Japan International Cooperation Agency (JICA)

Dhaka Transport Coordination Authority (DTCA)

The Project on the Revision and Updating of the Strategic Transport Plan for Dhaka

PRE-FEASIBILITY REPORT

（MRT LINE1）

Final Report

November 2016

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ABBREVIATIONS

ADB	Asian Development Bank
AFD	Agence Francaise de Developpement
BBA	Bangladesh Bridge Authority
BIWTA	Bangladesh Inland Water Transport Authority
BIWTC	Bangladesh Inland Water Transport Corporation
BR	Bangladesh Railway
BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BUET	Bangladesh University of Technology
C&B	Construction & Building
CASE	Clean Air and Sustainable Environment
CNG	Compressed Natural Gas
DAP	Detail Area Plan
DCC	Dhaka City Corporation
DF/R	Draft Final Report
DFID	Department for International Development
DHUTS	Dhaka Urban Transportation Network Development Study
DMA	Dhaka Metropolitan Area
DMDP	Dhaka Metropolitan Development Plan
DMP	Dhaka Metropolitan Police
DMTA	Dhaka Metropolitan Transport Authority
DMTC	Dhaka Mass Transit Company
DNCC	Dhaka North City Corporation
DPP	Department of Printing and Publications
DRTM	Directorate of Road Transport Maintenance
DSCC	Dhaka South City Corporation
DTCA	Dhaka Transport Coordination Authority
DTCB	Dhaka Transport Coordination Board
ECNEC	Executive Committee of the National Economic Council
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
F/R	Final Report
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIBR	Government Inspector of the Bangladesh Railways
GOB	Government of Bangladesh
GOJ	Government of Japan
GPS	Global Positioning System
HIS	Household Interview Survey
IC/R	Inception Report
IT/R	Interim Report
JICA	Japan International Cooperation Agency
LDC	Least Developed Country
LGD	Local Government Division

LGED	Local Government Engineering Department
MOC	Ministry of Communication
MOHPW	Ministry of Housing and Public Works
MOR	Ministry of Railways
MRT	Mass Rapid Transit
NGO	Non-Governmental Organizations
OD	Origin and Destination
ODA	Official Development Assistance
PPPO	Public Private Partnership Office
PT	Project Team
RAJUK	Rajdhani Unnayan Kartripakkha
RD	Record of Discussions
RHD	Road and Highway Department
RTC	Regional Transport Committee
SC	Steering Committee
SEA	Strategic Environmental Assessment
SPA	Survey and Plan Area
STP	Strategic Transport Plan for Dhaka
TDM	Traffic Demand Management
TOR	Terms of Reference
UMRT	Urban Mass Raid Transit
WB	World Bank
WG	Working Group

1. INTRODUCTION

1.1 Background

The Project on The Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP) was conducted by the Government of Bangladesh (GoB), with technical assistance from Japan International Cooperation Agency (JICA). It aimed at not only reviewing and modification of the Strategic Transport Plan (STP) as well as to help build the capacity of the DTCA.

Revised STP was formulated addressing gaps across subsectors in an integrated approach. The plan consists of five main components, namely: at-grade urban roads, expressways, urban/suburban rails, road-based public transport, and traffic management. Among others, transport networks were fashioned based on the growing demand, to deliver the desired urban growth and a favorable living environment. A urban railway network is one such plan including in Revised STP.

MRT Line 1 is envisioned to form the public transport backbone connecting the flourishing urban areas of Dhaka. This MRT Line is formulated with the North-South corridor line and Purbachal line. And this line is poised for implementation within the short-term period and has its beginnings in consideration during the RSTP.

1.2 Objectives

The objectives of this Supplemental Study are as follows:

(i) To identify and study candidate alignments for the 1st Priority Project, MRT Line 1;

(ii) To recommend the most appropriate one based on technical, economic, financial, social and environmental evaluation ; and

(iii) To preliminarily formulate a concept plan for a MRT at a selected location.

1.3 Project Scope

(1) Outline

The need for the immediate development of an efficient and affordable public transport system for Dhaka has been recognized at the highest levels of central government which must as a matter of first priority not only to resolve urgent short-term public transport issues, but also to develop a coherent and viable long-term public transport strategy in concurrence with the RSTP. The study team have identified a key component of the latter is the immediate development of the MRT Line 1 project.

The study team has identified one specific corridor which should be developed as a high priority project namely, the Mass Rapid Transit (MRT) Line 1 from Gazipur to Jhilmil and from Purbachal Kuril was examined by the study team in some detail. The output of the study has suggested that along this particular transport corridor, MRT system may be the most appropriate technology in matching the capacity of the urban mass rapid system with the predicted passenger ridership demand profile in 2035 and beyond.

(2) Project Components

The study objective is to identify and develop an urban mass rapid transit project MRT Line 1. The project includes formulation of a step-wise or phased development plan for an efficient mass transit system on the selected MRT Line 1 corridor. The final system by 2035 will be MRT Line 1 (52km) and major multimodal Interchange stations along the route

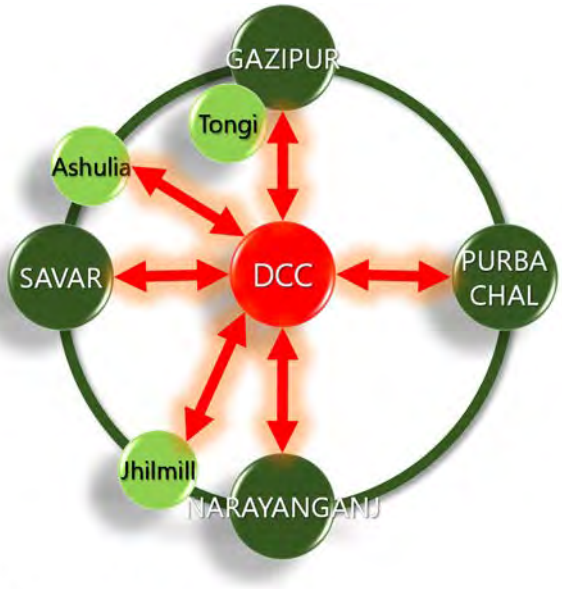
(3) Implementation Period

In the medium term (Phase 1, 2025), the operating section of MRT Line 1 will be between Airport, Purbachal and Kamalapur. And in the long term (Phase 2, 235) the operating section will be between Gazipur and Jhilmil. In this pre-feasibility report, phase 1 of MRT Line project was carried out.

2. PROJECT CONCEPT

2.1 Proposed MRT and BRT Network

These transportation corridors are indicated in Figure 2.1. And in RSTP, high capacity public transport system, like MRT or BRT will be proposed in each corridors.



(1) CBD – Tongi, Gazipur Corridor

(2) CBD – Purbachal Corridor

(3) CBD – Narayanganj Corridor

(4) CBD – Jhimil Corridor

(5) CBD – Savar Corridor

(6) CBD- Ashulia Corridor

Source: JICA Study Team

Figure 2.1 Transport Corridors in RAJUK Area

i. **CBD – Tongi, Gazipur Corridor (N3):** Gazipur area is a rapidly expanding towns north of Dhaka. This corridor is the main gateway to the north serving the northern suburbs of RAJUK area and beyond to Mymensingh.

ii. **CBD – Purbachal Corridor:** Purbachal is the biggest planned township in Bangladesh. This new town area comprise of about 6150 acres land located in between the Shitalakhya and the Balu River at Rupgonj thana of Narayanganj district and at Kaliganj Thana of Gazipur district, in the north-eastern side of Dhaka. The Township will be linked with 8(eight) lane wide express way from the Airport Road/Progati swarani crossing. The distance is only 6.8 km.

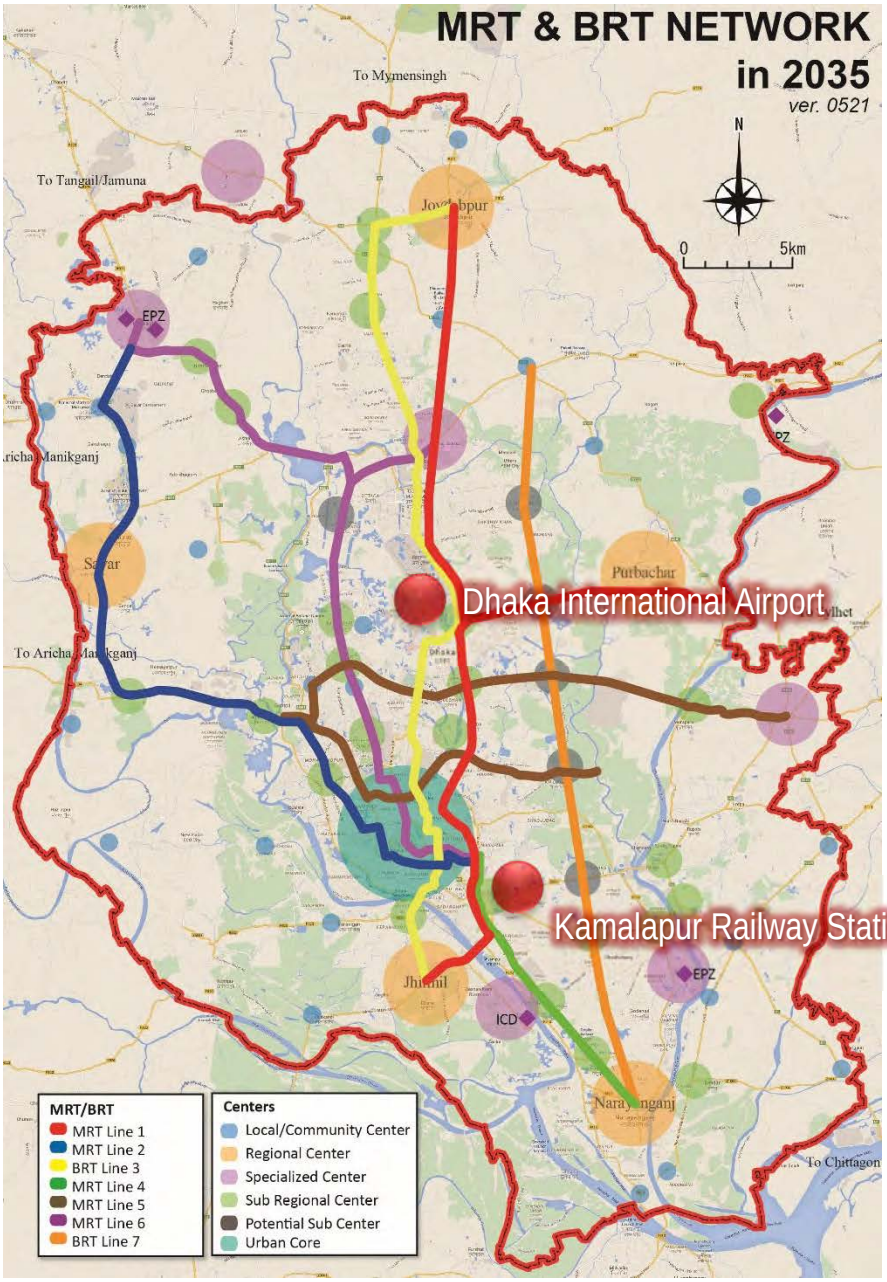
iii. **CBD – Narayanganj Corridor:** Narayanganj is a center of business and industry, especially the jute trade and processing plants, and the textile sector of the country. This corridor comprises a four-lane road and BR single-track rail line is on the transport corridor with several stations and grade crossings.

iv. **CBD – Jhilmil Corridor:** Jhilmil new town project is located at Keraniganj across the Buriganga River. The Project area comprises of 381.11 acres of land. There will be about 1,740 residential plots and 9,500 apartments for lower and middle income groups with available necessary infrastructure and urban services. And this transport corridor will be important logistic corridor after opening the Badma Bridge.

v. **CBD – Savar Corridor:** Savar is a new center of industry, especially the jute trade and processing plants, and the textile center. There is a major bus terminal, Gabtoli Bus Terminal on Dhaka – Aricha Highway and this area is one of the most congested area in Dhaka.

vi. **CBD- Ashulia Corridor:** Ashulia is a suburban area near Dhaka. Nearby areas are Savar and Tongi. Environmentalists and some NGOs in Bangladesh have expressed concern over rapid urbanization of Ashulia especially in the context of ongoing real estate development projects in the area. Most affected city around Dhaka is now Ashulia. Believe it or not only a few places are left for new industries, most of the places of Ashulia is now owned by the garments factory or any land developers.

Based on the above-mentioned urban structure and major issues of the STP Plan, the future MRT/BRT network plan toward 2035 is proposed in Figure 2.2 and Table 2.1. The proposed MRT/BRT development plan is eight (8) lines, of which six (6) lines are proposed for MRT system and the remaining two (2) lines are BRT Line.



Source: JICA Study Team

Figure 2.2 MRT/BRT Network in 2035

Table 2.1 Summary of MRT/BRT System Plan

	Section	Proposed System	Length (km)	notes
Line 1	Gazipur - Airport - Kamalapur - Jhilmill Purbachal - Khilkhet	MRT	52	
Line 2	Ashulia - Savar - Gabtali - Dhaka Unv. – DSCC - Kamalapur	MRT	40	
Line 3	Gazipur – International Airport - Jhilmill	BRT	42	On-going
Line 4	Kamalapur - Narayanganj	MRT	16	
Line 5	Bhulta - Badda – Mirpur Road – Mirpur 10 – Gabtoli Bus Terminal – Dhanmondi – Bashundhara City – Hatir Jheel Link Road	MRT	35	
Line 6	Ashulia - Uttara Phase 3 – Pallabi – Tejigaon –Motijheel - Kamalapur	MRT	41	On-going
Line 7	Eastern Fringe Area	BRT	36	

Source: JICA Study Team

The project cost to develop the MRT and BRT network is as follows:

Table 2.2 Estimated Development Cost of MRT/BRT lines

Unit: for Distance (km), for cost (Million)

		At-Grade	Elevated	Under Ground	Total	Cost
MRT Line 1	2025	0	20.6	6.0	26.6	BDT 219,846 (USD 2,827)
	2035	0	42.7	9.3	52	BDT 456,256 (USD 5,867)
MRT Line 2	2035	0	40.0	0	40.0	BDT 285,636 (USD 3,673)
MRT Line 4	2035	0	16.0	0	16.0	BDT 129,170 (USD 1,661)
MRT Line 5	2035	0	24.9	9.1	35.0	BDT 326,619 (USD 4,200)
MRT Line 6 *(extension)*	2035	0	21.8	0	41.8	BDT 162,454 (USD 2,089)
BRT Line 7	2035	36.0	0	0	36.0	BDT 19,986 (USD 257)

Source: JICA Study Team
Note: 1) Cost estimated by unit cost assumption
2) Excluding land acquisition and compensation

2.2 Alternative Project

(1) Approach

This section explains the evaluation of the proposed MRT and BRT projects comprehensively from the economic, financial, social, and environmental aspects. This process is important to clarify the nature of the projects and the priorities for implementation. The evaluation was made both for the Master Plan as a network and for major individual projects. After the collective network performance was deemed justifiable, individual projects or project packages were evaluated.

(2) Demand Forecast

Initial results of the 2025/2035 patronage demand forecasts for the proposed four MRT and BRT have been prepared and are as noted in Table 2.3. Depending on the particular

patronage demand forecast on each MRT/BRT corridor, the Study Team has selected the most appropriate technology be it MRT or BRT system.

A brief summary of the passenger demand forecasts would indicate that MRT Line 1, MRT Line 2, MRT Line 4, MRT line 5 and MRRT Line 6 daily passenger boarding would require a MRT system as the most appropriate technology, while BRT lie 7 would be more suited to be developed into a BRT project.

The patronage demand forecast results also indicate that the number of boarding and alighting increases significantly when good connectivity between the four systems through multimodal interchange stations is provided in the transportation model, therefore justifying the need to rationalize the original eight rail projects into four and providing multimodal interchange stations in the MRT and BRT network.

During the feasibility stage, a more detailed study of the selected MRT/BRT project will be required to determine the boarding and alighting at each of the MRT station in the network.

Table 2.3 Number of MRT/BRT passengers by Line, 2025 and 2035

	2025		2035	
	Daily Ridership (pax./day)	PPHPD	Daily Ridership (pax./day)	PPHPD
MRT Line 1	1,365,800	34,740	1,887,200	37,770
MRT Line 2	-	-	1,084,600	23,020
BRT Line 3	1,832,700	23,730	1,814,100	25,960
MRT Line 4	-	-	332,000	17,930
MRT Line 5	-	-	1,478,600	28,340
MRT Line 6	483,200	16,440	1,816,700	45,860
BRT Line 7	-	-	541,800	22,330
Total	3,681,700	-	8,955,000	-

Source: JICA Study Team

(3) Economic and Financial Evaluation

The study team conducted discounted cash flow analysis to assess all the public transport and road projects. The economic internal rate of return (EIRR) was calculated to determine the viability of projects. The following assumptions and standardizations were adopted for calculation of EIRR.

- The duration of the project was assumed to be 40 years – construction period of 10 years and operating period of 30 years.
- Traffic assignment was done for the year of 2025 and 2035, and the economic benefits were estimated for the two years and an interpolation was done for intermediate years. The economic benefits are the savings owing to the reduction in vehicle operation cost (VOC) and travel time cost (TTC) which are calculated from the result of traffic assignment. After 2035, economic benefit was assumed not to change.
- Social discount rate was assumed at 12%.
- Economic cost of a project was assumed to be 80% of the financial cost of project.
- Exchange rate was set as 1 TK = 0.0130 US$ on July 2015.

The unit cost of VOC and TTC were required to calculate the economic benefits. The following costs were applied as the unit of cost of VOCs. It was estimated by RHD. However the unit costs were converted to value of 2014 based on growth of GDP.

Table 2.4 Vehicle Operation Cost (VOC)

Unit: TK / Vehicle / Km

Car	Motorcycle	CNG	Bus	Truck
15.0	2.0	3.7	23.0	21.5

Source: JICA study team estimated based on RHD Road User Cost Annual Report for 2004 - 2005

TTCs each mode were estimated based on household income and working/ business trip shares by using result of household interview survey. Unit TTCs was assumed to growth in line with GRDP per capita of the study area.

Table 2.5 Travel Time Cost (TTC)

Unit: TK / min / person

Year	Car	Motorcycle	CNG	Bus	Truck
2014	6.3	3.0	1.7	1.8	1.8
2025	8.9	4.2	2.4	2.5	2.5
2035	12.0	5.7	3.2	3.4	3.4

Source: JICA Study Team

EIRR was shown in following tables. All projects are economically viable as the threshold of EIRR is 12%.

Table 2.6 Public Transportation Project Economic Evaluation Results

Projects	Capital Cost (US$ million)	O & M Cost in opening year (US$ million / year)	EIRR (%)
MRT1	5,867	97.8	22.1
MRT2	3,673	115.4	19.4
MRT4	1,661	46.2	13.2
MRT5	4,200	101.0	16.1
MRT6 extension	2,089	63.5	33.5
BRT7	257	40.0	47.9

Source: JICA Study Team

Discounted cash flow analysis was used to determine the financial viability of the proposed MRT and BRT projects. Cash inflow of the project includes fare revenue. Cash outflows of the project were consisted of recurrent costs such operation and maintenance expenses and capital expenditures. Main assumptions are described below.

- The duration of the project was assumed to be 40 years – construction period of 10 years and operating period of 30 years.
- Traffic assignment was done for the year of 2025 and 2035, and the fare revenue was estimated for the two years and an interpolation was done for intermediate years. After 2035, fare revenue was assumed not to change.
- Fare revenue was calculated based on the following fare settings. As MRT fare, the fare setting of MRT6 project by JICA was applied. In addition fare setting of BRT3 project by WB was applied as BRT fare.
- Discount rate was assumed at 12%.

Table 2.7 Fare Setting

Year	MRT	BRT
2014	16.0 + 2.0/km TK	7.0 + 3.2/km TK
2025	22.6 + 2.8/km TK	9.9 + 4.5/km TK
2035	30.6 + 3.8/km TK	13.4 + 6.1/km TK

Source: JICA Study Team, MRT6 project by JICA, BRT and Corridor Restructuring Implementation Study and Preliminary Design work for the Uttara – Mohakhali – Ramna – Sadar Ghat Corridor in Dhaka by World Bank

The results of financial evaluation were shown in following table.

Table 2.8 Public Transportation Project Financial Evaluation Results

Projects	Capital Cost (US$ million)	O & M Cost in opening year (US$ million / year)	FIRR (%)
MRT1	5,867	97.8	4.5
MRT2	3,673	115.4	3.0
MRT4	1,661	46.2	3.8
MRT5	4,200	101.0	4.0
MRT6 extension	2,089	63.5	9.7
BRT7	257	40.0	4.3

Source: JICA Study Team

(4) Environmental Evaluation

The MRT and BRT networks of the urban development scenario in 2035 are shown in Table 2.9.

Table 2.9 MRT and BRT Networks

Project	Length	Route	Description
MRT Line 1	52 km	• Gazipur - HSIA Airport -Badda - Kamalapur - Jhilmill • Purbachal – Khilkhet	• Backbone corridor of Dhaka Metropolitan Area • Connecting corridor between Purbachal and CBD
MRT Line 2	40 km	Ashulia - Savar - Gabtali - Dhaka Unv. - DSCC – Kamalapur	• Regional corridor in Savar area • Connecting corridor between Savar and CBD
MRT Line 4	16 km	Kamalapur – Narayanganj	• Commuter line between Kamalapur to Narayanganj
MRT Line 5	35 km	Bulta - Badda – Mirpur Rd. – Gabtoli Bus Terminal – Dhanmondi – Bashundahara City –Hatir Jheel Link Rd.	• Main corridor of East-West connection
BRT Line 7	36 km	Purbachal – Narayanganj	• Connection corridor in Eastern Fringe Area

Source: JICA Study Team

These MRT and BRT development projects are assessed and compared from the viewpoint of social and environmental impacts in Table 2.10.

It is then assumed that the required width of ROW of the MRT line will be 25 meters, considering the width of the constructing stations. Since the most alignment of the MRT networks will be built on the existing roads, the affected people that has to leave the area

by land acquisition of 25 meters width along the whole route shall be estimated through the satellite images multiplied by the population densities.

On the Eastern Fringe Road, the BRT Line 7 will be built; however, presently there is no road ROW. The proposed number of lanes of this road will be (6) lanes with BRT and will have enough ROW corridor of 60m to allow (8) lanes of MRT. Thus, the affected people to leave the area by land acquisition of 60m width along the whole route will be estimated.

Note that the estimated number of affected households shown in the table below does not include those in the depot. The structure type for all MRT lines is assumed to be elevated.

Table 2.10 Overall Assement of MRT and BRT Networks

MRT Line1	MRT Line 2	MRT Line 4	MRT Line 5	BRT Line 7
O: The lowest number of affected households both all elevated case and partial underground case O: Less impact on protected area and biodiversity O: Low risk of flooding X: Impact due to noise and vibration at the elevated section.	X: The largest number of affected households X: Impact on biodiversity in the wetland X: Risk of flooding X: Impact due to noise and vibration	△: A large number of informal settlers occupy the BR ROW. O: Less impact on protected area and biodiversity O: Low risk of flooding X: Impact due to noise and vibration	O: The second lowest number of affected households in the partial underground case. X: Impact on biodiversity in the wetland X: Risk of flooding X: Impact due to noise and vibration	X: The second largest number of affected households X: Impact on biodiversity in the wetland X: Risk of flooding O: Impact due to noise and vibration
The smallest number of affected households and fewer impacts on natural environment. Recommended as a priority project from the viewpoints of environmental and social considerations.	The largest number of affected households and moderate impacts on natural environment. The BRT should be considered for the short to midterm term plan in CBD.	A large number of informal settlers occupy the BR ROW. If the BR line will be double tracked, then the plan has to be reconsidered. Fewer impacts on natural environment.	The second lowest number of affected households. The extension to the Eastern Fringe will cause a significant impact on natural environment and increase the risk of flooding.	The large number of affected households. A significant impact on natural environment. The risk of flooding is very high. The eastern fringe road should be carefully planned to minimize the environmental impacts.

Source: JICA Study Team

(5) Multi Criteria Analysis

When the public sector invests in transport facilities, the primary purpose is “the public service”, or the social benefit. The proposed projects were evaluated for their economic IRRs to assign priority accordingly. The social benefit of a given project can be paraphrased as its impact in serving the twin purposes of reducing the operational cost of all the transport means available and reducing the travel time of all passengers on the available transport means (both users and non-users).

In addition, the projects are evaluated on the following aspects of implementation.

A. Economic Viability
B. Traffic Demand (Contribution to the improvement of transport capacity), Operational aspects
C. Consistency with Land Use
D. Financial Viability
E. Environmental and Social Impacts

As a first step, the scores are aggregated per project and are used to prioritize. Each project is evaluated by the threshold defined in the following Table 2.11.

Table 2.11 Ranking Threshold by Evaluation Criteria

	Weight	Indicator	5	3	1
A. Demand in 2035	0.15	PPHPD	X>30,000	30,000>X >20,000	X<20,000
B. Economic Return	0.40	EIRR	X>20%	20%>X>13%	X<13%
C. Financial Return	0.15	FIRR	X>4%	4%>X>3%	X<3%
D. Consistency with Urban Development Scenario	0.15	-	Contribute	Supportive	No Relation
E. Environment	0.15	SEC result	No impact	Some impact	Serious Impact

Source: JICA Study Team

As the second step, the rankings by five criteria were aggregated into a single rank, taking such process as (1) to give five points to rank “A”, three points to rank “B” and one point to rank “C”, (2) to add up each point after multiplication with “weight”, and (3) Classify into the first priority project. Results of the evaluation are given in Table 2.12 for MRT/BRT project proposed in RSTP.

Table 2.12 MCA Evaluation Results of MRT/BRT projects

		MRT Line 1	MRT Line 2	MRT Line 4	MRT Line 5	BRT Line 7
A. Demand in 2035	0.15	5	3	1	3	3
B. Economic Return	0.40	5	3	1	3	5
C. Financial Return	0.15	5	3	3	5	5
D. Consistency with Urban Development Scenario	0.15	5	4	5	5	5
E. Environment	0.15	4	1	4	2	2
		4.9	2.9	2.4	3.5	4.3

Source: JICA Study Team

MRT Line 1 is the highest score and will be interpreted as the first priority project.

