholders on the issue of axle-load control in order to ensure understanding and compliance, before measures are introduced. • RHD to install 18 weight bridges across the country (First Phase) • Government to ban import of 2-axle trucks with an unladen weight of more than 5 tons from 1 January 2008, and encourage use of multi-axle trucks. Regulations to be enforced to ensure that vehicles are not physically modified from the registered specifications.
Road building can damage the environment and cause social problems.	• Government to ensure that measures are introduced and adhered to that protect the physical and social environment from adverse effects of road construction. • Government will finalize and approve RHD's draft "Social Assessment Guidelines" and "Land Acquisition and Resettlement Guidelines". These and the already approved "Environmental Impact Assessment Guidelines" shall be followed for all road network. • Government shall develop a revised set of standard contract documents for maintenance and construction works that include environment and social protection clauses, and promotion of employment opportunities for local people.
More than 20% of the Zila Road network is in a very poor condition due to a history of poor maintenance.	• The Zila Road network will be rehabilitated over the next ten years in order to achieve a minimum accessibility level on all Zila Roads. • Minimum accessibility levels will be defined in the Road Master Plan.

Source: Road Master Plan (RHD)

Table 3.1-6 Road Sector Policy (Continuation)

Subject	Government Policy
Road classification does not fully meet the hierarchy required to assist economic development	• The road hierarchy will be reviewed and roads re-classified where necessary to meet economic objectives. • Within the hierarchy, road functions will be determined to ensure that traffic is managed to improve safety and efficiency of travel.
Design standards and quality can be improved to enhance safety and get better value for money.	• Design standards will be updated to meet international norms. • The quality of road infrastructure will be improved to higher standards.
Road safety is a priority and needs to be improved	• On National Highways strict safety measures will be enforced to protect vulnerable road users from fast moving traffic. • Encroachment of roadside activities onto the main carriageway will be prevented, also to protect vulnerable road users in these locations. • Local committees will be involved in implementing necessary measures. • An integrated approach to road safety will be introduced with agencies and measures coordinated across areas of education, awareness, enforcement and physical improvements.
Many level crossings are unsafe, and increased traffic will exacerbate this.	• Grade separation will be introduced where train frequencies and traffic levels warrant. • Unprotected road/rail crossings will be placed in a program for safety enhancement through manned gates. • RHD will coordinate with Bangladesh Railway on these issues.
Bridges are an important asset for the road network. Their conditions must be improved and maintained.	• Bridges in poor condition (category "D") will all be replaced or undergo major works to ensure safety and access over the next 10 years. • All Portable Steel Bridges (PSBs) will be replaced by permanent structures over the next 20 years. • Regular bridge maintenance will be introduced and enhanced. • All narrow bridges (less than 7.3 m) on national Roads will be replaced over the next 20 years by bridges having at least 7.3 m carriageway. • The Government will ask RHD to commission an independent study of the condition of all its bridges, by specialist consultants.
Flooding undermines the investment in roads, and road building needs to take better account of flooding.	• The Government will take necessary steps to protect its investment in the strategic road network from the adver4se effects of flooding. • All construction and rehabilitation works of National Highways will ensure that the road crest is at least 1 m above the highest flood level of 50 years. • For all other roads, the freeboard will be determined from time to time by the concerned agencies. • All new road construction and rehabilitation works will be subject to a full hydrological and morphological study.
The proposed Padma Bridge is urgently needed to unlock the development potential of the south-west of the country.	• Feasibility studies have been undertaken and the Government is fully committed to the construction of the proposed Padma Bridge.
More use should be made of Bangladesh's geographical position to encourage trade	• The Government will seek to make bilateral transport agreements with neighboring countries to avoid trans-shipment, and reduce transport costs. • In order to facilitate sub-regional movement, the Government will encourage SAARC to adopt a Sub Regional Transport Facilitation Agreement (ATFA). • The Government will explore investment in additional and enhanced international infrastructure connections where there are clear economic benefits to Bangladesh. • The Government will ratify the Asian Highway Network Agreement. • The Government will Gazette the relevant part of the road network to be part of the Asian Highway. These roads will be upgraded to appropriate standards to accommodate the growth in traffic from international transit.

Source: Road Master Plan (RHD)

The Master Plan long-listed the following priority projects which mainly consisted of rehabilitation of National Highways, Regional Highways and Zila roads. Some of the projects have been completed or are under construction.

Table 3.1-7 Master Plan Priority Projects

Project Name	Project Type	Remarks
N1 (Dhaka-Chittagong)	Widening to 4-lane	
N3 (Dhaka-Mymensingh)	Widening to 4-lane	
N102 (Mynamati-Brahmanbaria)		
R260 (Sylhet-Sunamganj)		
Dhaka Eastern Bypass		
Dhaka Western Bypass		
Dhaka Outer Orbital Road		
R750/Z5703 (Bhatiapara-Narial-Jessore)	Upgrading	
Deep Sea Port to N1		Closely related to the Matarbari Port Project
N1 (Chakaria-Chittagong)	Widening to 4-lane	ditto
N8 (Dhaka-Mawa)	Widening to 4-lane	
N4 (Dhaka-Tangail)	Widening to 4-lane	
N6 (Baneshwar-Belephur)	Widening to 4-lane	
N5 (Dhaka-Baniajuri)	Widening to 4-lane	
N2 (Bhairab-Moulvibazar)	Widening to 4-lane	
N2 (Dhaka-Bhariab)	Widening to 4-lane	
N2 (Habiganj-Sylhet)	Widening to 4-lane	
N8 (Jessore-Benapole)	Widening to 4-lane	
Chittagong Bypass		
N1-Hatazari Link Road		
N1 (2nd Meghna Bridge)		On-going under the assistance from JICA
N1 (2nd Meghna Gumti Bridge)		ditto
N8 Padma Bridge		

Source: Road Master Plan (RHD)

The total cost of the investment program was estimated to be BDT 667.68 billion over 20 years. The expected source for the programs and projects are funded by Road Fund (41%), private sector (14%), development partners (16%) and Government of Bangladesh (29%). The following are the major components of the action plans under the Master Plan:

- Overloading of trucks and buses causes excessive damage to pavements particularly on national and regional highways and thus, axle load control was urgently needed in Bangladesh. The Master Plan proposed installation of 27 weighbridges across the country.
- Lack of road safety on Bangladesh's road network was also emphasized in the Master Plan. Although in total 328 km-long sections on National Highways had been identified as having accident black spots on them, the lack of enforcement of existing laws was the critical issue. In order to cope with such situation, the Master Plan proposed to establish under law of an autonomous National Road Safety Agency.
- The Master Plan also made some suggestions onto the design standards for roads and bridges in order to meet the requirement of the Asian Highway standards.
- Depending on the type of encroachment and other constraints, the Master Plan proposed certain possible solutions as shown in the table below. Based on the basic concept, 15 bypass road projects were proposed and the 1.5 km-long bypass road of N1 in Patiya (its chainage is from 258+900 to 260+400) was proposed and is under construction.

Table 3.1-8 Types of Encroachments and Possible Solutions

Encroachments		Possible Solutions	
1	Major haats and bazaars are located along the highway and sufficient vacant land is not available on the road side within the RHD's right of way (ROW) for widening and straightening of the carriageway, or for creating service lanes for buses, trucks, NMTs, as well as for providing bus-bays/ stops, and for temporary parking of vehicles.	A	Provide separate bypass road with special design criteria, together with service lanes and well planned intersections.
2	Sizeable encroachment exists on the highway, but land within the ROW can be restored through eviction of encroachments to provide service lanes for buses, trucks and NMTs or if enough land is not available within the ROW, additional land required can be procured with less hassle, through easy resettlement of original owners.	B	Provide service lanes for buses, trucks and NMTs, and also bays for loading/ unloading together with foot over bridge(s) and iron fencing barriers on both sides of the road prohibiting all entry into the main carriageways around bazaar area with requisite road furniture.
3	Railway crosses the national highway at the market place, and there is densely built-up area and homestead just outside the ROW (may be on the private land) and spread over wide area on both sides of the road in such a way that land for future road expansion becomes expensive.	C	Provide over bridges for through traffic, and separate lanes for NMTs, and bus stops at the ground level, with requisite road furniture and delineators.
4	There are certain inter-sections on the national highways, which are unable to cope with the present level of traffic. These should therefore be designed properly.	D	Need to improve designs of intersections, roundabouts and islands at critical road crossings, and wherever possible use traffic signals or other traffic management techniques.

Source: Road Master Plan (RHD)

(4) On-going and Proposed Projects

As regards the road development plans in the Southern Chittagong Region, there are two (2) major on-going road projects and three (3) proposed road projects in the project area.

- The Cross-Border Road Network Improvement Project (JICA supported)
- CPGCBL's Matarbari Ultra Super Critical Coal Fired Power Project including provision of an access road (JICA supported)
- Proposed upgrading of National Highway No.1 (from Chittagong to Cox's Bazar)
- Proposed Road connecting Eidmony (Chakoria) to Chowfaldandi (Cox's Bazar)
- Proposed Road connecting Gorakghata to Sonadia Island

<u>The Cross-Border Road Network Improvement Project</u>

The project comprises of construction of 17 bridges including approach road, box-culverts construction and installation of axle loads control systems. Two types of bridges are to be constructed under the project, namely PC-I girder bridge and Nielsen Lohse bridge. Special steel, namely Steels for Bridge High Performance Structure (SBHS) is to be applied for a part of the Nielsen Lohse type bridge. The locations of the bridge construction site are mainly on the Asian Highway Network in order to improve road condition within the country and to improve movability across the neighboring countries. The following are the components of the project:

- Reconstruction of 5 bridges on AH1 in between Dhaka and Benapole
- Reconstruction of 8 bridges on R150 connecting between AH41 and Ramgarh (the border of India)
- Reconstruction of 4 bridges on AH41 (N1) in between Chittagong and Cox's Bazar
- Installation of weigh bridges at Benapole and Ramgarh

The third component of the project is the reconstruction of bridges on N1 (from Chittagong to Cox's Bazar) and is closely related to the Matarbari Port Development Project.

- Patiya Bridge in Patiya (bridge length: 55 m)
- Mazar Point Bridge in Khanzir Para (bridge length: 60 m)
- Sangu Bridge in Dohazari (bridge length: 215 m)
- Matamuhuri Bridge in Chakaria (bridge length: 315 m)

CPGCBL's Matarbari Ultra Super Critical Coal Fired Power Project

Coal Power Generation Company Bangladesh Limited (CPGCBL) is currently constructing a power plant in Matarbari at the north of the proposed Matarbari Port area under the financial support from the Japanese Government through JICA. The scope of the power plant construction project includes construction of an access road, which is comprised of the following components with RHD is the executing agency of the road components:

- Reconstruction & rehabilitation of 36.123 km existing roads from Ekotabazar to Yunushkhali;
- Construction of a new 680 m-long bridge on the Kohelia River; and
- Construction of a new 7.35 km-long road on Matarbari Island from Rajghat to Muhuruguna.

Detailed design of this project has been completed but the tendering has not been completed yet due to the change of design which needed revision of RAP. The revised RAP was concurred with by JICA in April 2018 after the environmental review done by JICA's Environmental and Social Considerations Advisory Committee. The current status of the tendering for the 3 contract packages is as follows:

- Contract Package 1 (reconstruction & rehabilitation of 36 km existing road from Ekotabazar to Yunushkhali): The scope of works is still under discussion between GOB and JICA. In order to avoid large-scale social environmental impact, minor rehabilitation would be the most probable option instead of reconstructing the road with upgrading the design standards;
- Contract Package 2 (construction of 680 m new bridge across Kohelia River): Tender documents were revised and it is expected that the JICA's concurrence will be issued soon.
- Contract Package 3 (construction of a new 7.35 km road on Matarbari Island from Rajghat to Muhuruguna): Tendering for the Contractor has been already closed and is awaiting for the approval of GOB to the signing of the contract.

Upgrading of National Highway No.1 (from Chittagong to Cox's Bazar)

Feasibility study and detailed design for upgrading of N1 was undertaken under the ADB's technical assistance for Subregional Transport Project Preparatory Facility (Road Component: Package-2). The proposed components of the project are as follows;

- Upgrading of N1 from Chittagong to Cox's Bazar to 4-lane with slow-moving vehicle traffic (SMVT) lanes at both sides of the road under better geometric design standards;
- Construction of 3 flyovers at Keranihat, Lohagara and Chakaria;
- Construction of 2 bypasss at Potiya and Dohazari.

Total length of the proposed part of N1 corridor is approximately 208 km starting from Chittagong (east end of Shah Amanat Bridge) and passes through plains, towns and forests and ends at Teknaf. In most locations along the road, the existing ROW is inadequate to accommodate the necessary width for 4-lane with SMVT lanes.

This study explored the possible approaches for Public Private Partnership (PPP) development scheme. However, the study concluded that the section from Chittagong through Cox's Bazar to Teknaf would not be feasible and was not attractive to private investors.

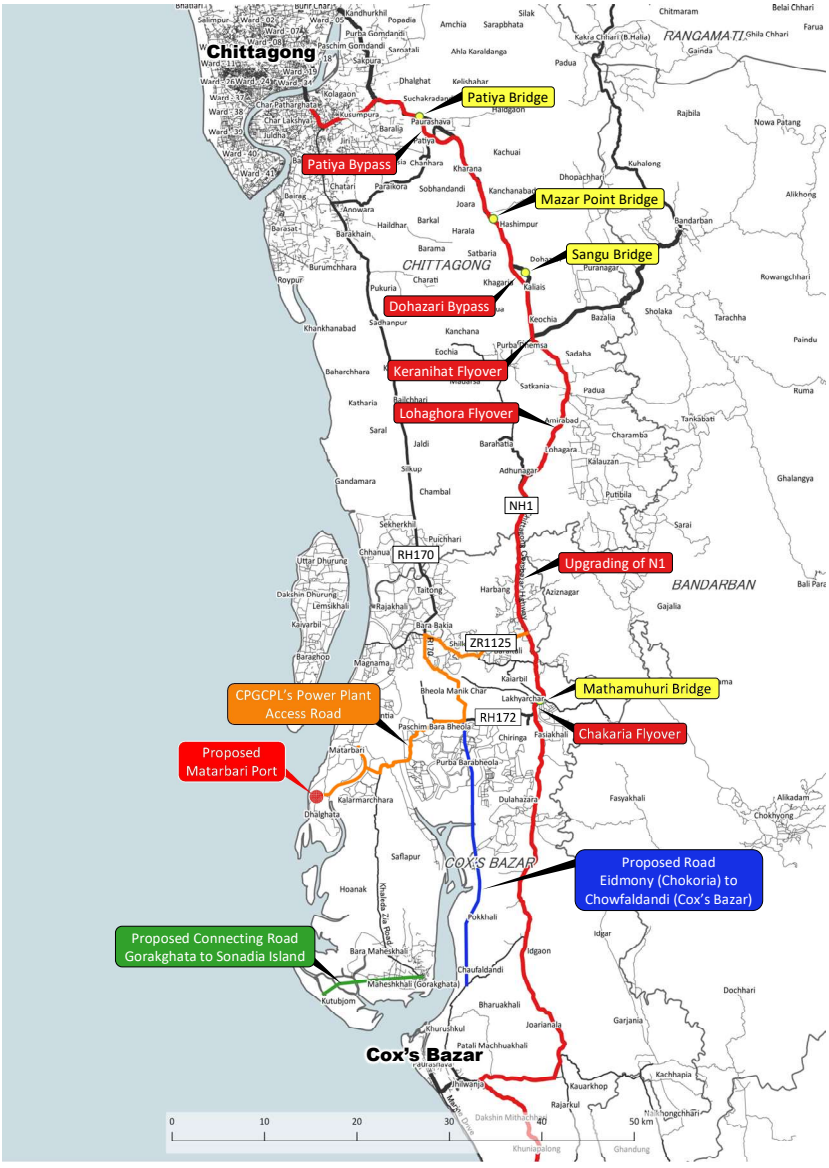
Due to the expected large-scale social environmental impact, financial source for the construction works of the project has not been confirmed yet.

Proposed Road connecting Eidmony (Chakoria) to Chowfaldandi (Cox's Bazar)

This new road construction project has been proposed by the Cox's Bazar Road Division of RHD. This road will be a 20 km long Regional Highway connecting R170 to Z1132 as a secondary road of N1. If this road will be constructed, the said ladder-type road network along the coastal line between Chittagong and Chakaria will be extended to Cox's Bazar and the regional connectivity would be improved.

Proposed Road connecting Gorakghata to Sonadia Island

This new road construction project has also been proposed by the Cox's Bazar Road Division of RHD. This road will be 12.8 km long Zila Road connecting Z1004 to Sonadia Island, which has potential to be a tourist attractive place as an environmental preservation area of wild life birds, coupled with a sandy beach and mangrove forest.



Source: JICA Survey Team

Figure 3.1-6 On-going and Proposed Projects

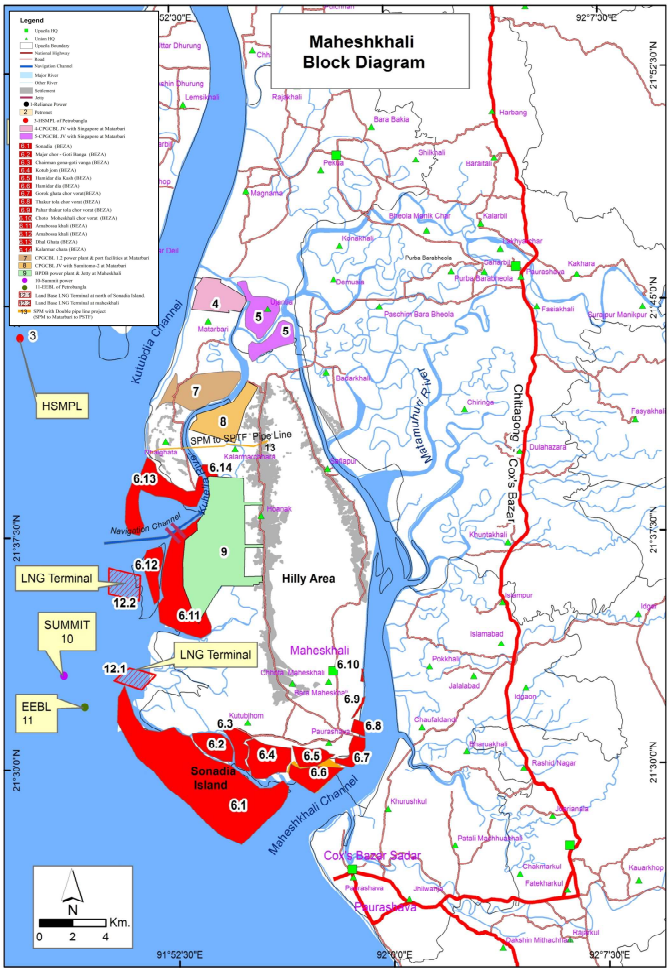
3.1.3 Existing Regional Development Plans and Proposals

Prime Minister's Office of Bangladesh is chairing the large-scale developments in Matarbari and Maheshkhali Area as the hub of power generation and economic zones. The proposed Matarbari Port is expected to function as the gateway not only for the domestic/international freight transport but also importation of the materials necessary at the proposed power plants.

Not only road access but also railway access to the area is also under study in connection with the on-going Dohazali-Cox's Bazar Railway Project.

Regional Development Plans

There are several proposals for development in Matarbari and Maheshkhali Islands as shown in the figure below. BEZA has 14 area development plans for establishing economic zones and tourist attractive places. CPGCBL has expansion plan of their power plant facility in Maheshkhali. In order to effectively develop these plans, inter-institutional coordination would be necessary and Government of Bangladesh is now arranging for establishment of a coordination committee called "Maheshkhali Coastal Development Committee (MCDC)", which is chaired by PMO. Transportation infrastructure such as road and railway network in Matarbari and Maheshkhali Islands is currently in poor condition so that development of transport infrastructure in these islands would be necessary to ensure the success of such developments.