3. PRELIMINARY DEMAND FORECAST

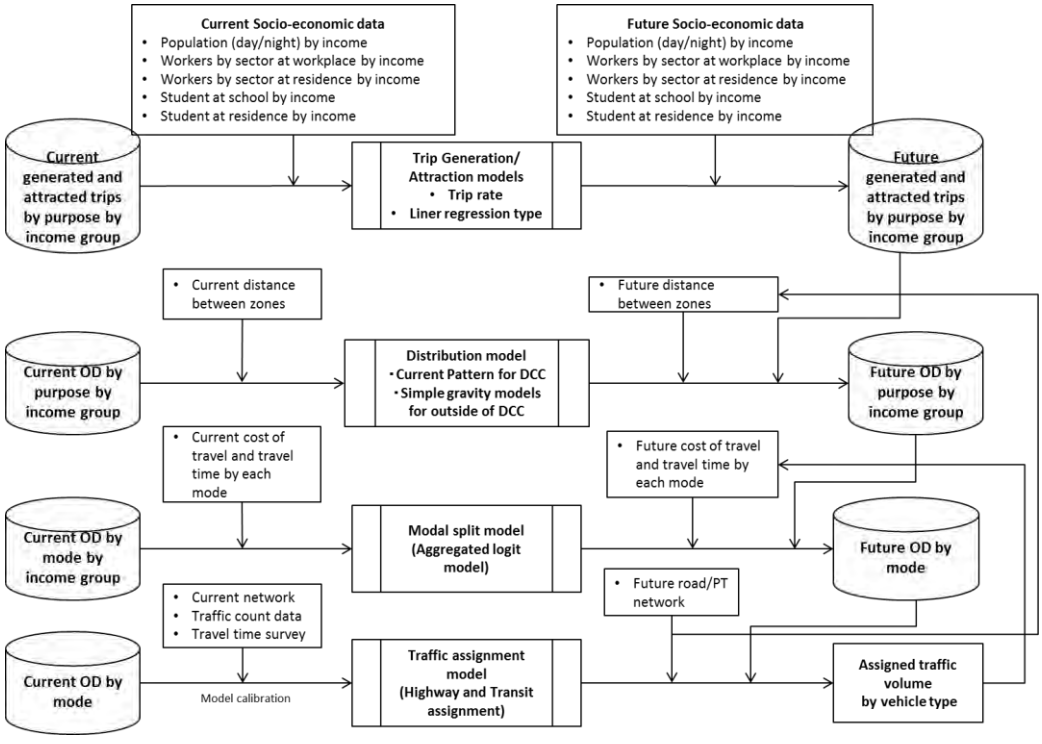
3.1 Methodology of Traffic Demand Forecast

The traffic demand forecast model for Dhaka was developed based on the result of the Household Interview Survey (HIS) conducted by DHUTS and the results of traffic surveys including the HIS, the Cordon and the Screen Line Survey and the Road Inventory Survey conducted by RSTP. The flow of traffic demand forecast was shown in Figure 12.1. Firstly, the current traffic demand characteristics were analyzed based on the results of surveys above. Considering the traffic characteristics, the demand forecast model was developed. At the same time, the future socio-economic data based on the future development scenario and the future transport network were formulated as input data for the demand forecast model. The Project on The Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP) was conducted by the Government of Bangladesh (GoB), with technical assistance from Japan International Cooperation Agency (JICA). It aimed at not only reviewing and modification of the Strategic Transport Plan (STP) as well as to help build the capacity of the DTCA.

3.2 Demand Forecast Model

(1) Outline

The demand forecast model in Dhaka was developed based on the conventional four steps demand forecast process. The demand model was constructed separately for low household income group (less than 20,000 TK/ month), middle household income group (20,001 – 50,000 TK/ month) and high household income group (more than 50,001 TK/ month) since their traffic characteristics are different. The outline of the four steps demand forecast modelling procedures and flow of data is briefly illustrated below. The model is consisted four steps which are trip generation/ attraction step distribution step, modal split step and traffic assignment step. These steps will be explained following sections.

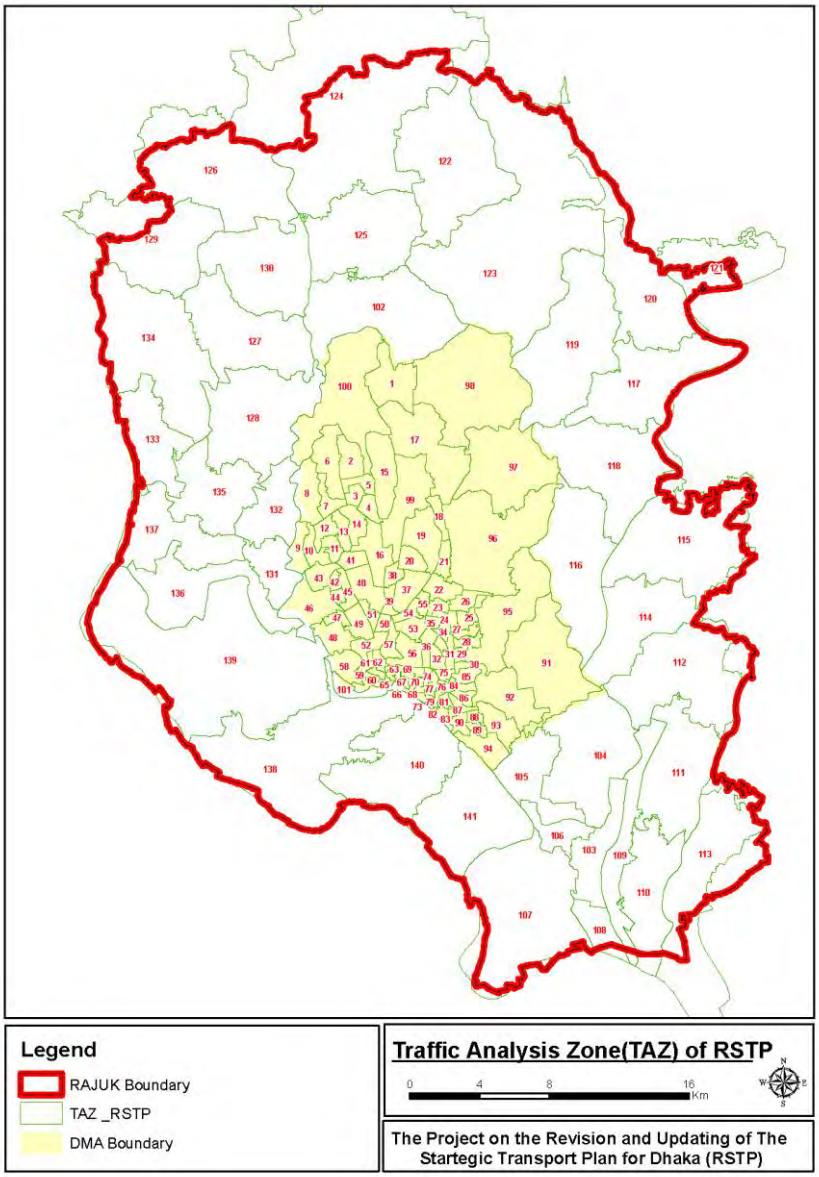


Source: JICA Study Team

Figure 3.1 Outline of the Four Steps Demand Forecast Model

(2) Zone System

The study area is divided into 141 internal zones as shown in Figure 3.2. In addition there are 49 external zones representing outside areas of RSTP study area and 5 special trip generation zones representing airport, ferry terminal and rail stations. The zone system is summarized in figure 3.2.



Source: JICA Study Team

Figure 3.2 Zone System

(3) Trip Generation and Attraction Models

The trip generation and attraction models were using trip rate and liner regression techniques. The trip rates and parameters of model were estimated separately by household income group by trip purpose. As trip purpose, eight purposes were applied to modelling. These are “Home to Work”, “Home to School”, “Home to Others”, “Work to

Home", "School to Home", "Other to Home", "Non home based others" and "Non home based business".

(4) Trip Distribution Models

It is expected that the urban structure in DCC will not change dramatically since most of the land in DCC area has developed already. Therefore it is also expected that the trip pattern in DCC will not change. Meanwhile, trip distribution pattern of surrounding area of DCC will change dramatically since population will increase rapidly with new urban development. Considering this situation, a current trip pattern method was adopted for DCC and a gravity model was developed for RAJUK area without DCC. The current trip pattern method is applied a current trip distribution pattern in the future also literally. On the other hand, the gravity model can predict trip distribution between zones by using Newton's law of universal gravitation. It can be applied to new development area. The equation of the gravity model was given below. The models were developed reparatory by purpose by household income group.

$$T_{ij} = k * \frac{G_i^{\alpha} * A_j^{\beta}}{d_{ij}^{\gamma}}$$

Where, G_i: Total trip generation in zone i
A_j: Total trip attraction in zone j
d_{ij}: Shortest route distance between zone i and j
α, β, γ: Parameters
k: Constant

(5) Modal Sprit Model

Firstly, the walking and bicycle trips were separated from all trips based on current share by distance between zones. The current share of walking and bicycle is shown in Table 3.1 . It was calculated from the result of HIS.

A binary logit model was adopted as a modal sprit model. The model structure and model equation show in below.

$$P = \frac{1}{1 + e^{k + \sum \alpha X}}$$

Where, α: Parameter
k: Constant
x: Time difference, Cost Difference

The time and cost between zones by mode for input of the modal sprit model were calculated as below.

1) Time

Car, MC, CNG: From assignment results

Bus & Train: Access and waiting time for bus (10 min) + In vehicle time of bus (Considering boarding and alighting time, it was applied 80% of

road assignment result) + Access time to rail station (100m / 4km/h) + Waiting time of rail (half of headway, Maximum is 30 min) + In vehicle time of rail

Rickshaw: 75% of road travel time from assignment result, however maximum speed is 6km/h

2) Cost

Car: Toll + Vehicle operation cost / Average occupancy

MC: Toll + Vehicle operation cost / Average occupancy

CNG: CNG fare / Average occupancy excluding driver

Bus & Train: Bus fare + Rail fare

Rickshaw: Rickshaw fare / Average occupancy excluding driver

Table 3.1 Share of Walking and Bicycle by Travel Distance

Dist (km)	Low Income	Middle Income	High Income
>2	70%	50%	37%
3	69%	47%	28%
4	59%	27%	13%
5	31%	13%	3%
6	22%	10%	3%
7	12%	7%	3%
8	12%	4%	2%
9	11%	3%	2%
10	10%	2%	1%
10<	0%	0%	0%

Source: JICA Study Team

(6) Trips from External and Special Generator Zones

Current numbers of trips from external and special generator zones were collected by the cordon survey. These were expanded to trips in 2025 and 2035 by using growth rate of GRDP.

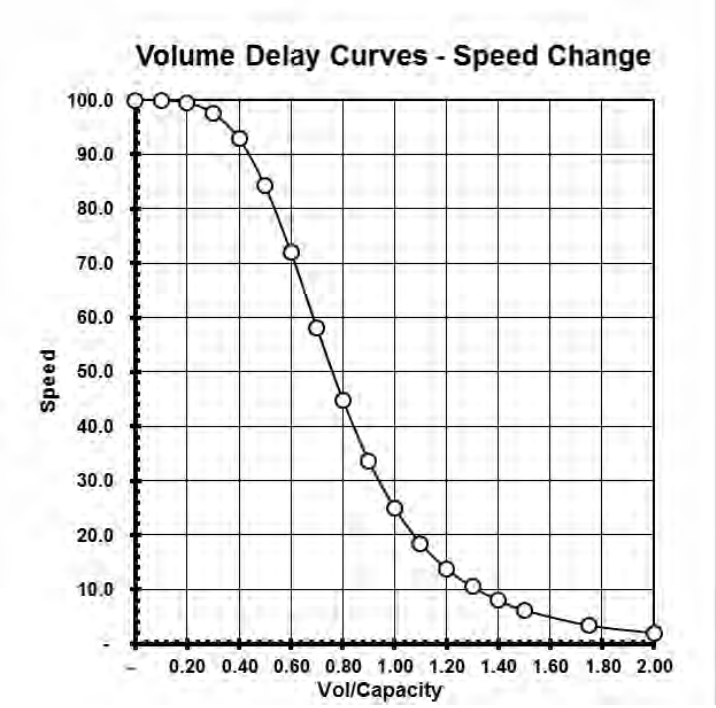
(7) Traffic Assignment

Traffic assignment process has two processes which are a highway assignment for private modes including Motorcycle, CNG, Car and Truck and a transit assignment process for Bus and Rail.

The highway assignment process used is based on well-known ‘equilibrium’ method, where the traffic from each O/D pair is assigned iteratively to the network until no cheaper/ quicker route could be found. The shortest path building was based on the generalized cost. The equilibrium method re-calculates the new travel time based on the road capacity and assigned traffic volume after each assignment iteration. The speed/ flow i.e., volume delay function was calibrated according to the network, and is based on the BPR function. The general form of the BPR function is described below and is graphically depicted in Figure 3.3.

BPR function $t = t_0 \left\{1 + \alpha \left(\frac{X}{C}\right)^{\beta}\right\}$

Where, t : Travel time
t_0 : Free flow time
X : Traffic volume
C : Road capacity
α, β : Parameter$\alpha = 3.0, \beta = 4.0$



Source: JICA Study Team

Figure 3.3 BPR Function

The transit assignment model assigns the public transport trips to bus & railway routes as operated. The transit assignment process is based on minimum generalized cost of travel between each origin and destination pair, and it includes: fare, access/ egress time, walk time, wait time, in vehicle time and transfer time. The output from the transit assignment model is the boarding and alighting passengers at bus stop, rail station, and line volumes.

3.3 Future Traffic Demand

(1) Number of Trips

The total production trips of study area in 2025 and 2035 will be 42 million and 51 million trips per day respectively. These shows 13 million trips in 2025 and 22 million trips will be increased from 2014 as results of population growth, increasing in income, increasing education continuance rate and so on. The number of production trips from external and special generator zones in 2035 is estimated to triple from 2014 with an economic growth. The summary of number of trip in 2025 and 2035 is shown in Table 3.2.

.

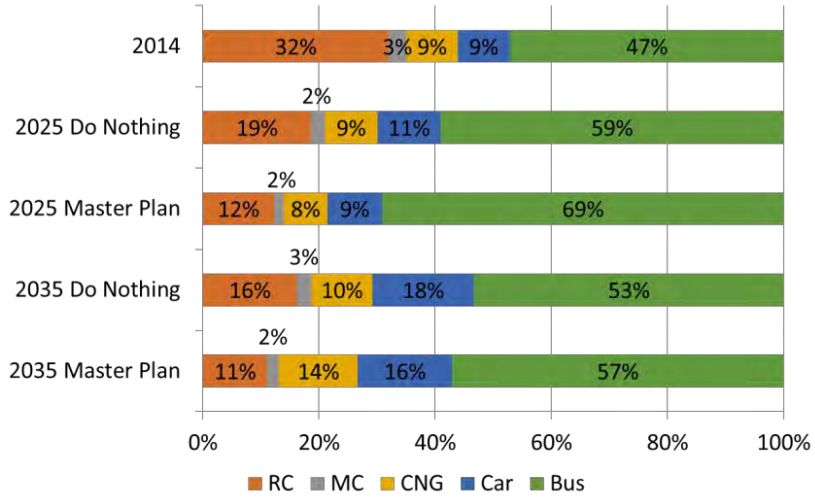
Table 3.2 Summary of Number of Trips

Year	2014 (Trips)	2025 (Trips)	2035 (Trips)
Total Production Trips (From study area, 1-141 zone)	29,824,387	42,702,370	51,179,487
Total Production Trips excluding intra trips (From study area, 1-141 zone)	14,386,514	20,828,071	23,749,687
Total Production Trips from External and Special Generator Zones (142-195 zone)	1,084,430	2,092,189	3,248,398
Assigned Trips	15,470,944	22,920,260	26,998,085

Source: JICA Study Team

(2) Modal Share

The modal share will be changed depend on the transport network. As shown in Figure 3.4, the rickshaw share will decrease. On the other hand, the bus share will increase in any of prepared cases. In master plan case in 2035, the bus share can be kept highest share as 57% since the MRT & BRT lines will be expanded. However the car share will be expected to double from 2014 due to increasing income.



Source: JICA Study Team

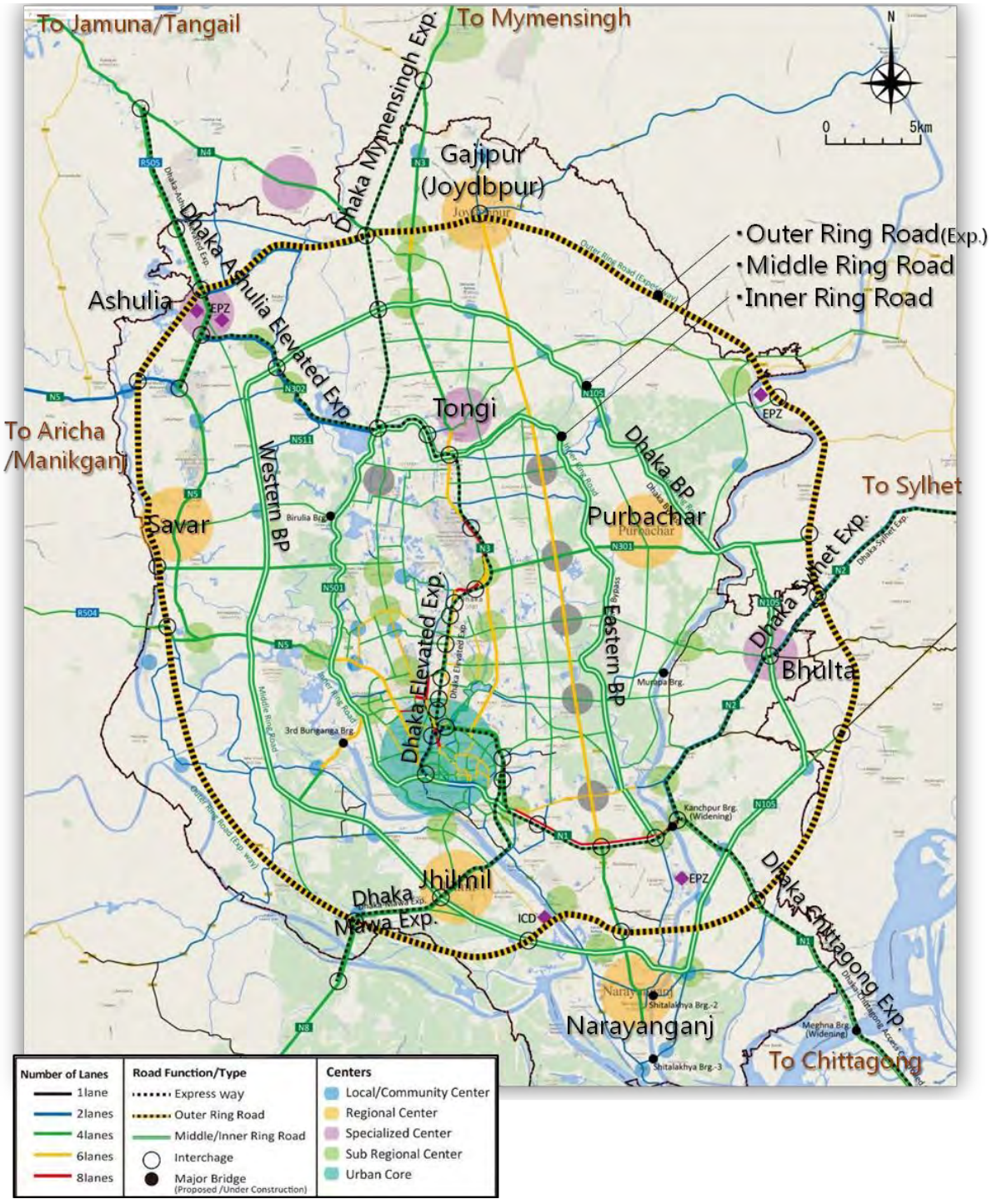
Figure 3.4 Modal Share of Inter Trips in 2025 and 2035

3.4 Estimated Ridership

(1) Future Urban Transport Development Plan

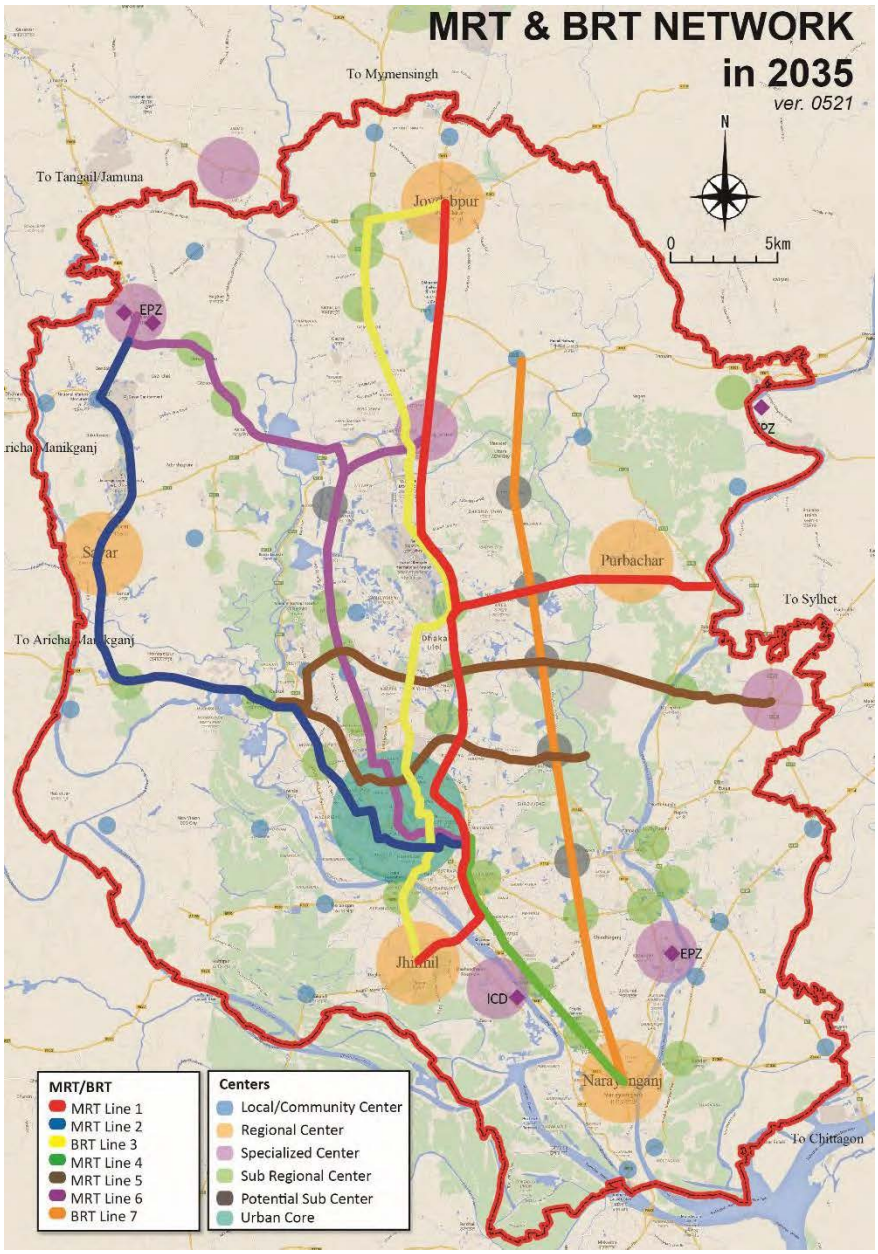
Figure 3.5 illustrates the proposed future road network in RAJUK area based on "(2) Planning Concept for Road Network Development." The proposed network is also taken into account the road projects in STP, current on-going projects, future projects proposed by the relevant authorities.

And based on the above-mentioned urban structure and major issues of the STP Plan, the future MRT/BRT network plan toward 2025 is proposed in Figure 3.6. The proposed MRT/BRT development plan is eight (8) lines, of which six (6) lines are proposed for MRT system and the remaining two (2) lines are BRT Line.



Source: JICA Study Team

Figure 3.5 Proposed Road Network in RAJUK area



Source: JICA Study Team

Figure 3.6 MRT/BRT Network in 2035

(2) Assignment Results

Figure 3.7 shows the highway assignment results of do nothing case in 2025 and 2035. The result indicates that the road transport in Dhaka in 2035 will not be worked due to traffic congestion if any roads and public transport will not be provided. The average congestion ratio in 2035 will be 3.7 from 1.2 in 2014. The average travel speed will decline to 4.7 km/h from 6.4 km/h in 2014.

However if the RSTP masterplan will be implemented, the road congestion will be solved as presented in Figure 3.8. The average congestion ratio and the travel speed in 2035 will be 0.8 and 13.7 km/h. The person-hours will be saved 35 million hours per day compared to the do nothing case.

2025 Do Nothing Case　　2035 Do Nothing Case

Source: JICA Study Team

Figure 3.7　Highway Assignment Results of Do Nothing Case in 2025 and 2035

2025 Master Plan　　2035 Master Plan

Source: JICA Study Team

Figure 3.8　Highway Assignment Results of Master Plan Case in 2025 and 2035

The transit assignment results of master plan case in 2025 and 2035 are shown in Figure 3.9 and Table 3.3. The total daily ridership of MRT and BRT in 2025 and 2035 will be estimated 3.7 million and 9.0 million respectively. Especially, MRT1, BRT3 and MRT6 will be expected huge passengers with 1.8 million respectively. Highest PPHPD will be recorded by MRT6 with 45,860 persons in 2035. Following, MRT1 will have 37,770 persons.

2025 Master Plan　　2035 Master Plan

Source: JICA Study Team

Figure 3.9　Transit Assignment Results of Master Plan Case in 2025 and 2035

Table 3.3　Number of Passengers of MRT and BRT in 2025 and 2035

Line	2025		2035	
	Daily Ridership (Pax/day)	PPHPD	Daily Ridership (Pax/day)	PPHPD
MRT1	1,365,800	34,740	1,887,200	37,770
MRT2	-	-	1,084,600	23,020
BRT3	1,832,700	23,730	1,814,100	25,960
MRT4	-	-	332,000	17,930
MRT5	-	-	1,478,600	28,340
MRT6	483,200	16,440	1,816,700	45,860
BRT7	-	-	541,800	22,330
Total	3,681,700	-	8,955,000	-

Source: JICA Study Team

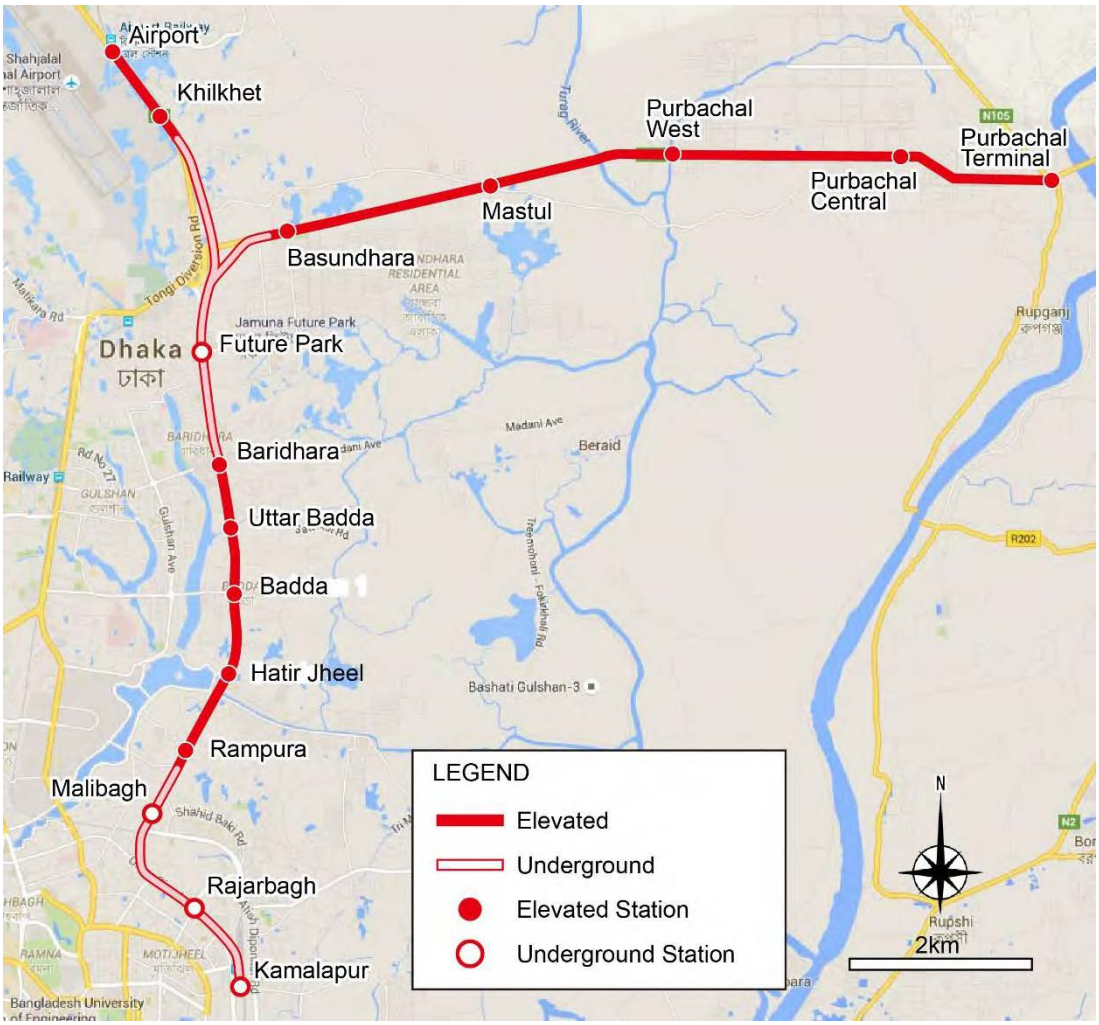
1) 2025 Case

The results for the daily passenger boarding and alighting and PPHPD by station for year 2025 are given in Table 3.4 and plotted in Figure 3.11 and Figure 3.12.

The average trip length of passengers is about 6.91 km, with total daily boarding of about 1.366 million passengers. It is noteworthy that the number of boarding and alighting passengers at the two Baridhara/Uttar Badda stations, estimated at more than 200,000 passengers each, are more than double that of the next high volume stations which are at just over 150,000 passengers, namely, Airport and Bashundhara.

Maximum line load for the southbound/eastbound direction is 278,200 passengers, occurring at Baridhara/Uttar Badda Station. And also, the maximum line load for the northbound/westbound direction is 284,800 at the same station.

And maximum PPHPD for the southbound/eastbound direction is 27,820 passengers per peak hour, occurring at Baridhara/Uttar Badda Station. And also, the maximum PPHPD for the northbound/westbound direction is 28,480 at the same station.



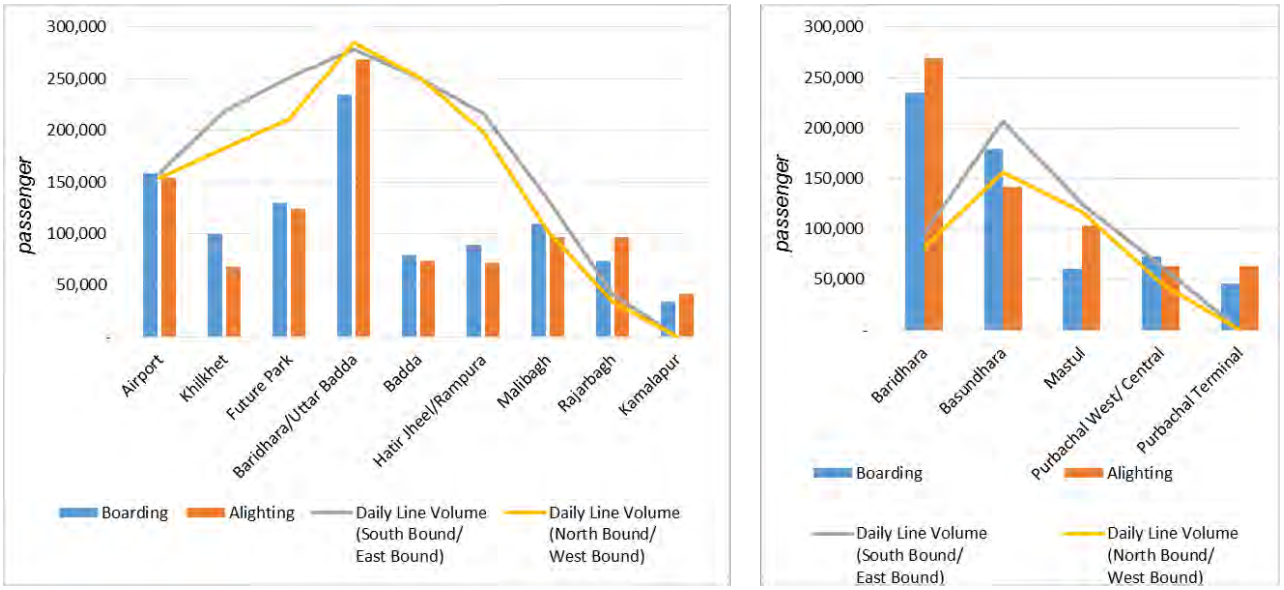
Source: JICA Study Team

Figure 3.10 MRT Line 1 Alignment in 2025

Table 3.4 Daily Two-Way Station Boarding and Alighting Passengers in 2025

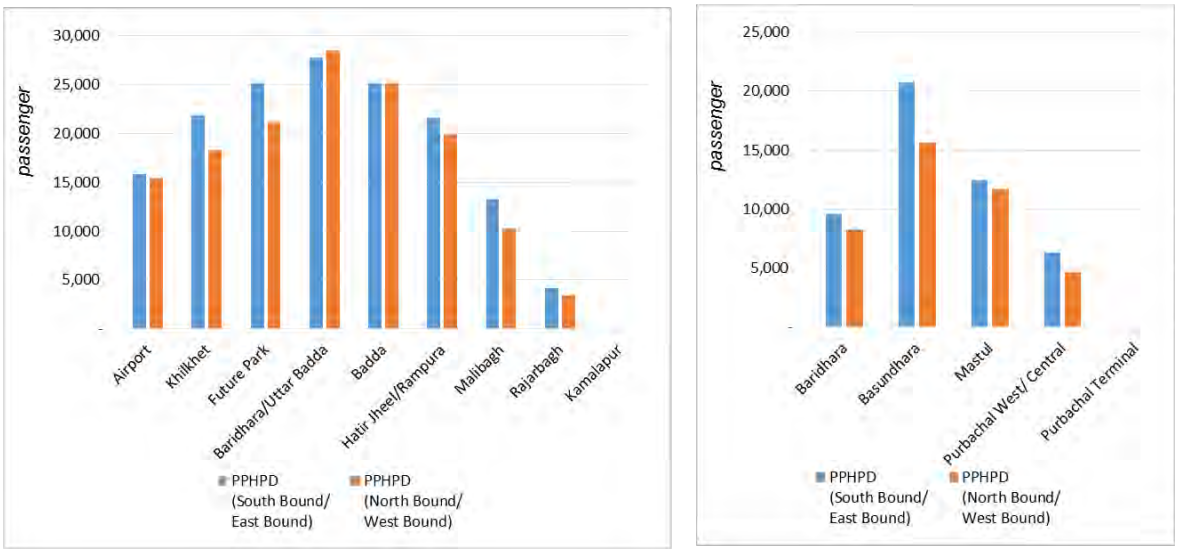
Station	Boarding	Alighting	Daily Line Volume (South Bound/ East Bound)	Daily Line Volume (North Bound/ West Bound)	PPHPD (South Bound/ East Bound)	PPHPD (North Bound/ West Bound)	km	Pax-km
Joydebpur	-	-						
Dhirasram	-	-						
Tongi	-	-						
Uttara	-	-						
Airport	158,600	154,100	158,600	154,100	15,860	15,410	0.9	293,900
Khilkhet	99,000	67,900	218,300	182,700	21,830	18,270	0.4	161,186
Future Park	129,000	124,000	251,500	210,900	25,150	21,090	0.1	23,490
Baridhara/Uttar Badda	234,600	268,700	278,200	284,800	27,820	28,480	1.9	1,081,782
Badda	79,300	73,300	251,100	251,700	25,110	25,170	1.0	484,242
Hatir Jheel/Rampura	89,000	71,100	216,300	199,100	21,630	19,910	0.3	125,280
Malibagh	109,900	97,100	132,700	102,700	13,270	10,270	0.5	113,522
Rajarbagh	73,600	96,200	41,200	33,900	4,120	3,390	0.6	42,992
Kamalapur	33,900	41,200	-	-	-	-	1.2	-
Gandaria	-	-	-	-	-	-	0.5	-
Postagola	-	-	-	-	-	-	0.0	-
Ekuria	-	-	-	-	-	-	2.0	-
Jhilmil	-	-						
Baridhara	234,600	268,700	95,900	82,700	9,590	8,270	2.3	404,456
Basundhara	179,300	141,600	207,200	156,300	20,720	15,630	0.2	72,555
Mastul	60,700	103,800	124,700	117,100	12,470	11,710	1.9	457,841
Purbachal West/ Central	72,700	63,600	63,000	46,200	6,300	4,620	2.0	223,789
Purbachal Terminal	46,200	63,000	-	-				
Total / Max	1,365,800	1,365,600	278,200	284,800	27,820	28,480	30.5	9,432,381
						Ave. Trip Length (km)		6.91

Source: JICA Study Team



Source: JICA Study Team

Figure 3.11 Daily Passenger Ridership in 2025



Source: JICA Study Team

Figure 3.12 PPHPD in 2025

2) 2035 Case

For the purpose of the demand analysis, 24 stations and a total length of 55 km in the network model was adopted. The alignment is shown is Figure 3.13 while the results of the model run are shown in Table 3.5 and plotted in Figure 3.11 and Figure 3.12.

Total daily boarding passengers are 1,877,200. It is noted that one station, Jydebpur Station is the highest passengers and accounts for almost 17% of total boarding, while the others are range of 7% and below. The maximum line lord for the Southbound/Eastbound is 118,600 at Basundhara Station. The average trip distance per passenger is at 11.05km.

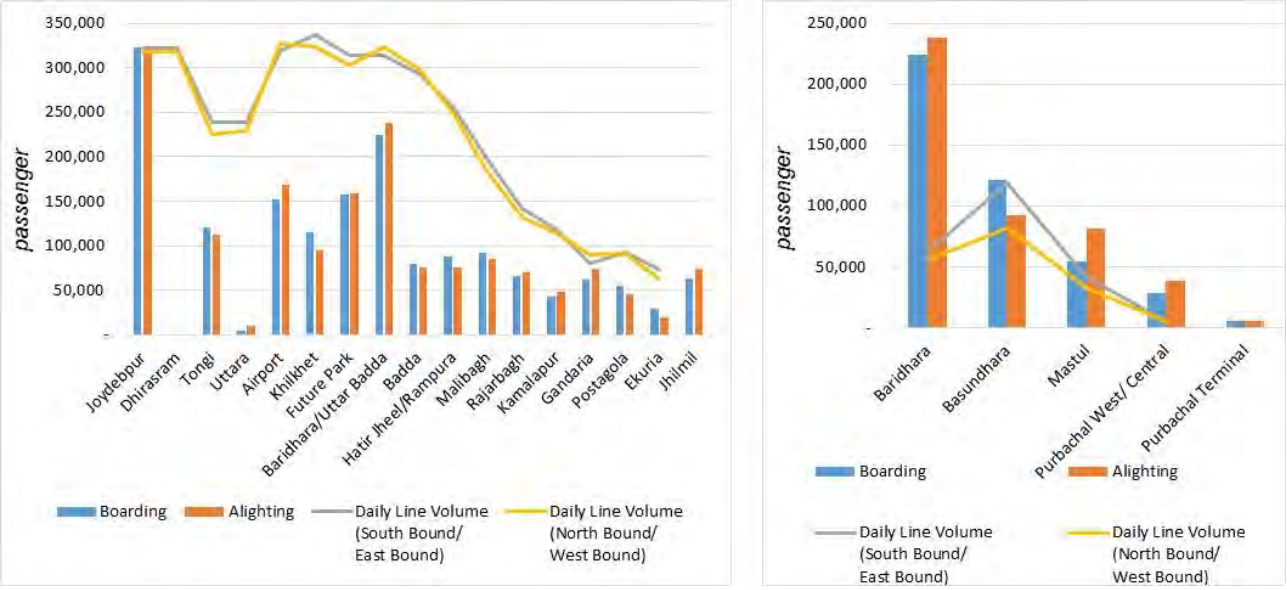
Source: JICA Study Team

Figure 3.13 MRT Line 1 Alignment in 2035

Table 3.5 Daily Two-Way Station Boarding and Alighting Passengers in 2035

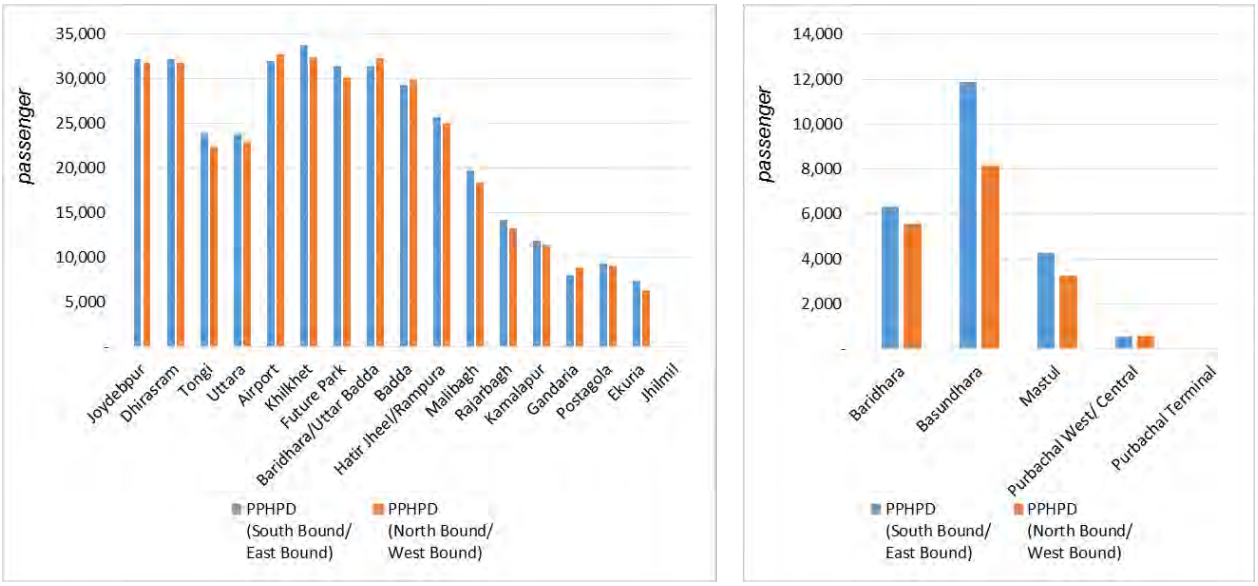
Station	Boarding	Alighting	Daily Line Volume (South Bound/ East Bound)	Daily Line Volume (North Bound/ West Bound)	PPHPD (South Bound/ East Bound)	PPHPD (North Bound/ West Bound)	km	Pax-km
Joydebpur	322,600	317,800	322,600	317,800	32,260	31,780	0.8	505,007
Dhirasram	-	-	322,600	317,800	32,260	31,780	5.6	3,616,019
Tongi	121,100	111,900	238,700	224,600	23,870	22,460	1.5	683,678
Uttara	5,300	10,600	238,100	229,300	23,810	22,930	1.0	474,640
Airport	152,000	168,700	319,600	327,500	31,960	32,750	0.9	608,196
Khilkhet	115,900	94,200	337,700	323,900	33,770	32,390	0.4	265,937
Future Park	157,200	158,900	314,400	302,400	31,440	30,240	0.1	31,333
Baridhara/Uttar Badda	224,100	237,900	314,400	323,700	31,440	32,370	1.9	1,226,084
Badda	79,100	75,000	293,300	298,500	29,330	29,850	1.0	569,957
Hatir Jheel/Rampura	88,000	76,100	256,900	250,100	25,690	25,010	0.3	152,906
Malibagh	92,200	85,300	197,500	183,900	19,750	18,390	0.5	183,930
Rajarbagh	66,200	70,600	141,700	132,500	14,170	13,250	0.6	156,971
Kamalapur	42,900	48,200	118,800	114,900	11,880	11,490	1.2	282,873
Gandaria	62,300	74,900	80,700	89,300	8,070	8,930	0.5	86,003
Postagola	55,600	45,300	92,800	91,100	9,280	9,110	0.0	2,582
Ekuria	29,300	20,000	74,200	63,300	7,420	6,330	2.0	278,640
Jhilmil	63,300	74,200						
Baridhara	224,100	237,900	63,300	55,700	6,330	5,570	2.3	269,486
Basundhara	121,800	92,600	118,600	81,700	11,860	8,170	0.2	39,980
Mastul	54,300	81,300	42,500	32,600	4,250	3,260	1.9	142,200
Purbachal West/ Central	28,400	38,600	5,300	5,600	530	560	2.0	22,338
Purbachal Terminal	5,600	5,300						
Total / Max	1,887,200	1,887,400	337,700	327,500	33,770	32,750	55.0	20,858,054
						Ave. Trip Length (km)		11.05

Source: JICA Study Team



Source: JICA Study Team

Figure 3.14 Daily Passenger Ridership in 2035



Source: JICA Study Team

Figure 3.15 PPHPD in 2035

4. PRELIMINARY SYSTEM DESIGN

4.1 Route and Alignment

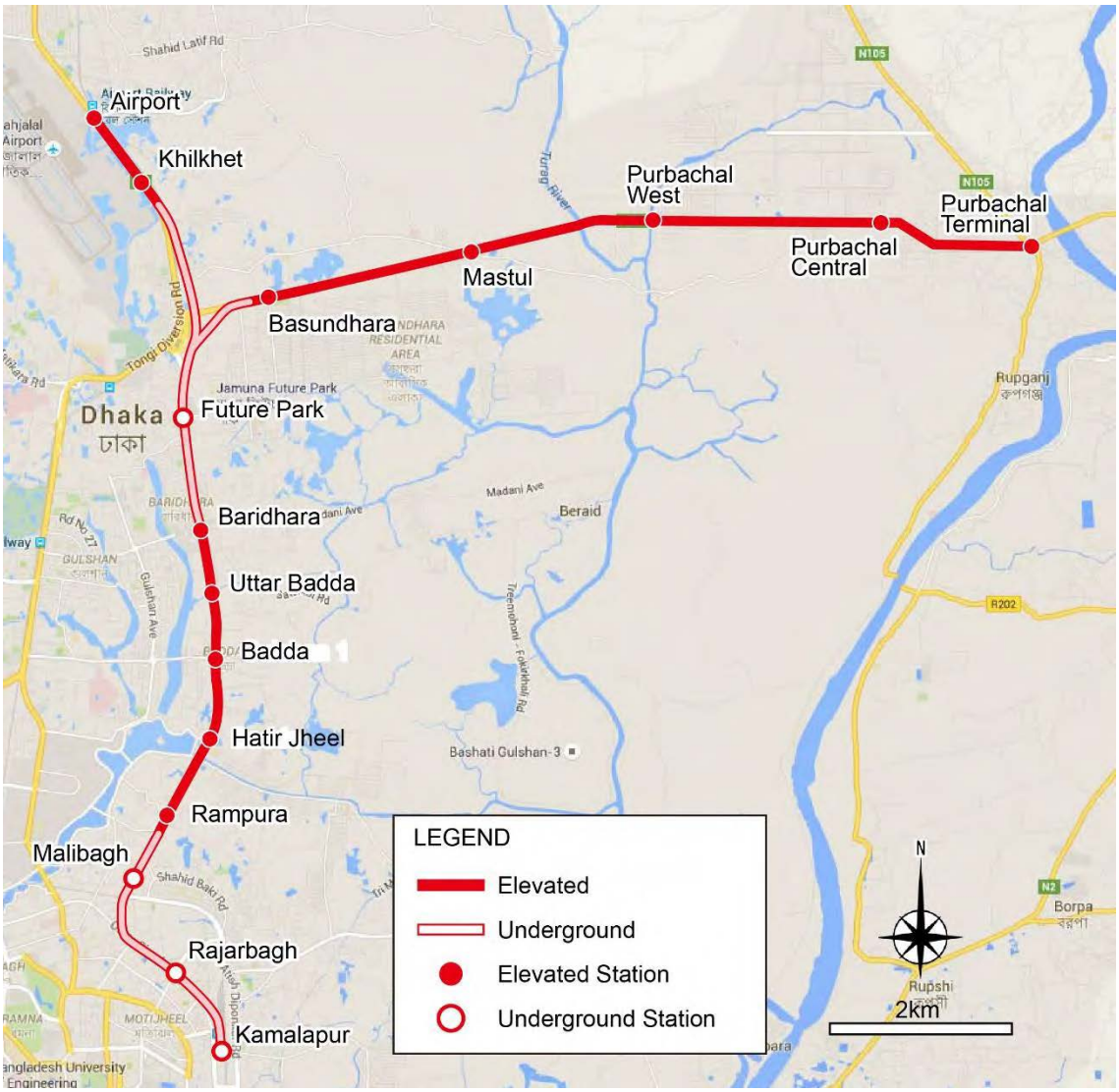
The JICA Study team proposed new MRT Networks to combat existing road congestion. In the study, three scenarios were discussed.

Under Case 1 (Do Nothing Case), the Rail-based Transportation Network consists of the existing Bangladesh Railway (BR), BRT line 3 and MRT Line 6, which is currently being designed for construction. In addition to this, the BR Narayanganj Line, which connects Kamalapur BR Station and Narayanganj Railway Station, will have an additional track added, so as to be double tracked.

Under Case 2, the rail-based transition system network consists of the Case 1 network and MRT Line 1, which connects the new developing area Purbachal and Kamalapur BR Station, branching at Bhatara to the Airport. In addition to Case 2, under case 3 (Do Maximum Case), two MRT Lines were proposed: MRT Line 4, which will be built on the Eastern Fringe connecting Gazipur–Purbachal–Narayanganj, and MRT Line 5, which was modified from the MRT Line 5 proposed by STP in order to penetrate Dhaka West to East.

In this chapter, we will discuss the technical aspects of the MRT Line 1, which connects Purbachal and Kamalapur BR Station via Kuril, and Badda via DIT road. MRT Line 1 will branch to the Airport at Bhatara. The proposed MRT Line 1 will be built within the ROW of the roads using the center divider in order to avoid resettlement and to provide easy access from public areas with minimum underground permanent way. A depot, which requires some 25 ha, will be constructed in Purbachal. MRT Line 1 will also connect the International Airport and the Kamalapur BR Station, with a branch at Bhatara Station that contains 2 platforms and 4 tracks on the viaduct.

The proposed MRT Line 1 alignment is shown in figure 4.1.



Source: JICA Study Team

Figure 4.1 MRT Line 1 Alignment and Proposed Stations in 2025

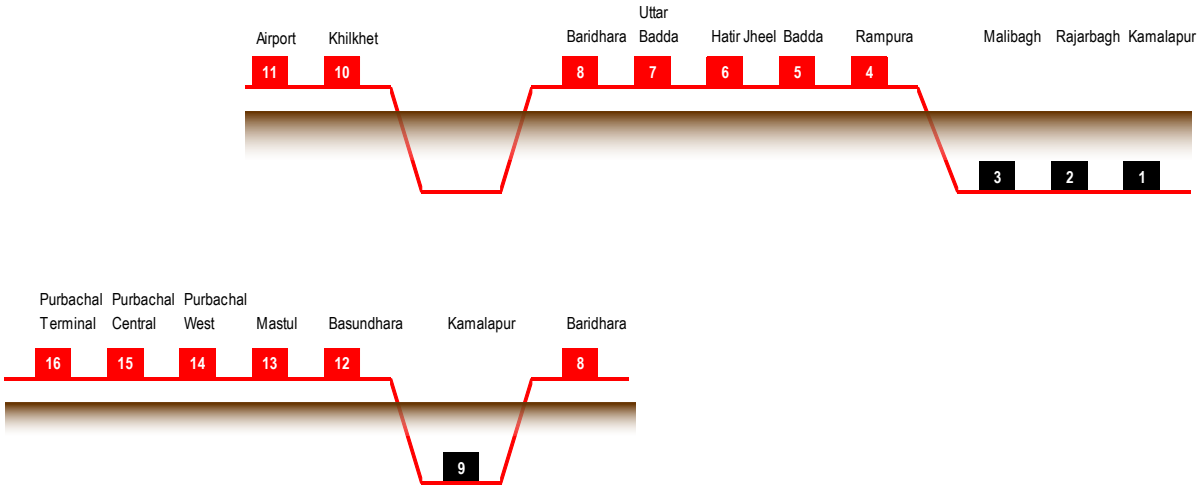
Between Kamalapur and Kuril, it is difficult to find adequate space for a Depot. The Study Team received information from the DTCA (Dhaka Transportation Coordination Authority) that space for a Depot may be available East of Purbachal area near the Kanchon Bridge. But the distance between Kuril and the proposed area is some 10.6 kilometers, which means that during the development period, trains shall be operated with few passengers over a longer distance. Long distance requires more vehicles and results in higher construction/operating costs. The Study Team is concerned about cash flow during the initial stage. On the other hand, development of the MRT System may greatly improve convenience for residents, which would then contribute to the increase in the number of inhabitants.