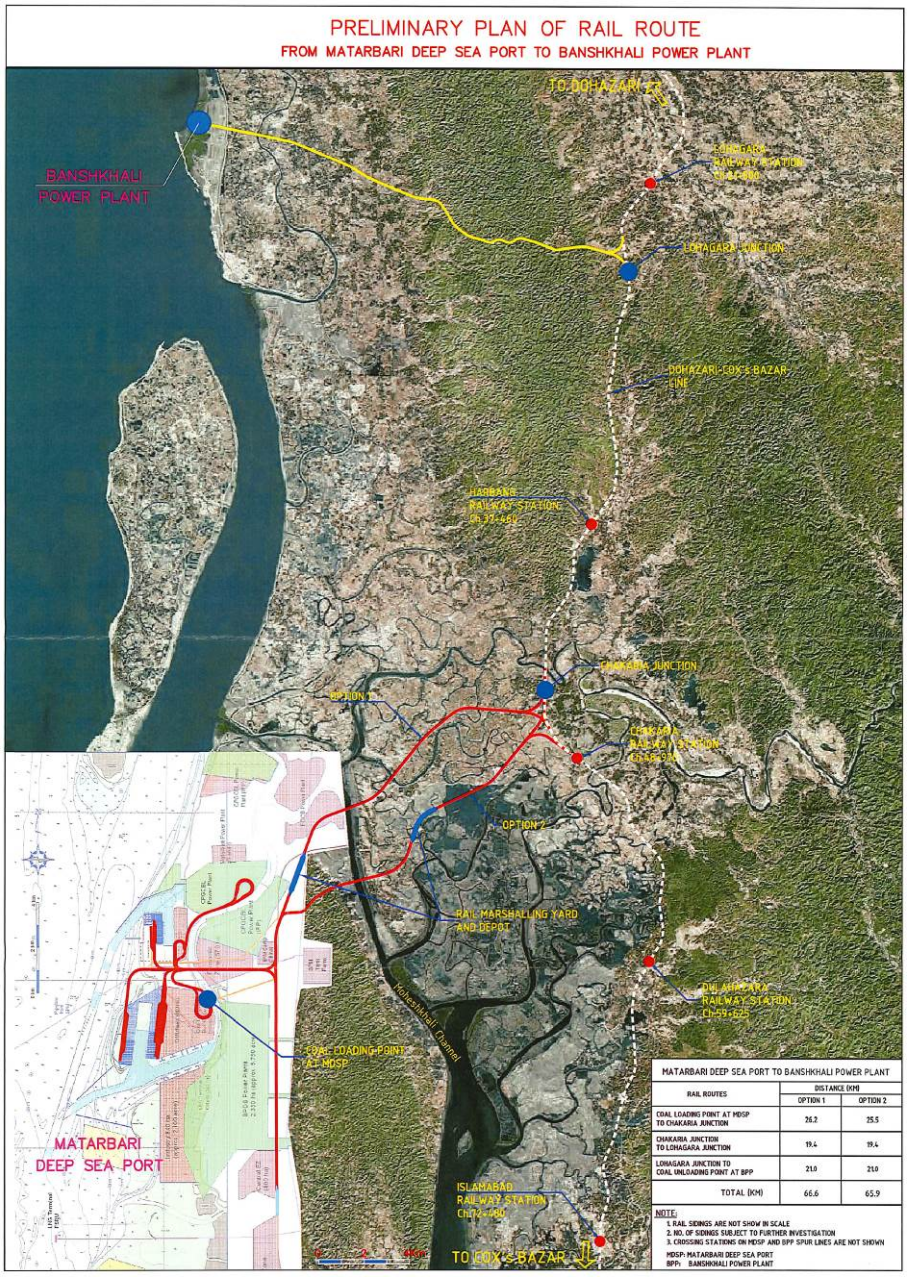


Source: Maheshkhali Development Commiittee

Figure 3.1-7 Maheshkhali Block Diagram

Railway Development Project

Construction of the Dohazari-Cox's Bazar Railway Line, which will have dual gauge, was commenced in September 2017. The alignment of the new railway will run near the N1 and three (3) station will be constructed at Harbang, Chakaria and Dulahazara. Also, Ministry of Railways has conducted a study called "Dhaka-Chittagong-Cox's Bazar Rail Project Preparatory Facility" under ADB loan No. 3295-BAN (SF), which includes the component of expansion of the railway network from the Dohazari-Cox's Bazar Line into Matarbari and Maheshkhali Islands. The following figure represents the preliminary proposal of the alignment of the feeder railway line to Matarbari and Maheshkhali Island and this Matarbari Port Development Project needs coordination with this railway project.



Source: ADB Consultant

Figure 3.1-8 Preliminary Plan of Rail Route to Matarbari

3.2 Road Freight Transport Planning

3.2.1 Required Developments for Road Freight Transport

For ensuring good road freight transport, the international corridors under the multinational forum should be taken into consideration. Bangladesh is expected to be a gateway of the freight transport route into the hinterland countries and that both good accessibility from Matarbari Port to N1 (AH41) and good accessibility to Chittagong through N1 (AH41) should be provided.

The proposed Matarbari Port will function as an alternative port to Chittagong Port and the majority of freight transport from the Matarbari Port will be destined for the major cities in the north, such as Chittagong and Dhaka. Thus, it is necessary to provide good accessibility from the Matarbari Port to the north. Also, as the said international corridors and the international forums expect Bangladesh to function as a gateway of the freight transport route into the hinterland countries, good connectivity and accessibility from Matarbari Port to the Asian Highway network should also be provided. In order to create good freight transport route from the Matarbari Port to inland area, the following two (2) components should be taken into consideration:

- Accessibility from Matarbari Port to N1 (AH41)
- Accessibility to Chittagong through N1 (AH41)

Accessibility from Matarbari Port to N1 (AH41)

Considering that the location of the proposed Matarbari Port is approximately 22 km in direct distance from N1 and that there are no arterial roads connecting to Maheshkhali Island, a new port access road should be constructed with a good connectivity between Matarbari/Maheshkhali Islands and N1.

The requirements for the port access road would be the following:

- To provide smooth movability for freight traffic between the port and N1;
- To ensure traffic safety for local traffic and communities against cargo truck traffic;
- To mitigate community severance by the access road construction;
- To mitigate negative impact caused by flooding and storm surge;
- To minimize natural and social environmental impact by the road construction; and
- To accommodate future expandability arterial road link into the Maheshkhali development area.

Accessibility to Chittagong through N1 (AH41)

The traffic volume on N1 between Chittagong and Cox's Bazar has been reaching its traffic capacity especially at the section through towns, which exist along the highway. As RHD has planned to improve/widen N1 to be 4-6 lanes highway and as shown the present situation of N1 in Figure 3.2, the section between Chittagong and Cox's Bazar is recognized as a bottleneck of traffic of the international corridor. Therefore, improvement of N1 is indispensable for providing smooth road freight transport from Matarbari Port.

The requirements for N1 would be the following:

- To provide smooth movability for all modes of traffic functioning as an international corridor and gateway of the freight transport route into the hinterland countries;
- To ensure traffic safety for both through traffic and local traffic;
- To support regional activities;
- To mitigate community severance by N1.

3.2.2 Port Access from National Highway

Three alternative route options (Route Options A to C) were examined as the comparative analysis of the optimum route and the following findings were identified:

- Route Option A is the shortest route to the north, and has the advantage of providing good accessibility to the north but requires land acquisition of a large number of private property, which presents the risk of delaying of project implementation;
- Route Option B is the shortest route to N1 which avoids Mahaeshkhali Hill, and has the advantage minimizing negative impacts to environmentally protected area and private property. Furthermore, it also provides good accessibility to both Matarbari Port and CPGCBL's Power Plant; and
- Route Option C is the shortest route to N1 passing through the Maheshkhali Hill, and has an advantage of minimizing construction costs and social-environmental impacts. The challenge is that the route needs to cross the Maheshkhali Hill and accessibility to CPGCBL's Power Plant would not be favorable

As a result of the discussions among concerned ministries, agencies and local government, it was agreed that the Route Option B was the optimal route for the following reasons:

- One access road should be constructed having good accessibility to both Matarbari Port and CPGCBL's Power Plant instead of constructing two access roads;
- Matarbari Port Development Project is a Fast Track Project of Bangladesh Government and early implementation is required. Social environmental impact such as land acquisition and resettlement of houses should be minimized for ensuring smooth implementation of the project;
- Natural environmental impact should be minimized. Cutting of Maheshkhali Hill, which would need the approval of PMO, should be avoided for smooth implementation of the project (after completion of this evaluation, it was revealed that Maheshkhali Hill is an environmentally protected area by law).

Also, the Matarbari Port Access Road should be designed and be constructed with securing compatibility to extend the arterial road link into the southern area of Maheshkhali as well as the road connection to Cox's Bazar in future. It is recommended that the forthcoming master plan of the Maheshkhali development should decide the position of the road link extended from the Matarbari Port Access Road.

(1) Route Selection of Access Road

Three Alternative Route Options

As mentioned earlier, "Matarbari Ultra Super Critical Coal-Fired Power Project" includes construction of a new access road in Matarbari/Maheshkhali and improvement of existing roads (R170, 172 and Z1125, 1004). Such existing regional highways function not only to cater for local traffic generated in this area but also to support local activities for school, commercial, social exchange, children playing, etc. Therefore, it is not suitable to invite many cargo trucks into the local roads in terms of traffic safety and freight transport planning. In order to provide safe and smooth traffic condition for long-distance freight transport, port access roads should have limited access for separation of freight transport and local traffic physically.

Through the discussions with RHD and other concerned ministries and agencies, the following route options were identified (see the figure below).

- Route Option A: Shortest connection route to the north
- Route Option B: Shortest connection route to N1 with avoiding Maheshkhali Hill
- Route Option C: Shortest connection route to N1

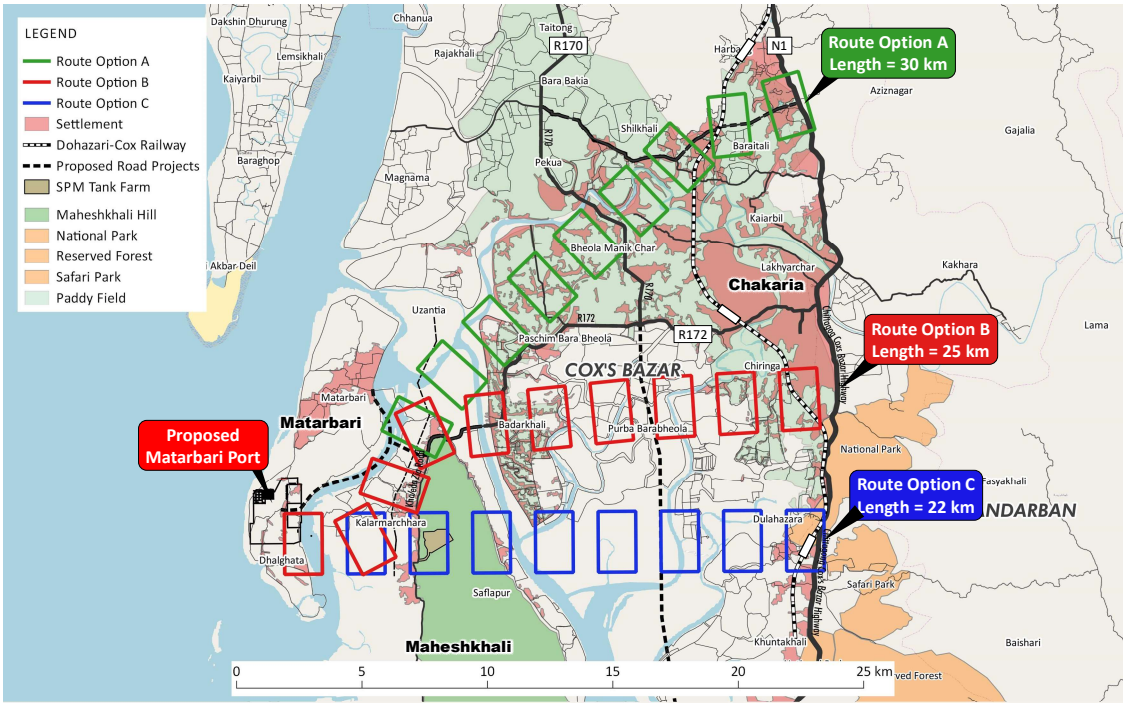
The Route Option A starts from the south part of Matarbari Port and crosses Kohelia River by bridge. In Maheshikhali Island, the alignment runs in parallel with the SPM pipeline on seaside and crosses Maheshkhali Channel at about 2 km upstream of the existing Badarkhali Bridge. The alignment extends up to the intersection of Z1125 and Z1127 and merges with Z1125. The route traverses Maheshkhali, Pekua and Chakaria Upazilas. The section in Maheshkhali and Pekua is dominated by salt farms while the section in Chakaria is dominated by paddy field where settlements are scattered across.

The Route Option B starts with the same alignment as the Route Option A for the first 8 km-long section and then diverts at the north of Maheshkhali Island and then connects to N1 by the shortest route. In contrast to the Route Option A, the lands where this alignment passes are dominated by salt farms and the section length through settled areas is less than is the case for Route Option A.

Route Option C is the shortest connection between Matarbari Port and N1 passing through Maheshkhali Hill. Similar to Route Option B, the land along this route is dominated by salt farms and sparsely populated.

The following figure represents the above alternative routes and present land use. Red colored areas are settled areas, light green colored areas are paddy fields, orange colored areas are environmentally protected areas, the green colored area is Maheshkhali Hill and the rest of areas are mainly salt farms.

It should be noted that the area used for salt farms in Chakaria (where the Route Option B and C pass) was formerly dominant with mangrove forests which were cleared for shrimp farming for the purpose of generating revenue (in 1980s, exportation business of frozen food was grown and cultured shrimp was the most common frozen food product in Bangladesh). However, the shrimp farming in the area was not successful and finally the land was turned into salt farms. Therefore, most of such area is not currently fully utilized.



Source: JICA Survey Team

Figure 3.2-1 Alternative Route Options

Evaluation Result of Alternative Route Options

Matarbari Port Development Project is a Fast Track Project of Bangladesh Government and early implementation is required. Land acquisition is one of the identified critical factors for smooth implementation of the project and the alignment of the access road should minimize the impact on such private lands and settled areas as much as possible. Thus the Route Option A, which has the longest access road length and with 55% of the lands along the alignment being privately owned, would not be preferable.

Although, Maheshkhali Hill was not recognized as an environmentally protected area (after completion of this evaluation, it was revealed that Maheshkhali Hill is an environmentally protected area by law), it is recognized as a hilly area where permission by Prime Minister's Office is required for hill cutting. As the result of the discussion among Ministry of Shipping (MOS), Ministry of Road Transport and Bridges (MORTB) and concerned agencies, it was decided that the cutting of Maheshkhali Hill should be avoided for the Matarbari Port Access Road construction because the application for the hill cutting would take time and it would cause delay of the project implementation. Thus the Route Options C, which passes through Maheshkhali Hill, would not be preferable.

Considering the following, the local government (namely, Cox's Bazar District Office) expressed their preference that instead of implementing the first component of the CPGCBL's Access Road Project, the Route Option B of the Matarbari Port Access Road should be constructed as the access road to both the power plant and the port:

- the first component of the CPGCBL's Access Road Project (reconstruction & rehabilitation of existing roads) will involve a lot of resettlement of houses and the scale of the social impact is too high; and
- the alignment of Route Option B has good accessibility to both the Mataribari Port and the CPGCBL's Power Plant with less social impact than the proposed power plant access road.

The table shown on the next page summarizes the results of the evaluation of alternative route options for the Matarbari Port Access Road. Each route option got scores for every evaluation factor on a scale of one to five with the weights representing the importance of each factor considering the above. As the result of comparison, Route Option B got the highest score among the three route options.

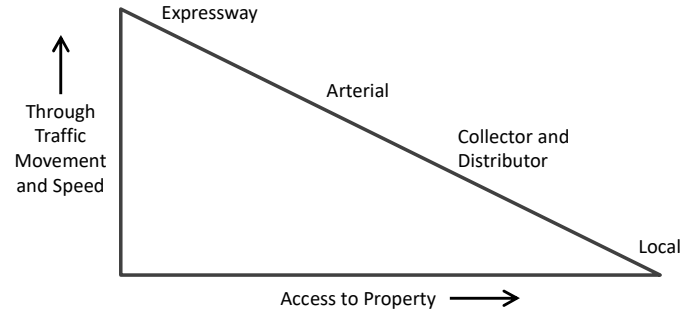
Consequently, Route Option B was evaluated as the optimal route for the Matarbari Port Access Road. However, the alignment of Route Option B will pass through a relatively high-densly populated area in the north of Maheshkhali and Badarkhali Bazar. Mitigating the scale of social impacts such as the number of houses to be resettled and community severance should be taken into consideration.

Table 3.2-1 Comparison of Route Options

		Route Option A		Route Option B		Route Option C	
Characteristic							
Road Length		30 km		25 km		22 km	
Length of River Crossings		3.5 km		5.4 km		5.0 km	
Land Use		Private Land: 16 km Government Land: 14 km		Private Land: 7 km Government Land: 18 km		Private Land: 2 km Government Land: 20 km	
Location of Intersection with N1		Baritali Road (Z1125) About 8 km north of Chakaria		Fashiakhali About 4 km south of Chakaria		Dulahazara About 8 km south of Chakaria	
Affected Buildings		More than 150		Less than 100		Less than 100	
Evaluation Factor	**Weight**		**Score**		**Score**		**Score**
Efficiency for Freight Transport	**3**	• Shortest route to the north (Chittagong, Dhaka). • Traffic congestion of N1 in Chakaria town center is not a problem. • The best option if N1 will not be improved to 4 or 6 lanes.	5 (**15**)	• Shortest connection to N1 with avoiding Maheshkhali Hill. • Traffic congestion of N1 will be the problem for smooth freight transport. • If N1 will be improved, the above disadvantage will be solved.	3 (**9**)	• Shortest connection to N1. • Traffic congestion of N1 will be the problem for smooth freight transport. • If N1 will be improved, the above disadvantage will be solved.	3 (**9**)
Regional Road Network Connectivity	**6**	• The section in Maheshkhali will be a part of the main road of Matarbari/Maheshkhali Development Plan. • Good accessibility to Port and Power Plant.	5 (**30**)	• Same as Route Option A	5 (**30**)	• Good accessibility to Port only.	3 (**18**)
Traffic Safety	**1**	• The route passes through settled areas in Chakaria and a lot of local traffic (mainly SMVs) will use this road. • Traffic safety measure is required.	3 (**3**)	• Intermediate between Route Option A and C	4 (**4**)	• The route passes through mainly on salt area (or shrimp farm) and not so much local traffic will use this road. • Not much traffic safety measure is required.	5 (**5**)
Constructability	**6**	• There are many crossing roads and easy to access to the construction site.	5 (**30**)	• There are few crossing roads and difficult to access to the construction site.	3 (**18**)	• There are few crossing roads and difficult to access to the construction site.	3 (**18**)
Social Environmental Impact	**6**	• Over 150 buildings need to be relocated. • Community severance at many locations will be occurred.	1 (**6**)	• The number of affected buildings is less than Route Option A. • Community severance at few locations will be occurred.	3 (**18**)	• The number of affected buildings is less than Route Option B. • Community severance at few locations will be occurred.	5 (**30**)
Natural Environmental Impact	**6**	• Not much impact	5 (**30**)	• Not much impact	5 (**30**)	• Cutting Maheshkhali Hill	1 (**6**)
Project Implementation	**10**	• Land acquisition may take time.	1 (**10**)	• There is no critical issue for this route.	5 (**50**)	• Hill cutting permission may take time.	3 (**30**)
Evaluation			**124**	**Recommended**	**159**		**116**

(2) Required Functions for Access Road

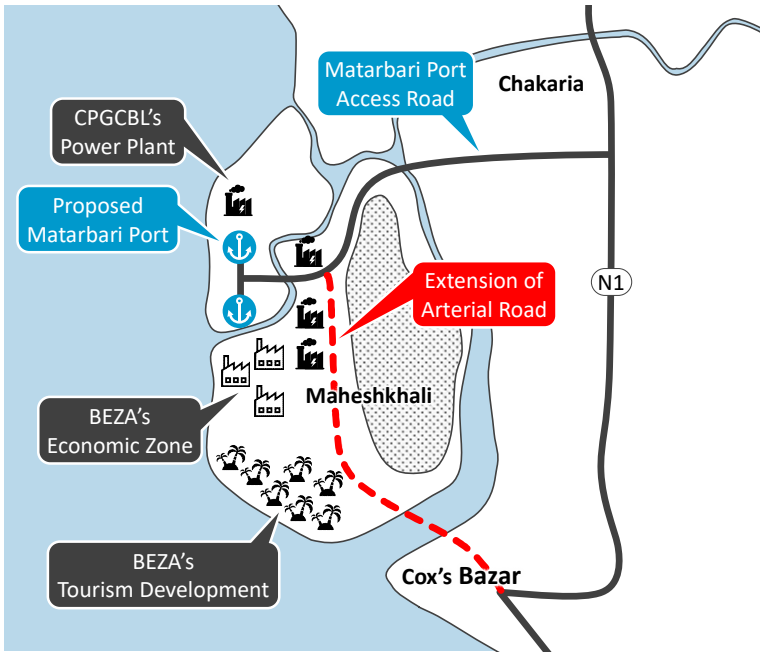
As described earlier, the Matarbari Port Access Road should provide smooth accessibility for freight traffic generated from the Matarbari Port. Such freight traffic is generally long-distance travel. Accordingly, provision of smooth mobility for through traffic would be more important than mobility for local traffic. Considering the hierarchy of functional classification of roads, such a road should be categorized as an arterial road, which is on top in terms of hierarchy where an expressway does not exist.



Source: JICA Survey Team

Figure 3.2-2 Hierarchy of Roads

Also, as described in the section 3.1.3, several development plans are proposed in Matarbari and Maheshkhali areas for power plant projects, economic zone constructions and tourism developments. If these development plans are implemented in future and if many investors are attracted to the area by the implemented developments, more traffic will be generated in the project area. Therefore, the Matarbari Port Access Road should be designed and be constructed with the objective of securing compatibility to extend the arterial road link into the southern area of Maheshkhali as well as the road connection to Cox's Bazar in the future. It is recommended that the forthcoming master plan of the Maheshkhali development should decide on the position of the road link extension from the Matarbari Port Access Road.



Source: JICA Survey Team

Figure 3.2-3 Possible Future Extension of Road in Maheshkhali

3.2.3 Traffic Demand Analysis

In this study, three (3) major types of traffic were considered for traffic demand analysis.

- Traffic demand generated from the Matarbari Port
- Diverted traffic from existing roads
- Traffic demand generated by the ongoing development activities

After traffic surveys and analyses of future development plans were conducted, the design traffic of the project road was calculated. The daily traffic of access road is calculated as 6,582 PCU in the year 2026, which will rise to 12,103 PCU in the year 2035. During peak hours, 592 vehicles (1,200 PCU) will use the project road by the year 2026 whereas 958 vehicles (1,970 PCU) in the year 2035. According to the Japan's port access road design manual, a 2-lane road can accommodate traffic up to the year 2027 while according to Roads and Highways Department (RHD) Geometric Design Manual (2005), a 2-lane road can accommodate the traffic up to the year 2035. However, if development plans such as economic zones are executed earlier, traffic on the project road will definitely increase and the demand for upgrading to a 4-lane road will actualize sooner.

The traffic demand result was also used to determine the design of the intersecting point between the project road with N1. Under this study traffic surveys were not carried out on the national highway; therefore, traffic survey data of RHD (2016) and detailed design of Cross Border Road Network Improvement Project were analyzed and future traffic of N1 was estimated. During peak hours, the intersection needs to accommodate 3,202 PCU by 2026, which is expected to increase up to 4,622 PCU by 2035. Therefore, a signalized intersection is proposed with a free left turning lane from Matarbari to Chittagong in 2026. However, in 2035 the intersection needs to be upgraded in order to accommodate heavy traffic from Chittagong to Matarbari direction.

(1) Present Traffic Situation

1) Traffic Survey

In order to grasp the traffic situation of present regional road in the project area various types of traffic surveys were carried out. 24 hours directional traffic count survey was carried out at 3 intersections to identify the needs for intersection design and potential future traffic. The survey was conducted for 2 days in 1 regular weekday (Mon, Tues and Wed) and 1 weekend (Fri or Sat). Sectional traffic count survey was conducted at one location for 16 hours (6AM-10PM) on a weekday. Road side origin-destination (OD) interview survey was also conducted at one location for 12 hours (6AM-6PM), through where majority of the vehicles on R172 will pass. Surveyed vehicles are classified as in Table 3.2-2.

Table 3.2-2 Vehicle Classification for Traffic Survey

Category	Group	Type	Classification
Motorized	Motorcycle	Motorcycle	Mainstream Traffic
	3 wheelers	Baby-taxi/CNG	Slow Moving Veh.
	Car	Private car (Sedan, SUV) & taxi	Mainstream Traffic
		Micro bus	
	Bus	Medium bus	
		Large bus	
	Truck	Small truck	
		Medium truck	
		Heavy truck	
		Trailer	
	Utility	Utility (Jeep, Pick-up, Leguna)	
Non-motorized	Bicycle	Bicycle	Others
	Riskshaw	Riskshaw	
	Others	Others	

In order to compile the data in an easier way the vehicle types are reclassified into mainstream traffic and slow moving vehicles as explained in Table 3.2-2. In this study, the RHD's PCU conversion factors, which are described in the RHD Geometric Design Manual (2005), are used to convert the vehicles into PCU as shown in Table 3.2-3.

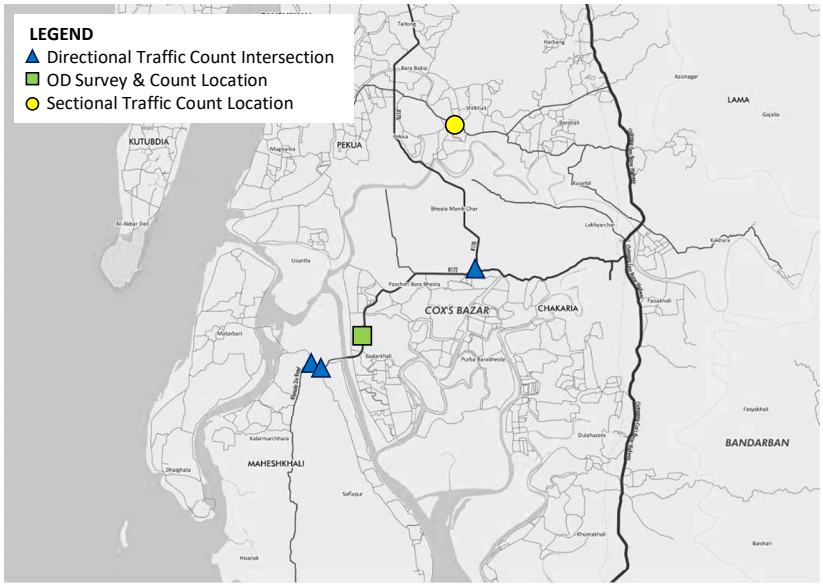
Table 3.2-3 PCU Conversion Factors

Type	PCU Conversion factor
Motorcycle	0.75
3 wheeler	0.75
Car	1
Bus	3
Truck	3
Utility	1
Bicycle	0.5
Riskshaw	2
Others	4

Source: Geometric Design Standard Manual, RHD (2005)

2) Survey Locations

Three (3) intersections are selected where directional traffic volume counts were carried out. The location of traffic volume count and road side O-D interview survey was conducted at a suitable location on R172 which is shown in Figure 3.2-4 in green color. Another one (1) location was selected where sectional traffic volume count was conducted (shown in Figure 3.2-4 in yellow color).



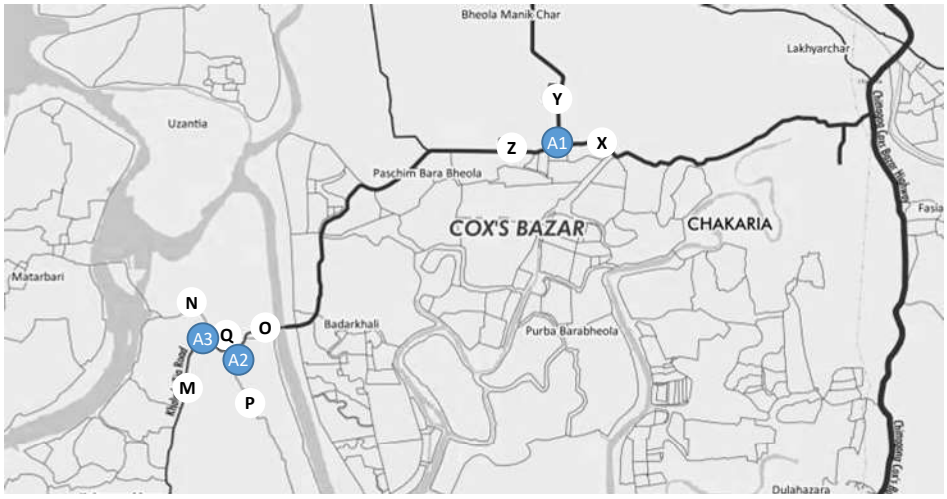
Source: JICA Survey Team

Figure 3.2-4 Traffic Survey Locations

3) Traffic Count Survey Result

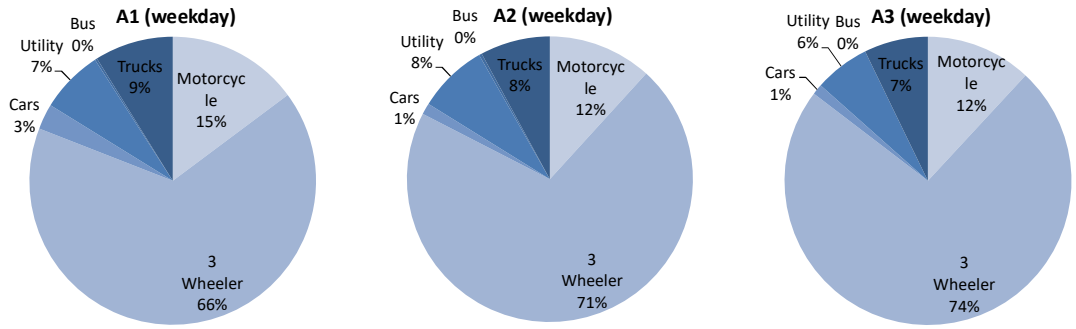
From the directional traffic count of 3 intersections, it was observed that intersection A1 (7,560 PCU/day) is the busiest out of all 3. 3 wheelers share a major role in modal contribution in this area as it was observed that the share varied from 66% to 74% for these intersections which is considered very high. Among mainstream traffic, the modal share of motorcycles is the highest for all 3 locations and the modal shares of the trucks and utility vehicles are also quite significant.

Detailed traffic count data of the 3 intersections is as shown in Figure 3.2-7 and described in the following tables. Traffic flow from A3 to A2 intersection varies even though the survey was conducted on the same day. The reason is the existence of a public transport stand between the intersections where 3 wheelers and buses were parked. This is the reason for increment of traffic count data from A2 intersection to A3 intersection.



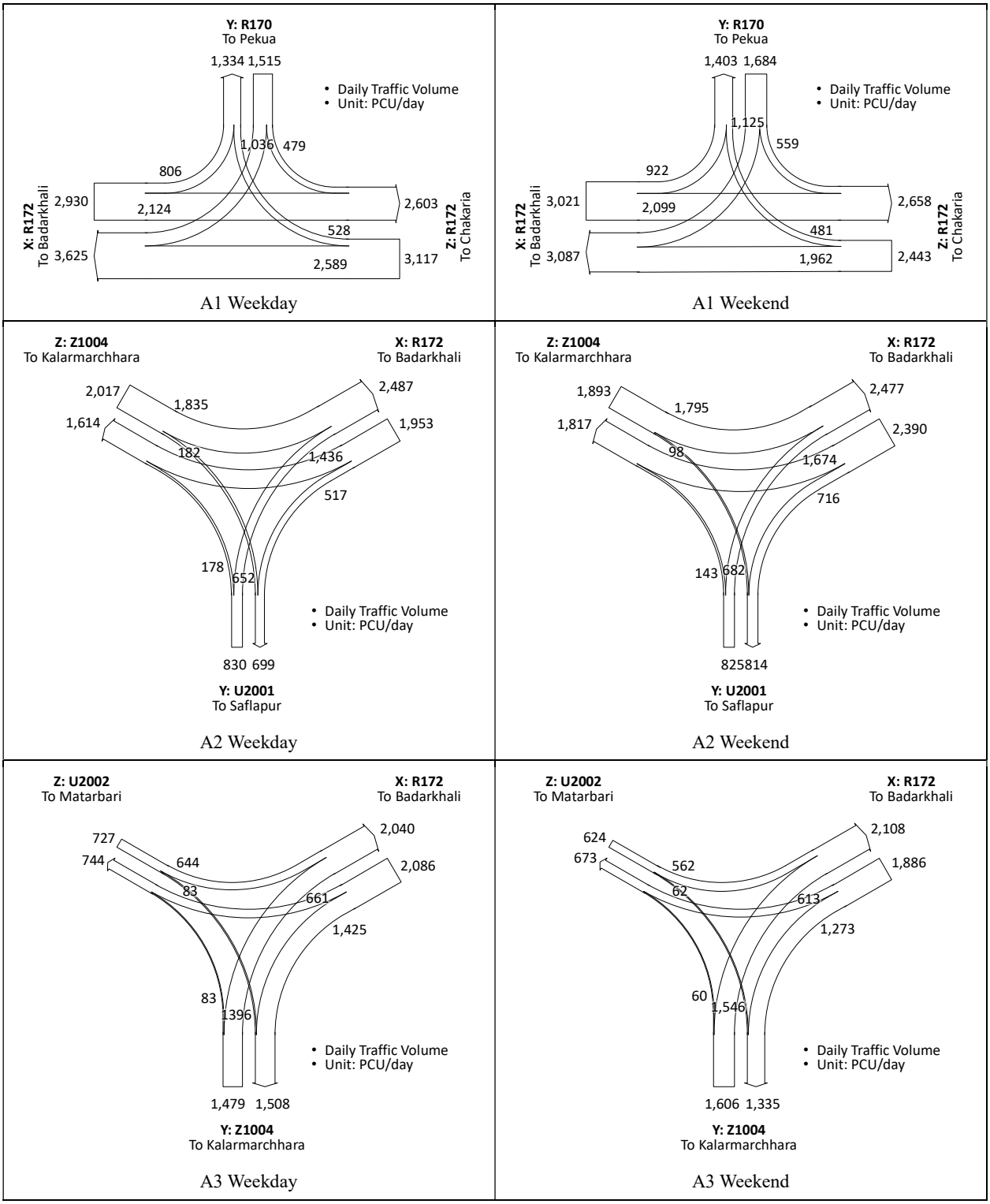
Source: JICA Survey Team

Figure 3.2-5 Directional Traffic Count Locations



Source: JICA Survey Team

Figure 3.2-6 Vehicle Based Modal share of Mainstream Traffic at 3 Intersections (Weekday)



Source: JICA Survey Team

Figure 3.2-7 Directional Traffic Flow at each Junction

Table 3.2-4 24-Hour Traffic Count Data at Intersection A1

Direction		Mainstream Traffic (veh)						Mainstream	SMV			SMV	Others	Total	Total
From	To	MC	Car	Utility	Bus	Truck	Sub T	Traffic (PCU)	3 W	Non-M	Sub T	(PCU)		Veh	PCU
Weekday															
X	Y	153	23	43	5	21	245	259	615	17	632	479	17	894	806
X	Z	265	63	182	8	188	706	1,032	1,285	28	1,313	1,008	21	2,040	2,124
Y	X	189	31	54	1	36	311	338	749	18	767	586	28	1,106	1,036
Y	Z	60	16	34	0	45	155	230	247	22	269	213	9	433	479
Z	X	285	53	153	4	267	762	1,233	1,335	14	1,349	1,020	84	2,195	2,589
Z	Y	60	9	18	1	47	135	216	276	16	292	220	23	450	528
All	All	1,012	195	484	19	604	2,314	3,307	4,507	115	4,622	3,525	182	7,118	7,560
Weekend															
X	Y	154	40	41	7	56	298	386	593	23	616	468	17	931	922
X	Z	265	98	134	16	178	691	1,013	1,212	25	1,237	943	36	1,964	2,099
Y	X	182	41	45	2	83	353	478	684	25	709	544	26	1,088	1,125
Y	Z	74	15	22	2	33	146	198	344	13	357	281	20	523	559
Z	X	234	98	109	11	153	605	875	1,227	28	1,255	972	29	1,889	1,962
Z	Y	59	7	19	0	25	110	145	342	15	357	272	16	483	481
All	All	968	299	370	38	528	2,203	3,093	4,402	129	4,531	3,479	144	6,878	7,148

Source: JICA Survey Team

Table 3.2-5 24-Hour Traffic Count Data at Intersection A2

Direction		Mainstream Traffic (veh)						Mainstream	SMV			SMV	Others	Total	Total
From	To	MC	Car	Utility	Bus	Truck	Sub T	Traffic (PCU)	3 W	Non-M	Sub T	(PCU)		Veh	PCU
Weekday															
X	Y	55	5	39	2	33	134	190	269	51	320	290	9	463	517
X	Z	143	19	139	5	80	386	520	1,011	57	1,068	863	13	1,467	1,436
Y	X	68	5	35	0	51	159	244	349	69	418	376	8	585	652
Y	Z	32	1	6	0	13	52	70	98	19	117	100	2	171	178
Z	X	156	24	119	6	151	456	731	1,237	65	1,302	1,040	16	1,774	1,835
Z	Y	51	1	3	1	12	68	81	81	16	97	81	5	170	182
All	All	505	55	341	14	340	1,255	1,837	3,045	277	3,322	2,749	53	4,630	4,798
Weekend															
X	Y	84	34	22	3	29	172	215	422	45	467	401	25	664	716
X	Z	183	41	74	17	102	417	609	1,179	42	1,221	956	27	1,665	1,674
Y	X	73	38	44	2	22	179	209	443	72	515	461	3	697	682
Y	Z	22	2	5	0	0	29	24	110	19	129	112	2	160	143
Z	X	171	45	82	9	99	406	579	1,397	96	1,493	1,187	7	1,906	1,795
Z	Y	31	6	4	1	3	45	45	42	22	64	53	0	109	98
All	All	564	166	231	32	255	1,248	1,681	3,593	296	3,889	3,170	64	5,201	5,107

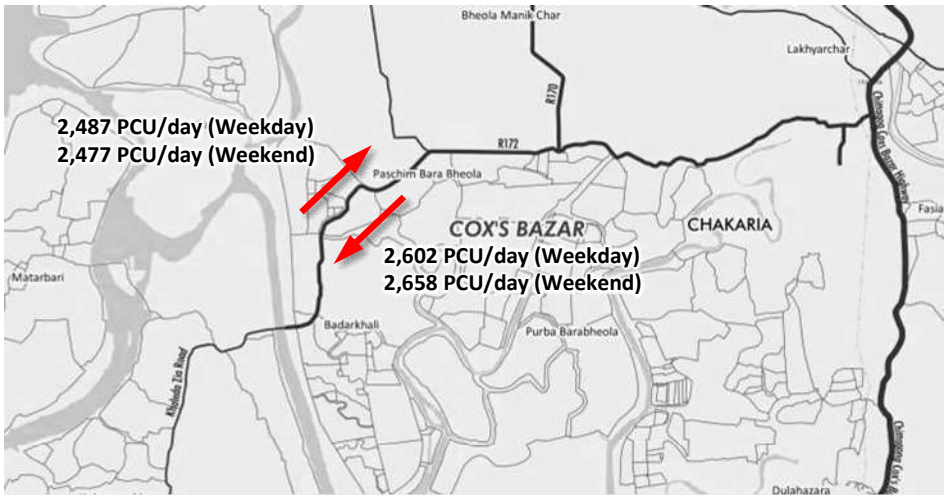
Source: JICA Survey Team

Table 3.2-6 24-Hour Traffic Count Data at Intersection A3

Direction		Mainstream Traffic (veh)						Mainstream	SMV			SMV	Others	Total	Total
From	To	MC	Car	Utility	Bus	Truck	Sub T	Traffic (PCU)	3 W	Non-M	Sub T	(PCU)		Veh	PCU
Weekday															
X	Y	81	12	42	0	66	201	313	350	14	364	285	16	581	661
X	Z	140	12	93	0	71	316	423	1,126	54	1,180	914	22	1,518	1,425
Y	X	75	9	43	0	62	189	294	329	16	345	277	18	552	644
Y	Z	19	0	3	0	4	26	29	53	3	56	41	3	85	83
Z	X	142	13	66	0	82	303	432	1,034	55	1,089	853	28	1,420	1,396
Z	Y	17	0	2	0	2	21	21	30	4	34	25	3	58	57
All	All	474	46	249	0	287	1,056	1,512	2,922	146	3,068	2,394	90	4,214	4,265
Weekend															
X	Y	73	10	55	0	43	181	249	361	23	384	312	13	578	613
X	Z	137	37	69	1	37	281	323	1,113	53	1,166	906	11	1,458	1,273
Y	X	84	4	44	0	42	174	237	327	28	355	297	7	536	562
Y	Z	7	1	5	0	4	17	23	38	2	40	31	2	59	62
Z	X	180	32	53	0	76	341	448	1,062	53	1,115	870	57	1,513	1,546
Z	Y	9	1	4	0	1	15	15	36	1	37	29	4	56	60
All	All	490	85	230	1	203	1,009	1,295	2,937	160	3,097	2,445	94	4,200	4,115

Source: JICA Survey Team

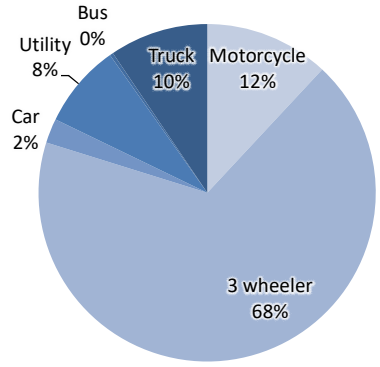
From the directional traffic count, 24 hours sectional traffic data on regional road R172 was calculated. It was observed that the traffic on this road over the weekend and weekdays does not vary much. Two way daily traffic on this road was about 5,100PCU (5089 PCU/day on weekdays; 5,135 PCU/day on weekends).



Source: JICA Survey Team

Figure 3.2-8 Daily Traffic (including SMV) on R172 to and from Matarbari Direction

Modal share of daily traffic flow on R172 is shown in Figure 3.2-9 as was observed in the traffic count survey carried out on 13th December, 2017. It was found that 3 wheelers accounted for 68% share which can be considered as extremely high.