Road traffic between the International Airport and downtown through Kuril, BADDA, Tejgaon, and Saidabad is very heavy. The new MRT System will contribute to alleviate heavy traffic congestion; it is an urgent issue. The JICA Study Team proposes a new MRT Line 1, which connects Purbachal and Kamalapur BR Station with the International Airport. The Airport section shall be extended to Tongi, and then to Gazipur in the future. In general, development of the MRT System will take some 7-8 years from the completion of the Feasibility Study to the commercial opening.

RAJUK, a 300”-wide road, runs between Purbachal and Kuril. The structure of this permanent road shall be studied during the FS stage. In the RSTP Study, the JICA Team estimated the cost of elevated track at a request from the DTCA. But in order to harmonize with the surrounding environment and reduce project cost, a semi-tunnel with a U-shaped structure may be recommended. From Kuril, the line runs down Progati Sharani Road, reaching BADDA and further along, DIT Road, and the New Circular Road, finally arriving at Kamalapur BR Station. The Permanent way shall be constructed on viaducts using road center dividers with a partial underground permanent way. Details of underground areas shall be discussed later.

As an alternative, between Kuril and the Kamalapur BR Station, MRT Line 1 should be built underground. In this case, the locations of station boxes and entrances, ventilation towers, and cooling towers are to be carefully studied. In general, an underground MRT may cost 3-6 times more than elevated structures. Further, location of the transition sections from/to elevated/underground sections shall be studied, taking into consideration road traffic, the possibility of closing road crossings, space availability, etc.

The proposed profile of MRT line 1 is shown in Figure4.2.



Source: JICA Study Team

Figure 4.2 MRT Line 1 Profile in 2025

The structure plan of the permanent way shall be discussed later in 4.2 (2) Civil Works and Structure.

4.2 Design

(1) Train Operation Plan

Please refer to Details of the Train Operation Plan discussed in Interim Report 2. Summaries of train operation plan are as follows:

Table 4.1 Train Operation Plan

Train Operation Time	5 am–10 pm (Commercial Operation)
Frequency	Peak 2 hours: 3.2 minutes, off peak: 5-10 minutes
Composition of Train	6 cars
Required number of cars	189 (2035), 72 (Initial Stage)
Depot	Purbachal with Workshop function
Rapid Operation service	Airport express, passes through the facility at Badda
Emergency Route	Crossings at Rampura, Kuril North
Branch Airport Line and Purbachal Line	At Bhatara (2 platforms and 4 tracks)
Future Extension	Forward to Tongi/Gazipur and Jihimil

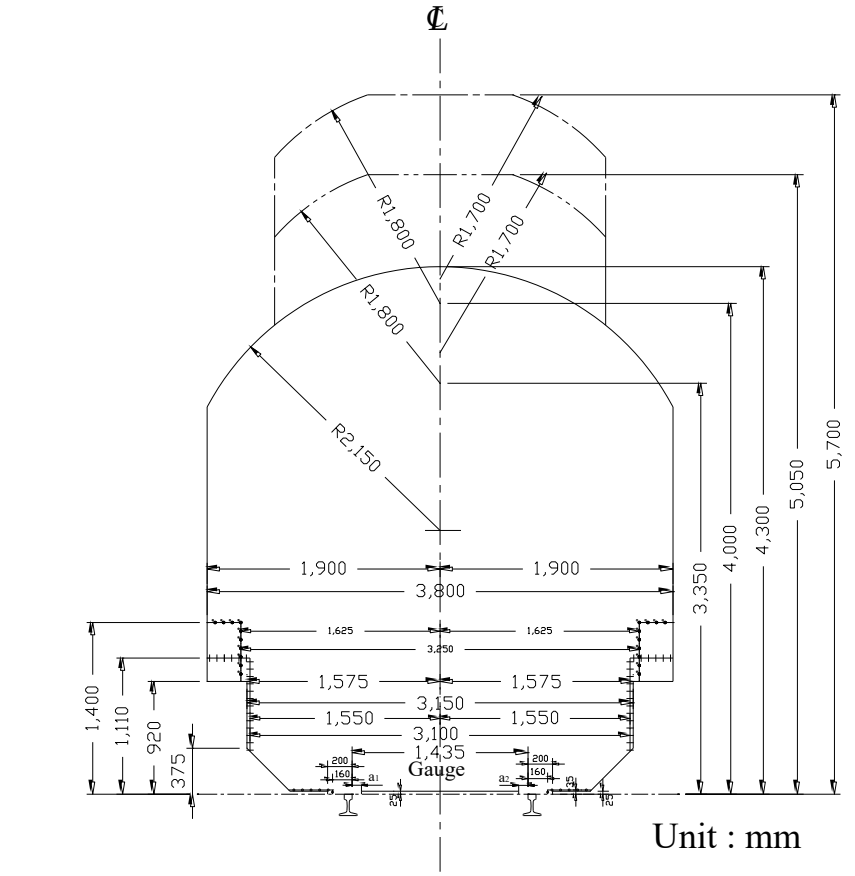
Source: JICA Study Team

(2) Civil Works and Structures

Basic features of MRT Line 1 are the same as MRT Line 6, which is being developed at present. Summaries of the features are as follows:

Table 4.2 Major Design Features

(General)	
1. Rail Gauge	Standard Gauge: 1,435 mm
2. Rolling Stock & Construction Gauges	As shown below
3. In Case of Fire	No stopping between stations, no evacuation path, but provide path for maintenance work
4. Earthquake	Seismic design shall be applied
(Alignment)	
1. Minimum Radius	R=600m, (In depot and where unavoidable R=200m)
2. Minimum Radius along platform	Straight(Unavoidable stations R=600m)
3. Distance between two track centerlines	3.6m(main track)approach track from/to depot 3.4m
4. Vertical gradient	Between stations: i=3.5% (unavoidable i=4.0%) Station: i=0.0%(unavoidable i=1.0%)
(Structure)	
1. Viaduct	PC Box Girders
2. Underground	TBM Method
(Track)	
1. Rail	UIC 54kg (main track) or JIC 50N, UIC 50kg (loop line & depot), CRW
2. Fastening system	Round Bar Steel
3. Turnout	No. 10(main track), No. 8 or No. 10(loop line & depot)
(Elevated station)	
1. Platform	Lateral type: train length + 5m x 2
2. Design	Universal Design, Barrier Free
3. Structures	1st floor concourse and station operation rooms, 2nd floor train runs
(Underground station)	
1. Platform	Island type: train length + 5m x 2
2. Design	Universal design, barrier free
3. Structure	Soil cover 2m: 1st floor concourse, station operation rooms, mechanical rooms, and toilets; 2nd floor platform
4. Platform Screen Door	Full height
5. Disaster Prevention	Japanese MLIT notification
6. Construction	Cut & Cover Method
(Electrical Power Supply)	
1. Traction Power	DC 1,500V
2. Power Supply	Overhead Catenary
(Signaling)	
1. Block System	Moving Block (CBTC) or Interlocking, ATS
(Rolling Stock)	
1. Body	Mild Stainless Steel or Aluminum.
2. Brake	Re-energize, air and electrical
3. Motor control	VVVF
4. Design speed	100km/hr



Basic structure gauge

Structure gauge for those other than overhead contact lines, their suspension equipment, and insulated reinforcing materials on railway tracks operated with DC electric power supplied through contact lines.

Structure gauge required for those other than overhead contact lines, their suspension equipment and insulated reinforcing materials in tunnels, bridges, over bridges, and platform roofing as wellas the sections before and after those structures on railway tracks operated with DC electric power supplied through overhead contact lines.

Structure gauge for platform

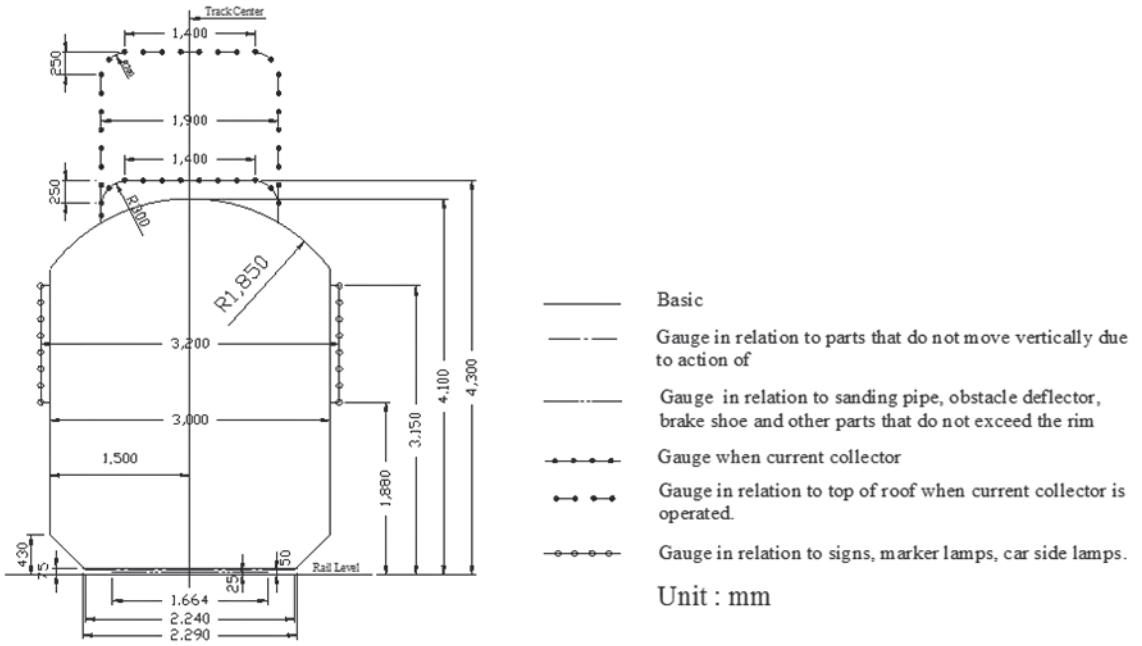
Structure gauge for signals, markers, signs, and special tunnels and bridges

Structure gauge for run-over type turnouts

Structure gauge for shunt and crossing

Source: General Consultant of MRT Line 6

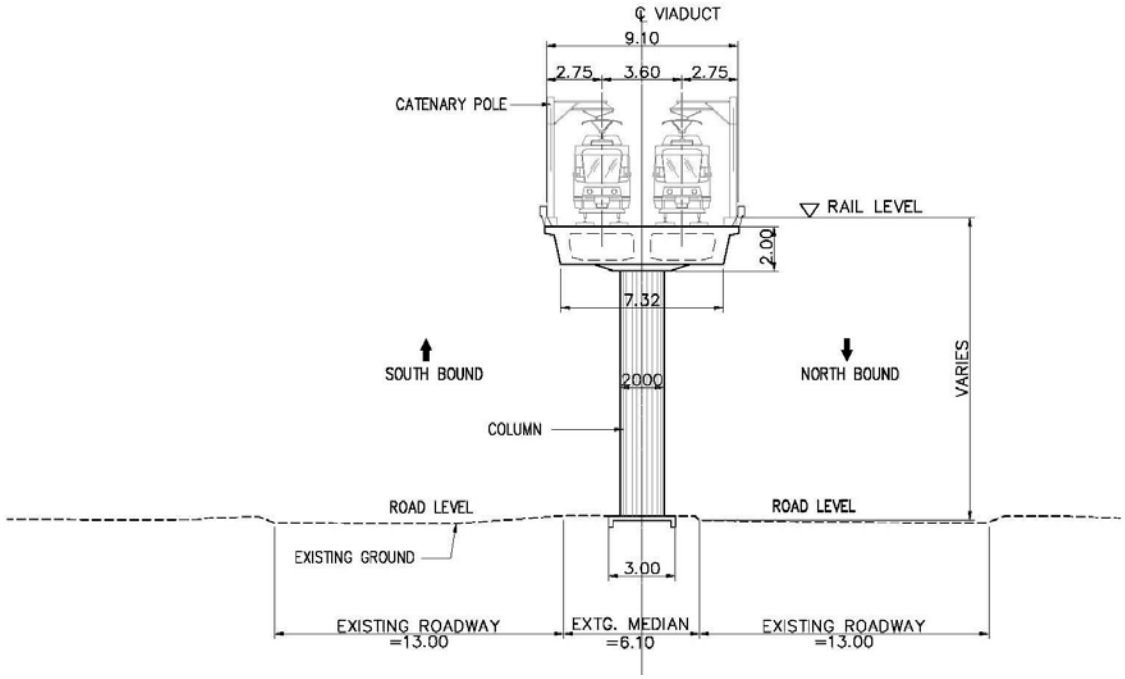
Figure 4.3 Construction Gauge



Source: General Consultant of MRT Line 6

Figure 4.4 Rolling Stock Gauge

Viaducts shall be erected along major roads using the center divider. The following figure



shows the general arrangement.

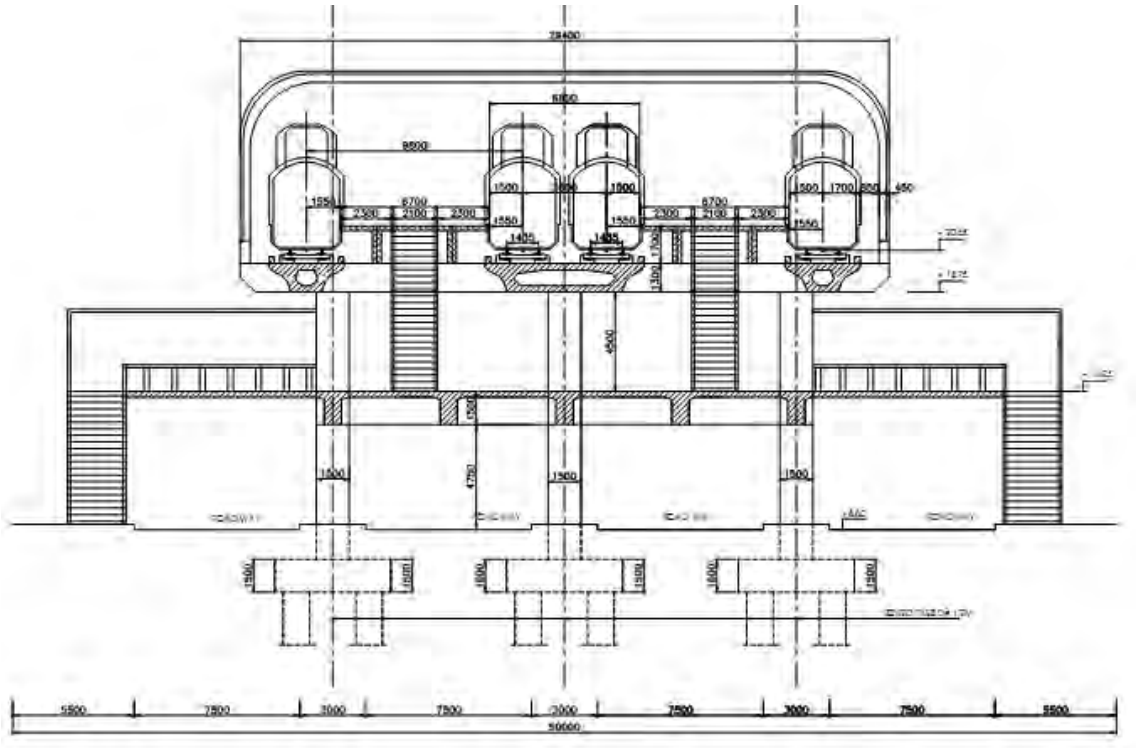
Source: General Consultant of MRT Line 6

Figure 4.5 General arrangement of Viaduct

Figure 4.6 shows an image of an elevated station on a viaduct.

Source: General Consultant of Jakarta MRT

Figure 4.6 Elevated Station

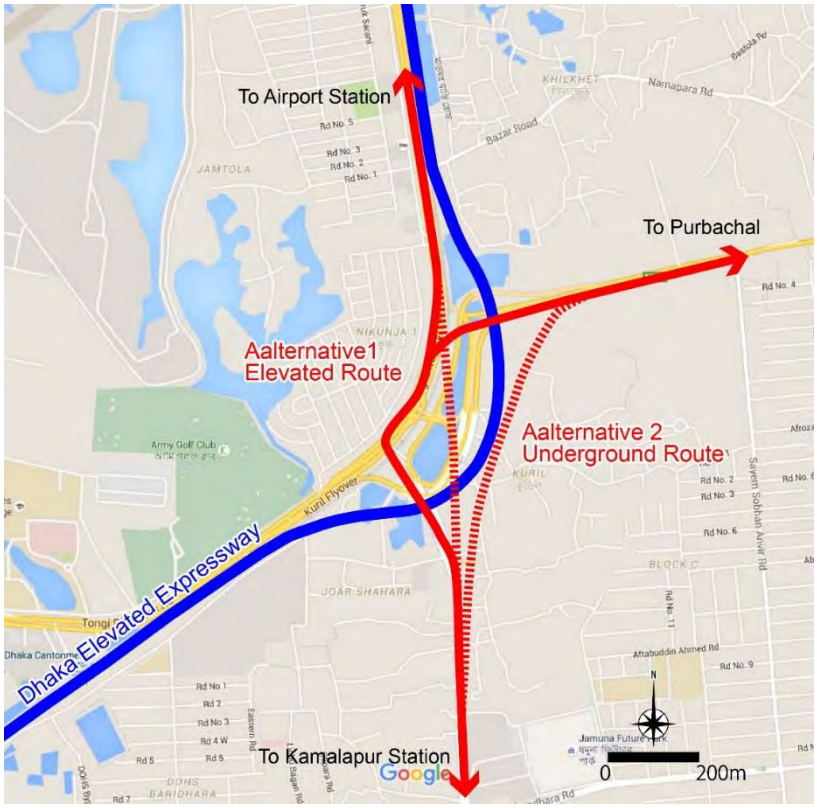


Source: GC for Hanoi line 2

Figure 4.7 Image of the Bhatara Station which contains 2 platforms and 4 tracks

Planning the permanent way around Kuril requires detailed topographic surveys that cover BR ROW and the Kuril Flyover, including the plan and profile of the existing flyover to harmonize the designs of the planned Dhaka Elevated Expressway (DEE), the BR addition of double tracks, and the proposed MRT Line 1.

Since MRT Line 1 may be constructed underground, it would cost 5–10 times as much as an Elevated Railway; the cost of operation and maintenance would also be higher. However, the JICA Study Team recommends that MRT Line 1 should be constructed as an underground structure in the Kuril Area in order to avoid resettlement of inhabitants.



Source: JICA Study Team

Figure 4.8 Kuril Flyover and Dhaka Elevated Expressway

Construction of MRT Line 1 shall match the existing Kuril Flyover, the Dhaka Elevated Expressway (DEE), and the BR Double Tracks Addition. According to the design of the DEE, the road surface is planned to be 24m above the existing ground; this means 6m under the girder is kept clear for the existing flyover. DEE is planned to be on the Eastern Side of the existing flyover along with a ramp, which will affect many buildings and residences.

As an alternative plan, MRT Line 1 may be constructed along the DEE with an elevated structure. But, in this case, MRT Line 1 will cause the resettlement of many inhabitants. This is not feasible under a Japanese ODA Project.

At this stage JICA Study Team proposes construction of an underground permanent way.

At the cross point between Madani Avenue and Progati Sharani Road, an elevated station (Bhatara Station) containing 2 platforms and 4 tracks shall be constructed. At this station the track forward to the airport and the track forward to Purbachal are separated.

The Progati Sharani Road consists of a 2.5m-wide pedestrian path, a 0.7m-wide drainage, 4 lane carriages some 15m in width, a 0.5m-wide center divider, 3 lane carriages about 11m wide, a 0.7m-wide drainage, and a 2m-wide pedestrian path. The total width of Progati Sharani Road is 32.4m while an elevated station, which has 2

platforms and 4 tracks, requires 30m. Figure 10 shows the cross section of station C2 of Hanoi Line 2 as an example for Bhatara Station. The actual Bhatara Station shall be modified based on existing conditions.

Between Bhatara and Demozemod Church, 4 track runways shall be constructed; 2-layer runways and the permanent way descend to an underground station that will be provided around Future Park (the cross section between Bashundara Road and Progati Sharani Road). The Future Park Station shall be a station box which has a 1st floor concourse, a 2nd floor platform for passengers traveling to Purbachal/Kamalapur, and a 3rd floor for those heading to the Airport.

The permanent way to the airport and Purbachal will be constructed underground by the TBM tunneling method in order to clear the Kuril Flyover. However, careful study shall be undertaken during the FS to avoid traffic impacts.

At present, for evaluation purposes, construction of the tunnel shall be done with 2 TBM machines.

Operation and maintenance for an underground railway costs more than double that of an elevated one because of electric power supply, drainage, and air conditioning. As an alternative, the elevated railway along DEE structures shall be studied. At present, a comprehensive comparison is shown in Table 4.3 below.

Table 4.3 Comparison between Underground and Elevated Railways

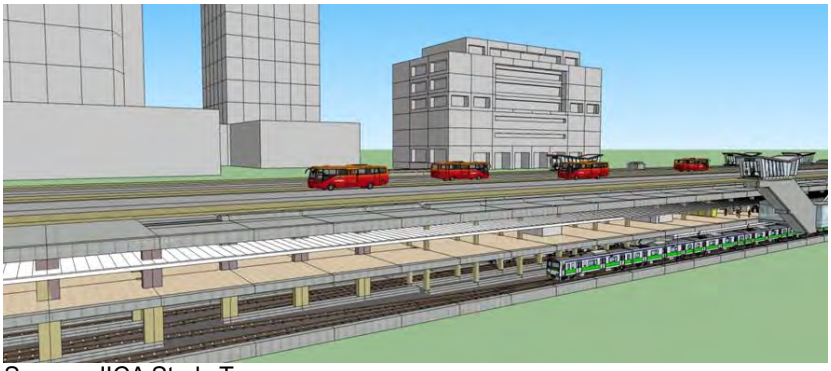
Subjects	Elevated	Underground	Note
Construction	Easy	Difficult	
Initial Cost	Low	High	
Resettlement	Expected	A little	Entrance
Environment	Big impact	A little	
O&M	Low	High	
Const. Duration	Medium	Long	
Bangladesh	Experienced	No Experience	
Laws & Regulations	Existing	New Reg. required	
Impact to Traffic	Heavy	Manageable	Station Box
Access to Platform	25–27m	10m	From GL
Total Evaluation		Recommended	

Source: JICA Study Team

Around the cross point between DIT Road and the BR, the Moghbazar–Mouchak Link Flyover, which will be built on the New Circular Road, is under construction implemented by the Ministry of Local Government. These Flyovers and the MRT Line 1 ROW coincide. There is no space to construct two elevated structures; the ROW of the MRT Line 1 shall be underground.

There are many piles under the center dividers of the DIT Road; MRT Line 1 shall pass under the eastside lane, while on the New Circular Road it shall pass under the north side lane.

At present, in front of the Bangladesh TV station, a U-Turn Flyover is under construction. MRT Line 1 shall pass above this Flyover and head to the Transition section. Before the BR level crossing, an underground station named Malibag Station will be provided. Between Malibag Station and Kamalapur Station, the line shall be constructed underground by TBM. At Kamalapur Station, the MRT Station is proposed at the existing BR Narayanganj Line Platform taking into consideration connectibility between BR and MRT Line 1.



Source: JICA Study Team

Figure 4.9 Image of the Underground Station

The underground station shall be constructed by the cut and cover method, which will effect surface-road traffic. Adequate traffic management shall be developed in relation to actual site conditions. Between underground stations, a tunnel may be constructed by TBM method in order to prevent affect to traffic. From the Kuril area and Ramna to the Kamalapur area, separate TBM shield machines shall be arranged. In the FS stage, more detailed construction plans shall be developed.

In general, an underground station requires approximately a 240–250m length for the mechanical room for ventilation and drainage equipment. The type of platform shall be selected in accordance with functions required, circumstances, and the environment. The following table shows station name, location, and platform type.

Table 4.4 MRT Line 1 Proposed Location of Station

Name	Distance	Location	Type of Station
Kamalapur	0	BR Narayanganj Platform	Underground 2 platforms with 4 tracks
Rajarbag	1.3 km	Rajarbag Police line	Underground island platform
Malibag	2.5 km	North of BR level crossing	Underground island platform
Rampura	3.5 km	Rampura Bazar	Elevated lateral platforms
BADDA	4.5 km	North side of the bridge	Elevated lateral platforms
Gulshan 1	5.4 km	Intersection between Mohakhali–DIT Road	Elevated lateral platforms
UTTRA BADDA	6.0 km	Mashritola Rd.	Elevated lateral platforms
Bhatara	6.7 km	Madani Avenue–Progati Sharani	Elevated 2 platforms with 4 tracks
Future Park	8.3 km	In front of the Future Park	Underground station with lateral platforms
Khilkhet	10.9 km	Cross Airport Road and Khilkhet Road	Elevated lateral platforms
Airport	12.6 km	In front of the BR Airport Station	Elevated 2 platforms with 4 tracks
Bashundhara	11.3 km	Namapara	Elevated lateral platforms
Mastul	13.5 km	Domani	Elevated lateral platforms
Purbachal W	16.3 km	Sector 13	Elevated lateral platforms
Purbachal Central	19.4 km	Sector 9	Elevated lateral platforms
Purbachal Terminal	21.5 km	Sector 5	Elevated 2 platforms with 4 tracks

Source: JICA Study Team

(3) Station and Station Facilities

The lateral-type platform is adopted as the standard type of platform for elevated stations because this type of platform is flexible for future expansions, extension of stairs, etc.