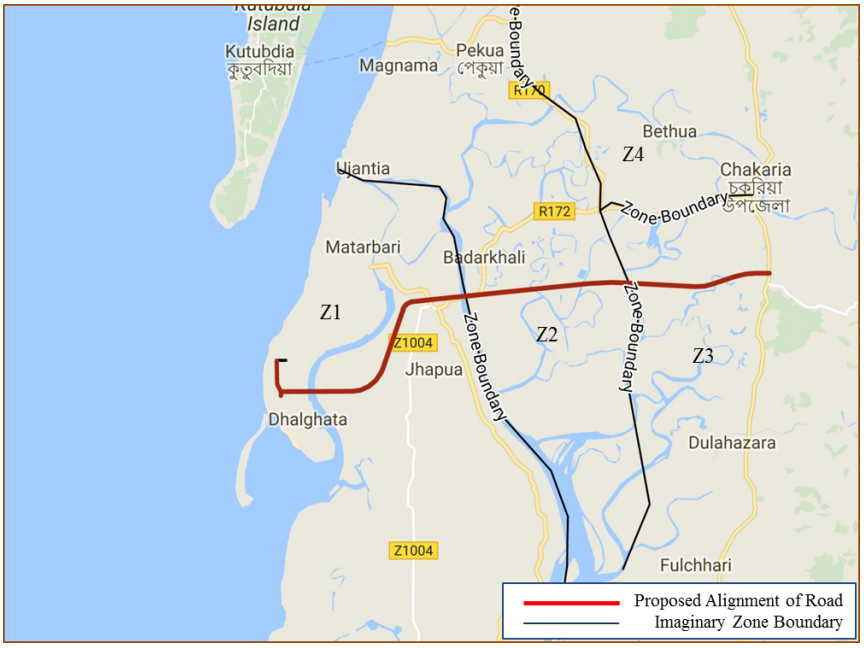


Source: JICA Survey Team

Figure 3.2-9 Modal Share of Daily Traffic Flow on R172 in 2017 (weekday)

4) OD Zoning

In order to identify the potential diverted traffic from existing roads, the study area was divided into 4 zones. As the site is located in Cox's Bazar district all the unions under this district are coded against the zone. During the OD interview survey, the origin and destination of the drivers were asked with respect to union. An OD matrix was then prepared for each mode and zone..



Source: JICA Survey Team

Figure 3.2-10 Zoning of the Study Area

Table 3.2-7 Zone Coding for OD Survey

Sl.	Union	Zone Code	Sl.	Union	Zone Code	Sl.	Union	Zone Code
1	AliAkbar Deli	2	25	Harbang	4	49	Shaplapur	1
2	Baroghop	2	26	Kakara	3	50	Chakmarkul	3
3	Dakshin Dhurong	2	27	Kaiarbil	4	51	Fatekharkul	3
4	Koiar Bil	2	28	Khutakhali	3	52	Garjania	3
5	Lemshakhali	2	29	Lakhyarchar	3	53	Idgar	3
6	Uttar Dhurong	2	30	Saharbil	3	54	Joarianala	3
7	Bharuakhali	3	31	Paschim Bara Bheola	2	55	Kachhapia	3
8	Chaufaldandi	3	32	Demushia	2	56	Ghuniapalong	3
9	Idgaon	3	33	Konakhali	4	57	Kowerkhope	3
10	Jhilwanja	3	34	Surajpur-Manikpur	3	58	Rajarkul	3
11	Khurushkul	3	35	Bara Bakia	2	59	Rashidnagar	3
12	Patali Machhuakhali	3	36	Magnama	2	60	Dakshin Mithachhari	3
13	Pokkhali	3	37	Pekua	2	61	Haldia Palong	3
14	Islampur	3	38	Rajakhali	2	62	Jalia Palong	3
15	Islamabad	3	39	Toitong	2	63	Raja Palong	3
16	Jalalabad	3	40	Uzantia	2	64	Ratna Palong	3
17	Badarkhali	2	41	Shilkhali	2	65	Palong Khali	3
18	Barawtali	4	42	Chhoto Moheshkhali	1	66	Baharchhara	3
19	Bheola Manik Char	4	43	Bara Maheskhali	1	67	Nhila	3
20	Bomobilchari	3	44	Dhalghat	1	68	St.Martin Dwip	3
21	Chiringa	3	45	Hoanak	1	69	Sabrang	3
22	Dulhazara	3	46	Kalarmarchhara	1	70	Teknaf	3
23	Purba Barabheola	4	47	Kutubjom	1	71	Whykong	3
24	Fasiakhali	2	48	Matarbari	1	99	Others	99

Source: JICA Survey Team

5) Traffic Condition on National Highway No. 1(N1)

Historical traffic survey data was collected from RHD by the study team and was analyzed to observe the traffic situation of N1 road. Under Cross Border Road Network Improvement Project (CBRNIP), a sectional traffic count survey was carried out at a location near Chakaria. The survey result was used to forecast the future traffic volume on national highway N1 of Chakaria section.

Table 3.2-8 Traffic Count Data on National Highway 1 (Near Chakaria)

	Motorcycle	3 wheeler	Car	Utility	Bus	Truck	Total (veh)	Total (PCU)
2017	2,427	5,168	1,175	1,548	827	1,863	13,008	16,489

Source: Cross Border Road Network Improvement Project (CBRNIP), 2017

To understand the traffic variation at various locations along N1 from Chittagong to Cox's bazar, traffic count data of 2016 for several locations on N1 highway was collected from RHD. This data is presented inTable 3.2-9. It was observed that the location in between Chunati R171 - Aziznagar Z1007 has the highest traffic volume on N1 between Chittagong and Cox's Bazar which is almost 1.25 times that of Chakaria area. Detailed traffic data and tentative survey locations are shown inTable 3.2-9 and Figure 3.2-11 respectively.

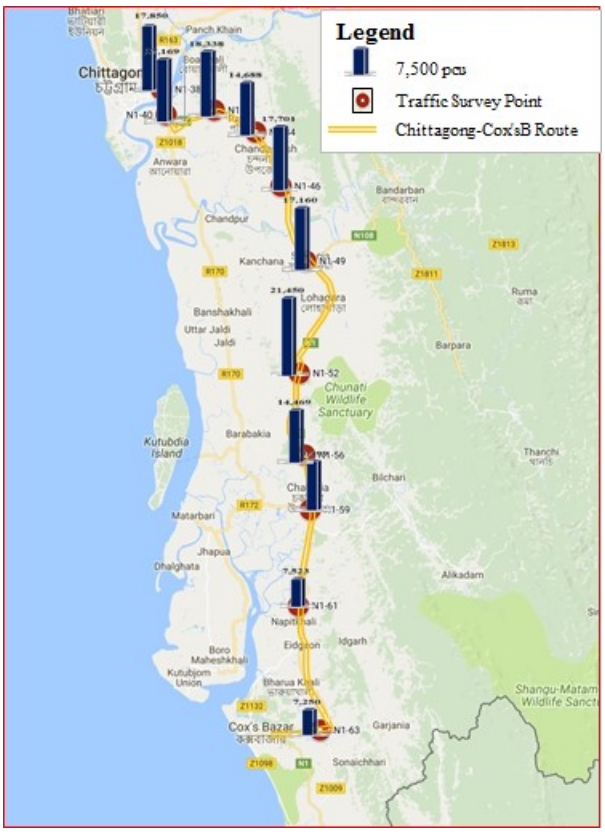
Table 3.2-9 Traffic Count Data on National Highway 1

Link No	Link Name	Motor cycle	3 wheeler	Car	Utility	Bus	Truck	Total (Veh.)	Total (PCU)
N1-38	Chittagong (Badderhat) - Maizzertek int with Z1804	612	3,063	1,294	192	2,107	2,429	9,697	17,850
N1-40	Sikolbaha Int with Z1018 - Santirhat Int. with Z1071	750	2,086	1,808	223	1,618	2,719	9,204	17,169
N1-43	Mansertek(Int.with N107)- Patiya (Int.with Z1059)	782	2,513	2,282	370	2,074	2,331	10,352	18,338
N1-44	Patiya (Int.with Z1059) - Patiya Dakbanglo (Int.with Z1057)	915	2,636	1,771	585	1,310	1,913	9,130	14,688
N1-46	Patiya (Int.with Z1039) - Khanhat Int.with Z1026	446	5,119	2,220	432	1,381	2,244	11,842	17,701
N1-49	Keranirhat N108 - Int.with Z1019	1,406	5,811	2,171	150	951	2,191	12,680	17,160
N1-52	Chunati R171 - Aziznagar Z1007	740	1,000	3,180	414	1,835	3,682	10,851	21,450
N1-56	Baraitali Int.with Z1002-Int.with Z1126	773	1,295	1,111	95	1,711	2,193	7,178	14,469
N1-59	Chokoria R172 - Faishakhali Z1005	1,221	2,983	1,437	353	1,015	1,837	8,846	13,499
N1-61	Dulahazra Z1130-Khutakhali Z1131	396	1,988	941	195	544	989	5,053	7,523
N1-63	Ramu (Int.with Z1001) - Ramu Intersection N109	501	2,062	975	96	605	814	5,053	7,250

Source: Traffic Summary Sheet (2016), RHD

According to the feasibility study of upgrading of Chittagong - Cox's Bazar - Teknaf road (2014), it was recommended that the section between Chittagong and Cox's Bazar be upgraded to 4 lanes with extra SMV lane immediately. In this study, the traffic between Chittagong and Keranihat was forecasted to be 48,206 PCU/day in the year 2026.

During field survey, it was observed that the section between Chandanaish and Chittagong is quite narrow due to side friction caused by the local activities. Some common examples of side friction are: 3 wheelers and buses stopping anywhere on the main carriageway to drop and pick up passengers; and roadside temporary shops setting up very close to the road. At road sections adjacent to markets (locally known as bazar) or upazila headquarters (example: Patiya, Dohazari), buses as well as 3 wheelers stop at the roadside and wait for the passengers for long periods.



Source: Traffic Summary Sheet (2016), RHD

Figure 3.2-11 Tentative Location & Traffic Volume on N1 (From Chittgong to Cox's bazar)

(2) Methodology of Traffic Demand Forecast

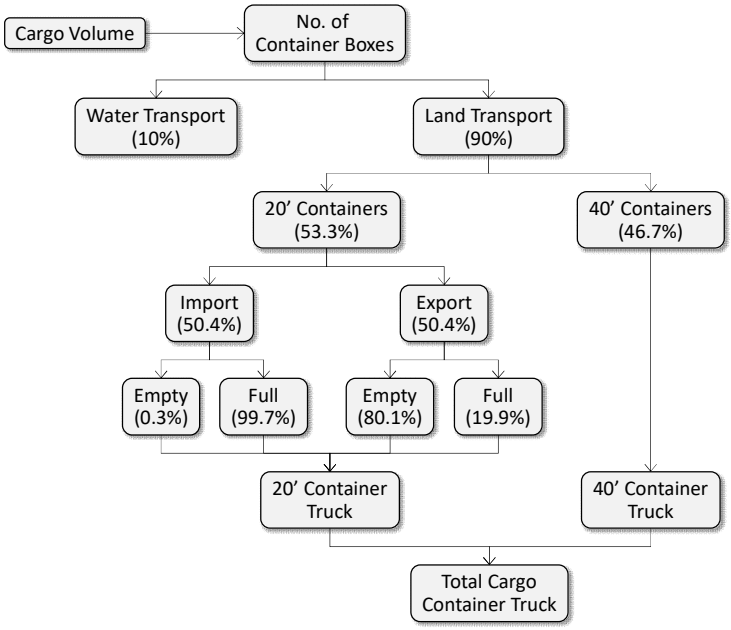
In order to forecast traffic demand of port access road, the following were considered; i) traffic from Matarbari Port, ii) diverted traffic from existing road and iii) induced traffic from other development activities. The methodology of forecasting future traffic is different for each item which is described in this section.

1) Traffic from Matarbari Port

Traffic generation from the port was calculated based on the estimated cargo container volume and bulk container volume of Matarbari port. The flow chart of how cargo container is converted into number of container trucks is described in Figure 3.2-12. The basic assumptions for the calculation are as follows:

Cargo Container Trucks

- Matarbari Port will handle 15% and 25% of total cargo volume in Bangladesh in 2026 and in 2041 respectively;
- Land transport will share 90% of the cargo volume and water transport will share 10% of it;
- Based on the historical data of Chittagong Port, 53.3% of land transport volume will be transported by 20' containers while the rest i.e. 46.7% will be transported by 40' containers;
- 50.4% of the 20' containers will be import cargo while 49.6% will be export cargo. The share of fully loaded containers will be 99.7% for import cargo and 19.9% for export cargo.



Source: JICA Survey Team

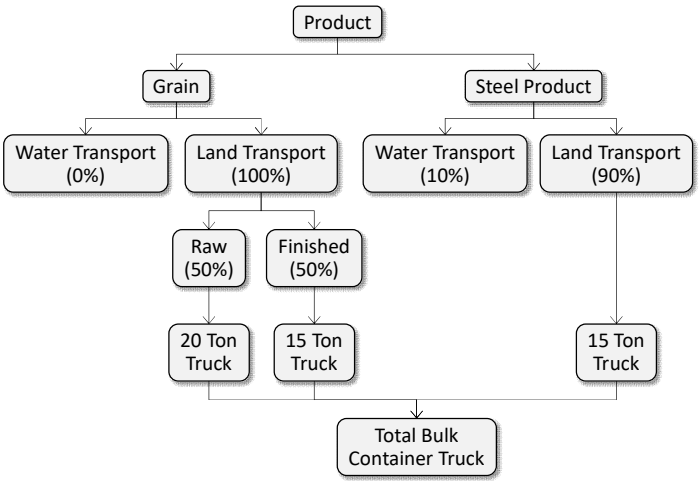
Figure 3.2-12 Flow of Estimation of Cargo Container Truck

In accordance with the Technical Note of National Institute for Land and Infrastructure Management of Japan No.21, general traffic trips other than cargo container trips to and from the port are calculated as 0.5 times of all cargo container truck trips.

Bulk Container Trucks

Matarbari port will also be used to handle bulk containers carrying different products such as grain and steel products. The bulk container traffic volume are calculated for grain and steel products separately.

- Land transport will carry 100% of grain products and 90% of steel products. The rest will be transported by water;
- 50% of the grain products will be transported by 20 ton trucks unprocessed and the remaining 50% will be processed and transported by 15 ton trucks;
- Steel products will be transported by 15 ton trucks



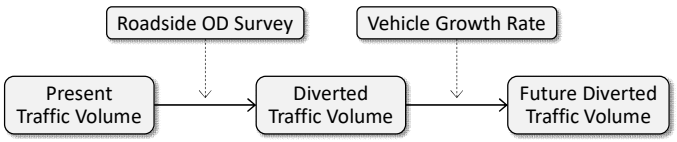
Source: JICA Survey Team

Figure 3.2-13 Flow of Estimation of Bulk Container Truck

It is assumed that the total trips including general trips such as commuter trips and business trips will be 2.8 times of all the bulk container truck trips (source: Table 4.3, Technical Note of National Institute for Land and Infrastructure Management of Japan No.21).

2) Diverted Traffic of Existing Road

As the travel speed will be higher than that on existing roads, it is predicted that some of the traffic from these roads will divert and use the port access road. A 24 hour traffic count survey was conducted to capture the present vehicle condition as well as a roadside OD survey. Using the OD result, the potential diverted traffic was calculated and then forecasted using the vehicular growth rate. The calculation of the future growth rate of each vehicle category is described in detail later. The methodology applied to estimate diverted traffic is stated in Figure 3.2-14.

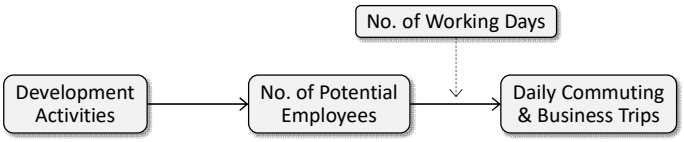


Source: JICA Survey Team

Figure 3.2-14 Flow of Estimation of Diverted Traffic

3) Traffic by Development Activities

The Development plans of the project area were collected and analyzed. Possible development activities were taken into consideration to calculate the potential number of employees from these facilities. The number of commuting and business trips of these employees is calculated to forecast the traffic demand due to development activities. The flow of forecasting method is described in Figure 3.2-15.



Source: JICA Survey Team

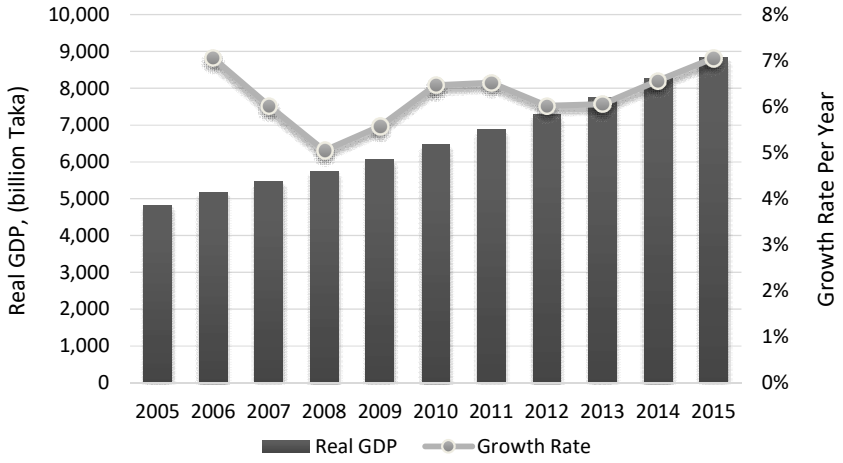
Figure 3.2-15 Flow of Estimation of Traffic Demand by Development Activities

4) Vehicular Growth Rate Calculation

To calculate the vehicular growth rate, a correlation was developed in between GDP and vehicle registration. Prior to that available socio-economic data such as GDP, GDP per capita, population, vehicle registration etc. were also studied.

Growth of GDP

Generally, Gross Domestic Product (GDP) is an indicator of the economic strength of any country, which also reflects the growth of traffic and overall economic capability of that country. According to Price Waterhouse Coopers, Bangladesh will become an emerging economic power in 2050 which will be ranked as 28th in the world. To understand to GDP trend of Bangladesh, past GDP of Bangladesh from 2005 to 2015 was studied and the details are shown in **Figure 3.2-16**.



Source: 2005~2010, World Bank; 2011~2015 Bangladesh Bureau of Statistics

Figure 3.2-16 GDP Growth Rate in Bangladesh (2005 - 2015)

However, in order to reflect most recent changes of GDP, the final analysis was limited 2011 to 2015. From 2011 to 2015, the average annual growth rate of the GDP of Bangladesh was calculated as 6.42%. As per 7th fiscal year plan of Bangladesh, the country targeted to achieve 8% GDP growth rate by 2020. However, it was concluded that this was an overambitious figure when compared to the actual annual average growth rate of 6.42% in recent years. Therefore, future real GDP annual growth rate was set at 7% from 2016 until 2025 and 6.5% from 2026 to 2035 in this study.

Table 3.2-10 Real GDP (Base year: 2005)

	GDP (billion TK)		Annual Average Growth Rate	
	Real*	Estimated	Real	Estimated
2011	6,885		6.42%	
2012	7,299			
2013	7,741			
2014	8,249			
2015	8,831			
2016		9,449		7.00%
2017		10,111		7.00%
2020		12,386		7.00%
2025		17,372		7.00%
2030		23,801		6.50%
2035		32,609		6.50%

Source: National Accounts Statistics (Provisional Estimates of GDP, 2015-16 and Final Estimates of GDP, 2014-15 page4); Bangladesh Bureau of Statistics

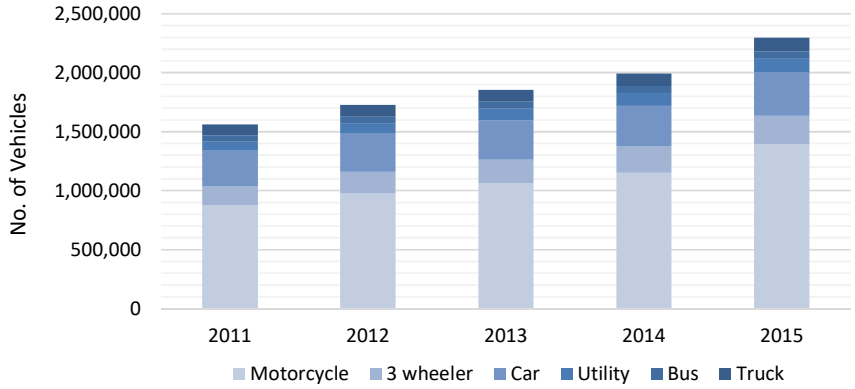
Vehicular Growth

In Bangladesh, the Bangladesh Road Transport Authority (BRTA) issues route permits for vehicles to run on the roads. Registered vehicle data for whole Bangladesh from 2011 to 2015 was collected from BRTA and analysed. Details of the collected vehicular data are shown in Table 3.2-11.

Table 3.2-11 Cumulative Registered Number of Vehicles in Bangladesh from 2011 to 2015

	Motorcycle	3 wheeler	Car	Utility	Bus	Truck
2011	873,873	161,627	303,210	77,120	55,459	90,198
2012	975,461	185,798	320,211	89,714	57,496	97,525
2013	1,061,269	201,890	332,479	98,908	59,184	101,860
2014	1,151,954	222,287	345,488	106,775	60,439	106,989
2015	1,392,312	243,382	364,500	118,199	62,183	115,125

Source: Bangladesh Road Transport Authority (BRTA)

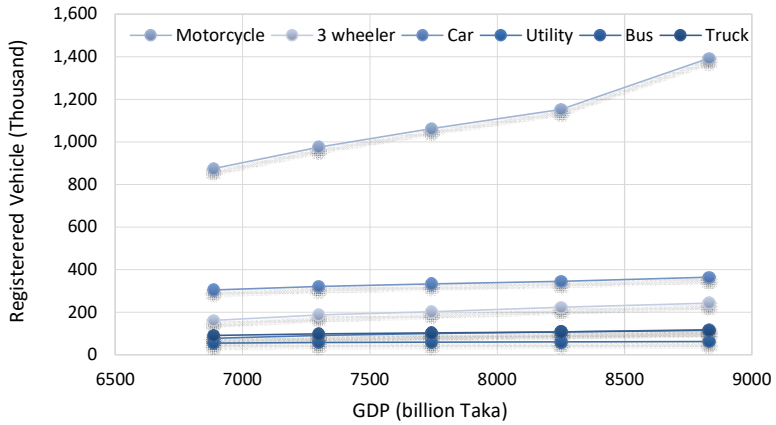


Source: Bangladesh Road Transport Authority (BRTA)

Figure 3.2-17 Change of Vehicular Growth of Bangladesh from 2011 to 2015

Future Traffic Production

In general, it is evident that traffic production volume correlates highly with the number of the vehicle registration. Therefore, the traffic production was assumed to be proportional to the expansion of the number of vehicle registration in this study. By using 2011-2015 data the relation between GDP and registered vehicle is shown in **Figure 3.2-18**. In order to develop correlation, simple linear regression method and logarithm regression method were considered in between GDP and number of vehicles of whole country.



Source: JICA Survey Team

Figure 3.2-18 Relation between GDP and Vehicle Registration Number

It was concluded that growth factor calculation by using simple linear regression was an overestimation which was not always directly proportional to economic growth. Therefore, the logarithm approximation model was chosen from the GDP growth and vehicle registration number. The number of the future vehicle registration was forecasted using formula 3-1 which was derived from the model and then future growth rate was calculated. The formula used for future vehicle calculation is:

Vehicle Registration Number=a×ln (GDP [million TK])+b…..Formula 3–1

Where; a is an independent variable and b is the intercepting point which is determined by regression analysis.

The values of different parameter (a and b) for each type of vehicle category are shown in Table 3.2-12.

Table 3.2-12 Parameters of the Vehicle Registration Number Forecasting Model

	Motorcycle	3 wheeler	Car	Utility	Bus	Truck
a	1968.512	322.1425	238.4599	159.7004	26.35957	95.71016
b	-30141.3	-4908.09	-3450.21	-2435.65	-359.266	-1416.19
R^2	0.957	0.996	0.996	0.992	0.990	0.991

Source: JICA Survey Team

The value of coefficient of determination (R^2) was realized as being very close to 1.0 therefore, it was concluded that the results from this model were highly reliable. The Future registered vehicles from 2016 to 2035 were then calculated using the formula. The forecasted values are shown in Table 3.2-13.

Table 3.2-13 Forecast of Future Vehicle Registration (in thousands)

	Motorcycle	3 wheeler	Car	Utility	Bus	Truck
2016	1,476	266	380	129	64	121
2017	1,609	288	396	140	66	128
2020	2,009	353	444	173	71	147
2025	2,675	462	525	227	80	179
2030	3,294	564	600	277	88	209
2035	3,914	665	675	327	97	240

Source: JICA Survey Team

These forecasted figures for the registered traffic volumes were used to calculate the yearly growth rate for each vehicle category for every 5 years. This growth rate for each category of the vehicle was used to forecast the future traffic on the existing road.

Table 3.2-14 Yearly Growth Rate of Registered Vehicles

Growth Rate	Motorcycle	3 wheeler	Car	Utility	Bus	Truck
2017 ~ 2020	7.67%	7.06%	3.92%	7.18%	2.64%	4.84%
2020 ~ 2025	5.89%	5.53%	3.39%	5.60%	2.39%	4.06%
2025 ~ 2030	4.26%	4.05%	2.71%	4.09%	1.99%	3.16%
2030 ~ 2035	3.51%	3.37%	2.39%	3.39%	1.81%	2.72%

Source: JICA Survey Team

(3) Result of Traffic Demand Forecast

1) Traffic Demand from Port

Volume of Container Cargo of Matarbari

The total share of container cargo handling of Matarbari was assumed to be 15% of the volume for the whole country in 2026 which will rise to 25% in 2041. The base capacity of Matarbari port was calculated as 691,200 TEUs in the year 2026 and 2,550,000 TEUs in the year 2041. However, from the year 2023, the port will be operational with 10% capacity of 2026 which will increase to 20% and 40% in 2024 and 2025 respectively;

Table 3.2-15 Estimated Number of Container Cargo of Matarbari Port (Thousand TEU)

Unit: thousand

Year	Case 1: Matarbari Container only	Overflow from Chittagong Port	Case 2: Matarbari with Overflow from Ctg. Port	Comment
2023	57.1			10% capacity of 2026
2024	121.8			20% capacity of 2026
2025	259.5			40% capacity of 2026
2026	691.2			100% capacity
2027	769.2			
2028	854.5			
2029	947.6			
2030	1,049.3			
2031	1,145.3			
2032	1,248.5			
2033	1,359.3			
2034	1,478.3	113.3	1,534.9	
2035	1,605.9	353.0	1,782.4	
2036	1,742.8	603.7	2,044.6	
2037	1,889.5	866.0	2,322.6	
2038	2,046.8	1,140.5	2,617.1	
2039	2,215.4	1,427.7	2,929.2	
2040	2,395.9	1,728.2	3,260.0	
2041	2,550.0	1,957.3	3,528.6	

Source: JICA Survey Team

Cargo Container related Traffic Volume

Basic user data for container types and export import ratio was collected from Chittagong port. The 2016 data was used as reference. From this data, the ratio of cargo to container was obtained as 1.47. Using the methodology stated jn section 1.3.1, container truck volume from Matarbari port from 2023 to 2041 was calculated as shown in Table 3.2-16.

Table 3.2-16 Total Traffic Volume related with Cargo Container

Unit: thousands

Year	Container (TEU)	Boxes	Trucks	Barges	Total Traffic Volume (Vehicle)
2023	57.1	38.9	31.3	3.9	46.9
2024	121.8	82.8	66.6	8.3	100.0
2025	259.5	176.5	142.0	17.7	213.0
2026	691.2	470.2	378.3	47.0	567.4
2027	769.2	523.3	421.0	52.3	631.4
2028	854.5	581.3	467.6	58.1	701.4
2029	947.6	644.6	518.6	64.5	777.9
2030	1,049.3	713.8	574.2	71.4	861.3
2031	1,145.3	779.1	626.8	77.9	940.2
2032	1,248.5	849.3	683.3	84.9	1,024.9
2033	1,359.3	924.7	743.9	92.5	1,115.9
2034	1,478.3	1,005.6	809.0	100.6	1,213.5
2035	1,605.9	1,092.4	878.9	109.2	1,318.3
2036	1,742.8	1,185.6	953.8	118.6	1,430.7
2037	1,889.5	1,285.4	1,034.1	128.5	1,551.1
2038	2,046.8	1,392.4	1,120.2	139.2	1,680.3
2039	2,215.4	1,507.1	1,212.4	150.7	1,818.6
2040	2,395.9	1,629.9	1,311.2	163.0	1,966.8
2041	2,550.0	1,734.7	1,395.5	173.5	2,093.3

Source: JICA Survey Team

General Bulk Cargo Volume

It is assumed that Matarbari port will be used for handling of steel products and food grain. The maximum capacity of handling steel products will be 1,200,000 Tons in 2026 and 1,500,000 Tons in 2041. In the case of grain, it was assumed that the maximum bulk cargo volume will be 727,000 Tons in 2026 and 926,000 Tons in 2041.

Table 3.2-17 Estimation of Multipurpose Berth (Thousand Tons)

Unit: thousands

Commodities	**2026**	**2041**
Food Grain of Bangladesh	4,853	6,175
10% - 20% by Large Ship	485 - 970	618 - 1,235
Median Value	**727.5**	**926.5**
Steel Products of Bangladesh	5,000 – 7,900	8900 - 14,000
Chittagong Port Capacity	4,100	4,700 – 5,400
Others	900 – 3,800	3,500 - 9,300
Matarbari (1/2)	450 - 1,900	1,750 – 4,650
Payra (1/2)	4,500 - 1,900	1,750 – 4,650
Median Value for Matarbari	**1,200**	**3,200**

Source: JICA Survey Team

Bulk Cargo Related Traffic Volume

The calculated results for forecasted Bulk cargo traffic volume are shown in Table 3.2-18.

Table 3.2-18 Traffic Volume of Multipurpose Berth

Unit: thousands

Year	Grain	Steel Product		Grain Loaded Trucks			Steel Loaded Trucks	Total Traffic Volume
				Raw	Finished	Total		
2023	72.8	120.0	10%	1.8	2.4	4.2	5.4	27.0
2024	145.5	240.0	20%	3.6	4.9	8.5	10.8	54.0
2025	291.0	480.0	40%	7.3	9.7	17.0	21.6	108.0
2026	727.5	1,200.0	100%	18.2	24.3	42.4	54.0	270.0
2027	740.8	1,220.0	100%	18.5	24.7	43.2	54.9	274.7
2028	754.0	1,240.0	100%	18.9	25.1	44.0	55.8	279.4
2029	767.3	1,260.0	100%	19.2	25.6	44.8	56.7	284.1
2030	780.6	1,280.0	100%	19.5	26.0	45.5	57.6	288.8
2031	793.8	1,300.0	100%	19.8	26.5	46.3	58.5	293.5
2032	807.1	1,320.0	100%	20.2	26.9	47.1	59.4	298.1
2033	820.4	1,340.0	100%	20.5	27.3	47.9	60.3	302.8
2034	833.6	1,360.0	100%	20.8	27.8	48.6	61.2	307.5
2035	846.9	1,380.0	100%	21.2	28.2	49.4	62.1	312.2
2036	860.2	1,400.0	100%	21.5	28.7	50.2	63.0	316.9
2037	873.4	1,420.0	100%	21.8	29.1	51.0	63.9	321.6
2038	886.7	1,440.0	100%	22.2	29.6	51.7	64.8	326.3
2039	900.0	1,460.0	100%	22.5	30.0	52.5	65.7	331.0
2040	913.2	1,480.0	100%	22.8	30.4	53.3	66.6	335.6
2041	926.5	1,500.0	100%	23.2	30.9	54.0	67.5	340.3

Source: JICA Survey Team

Total Traffic Volume from the Port

According to the Technical Note of National Institute for Land and Infrastructure Management of Japan No.21, peak hour factor, K30 can be calculated using the following formula:

$$K30\ (\%) = \min\ (\ 248.9 \times AADT^{-0.3283},\ 18\%\ )$$

Peak hour factor was calculated separately for each respective year. In order to convert the number of vehicles from the port into PCU, the value for the general traffic was assumed to be 1.0 given that buses and other large vehicles do not travel to the port on a regular basis.

Table 3.2-19 Total Induced Traffic from the Port

Year	Container Truck	Container Related General Traffic	Bulk Truck	Bulk Truck Related General Traffic	Total	AADT (veh/day)	K30	Peak Traffic Volume (veh/hr)	AADT (PCU/day)	Peak Traffic Volume (PCU/hr)
2023	31,271	15,636	19,288	7,715	73,909	202	18.0%	36	480	86
2024	66,639	33,320	38,575	15,430	153,964	422	18.0%	76	998	180
2025	142,008	71,004	77,150	30,860	321,022	880	18.0%	158	2,080	374
2026	378,274	189,137	192,875	77,150	837,435	2,294	18.0%	413	5,424	976
2027	420,964	210,482	196,223	78,489	906,158	2,483	18.0%	447	5,864	1,056
2028	467,624	233,812	199,571	79,828	980,834	2,687	18.0%	484	6,343	1,142
2029	518,590	259,295	202,918	81,167	1,061,971	2,910	18.0%	524	6,863	1,235
2030	574,226	287,113	206,266	82,506	1,150,112	3,151	17.7%	557	7,428	1,313
2031	626,793	313,396	209,614	83,846	1,233,648	3,380	17.3%	584	7,963	1,376
2032	683,266	341,633	212,962	85,185	1,323,045	3,625	16.9%	612	8,536	1,441
2033	743,911	371,955	216,309	86,524	1,418,699	3,887	16.5%	641	9,148	1,510
2034	809,007	404,504	219,657	87,863	1,521,031	4,167	16.1%	672	9,804	1,581
2035	878,854	439,427	223,005	89,202	1,630,489	4,467	15.8%	704	10,505	1,656
2036	953,770	476,885	226,353	90,541	1,747,549	4,788	15.4%	738	11,254	1,734
2037	1,034,091	517,046	229,701	91,880	1,872,717	5,131	15.1%	773	12,056	1,816
2038	1,120,178	560,089	233,048	93,219	2,006,534	5,497	14.7%	810	12,912	1,902
2039	1,212,411	606,206	236,396	94,558	2,149,572	5,889	14.4%	848	13,828	1,991
2040	1,311,198	655,599	239,744	95,898	2,302,439	6,308	14.1%	888	14,806	2,084
2041	1,395,541	697,770	243,092	97,237	2,433,639	6,668	13.8%	922	15,646	2,163

Source: JICA Survey Team

Overall summary of traffic flow between 2026 and 2035 from Matarbari Port is shown in **Table 3.2-20**.

Table 3.2-20 Future Peak Hour Traffic Flow from the Port

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Yearly Traffic (thousand)	837	906	981	1,062	1,150	1,234	1,323	1,419	1,521	1,631
Daily Traffic (veh/day)	2,294	2,483	2,687	2,910	3,151	3,380	3,625	3,887	4,167	4,467
Daily Traffic (PCU/day)	5,424	5,864	6,343	6,863	7,428	7,963	8,536	9,148	9,804	10,505
Peak Factor	18.0%	18.0%	18.0%	18.0%	17.7%	17.3%	16.9%	16.5%	16.1%	15.8%
Peak Volume (veh/hour)	413	447	484	524	557	584	612	641	672	704
Peak Volume (PCU/hour)	976	1,056	1,142	1,235	1,313	1,376	1,441	1,510	1,581	1,656

Source: JICA Survey Team

2) Diverted Traffic from the Existing Road

At present, the vehicles travelling from Chakaria to Matarbari use Regional Highway No.172. As mentioned earlier, it was observed that 3 wheelers carry passengers for short distances to and fro along the regional road. The project road will be semi-access controlled and it can be assumed that such short distance traffic will not divert to the project road. Therefore, only long-distance traffic (passenger cars, utility cars and trucks) would be diverted to the project road.

Peak hour factor for R172 was calculated as 8.1% using the traffic survey data of 2017. However, peak hour factor for this road was adopted as 10% as per RHD Geometric Design (2005) in order to get safer results. The Estimated diverted traffic from R172 to the new access road from 2026 to 2035 is shown in Table 3.2-21

Table 3.2-21 Estimated Diverted Traffic from the Existing Road to the New Access Road

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Car	53	54	55	57	58	60	61	63	64	66
Utility	26	28	29	30	31	32	33	34	36	37
Truck	107	111	114	118	122	125	128	132	135	139
Daily Traffic (Veh/day)	186	192	198	205	211	217	223	229	235	242
Daily Traffic (PCU/day)	401	414	427	440	454	467	480	493	506	520
Peak hour (PCU/hour)	40	41	43	44	45	47	48	49	51	52

Source: JICA Survey Team

3) Traffic Demand by Development Activities

At present, CPGCBL's Power Plant Project is under construction in Matarbari and in foreseeable future, more power related development activities such as construction of LNG terminal; coal terminal etc. will be undertaken. The commuting trip and business trip related with these activities are forecasted in this part of the report. The Future power related development activities at Matarbari area are described in Table 3.2-22. Although BEZA is planning to develop several economic zones in Maheshkhali, such developments will not be implemented during the period of this traffic demand forecast; thus, the traffic related to the economic zones is not considered in this study.

Table 3.2-22 Future Development Activities in Matarbari Region

	2026		2031		2041	
	Area (ha)	Capacity (MW)	Area (ha)	Capacity (MW)	Area (ha)	Capacity (MW)
Power Plant	110	1,704	180	2,904	680	11,304
Coal Terminal	70		120		140	
LNG Terminal	0		35		70	
Oil Refinery	400		400		400	
LPG	0		0		240	

Source: Data Collection Survey on Integrated Development for Southern Chittagong Region

Due to these activities, future potential traffic will be generated as a results of business trips and commuting trips. In order to calculate the number of working days, labour related laws and holidays in Bangladesh were studied and are summarized in Table 3.2-23. Assuming all the employees will take 100% of the paid leaves, the minimum attendance rate was calculated as 95%.

Table 3.2-23 Number of Working Days in Power Plant

Total number of working day/ year[1]	313 (only one weekly holiday)
Government holiday/year	22
No of real working days/year	313 – 22 = 291
Yearly paid leaves[1]	15
Average attendance rate	(291-15)/291 = 95% (assuming all paid leaves will be taken)

[1]Source: Bangladesh Labour Law Act, 2006

. To calculate commuting trips, the possible number of managerial and general staff were calculated for each of the facilities as shown in Table 3.2-24.

Table 3.2-24 Possible Number of Staff in Power Plant & Others

	2026		2031		2034		2041	
	Managerial Staff	Gen. Staff	Managerial Staff	Gen. Staff	Managerial Staff	Gen. Staff	Managerial Staff	Gen. Staff
Power Plant[1]	133	273	218	465	218	465	822	1,811
Coal Terminal[2]	85	174	145	298	145	298	169	347
LNG Terminal[2]			42	87	42	87	85	174
Oil Refinery[3]	219	548	219	548	219	548	219	548
Total	437	995	624	1,398	624	1,398	1,295	2,880

Note: [1]Number of managers and workers for the power plant are obtained from Preparatory Survey on Chittagong Area Coal Fired Power Plant Development Projects in Bangladesh (Section 13.6.5)
[2] Number of employees calculated as proportional to power plant area
[3]Number of employees of existing oil refinery of Bangladesh i.e., eastern refinery is adopted (source: www.erl.com.bd/organogram_manpower.php)

To calculate commuting trips, it was assumed that managerial staff will travel by car while general staff will travel by bus in consideration of the prevailing social situation in Bangladesh. Commuting trips were distributed in such a way that workers will travel to the site in 2 shifts. in order to calculate the trips of 2034 the same numbers as 2031 were adopted given that major facilities will start operation from 2041 onwards.. Daily commuting trips from the power plant and other facilities are described in Table 3.2-25.

Table 3.2-25 Number of Daily Commuting Trips to Power Plant & Others

		2026		2031		2034		2041	
		Managerial Staff	Gen. Staff	Managerial Staff	Gen. Staff	Managerial Staff	Gen. Staff	Managerial Staff	Gen. Staff
(a)	Maximum Commuting Trip (person-oneway);	437	995	624	1,398	624	1,398	1,295	2,880
(b)	Attendance Rate	95%							
(c)	Total Commuting Trips (person - oneway); (a)×(b)	414	942	591	1,324	591	1,324	1,227	2,729
(d)	Total Commuting Trips (person - bothway); (c)×2	827	1885	1,182	2,649	1,182	2,649	2,454	5,457
Occupancy Rate[1]									
(e)	Bus	40.25							
(f)	Car	1.44							
Total Commuting Trips (veh/day)									
(g)	Bus		47		66		66		136
(h)	Car	575		821		821		1,704	
(i)	Total Commuting Trips (PCU/day)	575	140	821	197	821	197	1,704	407
(j)	Peak Hour Factor	1/4 = 0.25							
(k)	Commuting Trips at Peak Hour (PCU/hour)	144	35	205	49	205	49	426	102

[1]Source: The Project on The Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP)

For potential business trip calculation, it was assumed that only the managers will go out of the area and that the business trips are equally distributed for core business time of 8 hours. The number of business trips are shown in Table 3.2-26

Table 3.2-26 Number of Business Trips to the Power Plant & Others

Item		2,026	2,031	2,034	2,041
(a)	No of Managerial Staff	437	624	624	1,295
(b)	Trip Rate[1]	6.9%			
(c)	Business Trip (person/day); (a)×(b)×2	60	86	86	179
(d)	Occupancy Rate Car*	1.44			
(e)	Business Trips (veh/day); (c)/(d)	42	60	60	124
(f)	No of Business Trips (PCU/day)	42	60	60	124
(g)	Peak Hour Factor	1/8 = 0.125			
(h)	Business Trips at Peak Hour (PCU/hour); (f)×(g)	5	7	7	16

[1]Source: The Project on The Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP)

Now when all the commuting trips and business trips are summed up, the number of trips for power plant related activities are obtained as shown in Table 3.2-27.