Figure 4.10 Minumadai-Shinsuikoen Station, Toneri Liner (Tokyo, Japan)

On the other hand, an underground station may be an island-type platform within the ROW of the road because of the limitation of land acquisition.

Locations of station entrances shall be determined with consideration of passenger convenience, land use, geological conditions, road traffic conditions, etc. Ticket barriers are located in one place in a station in order to monitor passenger movement intensively. Two entrances shall be provided at either end of a station.

One entrance is located at one side of the road, another is located at the opposite side of the road. The entrance will occupy the pedestrian walkway or car park; however, a minimum width of one half meter of pedestrian walkway shall be preserved in order for wheelchairs to pass each other. It is necessary to acquire the land in cases of a lack of minimum width for pedestrian walkways, so as not to interrupt pedestrian movement.

The station should have two floors: for elevated stations, the lower floor shall be the concourse and the higher floor shall be the platform, while underground stations will have the lower floor be the platform level and the upper floor for the concourse. The length of the platform shall be 130m (6 cars and allowance), and the platform height from the top of the rail shall be 1.10m. For underground stations, the full height of the PSD (Platform Screen Door) shall be provided taking into account the safety of passengers and operation costs for air conditioning. Elevated stations may have a semi-height of PSD for passenger safety.

All stations shall be designed in accordance with Universal Design, providing lifts, escalators, toilets for the handicapped, slope for wheel chairs, etc.

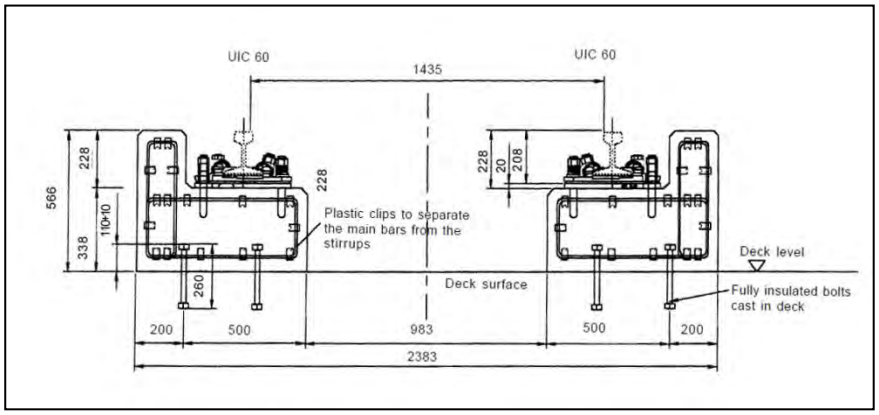
The locations of entrances are to be studied during FS.

(4) Track Design

The purpose of the track throughout its design life is to provide a safe, resilient, and durable permanent way for train operation for the required design load and speed with the required ride comfort.

Track, in general, means structures for train operation on the track formation and consists of rails, sleepers, fastening devices, ballast (sometimes ballast is omitted and the rails are fastened directly to a concrete slab or plinth), and other track materials.

The main line track consists mainly of rail, a turnout, a direct fixation system, and a fastening system. On the other hand, the depot track will be built on ballast with concrete sleepers.



Source: JICA Study Team

Figure 4.11 Plinth-type of DRF

In order to reduce maintenance cost, the Ballastless Track is preferred to Ballasted Track. Ballastless Track is sometimes called Direct Fixation Track. There are several types of Direct Fixation (DRF). What we recommend here is the Plinth-type DRF. It is easy to install and adjust to the required position. Also the noise and vibration is less than a slab-type DRF. The slab-type DRF is used for the Japanese bullet train the Shinkansen. It can bear the load from a train which runs at a high speed of over 200 km/hr. But construction of slab-type DRF needs skilled laborers to manage the concrete asphalt and accuracy of the concrete slab position. It is difficult to find skilled laborers in Bangladesh. Therefore we recommend the Plinth-type DRF. A sample of a Plinth-type DRF is shown in Figure 4.11.

This Figure shows the UIC 60 rail design; however, a detailed study may be required in the FS stage or Design stage.

A detailed profile of the Rail of UIC 54 and JIC 50N Kg are shown in the table below.

Rail material produced by the Basic Oxygen Furnace is recommended. In order to reduce rail head corrugation, the Brinell Hardness (HBS) shall be more than 320. Rails are welded into a long rail and further a CWR. Therefore, weldability is an important factor.

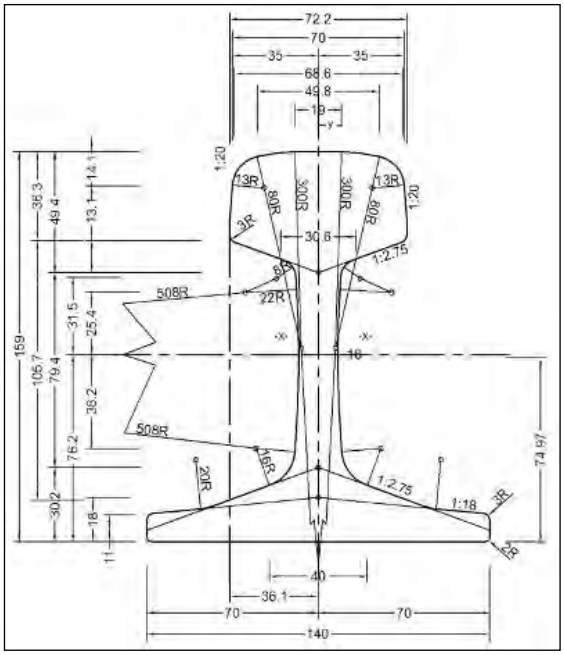


Figure 4.12 UIC54 Rail Section

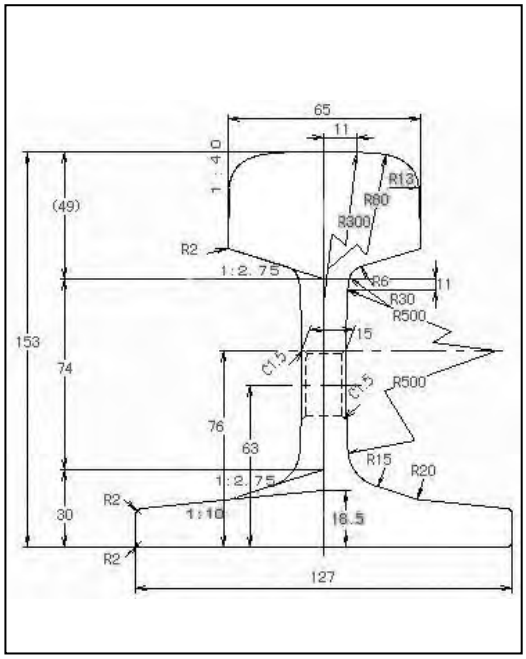


Figure 4.13 JIS 50N kg Rail Section

(5) Signal and Telecommunications

The role of a signal system is to ensure safe train operations. Therefore, a high reliability is required for signal facilities. In the event of a failure, the system must operate safely; this function is called a fail-safe.

In many cases, the fail-safe of a signal system means being able to stop the train safely. Therefore, as a general rule, the train should be able to be stopped safely in the event of a malfunction in the signal facilities.

The signal plan shall be based on the following prerequisites:

1) The signal facilities are the equipment to support safe and efficient train operations.
2) The signal safety system functions for a backup in case of a driver's human error.
3) The switch mechanisms of point machines on the mainline operate electrically and remotely through the Centralized Traffic Control (CTC) from the Operation Control Center (OCC) to signal facilities on-site. When remote control is impossible, complementary control is enabled from the station.
4) Train detection is possible in the section where a track circuit* is installed (at the station yard and between stations).

*Note: In the FS stage, the CBTC (Communication-based Traffic Control) system shall be studied.

Plan for Signal System

Types of signal safety systems include the Automatic Train Stop (ATS), Automatic Train Control (ATC), Automatic Train Operation (ATO), and Communication-based Train Control (CBTC). The CBTC is a train-control system based on radio communication with simple components and successful energy savings. However, this system does not have enough actual performance records as the signal safety system, and further improvement should be required. Automatic Train Control (ATC) is the traditional method for the signal safety system. The ATC system continuously monitors train movement

based on allowable speed information for the train. When exceeding the setting speed, the ATC automatically decelerates the train to an appropriate speed. Therefore, the train is programmed to keep running at the appropriate speed.

The CTC shall be recommended as the train operation control system. For the train operation dispatcher, information collection of train operation conditions shall be required. The CTC contributes efficient operation via a monitoring indicator of the train position using the remote-controlled interlocking device by the dispatcher.

This system includes a central CTC system, centralized indication panel, centralized control panel on the OCC side, CTC station systems, and interlocking devices at each station.

Telecommunication facilities are important for operational control of the train and the safety assurance of work on the wayside and in the yard. Moreover, it is possible in the station to provide information services to passengers in addition to communication with station staff. The basic concepts and facilities of the MRT are as follows:

1) Telecommunication facilities for security: These facilities consist of the dispatcher telephone, train radio system, wayside telephones, etc., to ensure safe train operation used by dispatchers, train crews, station staff, workers, and others.
2) Telecommunication facilities for passenger services: These facilities consist of the passenger information display system, clock system, public address facility, and Closed Circuit Television (CCTV), etc.
3) Transmission facilities: These facilities consist of the transmission path and other devices.
4) Information collection facilities: These facilities collect information from rain gauges, anemometers, seismometers, and smoke alarms, etc., installed at the stations and areas around the railway line.

(6) Power Supply

In order to establish an electric power plan for MRT Line 1, it is necessary to select the location of substations and estimate the maximum electricity power during peak hours for each substation. In addition, it is necessary to study the possible electric power supply for MRT Line 1 by Bangladesh Power Company.

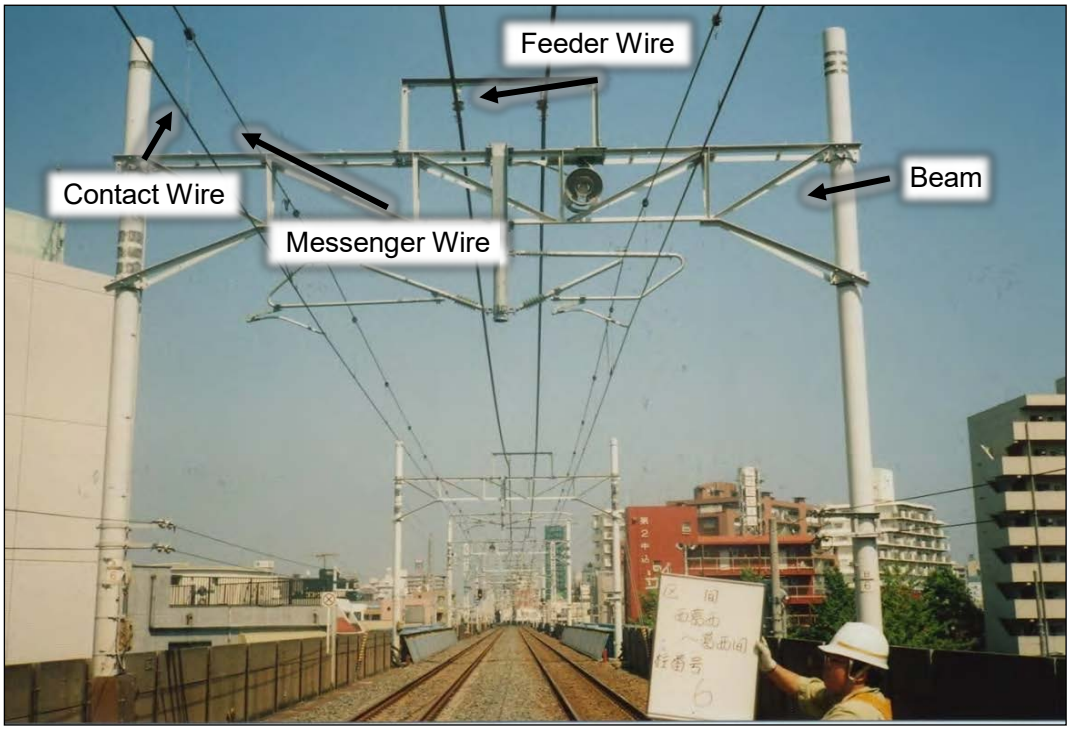
Required electric power for electric railways systems consists of two categories. One is to run the train, which is called the “electric power for the train” and accounts for most of the electric requirement. The other category is referred to as “electric power for services,” the power required for signal and communication equipment, lighting, ventilation and air-conditioning systems, escalators and elevators, namely everything required to run the train system.

Calculation of the necessary electric power for trains requires parameters of the distance between substations, headways during peak hours, the necessary electric power per one car to run for 1 km, and the number of cars comprising a set.

To determine the distance between substations, it is essential to ensure securing the voltage necessary for train operation, to set up a protection system to detect failure of the feeding circuit, and to reduce rail voltage to prevent trouble caused by electrolytic corrosion. These three conditions can be met with a set of six Variable Voltage Variable Frequency (VVVF) cars by setting the headway to 3 minutes 10 seconds and the substation distance from 4 to 5 km.

The experts shall carry out a detailed study for power level and location of sub-stations in the FS or Design stage.

The conventional catenary system consists of three electric lines: a feeder wire on the top, a messenger wire at an intermediate suspension, and a contact wire at the lowest position, as shown in Photo 1.



Source: DHUTS

Figure 4.14 Conventional Catenary System

The feeder wire is a thick electric wire used for providing a large power supply for trains and is directly connected to the substation. The suspension is used to hold the contact wire and keep its height constantly (isometry). The contact wire is used to supply electric power to trains through a pantograph (current collector installed on the train roof).

As an alternative to the conventional system, a simple catenary system is proposed for MRT Line 1 in which the feeder wire is also used as the suspension, as shown in Photo 2. The structure of this cantilever-type system is simpler than the conventional system.

Source: DHUTS 2 Final Report

Figure 4.15 Cantilever-type Simple Catenary System

Item		Recommended Specification	Remarks
Car Body Material		To be compatible with MRT 6	
Composition		6 cars: 3M3T (To study in FS)	Subject to vertical alignment
Electrical Power Supply		DC 1,500V	
Weight (Tare)		T_C: 25t, M: 28t, T: 22t	
Target Passenger Number		1,696 persons/train	
Seating Arrangement		Long-seat seating arrangement	
Car Dimensions		L 20,110mm × W 2,950mm × H 4,100mm	Leading car
		L 20,000mm × W 2,950mm × H 3,650mm	Middle car
No. of Side Entrances		4 doors/car each side	
Entrance Dimensions		W 1,300mm × H 1,850mm	
Traction Motor		1,100V, 140A, 200kw (1-hour rating)	
Controller		VVVF inverter control type	
Brakes		Re-generative electric brakes	
Electric Collection		Single-arm pantograph type	
Operation Protection System		Automatic Train Control (ATC) or CBTC	A more detailed study is needed
Maximum Running Speed		100km/h	
Car Performance	Acceleration	3.3km/h/s	
	Deceleration	Normal 3.5km/h/s	
		Emergency 4.5km/h/s	

Source: JICA Study Team

(7) Rolling stock and depot

Table 4.5 “Rolling Stock Design Criteria” shows basic rolling stock data.

Table 4.5 Proposed Rolling Stock Data

Item		Recommended Specification	Remarks
Car Body Material		To be compatible with MRT 6	
Composition		6 cars: 3M3T (To study in FS)	Subject to vertical alignment
Electrical Power Supply		DC 1,500V	
Weight (Tare)		T_C: 25t, M: 28t, T: 22t	
Target Passenger Number		1,696 persons/train	
Seating Arrangement		Long-seat seating arrangement	
Car Dimensions		L 20,110mm × W 2,950mm × H 4,100mm	Leading car
		L 20,000mm × W 2,950mm × H 3,650mm	Middle car
No. of Side Entrances		4 doors/car each side	
Entrance Dimensions		W 1,300mm × H 1,850mm	
Traction Motor		1,100V, 140A, 200kw (1-hour rating)	
Controller		VVVF inverter control type	
Brakes		Re-generative electric brakes	
Electric Collection		Single-arm pantograph type	
Operation Protection System		Automatic Train Control (ATC) or CBTC	A more detailed study is needed
Maximum Running Speed		100km/h	
Car Performance	Acceleration	3.3km/h/s	
	Deceleration	Normal 3.5km/h/s	
		Emergency 4.5km/h/s	

Source: JICA Study Team

Rolling stock maintenance includes cleaning, replacement of consumables, functional checks, parts replacement, equipment overhauling, and car body repair, which shall be conducted during regular inspections. The contents of typical regular rolling stock inspections to be conducted are shown in Table 4.6.

Table 4.6 Typical Regular Rolling Stock Inspections (Practical Standards)

Inspection	Cycle	Subjects
Daily Inspection	Before leaving depot for service	Major functions, braking system, etc.
Weekly Inspection	7-10 days	Major functions, exchange lighting system, etc.
Monthly Inspection	Less than 3 months	Major parts overhaul released from car, etc.
4 Year Inspection	4 year intervals or at 600,000km, whichever is shorter	Dismantle to repair, exchange major parts, etc.
8 Year Inspection	8 year intervals	Whole parts repaired
Repair and Remedy	On demand	Fault, damage, or new car

Source: JICA Study Team

The above typical regular inspections are proposed to be conducted on MRT Line 1. In particular, inspections of critical parts and general inspections, which require long periods of time, and rolling stock used to make up a set cannot be used during such inspections. For MRT Line 1, three to four spare train sets that include two to three sets for inspection and one set for standby operation are recommended to retain.

Recent rolling stocks are equipped with self-diagnosis systems, which enable automatic confirmation of functions within a short period of time. This will also help to save the amount of labor for inspections.

Maintenance intervals and operation plans will be relatively easy to establish if only one depot is used. If there are multiple depots and storage tracks, there will be many restrictive conditions such as operation time, staff, and number of rolling stock under maintenance.

In the FS/Engineering Design of the Depot, a more detailed rolling stock management system shall be studied and the required equipment will be specified. Following are major devices usually provided in a depot:

- Inspection/Light Maintenance Equipment
- Wheel Re-profiling Equipment
- Maintenance and Exchange Equipment
- Bogie and Wheel Repair Equipment
- Traction Motor Repair Equipment
- Mechanical Repair Equipment
- Brake and Compressor Repair Equipment
- Air Conditioner and Coupler Repair Equipment
- Door Repair Equipment
- Interior Fitting Shop Equipment
- Electric Component Repair Equipment
- Painting Equipment (if necessary)
- Battery Maintenance Equipment
- Washing Plant

The JICA Study Team recommends designing the depot with sufficient space and facilities for the maximum capacity of 30 6-car trains. The necessary area for a depot is approximately 200,000–250,000m2. This preliminary design is used for planning and

preliminary budget purposes and should be reviewed with RAJUK, NHA, BWDB, MOD and other related authorities, employing the same process as the selection of the depot location.

4.3 System Safety Design

Safety is the most important characteristic for the railway administration. In order to meet this mission, top management of the Operation and Maintenance Organization should put forward their best effort to provide man power, equipment, and education to employees, PR for passengers, etc.

In this section we discuss safety issues required from the O&M Organization regarding the following:

1. Safety Policy and Management Action
2. Rules and regulations
3. Organization
4. Maintenance
5. Safety for passengers
6. Security

These subjects will be compiled with the System Safety Plan in the design stage and updated during the construction stage and operation stage. The objectives of the System Safety Plan are:

1. To avoid loss of life, injury of persons, damage to property
2. To eliminate or minimize safety hazards
3. To make all employees aware of the importance of safety measures

(1) Safety for O&M Organization

1) Safety Policy and Management Action

Safety is the highest priority of the Transportation Entity. The top management of the company should put forth their best effort to meet this. They should invest in safety, providing enough staff, money, and equipment to maintain safe operations, as well as provide continuous education to staff, recognizing the importance of safety and how to move in case of an emergency.

Also, top management should provide tools required for smooth communication among departments, employees, and outside organizations. The most important thing is to share the information with staff. The top management of the O&M Company should:

1. Establish a Safety Policy and Safety Manual
2. Make organization simple so that the instructions reach the necessary level immediately
3. Invest enough money for safety
4. Provide enough resources, such as manpower and equipment
5. Educate staff

These issues shall be established during construction of the railway system as a “Safety Manual,” which is presented as the O&M Company’s policies, and “Safety Management Plans” will be required at all working depots, including the

administration office. The construction supervision consultant shall be required to prepare the guidelines for the Safety Manual and Safety Management Plans.

2) Rules and Regulations

In order to provide the customer with safe train services, establishment of adequate train operation rules is inevitable. The rules must include the following:

1. Train operation rules
2. Train operation control regulations–signal, power supply, AFC, etc.
3. Track maintenance standards
4. Rolling stock maintenance standards
5. Several operation manuals, including passenger handling manuals
6. Emergency manuals

These are internal regulations within the O &M Company. Additionally, high level country laws will be needed to secure safe train operation.

3) Organization

A simple and clearly demarked responsibility within the organization is preferred for maintaining safe train operation. Instructions should reach the lowest level of staff in a short time. Trains are operated in accordance with train diagrams and monitored and controlled by the command station in the Operation Control Center (OCC). If an accident occurs, the commander should find a way to recover to a normal situation. The commander will instruct various operators including train drivers regarding how they should perform. Prior to beginning commercial operation, it is necessary to decide who will be appointed Commander and what is his role will be. The Organization shall be as simple as possible so that the role and responsibilities are clear and effective.

In order to implement safe train operations, all staff of the O&M Company should strictly follow company regulations and complete their duties correctly. But once an accident occurs, all staff should commit to respond to the accident regardless their job descriptions. In order to achieve this, the same information shall be shared by all staff as much as possible.

Also, all staff should know emergency procedures: what things to do and how to do them in an emergency. Education and training is very important. Further, it is necessary to build up the emergency network including the police, army, local hospitals, local authorities, highway department, fire stations, etc.

All these procedures should be written in safety manuals as company policies and broken down into safety management plans for each working depot.

4) Maintenance

All facilities and equipment should be kept in good condition in order to perform required functions. In order to work correctly, maintenance shall be required in accordance with maintenance manuals. The Consultant will create guidelines for maintenance work, and then those guidelines will be developed as maintenance manuals during construction by contractors and suppliers for use by the O&M staff.

(2) Safety and Security for Design

A fail-safe philosophy is essential to prevent damage. Stopping trains is the most effective way to avoid an accident. The Train Operation Control system shall be built

based on this philosophy. In order to prevent train collisions, a blocking system with an Automatic Train Stop feature (ATS) or Automatic Train Control (ATC) will be employed.

Separate power sources are preferred. If one grid sub-station fails to supply power, another source should be in position to cover the outage. The sub-station will be designed as anti-seismic. The power supply system shall be protected against exposure to unsafe voltage.

Direct telephone lines for local emergency services should be provided along the line. The OCC will monitor the system and supervise emergencies. The OCC will be provided with a back-up computer, stand-by generators or UPS.

Emergency crossovers to another track will be provided at intervals of 5-6 km. Broken rails should be found by automatic detection. Expansion joints, which will be built at the end of the CWR, will absorb seismic loads.

Rolling stock shall be designed based on a fail-safe design philosophy. Evacuation is subject to discussion, but we recommend that trains should not stop between stations when the train is on fire.

All rolling stock shall be secured regarding emergency braking capability, and emergency batteries should be provided. Further rolling stock should not move while “Door Opened.” System safety shall be verified and validated by analysis, tests, and demonstrations of deliberately induced failures prior to starting commercial operation.

The passenger station shall have fire-fighting systems to meet local building codes. On the platform, emergency telephones will be provided. Train conductors will monitor passengers through CCTV which will be provided at the ends of platforms. A passenger information system is essential equipment for passenger comfort. A warning device to notify people in the stations of an approaching train will be provided at the platforms.

For passengers, communication equipment will be provided on board to make it possible to communicate with the OCC commander and train crews in an emergency situation.

The passenger station building shall be designed according to the Bangladesh National Building Code (2006). Regarding items for which this code is not applicable, international codes such as the International Building Code (USA), the Building Standards Law (Japan), the Fire Service Law (Japan), etc. shall be referred to.

5. PROJECT EVALUATION IN 2025

5.1 Overall

MRT Line 1 was selected the first priority project on from the proposed MRT/BRT network in RSTP. Total length of MRT Line 1 will be almost 52km in 2035. In RSTP this MRT line is proposed to divide a project into 2 phases. At the 1st phase project, the operating section will be between International Airport, Purbachal and Kamalapur in 2035. And at the 2nd phase project, Joydebpur and Jhilmil in 2035.

5.2 Project Cost

(1) Construction Cost

The construction cost estimate was completed by referring to actual contract data, which the OCG possesses in a database. Regarding viaduct construction, the Bangkok Purple line construction contract was referred to. On the other hand, underground structures referred to the Jakarta MRT Construction Project. Railway systems, including rolling stock, referred to the Bangkok Airport Link Project.

In this pre-feasibility study, project cost of MRT Line 1 has calculated in consideration of the following price escalations.

- Foreign Currency: 1.8%
- Local Currency: 6.1%

As a result of cost estimate, about 3.1 billion Yen excluding land acquisition costs are required for the 20.6 km-long MRT.

These costs are shown in Table 5.1 as of July 2015.

Table 5.1 MRT Line 1 Project Cost

Table 5.2 MRT Line 1 Project Cost by Year

Unit: in Million USD

	Total	Loan	Others
2017	0.0	0.0	0.0
2018	21.9	20.8	1.0
2019	22.5	21.4	1.1
2020	23.1	22.0	1.1
2021	453.7	432.0	21.7
2022	697.0	663.7	33.3
2023	740.1	704.6	35.4
2024	753.7	717.6	36.1
2025	386.8	368.1	18.7
2026	6.2	5.6	0.6
2027	3.3	2.9	0.4
Total	3,108	2,959	149

Source: JICA Study Team

(2) Operating and Maintenance Cost

The O&M cost was found by calculating unit figures such as the number of station staff, maintenance staff, electric power, track maintenance input, etc., which were obtained from neighboring countries as MRT disclosed on its website. The result is shown in the table below. Train frequency was assumed.