Table 3.2-27 Number of Daily Vehicular Trips to Power Plant & Others

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Commuting Trips - Bus	47	47	47	47	47	66	66	66	66	66
Commuting Trips - Car	575	575	575	575	575	821	821	821	821	821
Business Trips - Car	42	42	42	42	42	60	60	60	60	60
Total Trips (veh/day)	663	663	663	663	663	947	947	947	947	947
Total Trips (PCU/day)	757	757	757	757	757	1,078	1,078	1,078	1,078	1,078
No of Trips in Peak Hour (PCU/hour)	184	184	184	184	184	262	262	262	262	262

Source: JICA Survey Team

4) Induced Traffic by Future Development Plan

According to Bangladesh Economic Zone Authority (BEZA), a future development plan for establishing economic zones (EZ) has been prepared. The total area of planned EZ is about 17,323 acres i.e. 7,010 hectares. According to BEZA, the development plan will not be implemented in the next 10 years which means it will not have any effect on the project road until 2028. Even if the plan starts in 2028 it requires land reclamation and other facility construction before operation which will definitely go beyond 2034.

If all the planned EZs are completed and are fully operation, the traffic generated from the economic zones could go up to 8,676 veh/day. As the development plan of EZ is not yet confirmed, the future traffic from these facilities is not taken into consideration for the final figure. It is also not confirmed whether these economic zones will be constructed only for export or for internal use. Therefore, it is assumed that 50% will be used for local use which will be transported by land and the related traffic so generated will use the access road in the future. If 8,676 vehicles use the access road from Moheshkhali area, the impact will be magnified.

Table 3.2-28 Potential Container Truck Trips from Economic Zones

(a)	Operational Area BEZA (ha)	7,010
(b)	EZ Container trips[1]	1.65 TEU/ha/day
(c)	Total trips (TEU/day); (a)×(b)	11,569
(d)	Transportation by land: water	50:50
(e)	Ratio of 20' and 40' Container trucks	50:50
(f)	20' Container Trucks (veh/day) ; (c)/(2×2)	2,892
(g)	40' Container Trucks (veh/day) ; (c)/(2×2)	1,446
(h)	Total One-way Trips (veh/day) ; (f)+(g)	4,338
(i)	Total Two-Way Trips (veh/day) ; (h)×2	8,676

[1]Source: Table 4.8.2(4)-11, Project for development of Economic zones and capacity Enhancement of Bangladesh Economic zones authority

(4) Design Traffic Volume

1) Design Traffic for Access Road

Daily traffic of the access road was calculated as 3,144 vehicle/day (or 6,582 PCU/day) in 2026 which will increase up to 5,655 vehicle/day (or 12,103 PCU/day) in 2035. In order to get these figures, i) traffic from Matarbari Port, ii) diverted traffic from existing road and iii) induced traffic from power related development activities were summed up.

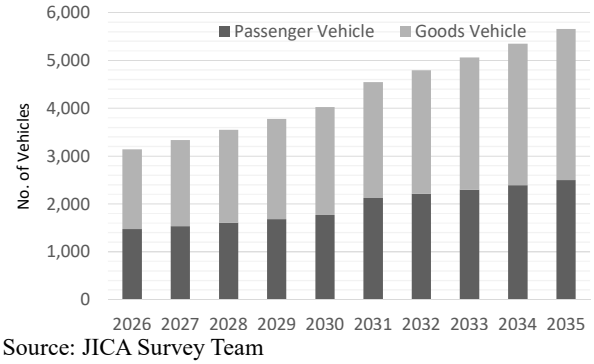
Table 3.2-29 Estimated Daily Traffic for the Access Road

	Veh Type	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Port Related Traffic	Truck	1,565	1,691	1,828	1,977	2,138	2,292	2,455	2,631	2,818	3,019
	Car.	730	792	859	933	1,013	1,088	1,169	1,256	1,349	1,448
Diverted Traffic from Present Road	Car	53	54	55	57	58	60	61	63	64	66
	Utility	26	28	29	30	31	32	33	34	36	37
	Truck	107	111	114	118	122	125	128	132	135	139
Power Plant Related Traffic	Car	616	616	616	616	616	881	881	881	881	881
	Bus	47	47	47	47	47	66	66	66	66	66
Total (veh/day)		3,144	3,338	3,549	3,777	4,025	4,544	4,794	5,063	5,349	5,655
Total (PCU/day)		6,582	7,035	7,527	8,060	8,639	9,508	10,093	10,719	11,388	12,103
Peak Hour Flow (veh/hour)		592	627	664	705	739	835	864	894	925	958
Peak Hour Flow (pcu/hour)		1,200	1,281	1,368	1,463	1,543	1,685	1,751	1,821	1,894	1,970
Required No. of Lanes (Ref: Japanese Port Road Standard[1])		2	2	4	4	4	4	4	4	4	4
Required No. of Lanes (Ref: RHD Standard[2])		2	2	2	2	2	2	2	2	2	2

Note: 1: If peak hour flow is more than 650 veh, 4 lanes are necessary
2: If peak hour flow is more than 2,100 pcu, 4 lanes are necessary

According to the Japanese port design manual, the traffic capacity of a 2-lane port access road connecting a port to a national highway is 650 vehicles/hour. Therefore, for purposes of planning for the port access road, the design traffic volume would necessitate 4 lanes. On the other hand, the 2-lane highway capacity of RHD's design standard is 7,000 vehicles/day (or 2,100 PCU/hour) and a 2-lane road would be able to accommodate the traffic up to the year 2035. However, if the proposed development plans such as economic zones are executed earlier, the traffic on the project road will definitely increase and the demand for upgrading to a 4-lane road will materialize sooner. In this regard, the project road could be built with 2-lane at interim stage but expandability to a 4-lane should be secured for future widening.

As most of the vehicle traffic will be generated from the port, the share of goods vehicles will definitely exceed that of passenger vehicles. The trend of share for passenger vehicles versus goods vehicles from the estimated daily traffic flow on the access road from 2026 to 2035 is as shown in Figure 3.2-19.



Source: JICA Survey Team

Figure 3.2-19 Change of Vehicle share for Daily Traffic Flow on Access Road (2026 ~ 2035)

2) Design Traffic for National Highway No.1

In comparison with the 2017 situation, it is estimated that the present daily traffic on N1 will increase by almost 1.6 times by the year 2026. In addition, by the same time, the traffic from the new access road will be merged which will certainly have an impact on this national highway. The combined daily traffic on this road was estimated to be 31,604 PCU by the year 2026.

Table 3.2-30 Forecast of Daily Traffic Flow on N1 (Chakaria Area)

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Motorcycle	4,206	4,385	4,572	4,766	4,969	5,143	5,324	5,511	5,704	5,904
3 wheeler	8,635	8,985	9,349	9,727	10,121	10,461	10,814	11,177	11,554	11,942
Car	1,600	1,644	1,688	1,734	1,781	1,823	1,867	1,911	1,957	2,004
Utility	2,605	2,711	2,822	2,938	3,058	3,162	3,269	3,380	3,495	3,613
Bus	1,026	1,047	1,067	1,089	1,110	1,130	1,151	1,172	1,193	1,214
Truck	2,702	2,788	2,876	2,966	3,060	3,143	3,229	3,317	3,407	3,500
Total (veh/day)	20,775	21,559	22,374	23,220	24,099	24,864	25,653	26,468	27,309	28,178
Total (PCU/day)	25,022	25,885	26,780	27,707	28,667	29,510	30,378	31,273	32,196	33,146

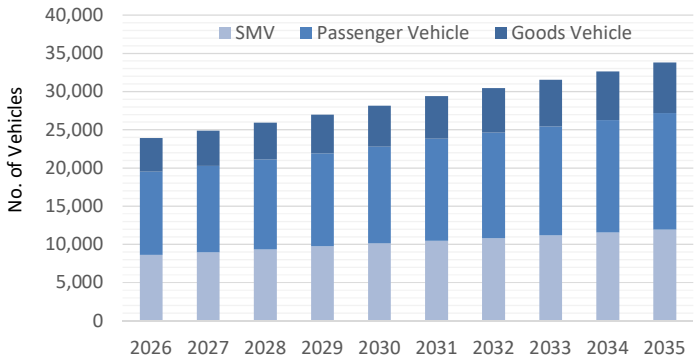
Table 3.2-31 Forecast of Daily Induced Traffic from the Access Road

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Car	1,398	1,462	1,531	1,606	1,687	2,029	2,112	2,200	2,294	2,395
Utility	26	28	29	30	31	32	33	34	36	37
Bus	47	47	47	47	47	66	66	66	66	66
Truck	1,672	1,802	1,942	2,095	2,260	2,416	2,584	2,763	2,954	3,158
Total (veh/day)	3,144	3,338	3,549	3,777	4,025	4,544	4,794	5,063	5,349	5,655
Total (PCU/day)	6,582	7,035	7,527	8,060	8,639	9,508	10,093	10,719	11,388	12,103

Table 3.2-32 Estimated Combined Daily Traffic Flow on N1 (Chakaria Area)

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Motorcycle	4,206	4,385	4,572	4,766	4,969	5,143	5,324	5,511	5,704	5,904
3 wheeler	8,635	8,985	9,349	9,727	10,121	10,461	10,814	11,177	11,554	11,942
Car	2,999	3,106	3,219	3,340	3,468	3,852	3,978	4,111	4,251	4,399
Utility	2,631	2,739	2,851	2,968	3,089	3,194	3,302	3,414	3,530	3,650
Bus	1,073	1,093	1,114	1,135	1,157	1,196	1,217	1,237	1,259	1,280
Truck	4,375	4,589	4,818	5,061	5,320	5,560	5,813	6,080	6,361	6,658
Total (veh/day)	23,919	24,897	25,922	26,997	28,124	29,407	30,447	31,530	32,658	33,833
Total (PCU/day)	31,604	32,920	34,307	35,767	37,306	39,018	40,472	41,993	43,584	45,249

Change of estimated traffic flow with the share for different types of vehicles on National Highway 1 from 2026 to 2035 is shown in Figure 3.2-20.



Source: JICA Survey Team

Figure 3.2-20 Change of Vehicle Share for Daily Traffic Flow on N1 (2026 ~ 2035)

It is already evident that SMV are playing a vital role in the traffic safety of Bangladesh. To understand the safety perspective due to existence of a high share of slow moving vehicles, future peak hour traffic flow was presented with and without SMV in Table 3.2-32. With respect to vehicle modal share, it was observed that slow moving vehicles account for almost 20% of the total share in PCU for 2026 traffic. Taking into consideration that heavy vehicles account for more than 45% of nodal share in 2016 and that SMVs are slow in speed and very reluctant to obey traffic rules, it is highly recommended to consider separate SMV lanes along N1 in future design.

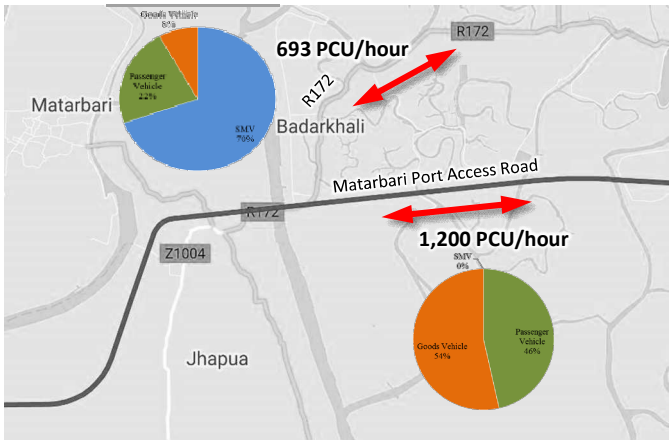
3) Traffic Volume for Intersecting Roads

Intersection of Access Road and Regional Road R172

Due to the high volume of heavy vehicles (53% trucks) from the access road, it is recommended that the intersection with R172 is designed as grade separated. Another objective of designing a grade separated intersection is to prohibit entrance of slow moving vehicles from R172 thereby ensuring safety. SMVs will cause slow movement and traffic accidents might happen when SMV are allowed to travel together with heavy vehicles. Future traffic forecast on R172 is as shown in Table 3.2-33

Table 3.2-33 Future Traffic Forecast on R172

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Motorcycle	951	992	1,034	1,078	1,124	1,163	1,204	1,247	1,290	1,336
3 wheeler	5,210	5,421	5,640	5,869	6,106	6,312	6,524	6,744	6,971	7,205
Car	95	97	100	102	105	108	110	113	116	118
Utility	596	621	646	672	700	724	748	773	800	827
Bus	17	18	18	18	19	19	19	20	20	21
Truck	524	540	557	575	593	609	626	643	660	678
Total (veh/day)	7,393	7,688	7,995	8,315	8,647	8,935	9,232	9,539	9,857	10,185
Total (pcu/day)	6,935	7,201	7,477	7,764	8,063	8,322	8,590	8,867	9,152	9,447
Peak Hour (pcu/hour)	693	720	748	776	806	832	859	887	915	945



Source: JICA Survey Team

Figure 3.2-21 Peak Hour Traffic Flow of R172 and Access Road in 2026

Intersection of the Access Road and the National Highway 1

Traffic from the access road will merge with the National Highway No.1. Due to the existing high traffic volume of N1, the intersection is expected to be more congested. Due to the high volume of slow moving vehicles, it is necessary to consider separate SMV lanes in order to ensure traffic safety. Including the SMV's the future traffic flow in 2026 will be 3,226 PCU/hour during peak hour. For intersection traffic design, it is assumed that all the heavy vehicles originating from Matarbari port will go towards Chittagong.

Table 3.2-34 Estimated Peak Hour Traffic (PCU/hour) at Intersection with SMV

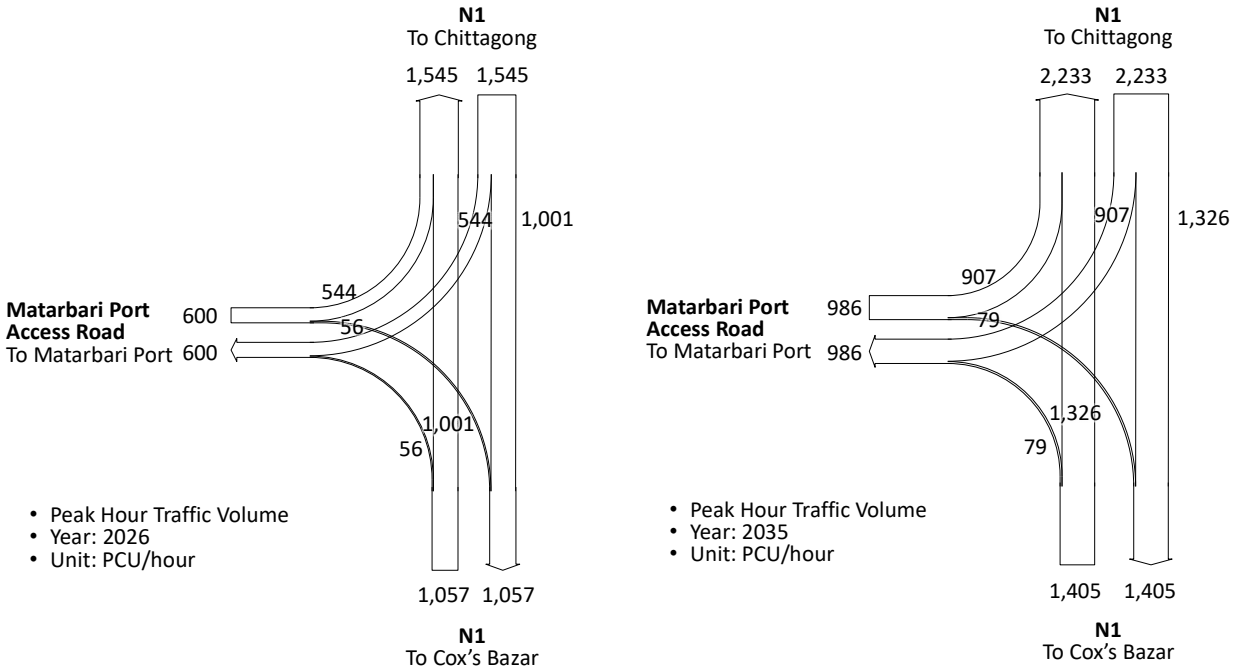
From	To	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Chittagong	Cox's Bazar	1,001	1,035	1,071	1,108	1,147	1,180	1,215	1,251	1,288	1,326
	Matarbari	544	584	628	675	714	765	798	833	869	907
Cox's Bazar	Matarbari	56	56	57	57	57	77	78	78	78	79
	Chittagong	1,001	1,035	1,071	1,108	1,147	1,180	1,215	1,251	1,288	1,326
Matarbari	Chittagong	544	584	628	675	714	765	798	833	869	907
	Cox's Bazar	56	56	57	57	57	77	78	78	78	79
Total		3,202	3,352	3,511	3,680	3,836	4,045	4,182	4,323	4,470	4,622

Source: JICA Survey Team

Table 3.2-35 Estimated Peak Hour Traffic (PCU/hour) at Intersection without SMV

From	To	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Chittagong	Cox's Bazar	742	766	791	816	843	867	891	916	941	968
	Matarbari	544	584	628	675	714	765	798	833	869	907
Cox's Bazar	Matarbari	56	56	57	57	57	77	78	78	78	79
	Chittagong	742	766	791	816	843	867	891	916	941	968
Matarbari	Chittagong	544	584	628	675	714	765	798	833	869	907
	Cox's Bazar	56	56	57	57	57	77	78	78	78	79
Total		2,684	2,813	2,950	3,096	3,229	3,418	3,533	3,652	3,776	3,905

Source: JICA Survey Team



Source: JICA Survey Team

Figure 3.2-22 Directional Traffic Diagram in 2026 at Intersecting Point with N1

3.2.4 Improvement of National Highway

For providing a smooth traffic condition for the fright transport form Matarbari Port, it's urgently necessary to implement the road widening project of N1.

The following methods would be essential to advancing project implementation:

- Full-scale project scopes at the identified major bottleneck sections only such as Patiya, Dohazari, Keranihat, Lohaghora and Chakaria should be implemented.
- Widening at the minor bottleneck sections only and provision of wider shoulder lanes at the other sections to be used as Slow-Moving Vehicle (SMV) lanes as a minimum investment for improving the traffic situation.

As a case study for traffic improvement of N1, Chakaria Section of N1 was examined under this study as a reference for the implementation stage, even though the scope of the work of the Matarbari Port Development Project does not include N1 improvement. The results of comparative analysis concluded that the flyover construction option would be the most preferable mainly because of the ease of implementation with minimum requirement of land acquisition. However, it is recommendable that further engineering study is undertaken to review the results of the comparative analysis given that the flyover construction option would require a bigger budget than the bypass construction option due to the length of bridge.

(1) Traffic Condition Analysis

Estimated future traffic demand along N1 (from Chittagong to Chakaria) in 2026 and 2035 are approximately 22,000-28,000 and 28,000-38,000 vehicles per day respectively (excluding the traffic to/from Matarbari Port), based on the traffic count surveys conducted by RHD in 2016 and by the detailed design for JICA-assisted Cross Border Road Network Improvement Project in 2017. The growth rates of the traffic volume, used for the estimation, are adjusted for every 5 years as described in Section 3.2.3.

Based on the estimated future traffic demand, it is expected that this road section of N1 will have severe traffic congestion. For example, the expected travel time from Chittagong to Chakaria (from the connecting point to the Matarbari Port Access Road) in 2017, 2026 and 2035 is 123, 232 and 438 minutes respectively. Therefore, the cargo trucks going to/from Matarbari Port will face such situation, if the road condition (namely, number of lanes) of N1 is not improved.

Even now, the highway traffic faces considerable congestion as they pass through the town sections; they are required to not only reduce their speed but also sometimes compelled to stop completely, which increases their travel time. Some of the main reasons behind such congestion at the town sections are:

- Presence of non-motorized transport (NMT) which are plying on the carriageway creating hindrance to through-traffic;
- Buses stopping on the carriageway for dropping and picking up passengers, blocking almost 60% of the road;
- Trucks stopping on the shoulder for loading and unloading goods;
- Rickshaws, cycle-vans, auto-rickshaws standing and parking on the shoulder or very near to the pavement; and
- Large numbers of pedestrians moving on the road (irrespective of footpath) without caring for the through traffic.

As stated in the RHD's Road Master Plan, one of the most important uses of a shoulder is to provide space for movement of slow-moving vehicles (SMVs) and for routine and emergency parking of vehicles. The Master Plan suggests that paved shoulders should be at least 2 m wide on both sides of a single carriageway. A narrow shoulder of 1.5 m is not wide enough to accommodate fully an animal-drawing cart or a parked or stranded truck. Therefore, provision of a wide shoulder would eliminate traffic problems.

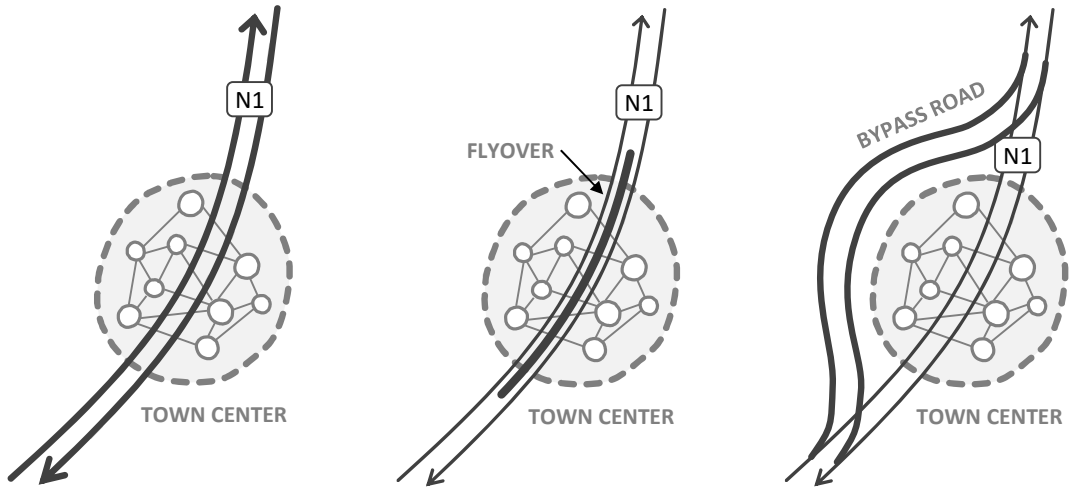
In order to overcome the problem of congestion created by encroachment on the shoulders and carriageways, it would be essential to provide dedicated lanes for buses, trucks and NMTs together with well-designed spaces for their loading/unloading, ensure strict enforcement of traffic rules and regulations and provision of well-located passenger sheds and ticket booking counters.

In order to accommodate such growing traffic demand, RHD is planning to widen N1 from 2-lanes to 4-lanes. Under the ADB's study, widening of the road and construction of 2 bypass roads and 3 flyovers at the major traffic bottlenecks, where widening is difficult due to the limited space, are proposed. Although, the financial source for the entire project has not been secured yet, construction of one of the proposed bypass roads at Patiya is currently under progress by the general budget of RHD but the number of lanes of the bypass at Patiya under construction is 2 instead of the proposed 4-lanes highway.

One of the reasons of the stagnation of implementation of the widening project would be the anticipated large-scale social impact by the project. The ADB's study proposed not only widening of the existing highway but also realignment by improving the road geometry to provide smooth and fast traffic flow so as to meet the geometric design standards of Asian Highways. This however requires a lot of resettlements..

(2) Possible Solution for Traffic Improvement

In general, there are three (3) types of traffic improvements often used, namely, widening of the existing road, construction of a flyover, construction of a bypass.



Widening Option **Flyover Construction Option** **Bypass Construction Option**

Source: JICA Survey Team

Figure 3.2-23 Example of Improvement of N1

The following table represents the possible scenarios of project implementation.

Table 3.2-36 Alternative Options for Improvement of N1

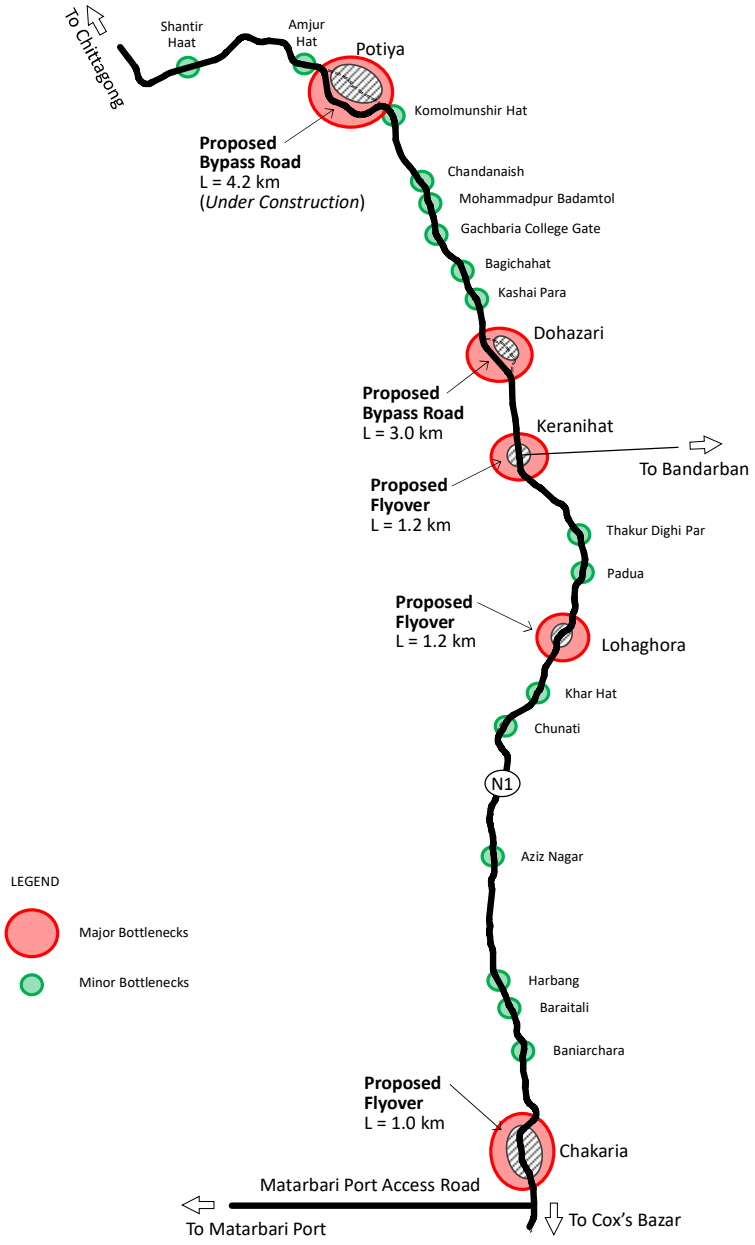
	5 Major Bottleneck Sections	Minor Bottleneck Sections	Other Sections
Case 1: Do nothing	* * *	* * *	* * *
Case 2	Bypass or Flyover	* * *	* * *
Case 3	Bypass or Flyover	4-lane Widening	Shoulder Paving
Case 4	Bypass or Flyover	4-lane Widening	4-lane Widening

As a result of the traffic situation analysis, the following findings were made:

- (Case-2) Even though the major traffic bottlenecks (14.5 km out of 90 km) are improved, the length of the improved section makes up only 16 % of the entire road. Due to the existence of large numbers of SMVs, severe congestion is not only at the bottleneck sections but also on the other sections of the road. Therefore, the impact of the project would be limited;
- (Case-3) If the major and minor bottlenecks are improved, and the shoulders of the entire section paved with asphalt at least 1.5 m wide (preferably 2.0 m) on both sides and if the SMVs use the shoulders properly, the traffic situation would be drastically improved with a minimum investment cost;
- (Case-4) If the entire section of N1 from Chittagong to Chakaria is widened to 4-lanes and at least 1.5 m wide f shoulders provided, the freight traffic will not be affected under the assumption that SMVs will use the shoulders. However, implementation of this scope would take time for land acquisition and resettlement of houses.

Table 3.2-37 Calculated Average Travel Time between Chittagong and Chakaria during Peak Period

	Year 2017	Year 2026	Year 2035
Case 1: Do nothing	123 min. (2.1 h)	232 min. (3.9 h)	438 min. (7.3 h)
Case 2	111 min. (1.9 h)	197 min. (2.3 h)	357 min. (6.0 h)
Case 3	92 min. (1.5 h)	117 min. (2.0 h)	163 min. (2.7 h)
Case 4	68 min. (1.1 h)	68 min. (1.1 h)	69 min. (1.12 h)



Source: JICA Survey Team

Figure 3.2-24 National Highway No.1 (Chittagong-Chakaria Section)

In view of the economic viability of the project, the relationship between the extent of travel time savings and the project cost was checked and the following are the findings:

- Major bottleneck improvement such as construction of a bypass or a flyover will contribute to the reduction of travel times but its cost-effectiveness is much lower than simple road widening. Therefore, the target section should be carefully selected.
- On the other hand, paving of shoulders would have a high potential of cost-effectiveness by improving the traffic situation where traffic flow is simple unlike town sections.
- Considering the difficulty in accommodating simple widening in the identified major bottleneck sections due to the limited space along the existing highway and a lot of internal traffic and parking needs, a large-scale investment such as construction of a bypass or a flyover would be inevitable.

Considering the above, implementation of Case 3 (combination of bottleneck improvement to 4-lanes and shoulder paving at other sections) would be recommended.

Table 3.2-38 Rough Cost Estimates for Improvements (Case 2)

	Unit Rate (US$ mil./km)		Length (km)		Construction Cost (mil. US$)
	Road	Bridge	Road	Bridge	
Bypass at Patiya	9.2	70	5.0	0.0	46
Bypass at Dohazari	9.2	70	7.5	0.5	104
Flyover at Keranihat	5.4	100	1.0	2.0	205
Flyover at Lohaghora	5.4	100	1.0	2.0	205
Flyover at Chakaria	5.4	100	1.0	2.0	205
Total					765

Table 3.2-39 Rough Cost Estimates for Improvements (Case 3)

	Unit Rate (US$ mil./km)		Length (km)		Construction Cost (mil. US$)
	Road	Bridge	Road	Bridge	
Bypass at Patiya	9.2	70	5.0	0.0	46
Bypass at Dohazari	9.2	70	7.5	0.5	104
Flyover at Keranihat	5.4	100	1.0	2.0	205
Flyover at Lohaghora	5.4	100	1.0	2.0	205
Flyover at Chakaria	5.4	100	1.0	2.0	205
4-lane Widening at Minor Bottlenecks	5.4	35	7.5	0.0	40
Shoulder Paving at Other Sections	1.4	-	68.0	-	95
Total					**900**

Table 3.2-40 Rough Cost Estimates for Improvements (Case 4)

	Unit Rate (US$ mil./km)		Length (km)		Construction Cost (mil. US$)
	Road	Bridge	Road	Bridge	
Bypass at Patiya	9.2	70	5.0	0.0	46
Bypass at Dohazari	9.2	70	7.5	0.5	104
Flyover at Keranihat	5.4	100	1.0	2.0	205
Flyover at Lohaghora	5.4	100	1.0	2.0	205
Flyover at Chakaria	5.4	100	1.0	2.0	205
4-lane Widening at Minor Bottlenecks	5.4	35	73.0	2.5	482
Total					**1,248**

Table 3.2-41 Rough Benefit Estimates for Different Cases compared to Case 1 (Do Nothing)

Unit (mil. USD)	Case 2	Case 3	Case 4
Travel Time Savings	127	464	572
Vehicle Operating Cost Savings	43	137	152
Total Benefit	170	600	724

Using the preliminary cost and benefit figures, Economic Internal Rate of Return (EIRR), Benefit Cost Ratio (B/C) and Net Present Value (NPV) are calculated for different cases. Economic evaluation calculations were undertaken considering a period of 30 years after start of operations. For the specific calculations of NPV, a discount rate of 12% was used.

Table 3.2-42 Effectiveness of Improvements

	Case 2	Case 3	Case 4
EIRR	12%	23%	20%
B/C	2.82	8.20	6.64
NPV	5 mil. USD	859 mil. USD	850 mil. USD

(3) Preliminary Engineering Study for Chakaria Section

The freight traffic generated from Matarbari Port will pass through the town section of Chakaria and severe traffic congestion would be expected. Whereas the abovementioned ADB study proposed the construction of a flyover at Chakaria, widening of N1 at this section would be difficult due to the limited ROW width. The current road width of this section is approximately 25 m and a 2-lane through traffic and SMVT lanes are separately provided.

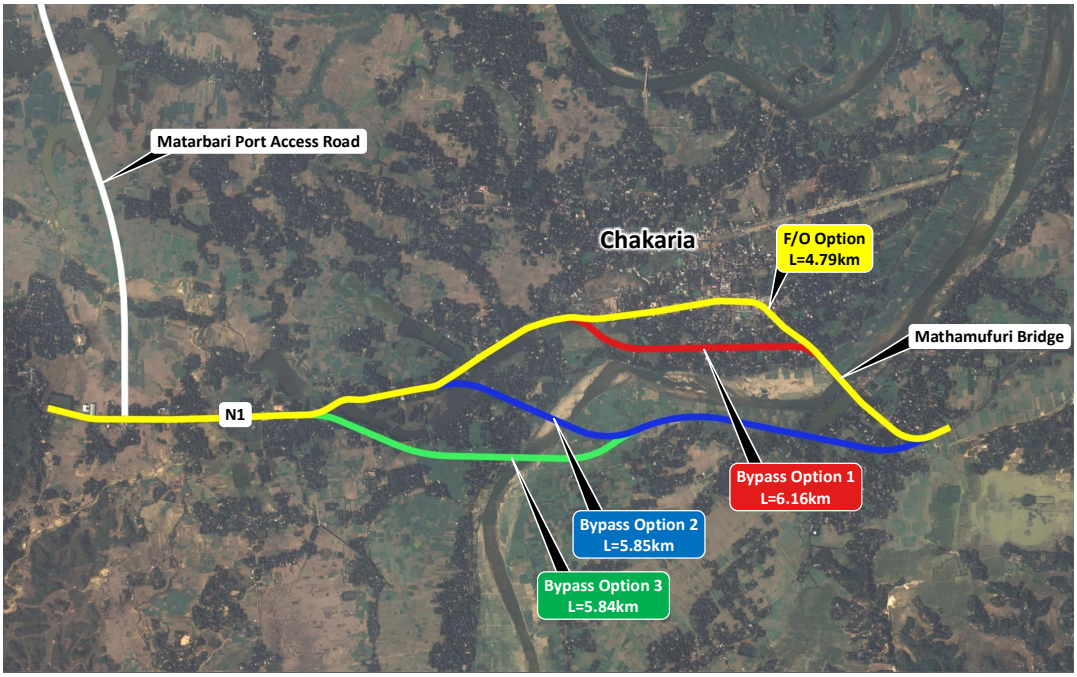
There are Slow Moving Vehicle (SMV) lanes on both sides of N1 and the SMV lanes are often congested severely.

SMV and pedestrians also use the 2-lane through traffic lanes at the center of the road and there are some parking vehicles on the lane.

Figure 3.2-25 Traffic Situation of N1 in Chakaria Town

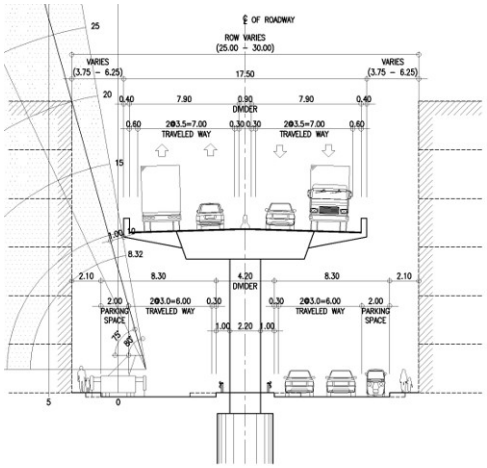
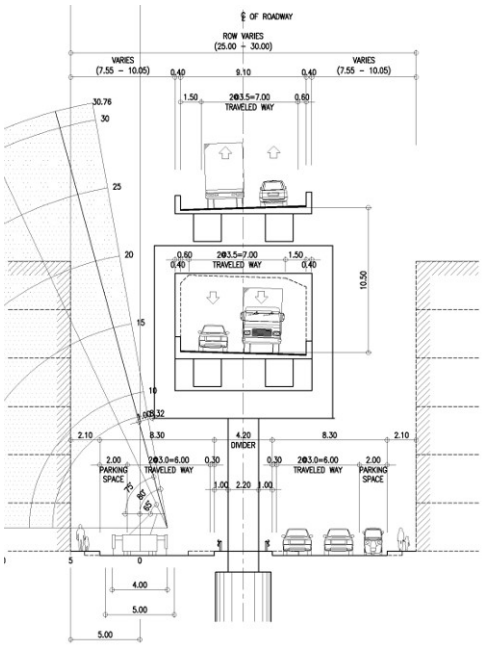
In order to justify the reasonableness of the ADB's flyover proposal, alternative options were examined with i) Do Nothing Option, ii) Flyover Construction Option and iii) three Bypass Construction Option. As shown in **Table 3.2-43,** the Bypass Construction Option-3 has a technical advantage with less construction cost requirement and a higher constructability. However, Flyover Construction Option was evaluated as the optimum option because this option would require minimum land acquisition and project implementation would be the easiest.

Table 3.2-43 Comparison of Improvement Method for N1 at Chakaria

	Do Nothing	F/O	Bypass-1	Bypass-2	Bypass-3
					
Road Length (km)	4.79	4.79	6.16	5.85	5.84
Bridge Length (m)	N/A	1,920	800	600	700
Construction Cost (US$ mil.)	N/A	130	105	91	96
Affected Buildings	N/A	**70**	Over 100	Over 100	Over 100
Required Land Acquisition	N/A	**2.1 ha**	14 ha	16 ha	19 ha
Efficiency for Traffic	Serious traffic congestion will occur	Good	**Better than F/O**	**Better than F/O**	**Better than F/O**
Constructability	N/A	Manageable	Better than F/O	Better than F/O	**Better than F/O and other bypass options**
Consistency with other Project	Await for widening project	**Mathamufuri River Bridge** to be constructed under Cross-Border Project can be fully utilized	**Mathamufuri River Bridge** will be utilized only for local traffic	**Mathamufuri River Bridge** will be utilized only for local traffic	**Mathamufuri River Bridge** will be utilized only for local traffic
Evaluation		If Mathamufuri River Bridge needed to be fully utilized, flyover option would be preferable.			If there is no constraint from other on-going projects, the bypass road option would be preferable.

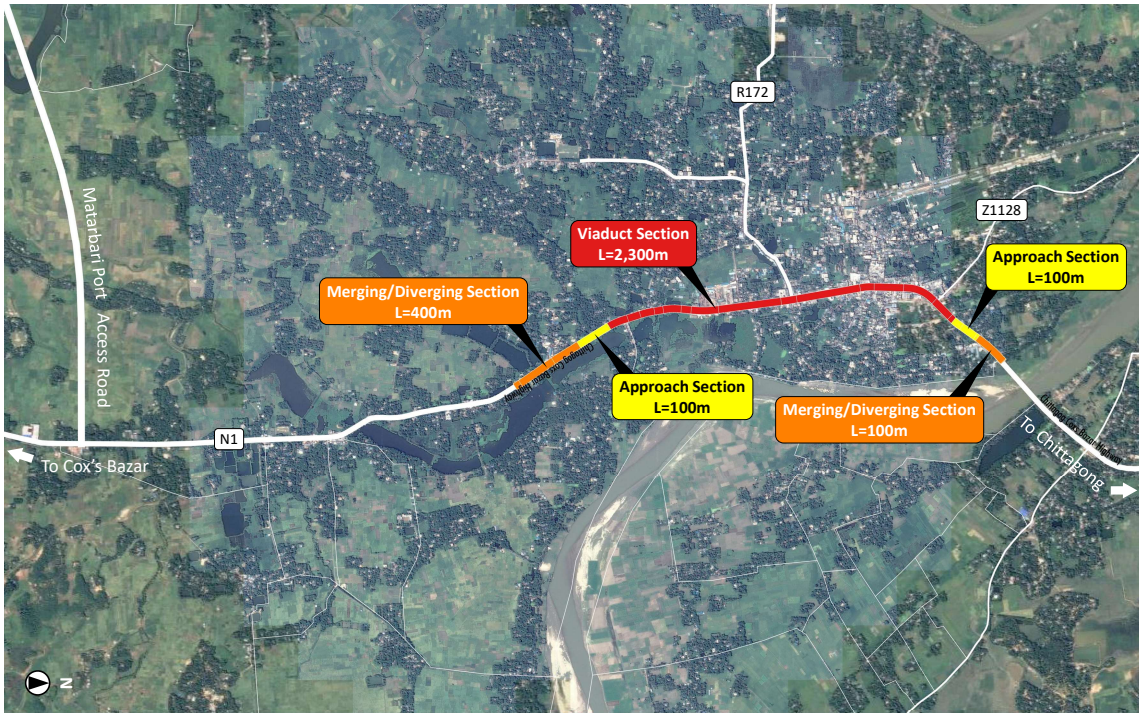
For the Flyover Construction Option, the Single Deck and Double Deck Options were also compared. Even though a Single Deck Option can be accommodated within the existing ROW, only 30-42% of the overhead open space can be provided for insolation to the ground level where some four floor buildings exist and the ground level would become darkened. However, the Double Deck Option would be more expensive than the Single Deck Option. Considering that the majority of the existing buildings in Chakaria Town are 2 to 3 floor buildings, Single Deck Option would be reasonable.

Table 3.2-44 Comparison of Bridge Type for Chakaria Flyover

	Single Deck Option	Double Deck Option
Cross Section		
Construction Cost	**Base Case** Rate: 1.0	**More Expensive** Rate: 1.5
Constructability	**Good** • Construction of single deck viaduct is not difficult.	**Fair** • Construction of double deck viaduct requires higher accuracy and technique.
Provision of Space for Firefighting from ground level	**Fair** • Firefighting works from ground level can reach up to 5th floor level.	**Good** • Firefighting works from ground level can reach up to 6th floor level, which is the tallest building in Chakaria Town as of now.
Insolation Condition	**Fair** • Only 30-42% of overhead open space can be provided for insolation to the ground level and ground level would be darkened.	**Good** • 64-70% of overhead open space can be provided for insolation and the negative impact for insolation condition would be limited.
Evaluation	**Recommended**	

As the result of preliminary engineering study, the following scope would be recommended. However, further engineering study should be undertaken at the implementation stage.