Table 5.3 Number of Train Operation

Operation Hour	PPHPD	No. of Train
0500 - 0700	6	24
0700 - 0900	18	72
0900 - 1600	6	84
1600 - 2000	12	96
2000 - 2300	3	24

Source: JICA Study Team

Regarding the number of staff, we made an assumption that the Head Office would be established upon opening MRT Line 6, and an additional 100 staff may be added for Line 1. Site staff, such as stations, drivers, and maintenance staff, shall be added separately.

Table 5.4 Operation & Maintenance Cost

Unit: Million USD

Year	Train Operation	Staff Salary	Sevcices	Car Maintenance	Facility Maintenance	Additional Car	Total
2025	4.67	10.09	6.38	5.33	11.67	0.00	38.13
2026	6.22	13.45	8.50	7.11	15.56	0.00	50.85
2027	6.22	13.45	8.50	7.11	15.56	0.00	50.85
2028	6.22	13.45	8.50	7.11	15.56	0.00	50.85
2029	6.22	13.45	8.50	7.11	15.56	0.00	50.85
2030	6.75	15.14	8.50	7.71	16.88	160.00	214.98
2031	6.75	15.14	8.50	7.71	16.88	0.00	54.98
2032	6.75	15.14	8.50	7.71	16.88	0.00	54.98
2033	6.75	15.14	8.50	7.71	16.88	0.00	54.98
2034	6.75	16.82	8.50	7.71	16.88	0.00	56.66
2035	7.91	16.82	8.50	9.04	19.78	156.80	218.84
2036	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2037	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2038	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2039	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2040	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2041	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2042	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2043	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2044	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2045	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2046	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2047	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2048	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2049	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2050	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2051	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2052	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2053	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2054	7.91	16.82	8.50	9.04	19.78	0.00	62.04
2055	7.91	16.82	8.50	9.04	19.78	0.00	62.04

Source: JICA Study Team

5.3 Economic Evaluation and Financial Analysis

(1) Economic Evaluation

1) Assumptions

The study team conducted discounted cash flow analysis to assess the MRT Line 1project. The economic internal rate of return (EIRR) was calculated to determine the viability of project. The following assumptions and standardizations were adopted for calculation of EIRR.

- The duration of the project was assumed to be 40 years – construction period of 10 years and operating period of 30 years.
- Traffic assignment was done for the year of 2025 and 2035, and the economic benefits were estimated for the two years and an interpolation was done for

intermediate years. The economic benefits are the savings owing to the reduction in vehicle operation cost (VOC) and travel time cost (TTC) which are calculated from the result of traffic assignment. After 2035, economic benefit was assumed not to change.

- Social discount rate was assumed at 12%.
- Economic cost of a project was assumed to be 80% of the financial cost of project.
- Exchange rate was set as 1 TK = 0.0130 US$ on July 2015.

2) VOC and TTC

The unit cost of VOC and TTC were required to calculate the economic benefits. The following costs were applied as the unit of cost of VOCs. It was estimated by RHD. However the unit costs were converted to value of 2014 based on growth of GDP.

Table 5.5 Vehicle Operation Cost (VOC)

Unit: TK / Vehicle / Km

Car	Motorcycle	CNG	Bus	Truck
15.0	2.0	3.7	23.0	21.5

Source: JICA study team estimated based on RHD Road User Cost Annual Report for 2004 - 2005

TTCs each mode were estimated based on household income and working/ business trip shares by using result of household interview survey. Unit TTCs was assumed to growth in line with GRDP per capita of the study area.

Table 5.6 Travel Time Cost (TTC)

Unit: TK / min / person

Year	Car	Motorcycle	CNG	Bus	Truck
2014	6.3	3.0	1.7	1.8	1.8
2025	8.9	4.2	2.4	2.5	2.5
2035	12.0	5.7	3.2	3.4	3.4

Source: JICA Study Team

3) Results of Economic Evaluation

The result of the economic analysis are shown in Table 5.7. The proposed alignment yielded EIRR is 19.4% and greater than 12% social discount rate. This indicates that prosed alignment is economically viable. The result also shows large ENPV (economic net present value).

Table 5.7 Public Transportation Project Economic Evaluation Results

Indicator	Unit	Value
EIRR	%	19.4%
FNPV	US$ Million	775.3
B/C Ratio		1.65

Source: JICA Study Team

A sensitive analysis was carried out to determine the sensitivity of EIRR to changes in costs and benefits. The results show that a 30% increase in cost accompanied by a 30% decrease in benefits will still render the project economically viable.

Table 5.8 Sensitivity Analysis of Economic Evaluation

	Cost	Change in Costs			
Revenue	**Change**	**Base Case**	**10% up**	**20% up**	**30% up**
Change in Benefits	**Base Case**	19.4%	17.8%	16.5%	15.3%
	10% down	17.7%	16.2%	14.9%	13.8%
	20% down	15.9%	14.5%	13.3%	12.2%
	30% down	13.9%	12.6%	11.5%	10.5%

Source: JICA Study Team

(2) Financial Evaluation

1) Assumptions

Discounted cash flow analysis was used to determine the financial viability of the proposed MRT projects. Cash inflow of the project includes fare revenue. Cash outflows of the project were consisted of recurrent costs such operation and maintenance expenses and capital expenditures. Main assumptions are described below.

- The duration of the project was assumed to be 40 years – construction period of 10 years and operating period of 30 years.
- Traffic assignment was done for the year of 2025 and 2035, and the fare revenue was estimated for the two years and an interpolation was done for intermediate years. After 2035, fare revenue was assumed not to change.
- Fare revenue was calculated based on the following fare settings. As MRT fare, the fare setting of MRT6 project by JICA was applied. Discount rate was assumed at 12%.

Table 5.9 Fare Setting

Year	MRT
2014	16.0 + 2.0/km TK
2025	22.6 + 2.8/km TK
2035	30.6 + 3.8/km TK

Source: JICA Study Team, MRT6 project by JICA, BRT and Corridor Restructuring Implementation Study and Preliminary Design work for the Uttara – Mohakhali – Ramna – Sadar Ghat Corridor in Dhaka by World Bank

2) Results of Financial Evaluation

The result of the financial analysis are shown in Table 5.10. The proposed alignment yielded FIRR is 5.2%. This indicates that prosed alignment is economically viable. The result also shows large FNPV (financial net present value).

Table 5.10 Public Transportation Project Financial Evaluation Results

Indicator	Unit	Value
FIRR	%	5.2%
FNPV	US$ Million	-707.3
B/C Ratio		0.52

Source: JICA Study Team

A sensitive analysis was carried out to determine the sensitivity of FIRR to changes in costs and benefits. The results show that a 30% increase in cost accompanied by a 30% decrease in benefits will still render the project economically viable.

Table 5.11 Sensitivity Analysis of Financial Evaluation

	Cost	Change in Costs			
Revenue	**Change**	**Base Case**	**10% up**	**20% up**	**30% up**
Change in Benefits	**Base Case**	5.2%	4.3%	3.5%	2.8%
	10% down	4.2%	3.4%	2.6%	1.9%
	20% down	3.2%	2.3%	1.5%	0.8%
	30% down	2.0%	1.1%	0.4%	-0.3%

Source: JICA Study Team

5.4 Social and Environmental Considerations

(1) Scoping for MRT Line 1 Project

It is expected that the MRT Line 1 Project have the smallest number of affected households and will also have lesser impact on the protected area and biodiversity among other projects of the urban transport development scenario. The risk of flooding and inundation is also low because the line will not pass through the flood prone areas. Therefore, the said project is highly recommended as a priority project from the viewpoints of the environmental and social considerations.

The alternative options in the route and structure will be studied in the succeeding feasibility study to avoid and minimize the involuntary resettlement.

The MRT Line 1 alignment shall match with the existing Kuril Flyover, the Dhaka Elevated Expressway (DEE) and the BR double tracks. As an alternative option, The MRT Line 1 will be constructed along the DEE with an elevated structure. However, this route option will cause displacement of hundreds of affected households including shops as stated in the table above. So as to avoid massive involuntary resettlement, the MRT Line 1 should be constructed as an underground structure in the Kuril area.

At the crossing point between the DIT Road and the BR line in Malibag, the Moghbazar-Mouchak Link Flyover will be built on the New Circular Road. The construction will be implemented by the Mininstry of Local Government. The MRT Line 1 ROW will coincide with these flyovers. The ROW of the MRT Line 1 should be underground since there is no enough space to construct the two elevated structures.

The prospective site of the depot (about 25 hectares) is located at the east of Purbachal New Town near the Kanchon Bridge according to the information from DTCA. There is no adequate space for the depot between Kamalapur and Kuril. However, the exact location will be determined at the next feasibility study stage.

In accordance with the JICA Guidelines, the draft scoping is conducted based on the proposed route and structure explained above. The results are summarized in the following matrix (Table 5.11).

Table 5.12 Scoping for MRT Line 1 Development Project

No	Items	Rating		Brief Description
		Pre-Con/ Construction phase	Operation Phase	
Social Environment				
1	Involuntary Resettlement	A-	D	【Pre-construction】 (-) Involuntary resettlement is unavoidable due to additional land acquisition for the facilities of underground stations such as entrance, ventilation and cooling towers. About 100 households might be displaced. In addition, about 300 households in the proposed depot site at East Purbachal might be affected.
2	The poverty group	C	C	• Informal settlers and the poverty group might be included in PAFs.
3	Indigenous and ethnic people	C	C	• There may be indigenous or ethnic people in or around the project site.
4	Local economy such as employment and livelihood, etc.	B±	B±	【Construction】 (+) Employment of skilled and unskilled labor will be expected. (-) Land acquisition will force some small businesses to move out and might cause income loss and unemployment. 【Operation】 (+) MRT may ease traffic congestion and boost regional economic activities along the route. (-) Resettlement and livelihood rehabilitation at the relocation site might take a longer period of time.
5	Land use and utilization of local resources	B-	B+	【Construction】 (-) Land use may be changed at the proposed Purbachal depot site because of conversion of arable land. 【Operation】 (+) Effective utilization of present unused land is anticipated due to new development in the surrounding area.
6	Social institutions such as social capital and local decision- making institutions	B-	B-	【Pre-construction】【Construction】 (-) The impact on local government and communities might be foreseen because of land acquisition and resettlement. (-) Conflict resolution between existing residents and new settlers might take longer in newly resettled community. 【Operation】 (-) The impacts to local government and communities might continue. (-) Development of new community of existing residents and new settlers might take longer.
7	Existing social infrastructures and services	B-	D	【Construction】 (-) Public facilities might be affected and construction works may inconvenience the communities.
8	Misdistribution of benefits and damage	B-	B-	【Construction】【Operation】 (-) Involuntary resettlement might cause the misdistribution of benefits and damage.
9	Local conflict of interests	B-	B-	【Construction】【Operation】 (-) Involuntary resettlement might cause the local conflict of interest.
10	Water Usage or Water Rights and Rights of Common	C	D	【Construction】 • Underground tunnel might affect groundwater flow and quality. 【Operation】 • Water usage or water rights, rights of common may not be changed since the routes of the alternative options will be planned along the existing roads.
11	Historical/ Cultural heritage	C	C	• No historical/cultural heritage will be directly affected since there is no such heritage in the ROW of MRT Line 1. During the succeeding feasibility study stage, survey whether or not there is any locally important monument affected along the alignment.
12	Landscape	B-	B-	【Construction】 (-) The railway will employ mostly viaducts and bridges. Local aesthetic views might be disturbed temporarily during construction. 【Operation】 (-) Aesthetic value of the town scape might be affected due to viaducts.

No	Items	Rating		Brief Description
		Pre-Con/ Construction phase	Operation Phase	
13	Gender, Children's right	B-	B-	【Construction】【Operation】 (-) Involuntary resettlement might affect "Gender" and "Children's Rights".
14	Work environment (occupational health/ safety)	B-	D	【Construction】 (-) Sanitary conditions will become unfavorable if enough portable toilets and litter bins are not provided at the construction site. (-) Noise & vibration at construction works might affect workers' health conditions.
15	Hazards (Risk) Infectious diseases such as HIV/ AIDS	B-	D	【Construction】 (-) Most construction workers will be hired locally. However, infectious diseases such as HIV/ AIDS might be spread due to workers from outside and poor sanitary conditions.
Natural Environment				
16	Topography and Geological features	B-	C	【Construction】 (-) There is a risk of land slide, slope failure and subsidence due to land alteration.
17	Soil Erosion	B-	D	【Construction】 (-) Construction activities that could lead to soil erosion brought about by rainfall and runoff include clearing vegetation, placing fill, open cut and soil removal.
18	Groundwater	C	C	• Open cut for underground tunnel and structures might affect groundwater flow and table.
19	Hydrological Situation (flooding)	C	C	【Pre-Construction】【Operation】 • The alignment will not go through the flood prone zone. However, confirm that the railway structures will not increase the risk of flooding and inundation.
20	Flora, Fauna and Biodiversity	B-	C	【Construction】 (-) Trees and vegetation within the construction limit might be removed. 【Operation】 • No protected area is located in the vicinity of the railway route. • Loss of habitat is likely to occur in wetland in the proposed Purbachal depot site and Khilkhet to airport area because of reclamation. Exact location of the depot is not specified yet.
21	Meteorology	D	D	• No impacts are expected through the project activities.
22	Global Warming	B-	C	【Construction】 (-) The operation of construction machines and vehicles will emit CO_2 temporarily but the impact on global warming will be slight. (-) Trees removal and land alteration might have impacts to global warming. 【Operation】 • The project may contribute to the ease of traffic congestion and decrease of CO_2 emission.
Pollution Control				
23	Air Pollution	B-	B+	【Construction】 (-) Emission of pollutants due to the operation of construction machines and vehicles might slightly deteriorate the ambient air quality. 【Operation】 (+) The project may contribute to the ease of traffic congestion and decrease of air polluting emissions.
24	Water Pollution	B-	B-	【Construction】 (-) Surface water will be likely to be deteriorated by suspended solids discharged from construction sites. 【Operation】 (-) Untreated wastewater from stations and maintenance facilities in the depot might deteriorate the surface water quality.
25	Soil Contamination	B-	B-	【Construction】 (-) Oil and grease emitted from ill-serviced construction machines and heavy vehicles might contaminate soil at the construction site. 【Operation】 (-) Soil contamination resulting from leaks of lubricants agents and used oil at the maintenance facilities in the Depot.

No	Items	Rating		Brief Description
		Pre-Con/ Construction phase	Operation Phase	
26	Waste	B-	B-	【Construction】 (-) Construction work may generate solid waste such as removed soil. Construction workers may also create additional garbage. 【Operation】 (-) Improper disposal of solid waste from stations and maintenance facilities in the depot might deteriorate the environmental quality of surrounding communities.
27	Noise and Vibration	B-	B-	【Construction】 (-) Noise and vibration due to construction activities and vehicles will be likely to affect the nearby communities. 【Operation】 (-) Noise and vibration will cause a nuisance along the route, especially for residential and noise sensitive areas.
28	Ground Subsidence	C	C	【Construction】【Operation】 • Since the facilities might be constructed on the soft ground, appropriate filling method should be selected to avoid ground subsidence.
29	Offensive Odors	D	D	• No impacts are expected through the MRT Line 1 Project.
30	Bottom sediment	B-	D	【Construction】 (-) Suspended solids discharged from construction sites might settle on bottom sediment on the nearby rivers and creeks. (-) Discharge of oil and grease emitted from ill-serviced construction machines, heavy vehicles and water from the site might degrade bottom sediment quality.
Others				
31	Accidents	B-	B+	【Construction】 (-) Traffic accidents are likely to occur due to the increase of construction vehicles. 【Operation】 (+) No accidents are anticipated since tracks will be elevated or underground. There will be no level crossing.

Source: JICA Study Team

Rating:

A±: Significant positive/ negative impact is expected.

B± : Some positive/ negative impact is expected.

C: Extent of positive/ negative impact is unknown. (A further examination is needed, and the impact could be clarified at the succeeding study stage.)

D: No impact is expected. IEE/EIA is not necessary.

(2) Expected Environmental Impacts of the MRT Line 1 Project

The expected impacts on social and natural environment during construction phase and operation phase are shown in the following tables. Mitigation measures including monitoring plan are also suggested in the tables.

1) Construction Phase

The environmental impacts due to construction of viaducts and underground tunnels are foreseen in the table below.

Table 5.13 Expected Environmental Impacts and Mitigation Measures - Construction Phase

Items	Environmental Impact	Mitigation Measures/ Monitoring Plan
Social Environment		
Involuntary Resettlement	• Involuntary resettlement is unavoidable due to additional land acquisition for the facilities of underground stations such as entrance, ventilation and cooling towers. About 100 households might be displaced. In addition, about 300 households in the proposed depot site at East Purbachal might be affected.	• Implementation of Resettlement Action Plan (RAP) to ensure that affected households and establishments are provided a proper relocation area and/or justly compensated. • Implementation of the Internal and External Monitoring of RAP to monitor the livelihood of relocated PAFs
The poverty group	• Informal settlers and the poverty group might be included in PAFs. • Informal settlers might be dwelled in the BR ROW from the section from Khilket to Gazipur through Tongi.	• Implementation of RAP to ensure that affected informal settlers are provided a proper relocation site and/or justly compensated. • Income restoration and livelihood development program for informal settlers and vulnerable persons (women-headed households, elderly, persons with disabilities and poor).
Indigenous and ethnic people	• There may be indigenous or ethnic people in or around the project site.	(Refer to the poverty group.)
Local economy such as employment and livelihood, etc.	• Employment of skilled and unskilled labor will be expected. • Land acquisition will force some small businesses to move out and might cause income loss and unemployment.	• The project proponent will mandate contractor to give priority to the local residents. • Implementation of RAP to ensure that affected PAFs including vendors and tenants are provided a proper relocation area and/or to ensure that replacement cost for the losses of affected business establishments and income loss. • Income restoration and livelihood development program for PAPs whose present mean of livelihood is now longer viable and will have to engage in a new income activity.
Land use and utilization of local resources	• Land use may be changed at the proposed Purbachal depot site because of conversion of arable land.	• Implementation of RAP to ensure that affected farmers are provided an equivalent productive land and/or justly compensated.
Social institutions such as social infrastructure and local decision-making institutions	• The impact on local government and communities might be foreseen because of land acquisition and resettlement. • Conflict resolution between existing residents and new settlers might take longer in newly resettled community.	• Implementation of RAP to ensure the integration of the host community with the resettled PAFs at the relocation sites.
Existing social infrastructures and services	• Public facilities might be affected and construction works may inconvenience the communities.	• Implementation of RAP to ensure that affected public facilities are relocated or justly compensated.
Misdistribution of benefits and damage	• Involuntary resettlement might cause the misdistribution of benefits and damage.	• Implementation of RAP to ensure that affected PAFs including vendors and tenants are provided a proper relocation area and/or to ensure that replacement cost for the losses of affected business establishments and income loss. • Income restoration and livelihood development program for PAPs whose present mean of livelihood is now longer viable and will have to engage in a new income activity.
Local conflict of	• Involuntary resettlement might cause the	• Implementation of the RAP to ensure the

Items	Environmental Impact	Mitigation Measures/ Monitoring Plan
interests	local conflict of interest.	integration of the host community with the resettled PAFs at the relocation sites.
Water Usage or Water Rights and Rights of Common	• Open cut for underground tunnel and structures might affect groundwater flow and table.	• To protect groundwater flow, appropriate construction methods such as tunnel boring machine (TMB) method or groundwater flow conservation method should be considered.
Historical/ Cultural heritage	• The locally important facilities such as monuments might be affected.	• During the succeeding feasibility study stage, survey whether or not there is any locally important monument affected along the alignment. • The preservation plan will be considered to integrate it into the development design if such facilities are existed.
Landscape	• Local aesthetic views might be disturbed temporarily during construction.	• Design on facilities will be harmonized with the surrounding landscape.
Gender, Children's right	• Involuntary resettlement might affect "Gender" and "Children's Rights".	• Implementation of RAP to ensure that affected ISFs are provided a proper relocation site and/or justly compensated. • Income restoration and livelihood development program for Women-headed households. • Secure the accessibility to go to school at the relocation sites. • Relocation shall be conducted during school holidays
Work environment (occupational health/ safety)	• Sanitary conditions will become unfavorable if enough portable toilets and litter bins are not provided at the construction site. • Noise & vibration at construction works might affect workers' health conditions.	• Provide appropriate sanitary facilities such as temporary toilet and bin at construction site and labor camp. • Provide appropriate personal protective equipment (PPE) to all construction workers. • Strict use of PPE by construction workers • Implement Occupational Health and Safety Management Plan • Put up fences / enclosures around the project site to keep away unauthorized persons • Provide First Aid Stations at construction sites.
Hazards (Risk) Infectious diseases such as HIV/ AIDS	• Most construction workers will be hired locally. However, infectious diseases such as HIV/ AIDS might be spread due to workers from outside and poor sanitary conditions.	• Construction workers submit Medical certificates for fitness to work. • Provide the sanitary facilities (toilets, bins) at all construction sites and labor camps.
Natural Environment		•
Topography and Geological features	• There is a risk of land slide and slope failure since the underground stations will be constructed by the cut and cover method.	• Appropriate construction methods should be selected to prevent land slide and slope failure. • Depot area must be re-graded to match the original topography.
Soil Erosion	• Construction activities that could lead to soil erosion brought about by rainfall and runoff include clearing vegetation, placing fill, open cut and soil removal.	• Use of silt fences and sediment traps, cover exposed earth especially before heavy rains are expected, benching of cuts, use of sediment basins • Provision of surface water runoff drainage systems • Minimize removal of vegetation cover as much as possible • Plan earthwork activities (e.g. excavation, cutting and filling) while considering weather conditions (rainy season)
Groundwater	• Open cut for underground tunnel and structures might affect groundwater flow and table.	• To protect groundwater flow, appropriate construction methods such as tunnel boring machine (TMB) method or groundwater flow conservation method should be considered. • Monitor the groundwater levels and water quality.
Hydrological Situation	• The alignment will not go through the flood prone zone. However, confirm that the	• Detailed hydrological study shall be conducted in the succeeding feasibility study to analyze the

Items	Environmental Impact	Mitigation Measures/ Monitoring Plan
(flooding)	railway structures will not increase the risk of flooding and inundation. • The surface drainage of the area is influenced by Balu River and Shitalakshya River at Purbachal area.	risk of flooding and inundation of structures. • Sufficient and effective drainage systems shall be incorporated in the designs.
Flora, Fauna and Biodiversity	• Trees and vegetation within the construction limit might be removed. • Reclamation of wetland might be occurred at the proposed Pubachal Depot site and Khilkhet to HSIA airport area along the BR line.	• Coordination with concerned agencies or groups for relocation sites of earth-balled trees. • For trees removed, seedlings will be prepared by the proponent for replanting. • Monitor the cutting trees and removal of vegetation. • The offset or restoration plan should be proposed if there are any wetlands to be reclaimed.
Global Warming	• The operation of construction machines and vehicles will emit CO_2 temporarily but the impact on global warming will be slight.	• Regular preventive maintenance of heavy equipment and service vehicles.
• Pollution Control		•
Air Pollution	• Emission of dust due to civil work will cause a health problem at surrounding communities. • Emission of pollutants due to the operation of construction machines and vehicles might slightly deteriorate the ambient air quality.	• Regular wetting of ground soil in the construction site. • Regular preventive maintenance of heavy equipment and service vehicle. • Monitor air quality in the vicinity of construction sites.
Water Pollution	• Surface water will be likely to be deteriorated by suspended solids discharged from construction sites. • Oil and grease emitted from ill-serviced construction machines and heavy vehicles might contaminate surface water quality in the vicinity of construction sites.	• Implementation of appropriate erosion control measures particularly during high precipitation periods. • Soil/sediments/debris and other excavated materials shall be hauled out from the site immediately and disposed by accredited waste handlers • Portable sanitary facilities (portalets) will be installed to collect wastewater, which will be collected and disposed by accredited waste handles • Equipment and machinery shall be regularly checked for fuel and oil leaks. • During repair of equipment and machinery, containers/drip trays shall be used to collect leakage. • Any spilled or spent oil will be collected, stored properly and disposed by accredited waste haulers. • Monitor river water quality in the vicinity of construction sites.
Soil Contamination	• Oil and grease emitted from ill-serviced construction machines and heavy vehicles might contaminate soil at the construction site.	• Provide proper construction machines and heavy vehicles and maintain them properly. • Oil and grease traps in the drainage system. • Establish and implement health and safety management plan and emergency and contingency plan in case of spills.
Waste	• Construction work may generate solid waste such as removed soil. Construction workers may also create additional garbage.	• Submission and implementation of Solid Waste Management Plan as part of contractors' engagement. • Provision of waste bins to avoid dispersal of litter and regular site maintenance duties. • Regular collection, transportation and disposal of wastes to minimize the attraction of vermin, insects and pests. • Recycling of wastes including soil, as much as possible. • Proper sorting of waste for disposal and designation of appropriate temporary storage area.

Items	Environmental Impact	Mitigation Measures/ Monitoring Plan
		• Disposal of non-recyclable wastes by a licensed contractor.
Noise and Vibration	• Noise and vibration due to construction activities and vehicles will be likely to affect the nearby communities.	[Noise] • Installation of control devices such as mufflers and noise suppressors to all construction equipment. • Regular maintenance of heavy equipment, construction machinery. • Provision of temporary noise barriers such as galvanized iron shields, particularly in noise-sensitive areas such as churches, schools, and hospitals in the immediate vicinity of the construction area. • Construction workers must be provided with personal protective equipment (PPE). • Scheduling of high noise generating activities during daytime • Construction sites must be fenced for safety and security reasons. • Monitor the noise levels at residential area and noise sensitive facilities near the construction sites. [Vibration] • Use of construction machinery with minimal vibration generation. • Identify nearby sensitive receptors likely to be affected and monitor vibration levels. • Monitor the vibration levels at residential area and noise sensitive facilities near the construction sites.
Ground Subsidence	• Since the facilities might be constructed on the soft ground, appropriate filling method should be selected to avoid ground subsidence.	• Design of structures and facilities to withstand ground subsidence. • Monitor the depth of ground settlement.
Bottom sediment	• Suspended solids discharged from construction sites might settle on bottom sediment on the nearby rivers and creeks. • Discharge of oil and grease emitted from ill-serviced construction machines, heavy vehicles and water from the site might degrade bottom sediment quality.	• Implementation of appropriate erosion control measures particularly during high precipitation periods. • Soil/sediments/debris and other excavated materials shall be hauled out from the site immediately and disposed by accredited waste handlers
Others		
Accidents	• Traffic accidents are likely to occur due to the increase of construction vehicles.	• Strict implementation of Traffic Management Plan (TMP) that details the activities to adequately manage traffic flow. • The TMP will be properly coordinated and approved by Local Government concerned prior to implementation of activities in the areas concerned. • Monitor the traffic congestion of the trunk roads in the vicinity of construction sites.