- Length of flyover: 2,300 m
- Approach section: 100 m
- Merging & diverging section: 400 m and 100m



Source: JICA Survey Team

Figure 3.2-26 Proposal for Chakaria Flyover

3.3 Natural Condition Survey

3.3.1 Topographic Survey

(1) Benchmark Installation

Under this study, digital terrain data was purchased instead of conducting a topographic survey. However, benchmark installation along the project road was conducted in order to ensure the accuracy of the digital terrain data.

For benchmark installation, Real Time Kinematic (RTK) method was applied in reference to the nearest national benchmarks established by the Survey of Bangladesh (see Table 3.3-1).

Table 3.3-1 RTK-GNSS Static Observation Points of Survey of Bangladesh (SoB)

National Benchmark	Easting (m)	Northing (m)	Elevation (mMSL)
BM 8504	388,562.263	2,389,236.178	4.496
BM 8508	383,296.133	2,398,788.455	2.186
GPS 282	391,620.462	2,402,102.508	2.132
GPS 322	404,306.233	2,395,896.049	4.637
GPS 6010	384,670.355	2,402,479.624	2.434
GPS 8508	383,296.133	2,398,788.455	2.186

Source: JICA Survey Team

The specifications of the installed benchmarks are as follows:

Permanent Control Points

- Size: 300 mm x 300 mm x 1,000 mm
- Real Time Kinematic (RTK) method
- More than six (6) satellites shall be observed at the time
- More than six (6) hour observation
- Data radio wave receiving observation interval every less 30 seconds
- Closure tolerance: Horizontally (ΔN, ΔE) 20 mm $\sqrt{}$N, N: number of sides
- Closure tolerance: Vertically (ΔU) 30 mm $\sqrt{}$N, N: number of sides
- Overlapping Session Observation Distance Tolerance: Horizontally 20 mm, and Vertically 30 mm

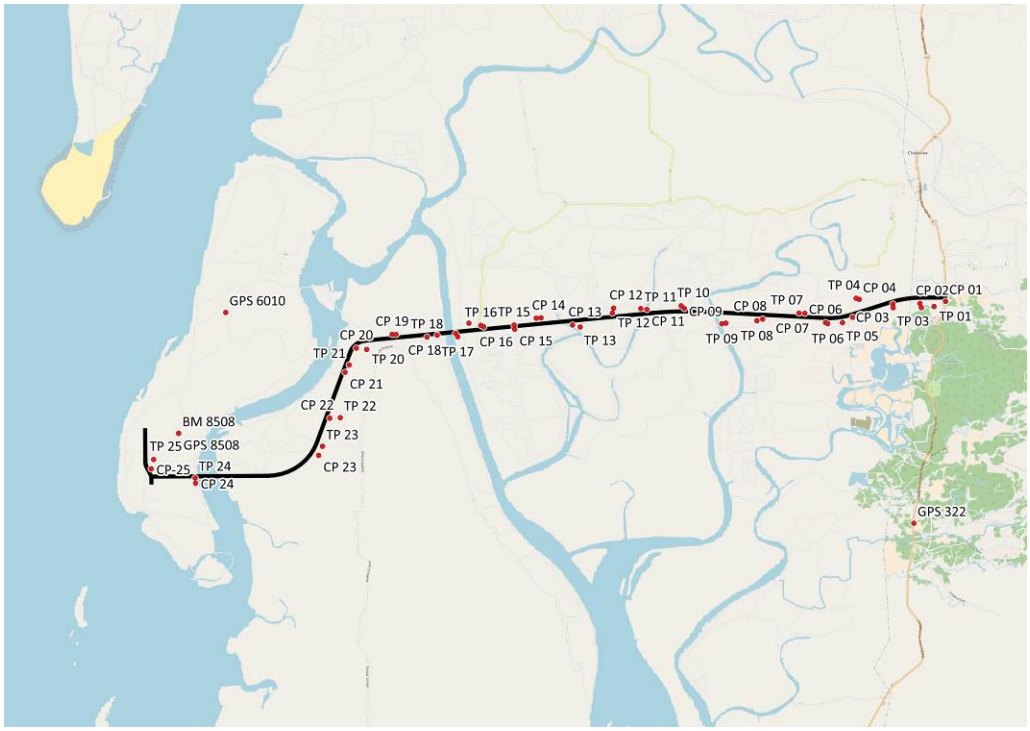
Traverse Points

- Size: 200 mm x 200 mm x 800 mm
- More than six (6) satellites shall be observed at the time
- More than one (1) hour observation
- Instrument accuracy: more than angle min. gradient 1"
- Distance measurement accuracy: ± (5 mm + 5 x 106 x D)
- Horizontal angle shall be two (2) pair observation in direct and reverse angles with gradient 0° and 90° and take an average
- Vertical angle shall be observed from both direct and reverse. The average angle shall be calculated
- Distance measurement shall be double observations as forward and backward tolerance 30 mm
- Angle closure between adjacent control points tolerance 20" and coordinate closure tolerance 1/10,000

Table 3.3-2 RTK-GNSS Static Observation Results of CP & TP Pillar

Sl.	Point ID	Easting (m)	Northing (m)	Elevation (mMSL)	Sl.	Point ID	Easting (m)	Northing (m)	Elevation (mMSL)
1	CP 01	405,253.449	2,402,685.807	4.849	26	TP 13	394,803.336	2,401,965.179	2.230
2	TP 01	404,923.653	2,402,529.197	2.940	27	CP 14	393,545.651	2,402,241.822	1.254
3	CP 02	404,522.212	2,402,624.381	2.307	28	TP 14	393,684.250	2,402,254.277	1.277
4	TP 02	404,559.499	2,402,500.593	3.732	29	CP 15	392,928.284	2,401,909.373	1.522
5	CP 03	403,747.390	2,402,614.050	3.266	30	TP 15	392,911.756	2,402,038.691	1.359
6	TP 03	403,756.031	2,402,499.005	3.301	31	CP 16	392,043.013	2,401,988.004	1.525
7	CP 04	402,788.525	2,402,760.163	2.508	32	TP 16	391,961.405	2,402,034.527	1.529
8	TP 04	402,697.891	2,402,796.181	2.235	33	CP 17	391,237.295	2,401,795.921	6.171
9	CP 05	402,594.744	2,402,213.840	2.362	34	TP 17	391,299.688	2,401,689.125	2.199
10	TP 05	402,303.519	2,402,050.887	2.218	35	CP 18	390,710.550	2,401,741.548	3.907
11	CP 06	401,817.973	2,402,057.666	2.501	36	TP 18	390,419.452	2,401,687.253	2.961
12	TP 06	401,879.091	2,402,024.262	1.912	37	CP 19	389,421.379	2,401,776.096	2.450
13	CP 07	401,061.122	2,402,350.233	2.135	38	TP 19	389,536.986	2,401,771.292	2.576
14	TP 07	401,227.926	2,402,343.242	1.933	39	CP 20	388,396.914	2,401,361.288	2.724
15	CP 08	400,019.383	2,402,173.113	2.177	40	TP 20	388,692.595	2,401,320.531	2.355
16	TP 08	399,855.847	2,402,126.108	1.880	41	CP 21	388,067.934	2,400,624.164	2.538
17	CP 09	398,968.668	2,402,057.350	3.687	42	TP 21	388,189.398	2,400,847.290	3.122
18	TP 09	398,851.501	2,402,039.438	2.725	43	CP 22	387,620.255	2,399,221.866	2.678
19	CP 10	397,783.826	2,402,512.364	2.151	44	TP 22	387,923.234	2,399,236.329	2.436
20	TP 10	397,693.511	2,402,594.776	2.606	45	CP 23	387,295.385	2,398,086.384	1.723
21	CP 11	396,712.205	2,402,489.265	2.351	46	TP 23	387,409.063	2,398,362.055	2.143
22	TP 11	396,537.182	2,402,518.089	2.683	47	CP 24	383,768.826	2,397,258.877	1.723
23	CP 12	395,760.559	2,402,536.891	2.344	48	TP 24	383,758.077	2,397,420.862	3.872
24	TP 12	395,725.154	2,402,384.792	2.348	49	CP-25	382,502.672	2,397,705.755	2.040
25	CP 13	394,584.060	2,402,025.732	3.043	50	TP 25	382,576.391	2,397,993.868	1.652

Source: JICA Survey Team



Source: JICA Survey Team

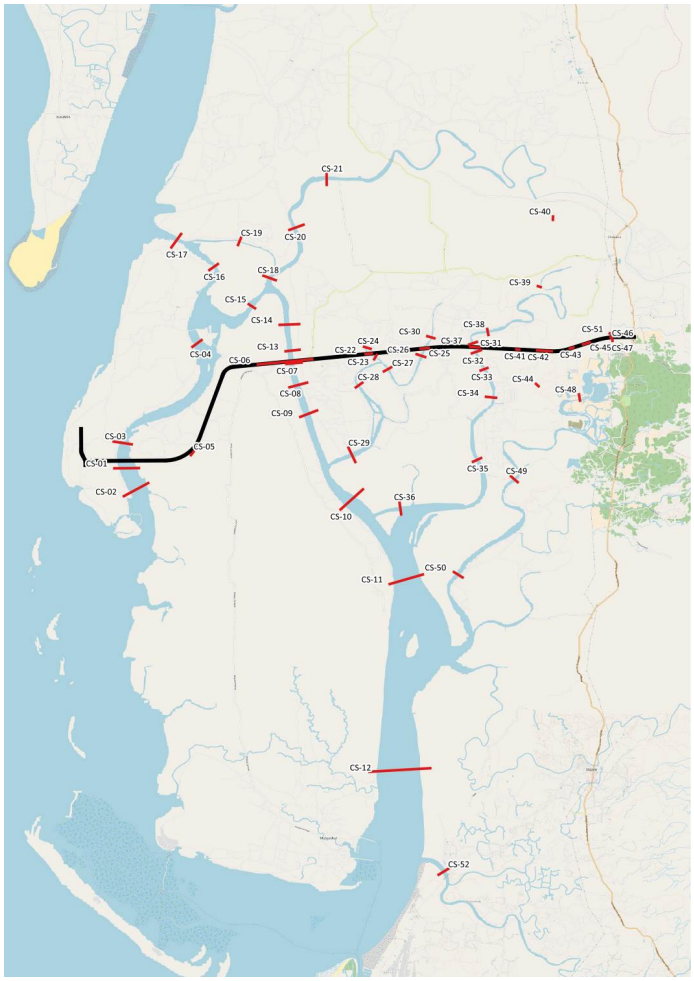
Figure 3.3-1 Location of Installed Benchmarks

Source: JICA Survey Team

Figure 3.3-2 Photograph of the Installed Bench Marks

(2) River Cross Section Survey

In order to analyze the hydrological condition of the project site, river cross section survey was undertaken at 52 cross sections.



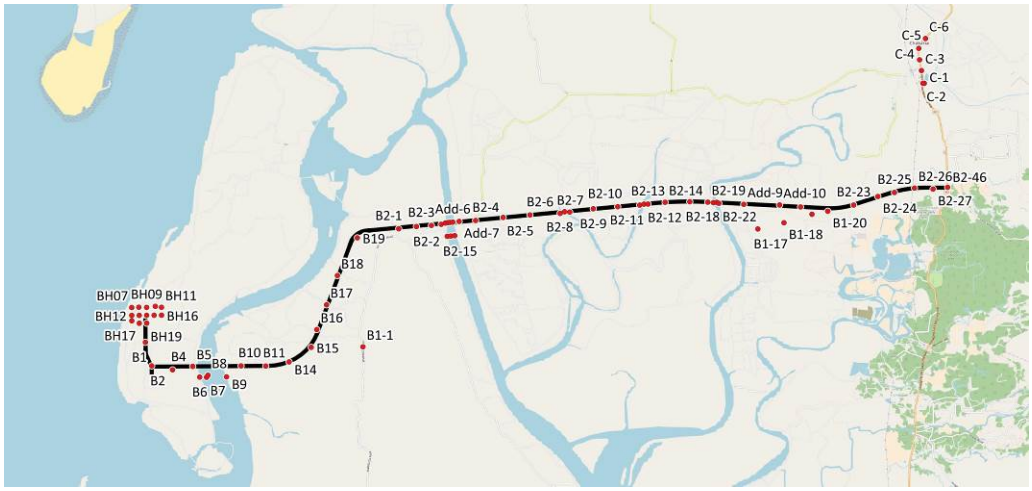
Source: JICA Survey Team

Figure 3.3-3 Location of River Cross Section Surveys

3.3.2 Geotechnical Investigation

(1) Borehole Drilling

Boring investigations were carried out at 59 locations in order to figure out the subsoil condition including bearing layer for structure foundation and soft soil distribution along the access road alignment. Another 06 boreholes were conducted in Chakaria on N1 to determine the existing condition.



Source: JICA Survey Team

Figure 3.3-4 Location of Boring Investigations

Boreholes were conducted using rotary drilling method with termination depth from 20 m to 50 m. Standard Penetration Test (SPT) conforming to ASTM D1586-11 was conducted at 1.5 m interval to evaluate the state of sub-soil and collect the disturbed samples for physical laboratory tests. Furthermore, undisturbed samples for soft soil layers were collected by Shelby tube to minimize the disturbance for samples.

Disturbed and undisturbed samples were taken to laboratory for necessary tests including the following. Borehole logs with SPT test and detailed laboratory test results are shown in Appendix 3.1.

- Soil Classification (ASTM D2487)
- Moisture Content (ASTM D2216)
- Atterberg Limits (ASTM D4318)
- Specific Gravity (ASTM D854)
- Unconfined Compression Test (ASTM D2166)
- Unconsolidated Undrained Triaxial Compression Test (ASTM D 2850 – 95)
- Consolidation Test (ASTM D2435)

(2) Material Testing

Lean Clay at Maheshkhali Hill and dredging sand samples from Kohelia Channel were collected to check their suitability for project material utilization. The following tests were conducted:

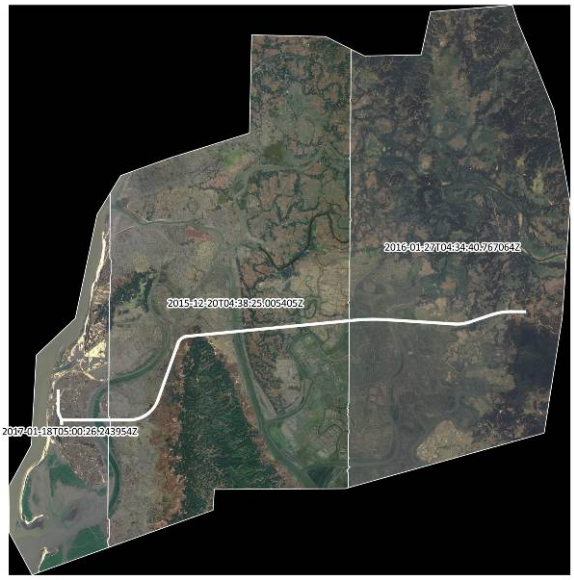
- Soil Particle Size Analysis (ASTM D422)
- Proctor Compaction Test (ASTM D-698)
- California Bearing Ratio Test CBR (ASTM D 1883 – 99)

Moreover, CBR tests were conducted for selected three (3) locations on to check the stiffness of existing sub-grade conforming to ASTM D 4429-93. Details of the results are attached in Appendix 3.1.

3.3.3 Satellite Image and Digital Terrain Data

(1) Satellite Image

40 cm resolution satellite image covering a 500 m^2 area of the project site was purchased from NTT Data in Japan. The satellite image was produced by combining three (3) satellite images taken on i) Jan 18, 2017, ii) Dec 20, 2015 and iii) Jan 27,2016.

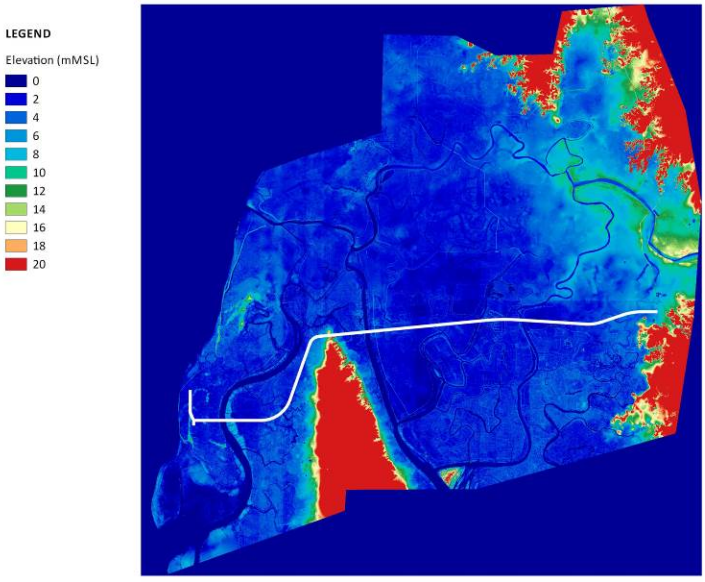


Source: NTT Data

Figure 3.3-5 High-Resolution Satellite Image (40cm Resolution)

(2) Digital Terrain Data

High-Definition Digital Terrain Model (0.5m DTM) covering a 500 m^2 area of the project site was purchased from NTT Data in Japan. As mentioned earlier, the elevation of the DTM data was adjusted in reference to the installed benchmarks. The accuracy between the survey data and the DTM data resulted in 0.64 m RMSE and this would be good enough for quantifying the volume of the construction works.



Source: NTT Data

Figure 3.3-6 High-Definition Digital Terrain Model (0.5 m DTM)

Table 3.3-3 Check Result of Accuracy of DTM

No.	Benchmark	Elevation (mMSL)		
		DTM	Survey Result	Difference
1	CP 01	3.961	4.849	-0.888
2	TP 01	2.335	2.940	-0.606
3	CP 02	1.396	2.307	-0.912
4	TP 02	3.660	3.732	-0.072
5	CP 03	2.931	3.266	-0.336
6	TP 03	3.476	3.301	0.174
7	CP 04	2.527	2.508	0.019
8	TP 04	1.977	2.235	-0.258
9	CP 05	1.646	2.362	-0.715
10	TP 05	1.998	2.218	-0.220
11	CP 06	2.276	2.501	-0.226
12	TP 06	1.255	1.912	-0.657
13	CP 07	1.106	2.135	-1.028
14	TP 07	1.834	1.933	-0.099
15	CP 08	1.975	2.177	-0.202
16	TP 08	0.767	1.880	-1.113
17	CP 09	0.846	3.687	-2.842
18	TP 09	2.493	2.725	-0.232
19	CP 10	1.485	2.151	-0.666
20	TP 10	2.132	2.606	-0.473
21	CP 11	2.109	2.351	-0.243
22	TP 11	1.431	2.683	-1.251
23	CP 12	1.557	2.344	-0.787
24	TP 12	2.287	2.348	-0.061
25	CP 13	2.582	3.043	-0.461
26	TP 13	1.674	2.230	-0.556
27	CP 14	1.260	1.254	0.006
28	TP 14	0.668	1.277	-0.609
29	CP 15	1.984	1.522	0.462
30	TP 15	1.205	1.359	-0.154
31	CP 16	2.324	1.525	0.800
32	TP 16	1.866	1.529	0.337
33	CP 17	6.533	6.171	0.362
34	TP 17	1.863	2.199	-0.336
35	CP 18	4.250	3.907	0.343
36	TP 18	3.306	2.961	0.345
37	CP 19	1.970	2.450	-0.481
38	TP 19	1.965	2.576	-0.611
39	CP 20	2.570	2.724	-0.154
40	TP 20	2.724	2.355	0.370
41	CP 21	2.514	2.538	-0.024
42	TP 21	3.794	3.122	0.673
43	CP 22	2.748	2.678	0.070
44	TP 22	1.997	2.436	-0.439
45	CP 23	2.033	1.723	0.309
46	TP 23	1.825	2.143	-0.318
47	CP 24	1.029	1.723	-0.695
48	TP 24	1.883	3.872	-1.990
49	CP-25	1.272	2.040	-0.769
50	TP 25	1.386	1.652	-0.266
51	CP 01_N1	9.069	9.070	-0.001
52	TP 01_N1	7.496	7.493	0.003
53	CP 02_N1	7.584	7.583	0.000
54	TP 02_N1	7.229	7.229	0.000
55	CP 03_N1	6.966	6.966	0.000
56	TP 03_N1	6.715	6.716	0.000
57	CP 04_N1	6.191	6.191	0.000
58	TP 04_N1	6.075	6.075	0.001
59	CP 05_N1	6.484	6.485	-0.002
60	TP 05_N1	5.327	5.327	0.000
61	CP 06_N1	5.276	5.276	0.001
62	TP 06_N1	5.257	5.257	0.000

- Average Difference: -0.282 m
- Medium Difference: -0.178 m
- Standard Deviation: 0.584 m
- RMSE: 0.644

Note, RMSE: Root Mean Square Error