Source: JICA Study Team

2) Operation Phase

The expected environmental impacts due to operation of MRT trains are described in the table below.

Table 5.14 Expected Environmental Impacts and Mitigation Measures - Operation Phase

Items	Environmental Impact	Mitigation Measures/ Monitoring Plan
Social Environment		
Local economy such as employment and livelihood, etc.	• MRT may ease traffic congestion and boost regional economic activities along the route. • Resettlement and livelihood rehabilitation at the relocation site might take a longer period of time.	• Implementation of the Internal and External Monitoring of RAP to monitor the livelihood of relocated PAFs. • Encourage commercial development at Stations.
Land use and utilization of local resources	• Effective utilization of present unused land is anticipated due to new development in the surrounding area.	• Identification of future land use of surrounding areas that will result to a significant increase in commercial activities especially near train stations, to guide urban planners to adapt future development plans accordingly.
Social institutions such as social infrastructure and local decision-making institutions	• The impacts to local government and communities might continue. • Development of new community of existing residents and new settlers might take longer.	• Implementation of the Internal and External Monitoring of RAP to monitor the integration of the host community with the resettled PAFs at the relocation sites.
Misdistribution of benefits and damage	• Involuntary resettlement might cause the misdistribution of benefits and damage.	• Implementation of the Internal and External Monitoring of RAP to monitor the livelihood of relocated affected families.
Local conflict of interests	• Involuntary resettlement might cause the local conflict of interest.	• Implementation of the Internal and External Monitoring of RAP to monitor the integration of the host community with the resettled affected families at the relocation sites.
Landscape	• Aesthetic value of the town scape might be affected due to viaducts.	• Design on facilities will be harmonized with the surrounding landscape.
Gender, Children's right	• Involuntary resettlement might affect "Gender" and "Children's Rights".	• Implementation of the Internal and External Monitoring of RAP to monitor the livelihood of relocated PAFs.
Natural Environment		
Hydrological Situation (flooding)	• The alignment will not go through the flood prone zone .However, confirm that the railway structures will not increase the risk of flooding and inundation.	• Confirm that the design of the railway structures will not increase the risk of flooding and inundation. •
Flora, Fauna and Biodiversity	• No protected area is located in the vicinity of the railway route. • Loss of habitat is likely to occur at the reclaimed wetland in the proposed Purbachal depot site and Khilket to HSIA airport area.	• Monitoring of survival of trees planted. • Monitor the status of restored or offset wetlands. Conduct seasonal bird count to monitor the bird population in cooperation with DOE.
Global Warming	• The project may contribute to the ease of traffic congestion and decrease of CO2 emission.	• Design in making infrastructure robust or resilient to the effects of climate change should be taken into consideration • Improvement of current drainages along the alignment to be resilient to climate change.
Pollution Control		
Air Pollution	• The project may contribute to the ease of traffic congestion and decrease of air polluting emissions.	• Proper preventive maintenance of service vehicles and equipment • Use of cleaner fuel for the generator sets at maintenance facilities.

Items	Environmental Impact	Mitigation Measures/ Monitoring Plan
Water Pollution	• Untreated wastewater from stations and maintenance facilities in the depot might deteriorate the surface water quality.	• Wastewater with oil shall be separately collected and disposed for treatment. • A wastewater treatment facility with oil removal will be constructed at the depot. • Sanitary facilities at the stations will be installed to collect wastewater, which will be collected and disposed by accredited waste handles
Soil Contamination	• Soil contamination resulting from leaks of lubricants agents and used oil at the maintenance facilities in the Depot.	• Provide proper machines and equipment and maintain them properly. • Store bulk waste oils and lubricants in impermeable area and with appropriate secondary containment. • Emergency and contingency plan in case of spills and health and safety management plan must be in place.
Waste	• Improper disposal of solid waste from stations and maintenance facilities in the depot might deteriorate the environmental quality of surrounding communities.	• Proper segregation of wastes • Provision of waste bins that will allow proper waste segregation • Regular collection and transportation of wastes for recycling or disposal at licensed facilities
Noise and Vibration	• Noise and vibration will cause a nuisance along the route, especially for residential and noise sensitive areas. • Emitted noise level will be predicted based on the train operation schedule. • Vibration level will be also predicted based on the train operation.	[Noise] • Noise barrier will be considered for the sensitive facilities such as school, hospital, etc. near the viaducts. • Detailed survey in measuring the distance from sensitive area should be carried out at detail design stage. • Proper maintenance of structures and tracks, such as regular rail grinding, must be conducted. • Monitor the noise levels. [Vibration] • Design of rail tracks must incorporate measures to reduce level of vibration generated by the railway during train operations, such as use of long rail, sleeper with the anti-vibration mat. • Proper maintenance of trains structures and tracks, such as regular rail grinding, must be conducted. • Regular reconditioning of train and its components, such as suspension system, brakes, wheels and slip-slide detectors. • Monitor the vibration levels.
Ground Subsidence	• Since the facilities might be constructed on the soft ground, appropriate filling method should be selected to avoid ground subsidence.	• Regular monitoring and measurement of level of ground subsidence.
Others		
Accidents	• No accidents are anticipated since tracks will be elevated or underground. There will be no level crossing.	• Designate and provide for loading and unloading areas. • Fielding of traffic enforcers near the stations • Provide bus terminals and CNG bays.

Source: JICA Study Team

(3) Scope of EIA for the MRT line 1 Project

The MRT Line 1 project is regarded as Category A in accordance with the JICA Guidelines because this is the large-scale projects in the sector of roads, railways and bridges. In addition to this, large-scale involuntary resettlement will be foreseen. Therefore, based on the results of scoping for the priority projects, the Terms of Reference (TOR) for EIA and RAP is proposed for the succeeding feasibility study.

The significant and potentially significant impacts to be studied are selected based on the scoping matrix (Table 17.4). The scope and methods for the survey are summarized in the TOR in Table 17.10.

Table 5.15 TOR for MRT Line 1 Development Project

Impact Items	Survey Items	Methods of Survey/Prediction/Assessment
Alternatives		
Analysis of Alternatives	1. Alignment 2. Location of depot 3. Structure type - Elevated, at grade or underground	To conduct the comparative analysis from the following viewpoints: 1. Cost, construction method and period, operation & maintenance, traffic management 2. Land acquisition and involuntary resettlement 3. Environmental impacts and pollution prevention 4. Flood risk
Stakeholder Consultation		
Stakeholder Consultation	1. Stakeholders (relevant government agencies, local government units, community organization, business association, NGOs, etc.) 2. Project Affected Persons (PAPs)	Stakeholder Consultation Meetings: 1. Draft Scoping Stage 2. Draft Report Stage Focus Group Discussions: 1. Informal Settlers 2. Social Vulnerable Group The meeting of each stage will be held by DTCA at several venues for the affected local government units along the alignment.
Pollution Prevention Measures		
Air pollution	1. Air Quality Standards 2. Present conditions of air quality 3. Sensitive receptors and their location 4. Impact during construction 5. Increase/decrease of air pollutants at operation stage	1. Data collection: ・Survey on existing/secondary data ・Actual field measurement 2. Construction ・Based on the construction plan, estimate the emission of pollutants from operation of construction machines and heavy vehicles, and compare the predicted concentrations with the ambient air quality standards. 3. Operation ・Qualitatively assess the positive effect on improvement of ambient air quality due to the modal shift from vehicle to railway transport.
Water pollution	1. Water Quality Standards 2. Present conditions of surface water quality 3. Water use 4 Impacts during construction 5. Discharge of wastewater from the facilities at operation stage	1. Data collection: ・Survey on existing/secondary data ・Actual field measurement 2. Construction ・Based on the construction plan, estimate the generation of suspended solids from the construction work such as piling, predict the diffusion of turbid water and assess the impacts on river water quality. 3. Operation ・Predict the impacts on surface water quality due to the discharges of wastewater from stations, depot facilities and substations
Soil	1. Soil Quality Standards	1. Data collection:

Impact Items	Survey Items	Methods of Survey/Prediction/Assessment
contamination	2. Present conditions of soil quality 3. Record of soil contamination 4. Impacts during construction 5. Spill of oil and chemicals in the depot at operation stage	・Survey on existing/secondary data ・Actual field measurement 2. Pre-construction ・Record of soil contamination and remediation 3. Operation ・Survey the activities in the depot which cause spilling of oil and chemicals on soil
Waste	1. Local government policy and procedures for solid waste management 2. Construction waste generation during construction 3. Waste generation in the stations and depot at operation stage	1. Survey on existing/secondary data 2. Construction ・Based on the construction plan, estimate the generation of solid waste and by-products, and assess the impacts on the present practices 3. Operation ・Estimate the generation of solid waste at the stations, depot facilities and substations, and assess the impacts on the present practices
Noise and vibration	1. Standards for Noise and Vibration 2. Present levels of noise and vibration 3. Distance to sensitive receptors such as schools 4. Impacts during construct 5. Noise and vibration levels due to train operation	1. Data collection: ・Survey on existing/secondary data ・Actual field measurement 2. Construction ・Based on the construction plan, estimate the emissions of noise and vibration from the operation of construction machines and heavy vehicles, predict and assess the surrounding sound environment to compare the environmental standards 3. Operation ・Predict the emitted noise and vibration from trains and assess the surrounding sound environment to compare the environmental standards
Ground subsidence	1. Geotechnical data 2. Impacts during construction	1. Data collection: ・Survey on existing/secondary data ・Actual measurement of geotechnical data 2. Construction ・Based on the design and construction methods of tunnels and underground facilities, study whether or not ground subsidence will occur.
Offensive odor	No sources of offensive odor are expected due to this project.	-
Bottom sediment	1. Bottom Sediment Standards 2. Present conditions of bottom sediment 3. Impacts during construction 4. Discharge of contaminants from the facilities at operation stage	1. Data collection: ・Survey on existing/secondary data ・Actual field measurement 2. Construction ・Based on the construction plan, predict the impacts on benthos due to turbid water and/or disturbance due to construction work of bridge piers, e.g., piling 3. Operation ・Evaluate the impacts on sediment quality due to wastewater from the facilities at the stations and depot
Natural Environment		
Topography and Geological features	1. Existing conditions on geologically and geomorphologically hazard locations, such as soft ground 2. Impacts by cut and cover construction	1. Data collection: ・Survey on existing/secondary data ・Actual measurement of geotechnical data 2. Construction ・Based on the construction plan, predict and assess the risk of land slide, slope failure and subsidence due to land alteration
Soil Erosion	1. Existing soil conditions 2. Impacts during construction	1. Data collection: ・Survey on existing/secondary data

Impact Items	Survey Items	Methods of Survey/Prediction/Assessment
		2. Construction ・Based on the construction plan, evaluate the possibility of soil erosion and soil runoff at the construction sites
Hydrological Situation (flooding)	1. Existing conditions on flood prone 2. Impacts during construction 3. Inundation risk at operation stage	1. Data collection: ・Survey on existing/secondary data 2. Construction ・Based on the structure design, predict the impacts on hydraulic conditions of natural drainage channels and assess the risks of flooding and inundation. 3. Operation ・Assess the risk inundation of railway facilities especially underground tunnels
Groundwater	1. Groundwater quality standards 2. Present conditions on groundwater 3. Impacts during construction 4. Groundwater contamination due to discharge of wastewater from the facilities at operation stage	1. Data collection: ・Survey on existing/secondary data ・Actual field measurement 2. Construction ・Based on the underground facilities design and construction methods, predict and assess the impacts on groundwater flow and quality 3. Operation ・Predict the impacts on groundwater quality due to the discharges of wastewater from the station facilities
Protected area	1. Policy on conservation of protected areas 2. Distance between protected area and the railway track	There is no protected area in the vicinity of the project site 1. Data collection: ・Survey on existing/secondary data ・Satellite image
Flora, fauna and biodiversity	1. Policy on conservation of threatened species of flora and fauna 2. Present conditions on flora and fauna 3. Impacts during construction, e.g., cutting trees and removal of vegetation	1. Data collection: ・Survey on existing/secondary data ・Actual field survey 2. Construction ・Based on the construction plan, estimate the land alteration area to cut trees and remove vegetation
Social Environment		
Involuntary Resettlement	1. Policy on land acquisition and involuntary resettlement 2. Affected area due to land acquisition 3. Affected structures 4. Project Affected Persons (PAPs) 5. Relocation sites for affected informal settlers	1. Data collection: ・Survey on existing/secondary data of affected area ・Actual field survey and interview survey 2.Pre-construction ・The draft RAP will be prepared based on the result of: - Socio-economic surveys - Public consultation meetings and focus group discussion - Relocation site development plan
The Poor	1. Definition of the poor 2. Existence of Informal Settlers in PAPs 3. Livelihood/living conditions	(Refer to involuntary resettlement)
Ethnic minorities and indigenous people	1. Policy on ethnic minorities and indigenous people 2. Existence of ethnic minorities and indigenous people in PAPs 3. Livelihood/living conditions	(Refer to involuntary resettlement)
Local economy such as employment and livelihood, etc.	1. Present conditions of local economy and employment 2. Affected commercial and business temporarily or permanently 3. Livelihood of local transport workers, e.g., rickshaw	1. Data collection: ・Survey on existing/secondary data of affected area ・Actual field survey and interview survey 2. Pre-construction ・The draft RAP will be prepared based on the result of: - Socio-economic surveys

Impact Items	Survey Items	Methods of Survey/Prediction/Assessment
	pullers	- Public consultation meetings 3. Construction ・Assess the positive impacts on the local economy due to employment of the construction workers. 4. Operation ・Assess the positive impacts on the local economy due to development of Purbachal area
Land use and utilization of local resources	1. Land use plan (RAJUK) 2. Present land use 3. Changes in land use, e.g., conversion of arable land at the proposed depot site	1. Data collection: ・Survey on existing/secondary data ・Actual field survey and interview survey 2. Pre-construction ・The draft RAP will be prepared including compensation for agricultural land if any at the proposed depot site. 3. Construction and Operation ・Assess the impacts on land use change.
Social institutions such as social capital and local decision-making institutions	(Refer to involuntary resettlement)	(Refer to involuntary resettlement)
Existing social infrastructures and services	1. Policy on land acquisition and involuntary resettlement 2. Affected social infrastructure and utility services	1. Data collection: ・Survey on existing/secondary data ・Actual field survey and interview survey 2. Pre-construction ・The draft RAP shall include compensation for affected social infrastructures.
Misdistribution of benefit and/or damage	(Refer to involuntary resettlement)	(Refer to involuntary resettlement)
Local conflict of interests	(Refer to involuntary resettlement)	[Construction] [Operation] • Predict and assess the influence on local communities in terms of the station locations.
Water usage or water rights and rights of common	1. Policy on usage of water resources 2. Present water usage and existing water rights 3. Domestic/potable water sources	1. Data collection: ・Survey on existing/secondary data ・Actual field survey and interview survey 2. Construction ・Based on the underground facilities design and construction methods, predict and assess the impacts on groundwater sources. ・Assess the impacts on navigation of rivers and creeks during construction.
Historical/ cultural heritage	1. Policy on preservation of historical/cultural heritage 2. Existing conditions 3. Affected historical/cultural heritage	1. Data collection: ・Survey on existing/secondary data ・Field reconnaissance 2. Construction ・Assess the impacts on the historical/cultural heritages by railway facilities siting plan and construction work.
Landscape	1. Policy on preservation of landscape resources 2. Existing conditions 3. Affected landscape resources temporarily and permanently	1. Data collection: ・Survey on existing/secondary data ・Field reconnaissance 2. Construction and Operation ・By using visual presentation methods such as perspectives, evaluate the visual impacts on the city scape referring to the opinions and comments obtained through public consultation.
Gender	(Refer to involuntary resettlement)	(Refer to involuntary resettlement) • The draft RAP shall be prepared with special attention to the

Impact Items	Survey Items	Methods of Survey/Prediction/Assessment
Children's right	(Refer to involuntary resettlement)	vulnerable groups such as women, children, elders and disabilities.
Hazards (Risk) of Infectious diseases such as HIV/AIDS	1. Policy and measures of DTCA and local governments for preventing Infectious diseases 2. Present conditions 3. Impact during construction	1. Data collection: ・Survey on existing/secondary data 2. Construction ・Based on the DTCA policy and measures for preventing HIV/AIDS, predict the possibility of propagation of infectious diseases, by drawing from examples of similar projects.
Occupational health and safety	1. Regulations on health and safety management 2. Impact on construction workers during construction 3. Impact on operational personnel at the operation stage	1. Data collection: ・Survey on existing/secondary data 2. Construction ・Based on the construction plan, due to the improper work/operations and/or poor working conditions, predict and assess the impacts on health and safety of workers. 3. Operation ・Predict and assess the impacts on health and safety of workers at train operation and maintenance.
Others		
Global Warming	1. Policy and measures against global warming 2. Impacts during construction 3. Decrease or increase of GHG emission at operation stage	1. Data collection: ・Survey on existing/secondary data 2. Construction ・Based on the construction plan, estimate the emission of CO2 from operation of construction machines and heavy vehicles, and assess the impacts on global warming. 3. Operation ・Based on the predicted future traffic demand, estimate the increase or decrease of CO2 emission for both with and without-project cases and compare the difference.
Accidents	1. Present practice of traffic management 2. Impacts during construction 3. Traffic management at operation stage	1. Data collection: ・Survey on existing/secondary data 2. Construction ・Based on the construction plan, evaluate the risk of traffic accidents 3. Operation ・Assess the traffic conditions of main roads at stations

Source: JICA Study Team

5.5 Public Participation

Participation of stakeholders from an early stage is indispensable in developing the RSTP and in conducting the Social and Environmental Impact Assessment to ensure social acceptability and sustainability of the projects. This participative process is one of important aspects of the Strategic Environmental Assessment (SEA), according to the JICA Guidelines.

Four (4) stakeholder consultation meetings were held by DTCA at Kamalapur, Rampur, Kalachandpur and Uttara along the route of proposed MRT Line 1 as shown in Table 17.8.

In these consultation meetings, the overview of RSTP and urban transport development scenario, the outline of the proposed priority project and the environmental and social considerations on the priority project were presented to obtain their opinions and comments of stakeholders.

The main opinions and views of participants are summarized in Table 17.9, together with how these comments should be reflected in the design and EIA study at the next feasibility study.

Table 5.16 Scadule of Stakeholder Consultation Meetings

Date and Time	Target Area	Main Participants	No. of Participants
August 6, 2015, 11:30 - 13:30	Kamalapur Sadek Hossen Khoka Community Centre	Ward councilors, Women's group, Religious leaders, Teachers of Educational Institutes, Business Association and store owners, Residents, DTCA	27 Male: 22 Female: 5
August 6, 2015, 15:45 - 17:40	Rampur Bazar Purba Rampura High School	Ward councilors, LGUs officials, Women's group, Religious leaders, Teachers of Educational Institutes, Business Association and store owners, Residents, NGO, DTCA	46 Male: 37 Female: 9
August 16, 2015, 11:30 - 13:30	Kalachandpur Ward Councilor's Office in Kalachadpur	Ward councilors, LGUs officials, Women's group, Religious leaders, Business Association and store owners, Residents, DTCA	33 Male: 23 Female: 10
August 17, 2015, 11:45 - 13:40	Uttara (near Tongi) Zone-1 Office of Dhaka North City Corporation	Ward councilors, LGUs officials, Women's group, Religious leaders, Residents, Business Association and store owners, DTCA	85 Male: 73 Female: 12

Source: JICA Study Team

Table 5.17 Summary of Main Opinions/Comments of Stakeholder Consultation Meetings

Major Opinions/Comments	Reply/Countermeasures
Kamalapur	
This project will be very positive for the local people. Government should prioritize this project and build as early as possible.	Representative of DTCA noted.
What distance may consider for two adjacent stations.	Minimum distance is between 700-1000m.
Traffic congestion will be increased.	Traffic management plan will be considered.
Soil quality of Dhaka city is very poor and soft. The proposed structure may collapse.	Adequate drainage facilities will be designed and developed.
Land acquisition due to the implementation of the Project especially in congested densely populated areas	Land acquisition will be minimized as the Project will be constructed in the median of the existing road. However, a few land acquisitions may require at the station areas.
Due to the construction of the metro rail project, existing environment will be imbalance. Trees will be cut.	The mitigation measures will be prescribed in the Environmental Management Plan, including a tree plantation plan.
Rampur Bazar	
This project will be very positive for the local people. Government should prioritize this project and build as early as possible.	Representative of DTCA noted.
Metro train design and locomotives should use latest technology.	Representative of DTCA noted.
The existing roads are not enough to support the extended traffic carrying construction materials. Traffic congestion will increase.	Existing road transport development will be recommended prior to the construction. Traffic management plan will be considered.
General road traffic is getting of poorer situation due to huge number of private vehicles.	After implementation of MRT, number of private vehicles on the roads will reduce.
Proposed metro rail will cause land acquisition throughout the proposed alignment.	Land acquisition will be minimized as the Project will be constructed in the median of the existing road.

Major Opinions/Comments	Reply/Countermeasures
Government must ensure proper compensation for project affected people.	Issues of rehabilitation and compensation to PAPs will be referred to the social safeguard policy.
Sound pollution during construction and operational period should be minimised.	The mitigation measures will be prescribed in the Environmental Management Plan (EMP).
Due to the construction of the metro rail project, existing environment will be imbalance. Trees will be cut.	The mitigation measures will be prescribed in the EMP, including a tree plantation plan.
Adequate waste management facility should be developed.	Adequate and international standard solid waste management system will be a part of this Project.
Tariff to use MRT should be as low as possible to that mass people can use it.	Tariff will be low if this project will be under JICA's soft loan policy.
Kalachandpur	
The project must be implemented to reduce the existing traffic congestion and reduce the valuable travel time of the people.	Representative of DTCA noted.
How government will provide this power to run its smooth operation as he have limited power supply.	Dedicated and uninterrupted power supply will be installed only for metro rail.
In the case of underground metro: ・ drainage system ・ construction method for soft soil in Dhaka city	Adequate drainage facilities will be designed and developed. The depth of the underground metro will be around 30m.
Earthquake resilience. Water penetration to tunnel since ground level/table is shallow	All structures will be earthquake resilience. The design of the tunnel will be water proof.
Minimum distance between two stations and the nearest stations from 18 No. Ward	Minimum distance is between 700-1000m. Specific location of the station has not been finalized yet.
Land acquisition due to the implementation of the Project especially in congested densely populated areas	Land acquisition will be minimized as the Project will be constructed in the median of the existing road. However, a few land acquisitions may require at the station areas.
Maintenance (cleanliness) of the metro rail and its stations. Solid waste management facility of metro rail	An awareness program will be developed for the passengers and adequate dustbin will be provided. A high quality solid waste management system will be a part of the metro rail system.
Safety and security of the passengers especially in underpasses.	CCTV camera and security guards will be at surveillance at all times.
Facilities for the physically disabled passengers.	They will obtain all convenient facilities to access the station counters and platform. Reserve seats are provided in the metro.
How to mitigate technical fault of metro rail in between of two stations. Possibility of accident.	Representative of DTCA replied that This is not a traditional train. This metro train will be controlled from central control centre. There will be no chance of accident as incoming and outgoing trains will have its own lines. Technical problem of this train will be detected automatically in advance.
Suggested to have the following facilities for women: ・ Reserved seat for women ・ Separate toilets for women at the stations ・ Separate ticketing counters ・ Separate queue and access to metro	Representative of DTCA replied that discuss all your recommendations with technical JICA team as well as government to incorporate them.

Major Opinions/Comments	Reply/Countermeasures
Uttara	
This project is crucial for Dhaka city as well as for Uttara to reduce existing traffic, and it must build as quickly as possible.	Representative of DTCA noted.
Extension of the starting point of the proposed alignment from Tongi instead of International Airport in Phase I.	Representative of DTCA explained that after implementation of the proposed BRT project from Joydebpur to Kamlapur, there will be less traffic and dwellers of Uttara do not need to wait for MRT.
Suggested to join MRT Line 6 with Line 1 at some point of Uttara so that people whoever using Line 6 or 1 can easily to nearby locations of Line 1 or 6.	Representative of DTCA noted.
Tariff to use MRT should be as low as possible to that mass people can use it.	Tariff will be low if this project will be under JICA's soft loan policy.
Lot of waste will be generated in station areas. Adequate waste management facility should be developed as per international standards.	Adequate and international standard solid waste management system will be a part of this Project.
A woman said the existing traffic is getting worse due to uncontrolled pedestrian crossing and illegal shops on the road side. They are not using foot over bridge.	Representative of DTCA replied that after implementation of MRT, number of private cars on the roads will reduce.
Suggested to have the following facilities for women: ・ Reserved seat for women ・ Separate toilets for women at the stations ・ Separate ticketing counters ・ Separate queue and access to metro	Representative of DTCA replied that discuss all your recommendations with technical JICA team as well as government to incorporate them.

Source: JICA Study Team

Overall, participants were supportive of the scenario and the proposed MRT Line 1 Project. They recognized the need for the project given the increasing demand in the study area. They feel the Project has national interest that will bring economic development to their area and to the country. There were no objections to the project at four meetings. However, the following points should be considered in the design and EIA study at the feasibility study stage.

- Minimization of land acquisition and involuntary resettlement;
- Design for gender consideration on facilities and trains;
- Environmental management plan to mitigate adverse impacts on safety, health and environment of surrounding communities during construction and operation; and,
- Traffic management plan during construction.

6. PROPOSED IMPLEMENTATION STRATEGY

6.1 Implementation Strategy

(1) Project Sequence

Figure 6.1 shows the development timeline of the rail transit section of MRT Line 1 from its inception in 2016 to operational revenue within 9 to 10 years or about year 2025 depending on the phasing of the project. The schedule is based on the premise of the Government of Bangladesh making use of ODA bilateral fund sources for part of, or the whole project. This financing mode will entail a minimum 2 years lead-time, before actual tendering or construction of the civil and structural works contract can commence. The normal and mandatory stages on which the project will go through to use ODA funds are as follows:

- Preparation of the feasibility study;
- Evaluation of the study and inclusion of the project in the lending agency's portfolio;
- Appoint a consultant to carry out the basic engineering design including the
- Preparation of detailed design, bill of quantities, and firm cost estimates;
- Preparation of bid documents, followed by bidding, evaluation and award;
- Actual construction of the civil works, with the manufacture and installation of the electromechanical systems components following suit;
- Testing and commissioning;
- Commercial revenue service or operation

If the Bangladesh Government chooses to finance the project with its own internal resources, it could perhaps shorten the project development period of the project implementation schedule by about 2 years. However, the government would still have to undertake detailed engineering works for the civil works as well as the various electromechanical systems which would take about 12 to 15 months therefore the potential time savings would only be about twelve (12) months if the Bangladesh government was to fund the transit system from its own fund sources.

The Design and project management of a modern MRT system implementation programme would most likely require the assistance from experienced foreign consultants as the required urban mass rail transit expertise is not available domestically. Rail transit systems are not off-the-shelf commodity products; they are purpose built to order and adapted to meet the particular needs of every city. But before they can be built and operate successfully, the manufacturer or systems supplier must know what the buyer/operator wants – which means detailed technical performance specifications will have to be prepared by the project consultants.

(2) Project Schedule

As indicated earlier, there is no extreme urgency for Dhaka to commit to a rail transit line in the short term and then rush its development and implementation. Therefore the government of Bangladesh It has the benefit of time to fully develop the basic engineering concepts included in this study and project implementation schedule to match the demand forecast for public transit project on this corridor. The study team would caution against the government committing too early to a particular individual supplier or manufacturer which may or may not be the most favourable option for the government of Bangladesh, in terms of cost, technology risk and potential unforeseen

delays in the project implementation due to affordable project financing (such as ODA) not being readily available. A competitive bidding process with international suppliers/contractors will most probably result in an overall lower project cost the government.

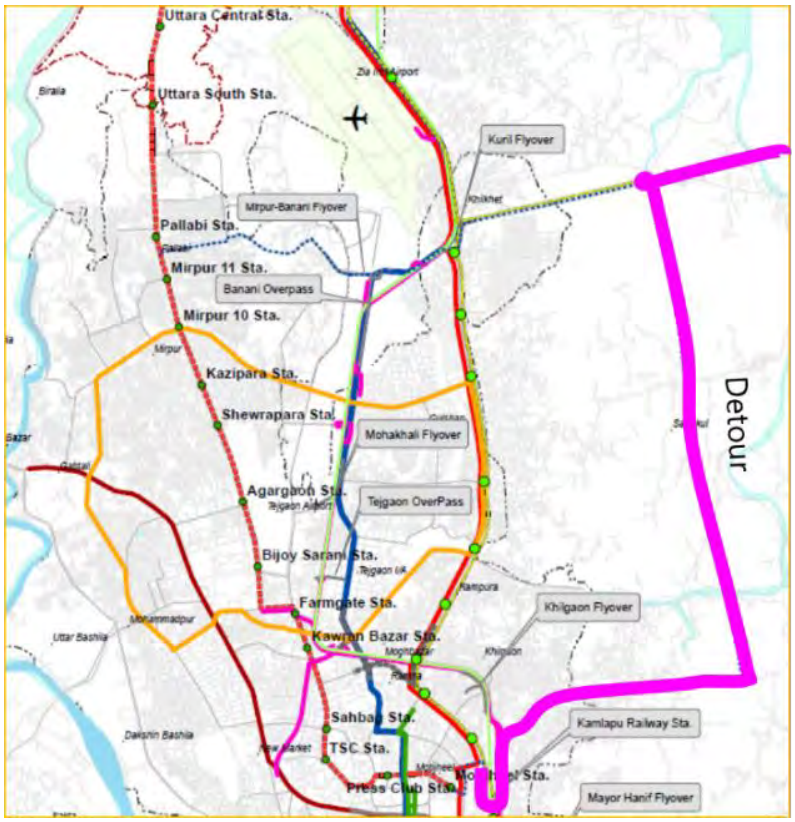
The time for government to make the final decision to go ahead with the project would be in the next 18 to 24 months from now or when the project is in the ODA pipeline and the design of the transit system has been developed to the next level of detail. Such a “go/no go” decision should also have the advantage of being able to monitor bus patronage data on the MRT line 1 corridor. The government and its consultants would then be in a position to better assess the willingness to pay by passenger for the provision of modern rail transit, and whether there is likely to be a major shift from private transportation to public transport commuting.

(3) Implementation Schedule for the New Bus Network

In 2025, MRT Line 1 has 2 service line, one line is from Kamalapur station to Airport station, and another line is from Kamalapur Station to Purbachal Terminal Station. And at the next phase 2035, the alignment of MRT line 6 will be extended from Airport Station to Gazipur Station via Tongi, and from Kamalapur Station to Jhilmil Station.

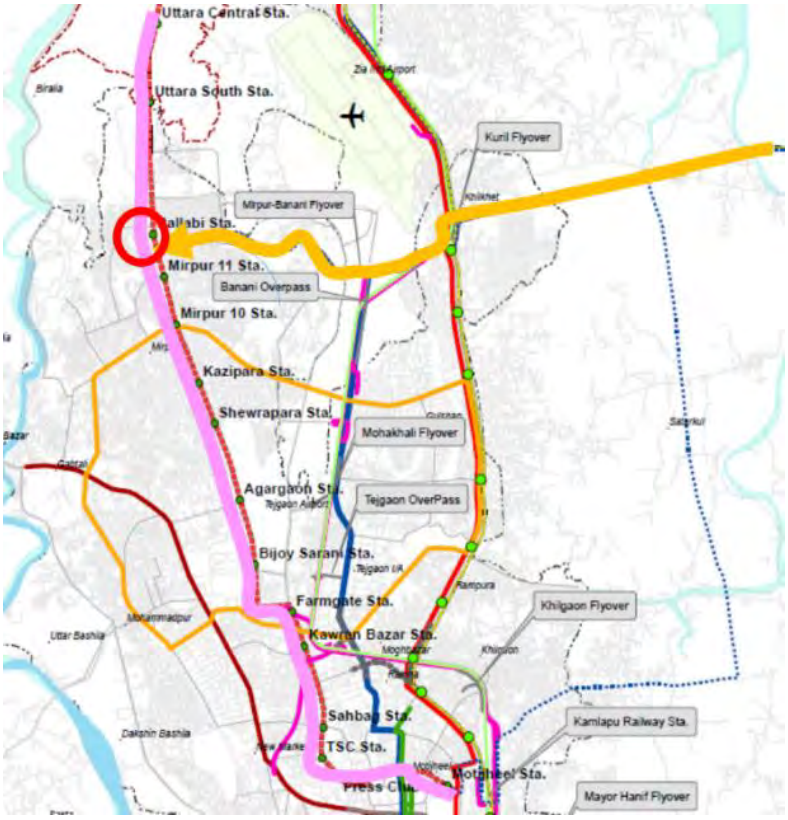
Traffic management during the construction of MRT Line 1 should be implemented in the short-term. During the construction of MRT Line No.1, two lanes will be used for construction works on DIT Road, and reduction of lanes would lead to serious traffic congestion on the road. So it is important to manage traffic demand and to alleviate expected traffic congestion.

To avoid traffic congestion on the DIT road, bus service can be operated on new Purbachal road and extended from Kuril Intersection to Pallati station in order that passengers may transfer to MRT Line No.6 at the point.



Source: JICA Study Team

Figure 6.1 Feeder Bus Service for MRT Line 1 (1)

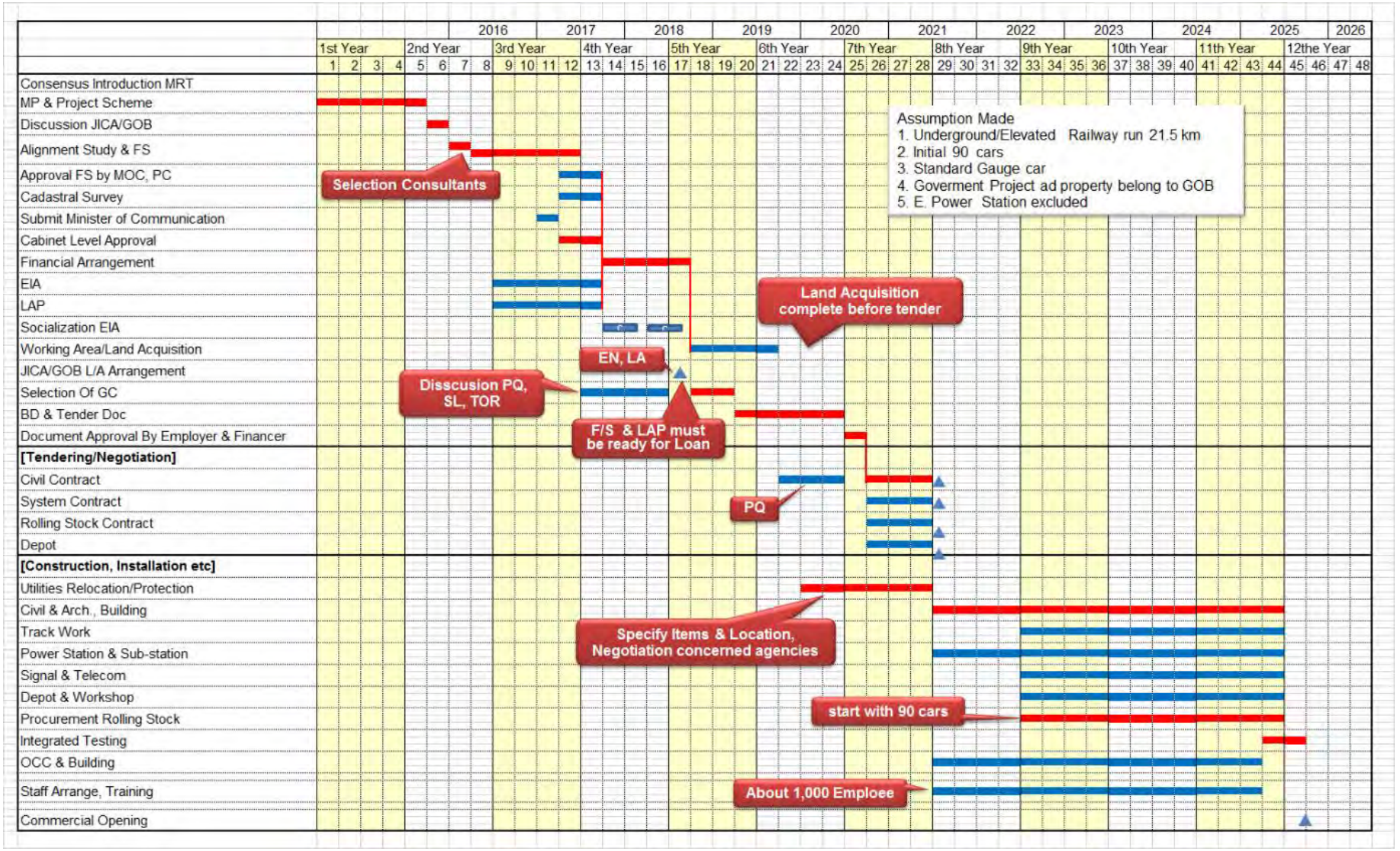


Source: JICA Study Team

Figure 6.2 Feeder Bus Service for MRT Line 1 (2)

During construction period on DIT road, serious traffic congestion will be expected. A new bus route shall be provided plying on the proposed road for BRT No. 7. And priority project should be given to development of the arterial road between Gazipur and Narayanganj since this road shall provide space for detour of bus operation during construction period of MRT Line 1. New bus operation with quality service shall be provided on DIT road to replace the existing bus services. And suspension of Rickshaw operation on DIT road shall be taken into account.

Figure 6.3 Implementation Schedule for MRT Line 1 (Rail Transit Segment)



6.2 Construction Planning

Under a traditional mode of project implementation, the full burden for contract administration, construction coordination management, and interface with various contractors and suppliers fall on the Project Management Unit (PMU). At the opposite end of the spectrum, where a Build-Own-Operate model is adopted, this responsibility falls squarely on the concessionaire – with the PMU providing a monitoring and reporting role only to the concessionaire.

For the civil works aspects, it is possible to divide the contracts into five discrete bid-construct packages:

(1) The underground tunnel works and stations including the tunnel portal;

(2) The elevated viaducts and stations and the major river bridge crossings;

(3) Depot including workshops, stabling, ancillary buildings and facilities and substations;

(4) Trackwork and trackside equipment.

The fewer the contract packages, the easier it will be for the PMU to manage. In fact there may be some strong merit in appointing a managing contractor for the civil works programme who would take responsibility for a fee for the successful completion of the project on time, within project budget and to the desired quality and workmanship. However, the risk of construction delays (or failures) also decreases.

On the other hand, dividing the works into many smaller packages may allow more domestic contractors to participate but complicate the required integration and coordination tasks and also increase the risk of late delivery of the completed project if one contractor does not complete his section of the works on schedule.

The Timetable for construction could be shortened by dividing the project into discrete works packages. For the electro/mechanical system components – which encompass rolling stock, traction power and signaling/communications, AFC, SCADA, escalators/elevators, tunnel ventilation and fire protection systems – a single EPC contractor is envisaged.

6.3 Organizational Plan

(1) Interim Organization

At the inception of the project, a Project Management Unit (PMU) which mainly consist of DMTCL (Dhaka Mass Transit Company Limited) can be formed to undertake all the necessary project preparation such as design, site investigation, survey and construction planning and other pre-investment activities possibly with the assistance of foreign consultants experienced in railway transit projects. This is the normal procedures for a project of this magnitude. What requires further discussion and agreement is whether this PMU shall be

a) organized mostly by the Dhaka Mass Transit Company Limited (DMTCL).

b) organized with the related agencies, RAJUK, BBA, RHA and others

c) directly under the Ministry of Road Transport and Bridges (MORTB).

To ensure vertical and horizontal coordination, a Steering Committee should be formed to oversee the activities of the PMU. This Committee should include the Secretary of MORTB, Executive Director of DTCA and other high officials of the related agencies.

From 2016 to 2020, the PMU will be the organization to guide the development of the MRT Line 1 from the initial concept planning, thru detailed engineering or design and construction phases of the project to commissioning and the start of revenue operations.

At that stage the PMU would be reorganized or disbanded after the transit system is completed and put into commercial revenue service.

In the first two years of the project, the PMU should focus on the following:

- Review and develop the proposed alignment and gather and collate all necessary technical information along the alignment, including topographic survey, geotechnical data, building condition surveys existing and new utilities, prepare parcilliary plans defining lot boundaries and ownerships;
- Secure the land for the proposed Depot and tunnel portal and other works sites, or secure commitments for a better site;
- Secure the necessary rights-of-way including the station sites;
- Explore development opportunities with property owners along the alignment particularly at station ;
- Develop the performance specifications, materials & workmanship for key technical issues in more detail including the tunnel works, viaduct construction, station planning and for the systems rolling stock, traction power (DC vs AC, 750v or 1500v), heavy rail or light rail, automated driverless system versus driver-controlled trains, preferred train control and signaling system, fare system, communications and control systems (SCADA) and the like.
- Perform other detailed planning and project preparation tasks, including re-assessment of project programming and economic viability

The study team believes that MRT Line 1 should avoid locking itself to a particular Supplier at an early stage in the project development until after the technical and financial team has fully examined all the developmental and technical options. And review the lessons learnt by MRT Line 6 project and other cities in their rail transit development programme.

To aid the PMU during this crucial time of project development the study team firmly believe that it will be extremely beneficial for MRT Line 1 to appoint an impartial experienced international rail consultant to assist the PMU team during this critical phase and developing a bankable, cost effective and efficient MRT System for Dhaka.

(2) Permanent and Long-term Organization

The study team would suggest that no later than the completion of MRT line 1 construction, and no earlier than approval of the investment or the financing arrangements are in place that a new section/department for MRT Line 1 in DMTCL should be formed. Which would suggest formation of the new Section/Department around 2020. A tentative name for the new Section/Department is the DMTCL Team 01, which should be organized in DMTCL.

And also the study team would suggest that urban development section should be organized in DMTCL to achieve the TOD project with RAJUK, DNCC and DSCC.

(3) Bus and Busway System

A policy issue is whether the DMTCL should also be authorized to engage in other forms of public transport, such as taxi and feeder bus services. The combination of MRT, BRT and Bus System on MRT Line 1 may argue for an integrated organization, i.e., DMTCL as the unified agency to own and operate the MRT Line 6 and MRT Line 1, as well as the bus services in Purbachal and from Purbachal to Kuril Flyover.

Nevertheless, the recommendation is for DMRTCL to focus on rail transit and to outsource the Busway service provisions to existing bus operators or the existing bus operator on the route. In this way, there is a resulting specialization. Separation also

avoids potential conflict with private bus operators, as the bus routes extend outside the MRT Line 1 corridor. There is little, if at all, economies-of-scale to be achieved in placing bus and rail in one organization when there is only one line involved. More importantly, separation will insulate the liabilities and weaknesses of one from the other. However there is a high degree of inter dependence of the two transit modes with a “win win” situation possible where Busway traffic will feed passengers to the rail transit system. Close coordination of services will be necessary to ensure a fully integrated and efficient transport system is developed for the corridor.

The desired coordination of services between the rail and bus segments can be realized in various ways, without necessarily placing both under one body. The ticketing system can be designed such that a ticket for the rail can be used in the Busway and vice-versa. The schedules and frequencies for the rail vehicles (under DMTCL) can be synchronized with the Bus/Busway operations through mutual agreement or by order of Bangladesh. Organizational Responsibilities against Time

As the Project moves from concept to operation, the challenges to specific organizations would also change, as shown in Table 6.1.

Table 6.1 Allocating Responsibility through Time

Aspects	DTCA	Project Management Unit	DMTCL Team 01
Main focus: short-term	DTCA to plan and implement bus priority measures on line 1 corridor	Project preparation Securing of ROW Resolution of pre-implementation issues	None
Main focus: medium-term	DTCA to supervise bus operator on line 1 to adjust service in accordance with Busway standards	Construction of rail line and Busway sections	Organizational development for rail operations Maintenance framework & contractual terms
Main focus: long-term	DTCA (and affected bus operators) to adjust bus services in light of Line 1 operation	None, unless construction of MRT Line 1 is commenced	Efficient management of commercial service
Required External Expertise	Minimal, perhaps in the area of corridor traffic engineering	• Project development; • Detailed engineering; • Construction Management	Maintenance of rail assets

Source: Study Team

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Recommendations

(1) Integrated Urban Development Concept

1) Non-transport Role of the Project

The proposed MRT Line 1 (Phase1 in 2025) is expected to have a multiplier effects on greater Metro Manila, as it is envisaged to be the main backbone of the public transport network providing travel unhampered by road congestion. At the same time, the project will open up new areas for development especially around stations and terminals.

The reliable and high-quality transportation services of MRT Line 1 are available to rich and poor alike. It is, thus a social equalizer affording the lower income households to reach their work places or school faster or almost at the same time as the wealthier car- owners.

The detailed feasibility study would quantify the expected savings from avoided fuel cost of the proposed MRT Line 1 in Dhaka. When commuters take the MRT Line 1 rather than drive in individual cars or motorcycles, everybody benefit from cleaner air.

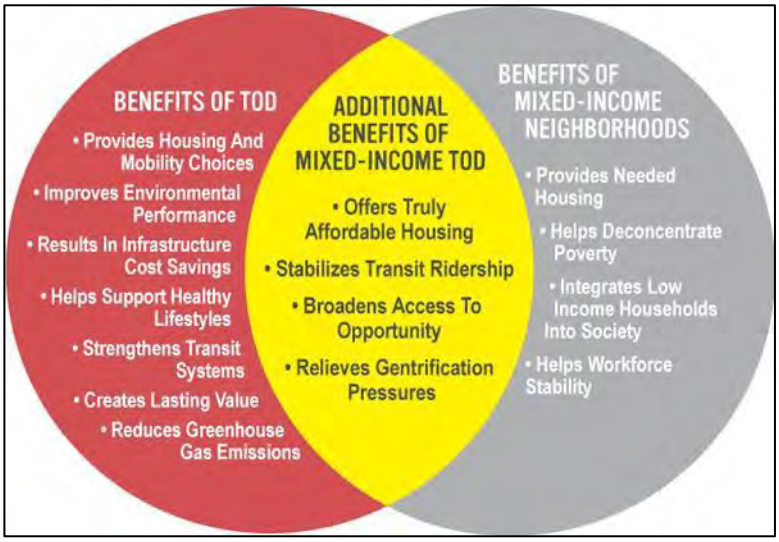
2) Concept of Integrated Development and Opportunities

In the Bangladesh, none of the rail entities have engaged in or pursued large-scale property developments in and around stations that could be classified as Transit Oriented Developments (TOD).

The development of TODs is much to be desired as they lead to higher and stable transit patronage. TODs are crucial to the realization of Dhaka's vision as a livable city. The benefits from integrated development are shown on Figure 7.1.

To maximize the benefits that can be derived from MRT Line 1 developments, a proven and successful approach is the adoption of an integrated urban development. At stations and terminals and in their adjoining areas, commercial and public facilities are integrally developed with transportation. When this occurs, the MRT Line 1 attracts higher patronage while the commercial/urban development benefits from good accessibility. This synergy is often so huge that many private companies in Japan have captured the external benefits for their own financial gains.

The urbanizing fringes of RAJUK Area – particularly in Purbachal offer the greatest potential for applying the TOD concept – because it's less hampered by existing land uses and ownership. These Greenfield or new sites can be planned and designed with a clear transit focus. To succeed, these Greenfield sites must be provided with high quality, fixed guideway public transport systems with regular connections to the CBD and other regional centers and other TOD nodes. This concept of urbanism seeks to bring together modern lifestyles, housing, and places of employment, retail activity and leisure time in a compact pedestrian-dominated neighborhood with linkages by transit to other points of interests in RAJUK area.



Source: www.mitod.org

Figure 7.1 Illustration of TOD Benefits

The MRT Line 1 is the key driver to the realization of TOD – because of its new alignment that deviates from the radial-circumferential pattern of the metropolis, its highest passenger carrying capacity among all public transport modes, and a route through the most-traffic-intensive CBDs. While the MRT Line 1 is expected to form the transportation backbone of Mega Manila, buses and minibuses will remain to be the most important road-based public transportation mode even in the future, providing services in areas not covered by the MRT Line 1 and LRTs or providing feeder services to them.

The differences in land uses among the stations of MRT Line 1 Line offer diverse opportunities for urban development. For stations surrounded by built-up areas, future developments would be of the re-development or urban renewal kind. Changes in land uses towards higher intensity would be slower – except when a single-owned large land area is available. Land owned by government belongs to this category. On the other hand, new large-scale urban developments are less constrained on the end points of the MRT Line 1, particularly in and around stations at Purbachal and Eastern Fringe Area. The stations in the urban periphery also have the potentials to pull more users as a regional center of urban services and transportation hub to other areas. Many users from surrounding areas of Dhaka and Eastern Fringe Area will go to these stations, if and when more varied commercial services get provided. Thus, these stations could grow beyond their simple transportation hub functions and into full- pledged commercial and business centers of suburban areas.

3) Necessary Institutional Arrangement

There are two roles in the preceding sections that no public sector entities currently perform: (i) the development of TODs as the embodiment of integration of land uses at or around MRT Line 1 stations, and (ii) the re-organization of buses and minibuses on the road network.

The planning and construction of the MRT Line 1 falls squarely with MORTB. Funding from the national government – as well as loans - will have to be included in the Budget, and hence in the investment program of MORTB. The funding could not be earmarked directly to DMTCL.

Logically, there should be a single MRT company in Dhaka. And DMTCL will be established as a Dhaka MRT company of MRT Line 6 before MRT Line 6 opens in 2019. DMTCL should be a single MRT company in Dhaka and they need to operate and manage MRT Line 1.

7.2 Conclusions

The preliminary analysis shows that Dhaka MRT Line 1 Project is economically viable. There are compelling reasons, other than economics, for a high-capacity railway system for a sustainable Dhaka and RAJUK area. With proper phasing of construction, the economic benefits could be enhanced further.

The final route still needs to be fleshed out. This can only be done in a subsequent detailed feasibility study phase with the involvement of relevant stakeholders. A principal determinant to the alignment study is the legal issue of subterranean rights. This should be clarified at the start. The different alignments considered here followed closely the existing public roads, on the presumption that the State may have to expropriate lands where the rail line passes through – even if there is no impairment to the use thereof. Such a rigid interpretation, however, runs counter to the accepted right of the State to limit building heights. A better and more efficient alignment would emerge, if height restriction below the surface also applies.

The obstacles for a proposed transport infrastructure, when at-grade or elevated, can be ascertained visually. A small part of the subway project will be underground. Thus, sub-surface testing and investigations need to be undertaken before a final alignment – vertical and horizontal – can be arrived at. Such a level of effort is beyond the scope of this study.

The station locations here are indicative only; their actual siting, layout, and scale have to take into account several critical factors; the final route, the expected volume of passengers, passenger mode of access to/from the station, existing and expected land uses within 500 meters radius, and openness of property owners as well as local government units to integrate the station into the overall fabric of their developments. These will come into play during the feasibility study phase.

In this study, 3 possible termini of the MRT Line 1 were identified. These are the International Airport, Kamalapur and Purbachal. They have to be revisited in the next phase of the feasibility study. More than just stations, these termini have other functions, aside from the technical requirements of turn back facilities. Therefore, they will require special planning attention. The location of the Depot will require a larger land area for acquisition and will dictate where one of the line Terminus will be.

The method of tunneling also needs to be explored in detail, since it will significantly affect construction cost. The choice is expected to be influenced by the vertical elevation of the subway, geotechnical characteristics of the route, and length of the tunnel. The Guadalupe plateau, where the line would traverse, lends itself to the use of a Tunnel Boring Machine (TBM), which are made-to-order. On the other hand, cut-and- cover would be disruptive to surface activities and would be objectionable in the CBDs.

The Dhaka MRT Line 1 is only one of several mass transit lines. The basic assumption in this study is that all of the other lines are in operation in 2035, or when it starts commercial service. The demand of the subway will be different under this scenario. Thus, the subsequent study needs to consider the mostly occurrence of the various components of the RSTP 2035.