BUS RAPID TRANSIT (BRT) FOR CITIES OF BANGLADESH: A STUDY OF IDENTIFICATION OF POTENTIAL CITIES AND DEVELOPING POLICY FRAMEWORK

by

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March, 2019

The thesis titled **"BUS RAPID TRANSIT (BRT) FOR CITIES OF BANGLADESH: A STUDY OF IDENTIFICATION OF POTENTIAL CITIES AND DEVELOPING POLICY FRAMEWORK"** submitted by Bristi Basak, Student No: 0412152033 (P), Session: **April 2012**, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of MASTERS OF URBAN AND REGIONAL PLANNING by Coursework and Thesis on 30/03/2019.

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It is hereby declared that this thesis titled **"BUS RAPID TRANSIT (BRT) FOR CITIES OF BANGLADESH: A STUDY OF IDENTIFICATION OF POTENTIAL CITIES AND DEVELOPING POLICY FRAMEWORK"** or any part of it has not been submitted elsewhere for the award of any degree or diploma.

_____

Bristi Basak

DEDICATION

To my loving husband, Dr. Manik Chandra Das, without whose constant support and faith (on me), this thesis would never have been possible.

Acknowledgement

At the end of my thesis titled ‘Bus Rapid Transit (BRT) for Cities of Bangladesh: A Study of Identification of Potential Cities and Developing Policy Framework’, I hereby take this opportunity to thank all those without whom it would not have been possible to complete this work.

First and foremost, I would like to extend my gratitude towards my thesis supervisor Dr. Md. Musleh Uddin Hasan, Associate Professor of Department of Urban and Regional Planning, who was the guiding factor as well as a constant source of encouragement during the course of this thesis.

I would like to extend my sincere gratitude to all the teachers of URP department for their valuable suggestions, helpful advices and positive criticisms at all stages during the course of this study.

I am deeply indebted to all the members of the expert panel for helping me with my research by providing their judgment pondering over the factors. I am especially thankful to Mohammad Nazrul Islam, Transport Specialist, Asian Development Bank (ADB); Mr. Stephen Moriarty, Urban Planner and Former Team Leader of Greater Dhaka Sustainable Urban Transport Project (GDSUTP); Charisma F. Choudhury, Deputy Director, Choice Modelling Centre & Associate Professor, Institute for Transport Studies & School of Civil Engineering University of Leeds, Leeds, UK and Shafiq-Ur Rahman, Professor, Department of Urban and Regional Planning, Jahangirnagar University for giving time to formulate factors in spite of having busy schedule.

I am also indebted to all those persons who provided me relevant data to complete this thesis: Abul Monzur Mohammed Sadeque, Executive Engineer, Local Government Engineering Department (LGED); Sitangshu Shekhar Biswas. Director (Operation), Bangladesh Road Transport Authority (BRTA); Mr. Md. Anisur Rahman, Project Director, Clean Air and Sustainable Environment CASE- and Traffic Engineer Project, Dhaka Transport Coordination Authority (DTCA).

Further I would like to express my thanks to my colleagues and friends Laila, Nilima, Riad, Irina, Rida and Farhan who cheered me on; to my parents Advocate Niranjan Basak and Shipra Basak for their support and blessing; to my dearest daughter and mother-in-law for being patience during my hard time.

Above all I thank the Almighty God for giving me strength and courage throughout this period.

Abstract

Bus Rapid Transit (BRT) is an urban transport solution for many of countries around the world. But up to now, there is no BRT operating in Bangladesh – construction of one is ongoing in Dhaka - nor there is any appropriate method for assessing the merit for choosing and prioritizing cities of Bangladesh to have BRTs. This study has identified a set of criteria for the cities of Bangladesh to assess their merit in this regard. The study has enlisted five major factors, namely Demography, Regional/Surrounding context, Transport, Major Activity center/ Land use and Economy which govern the potentiality of BRT development in the cities of Bangladesh. Sub factors in each category has also been identified. A two-stage consultation was done with 10 experts in transport authority, academia and practitioners. At first a list of 27 potential factors has been identified based on literature review. Among them 15 factors are selected by the experts. Those are grouped in five categories of factors mentioned above. In the second stage, the consultants were again contacted for putting their priority to factors and subfactors separately. Analytic Hierarchy Process (AHP) has been used for calculating weights or scores for factors and subfactors. A composite value has been found each of 30 studied cities – excluding Dhaka, Gazipur and Narayanganj - on the basis of weights of the five factors (and subfactors) and respective city wise value of these factors. Finally, the priority city for BRT development have been identified on the basis of highest composite value. This study shows that, Chattogram has the highest composite value (0.849) and developing BRT system has become an overdue for the city. Other cities having potential for BRT development in near future are Bogura, Cumilla, Mymensingh, Noakhali, Tangail and Rajshahi. A total number of eight successful case studies are studied thoroughly to understand factors behind their success It has been found that successes in BRT development depends on the institutional strength, co-ordination, steady political support, good design standard and public involvement. Finally, the study has recommended for addressing the issues in Governance, Urban Planning and Design and Social factors for successful implementation of BRT in the prioritized cities of Bangladesh.

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List of Abbreviations

BRT	Bus Rapid Transit
BRTA	Bangladesh Road Transport Authority
BUET	Bangladesh University of Engineering and Technology
BUF	Bangladesh Urban Forum
CBD	Central Business District
CVD	Commercial Vehicle per day
DCC	Dhaka City Corporation
DHUTS	Dhaka Urban Transport Network Development Study
DMA	Dhaka Metropolitan Area
DMDP	Dhaka Metropolitan Development Plan
DMTA	Dhaka Mass Transit Authority
DMTC	Dhaka Mass Transit Company
DTCA	Dhaka Transport Coordination Authority
DTCB	Dhaka Transport Coordination Board
EPZ	Export Processing Zones
EZ	Economic Zone
GDA	Greater Dhaka Area
GDP	Gross Domestic Product
GDSUTP	Greater Dhaka Sustainable Urban Transport Project
GOB	Government of Bangladesh
HCR	Head count ratio
ITDP	Institute for Transportation and Development Policy
JICA	Japan International Cooperation Agency
LGED	Local Government Engineering Department
LGED	Local Government of Engineering Department
LRT	Light Rail Transit
MCDM	Multi-Criteria Decision Making
MNL	Multinomial Logistic Regression
MRT	Mass Rapid Transit
MT	Motorized Transport
NH	National Highway
NMT	Non-Motorized Transport
RAJUK	Rajdhani Unnayan Katripakkha: Capital City Development Authority
RH	Regional Highway
RHD	Roads and Highways Department
RHD	Roads & Highways Department
RSTP	Revised Strategic Transport Plan
STA	Sustainable Transport Award
STP	Strategic Transport Plan
TOD	Transit Oriented Development
UNDESA	United Nations Department of Economic and Social Affairs
ZR	Zilla Road

Chapter 1
Introduction

Chapter 1: Introduction

1.1 Background of the Study

Cities are the major source of national economic growth, transport is the lifeblood for the cities and nation (Gwilliam, 2002). Cities of developing countries are growing rapidly and becoming automobile- dominated and less sustainable (Pojani & Stead, 2015). By 2030, the world is projected to have 43 megacities with more than 10 million inhabitants, most of them in developing regions (UN, 2019). The urban population in developing countries is set to double from 2010 to 2050 while remaining stable in developed countries (UN, 2019; UNDESA, 2018). The fastest-growing urban agglomerations are medium-sized cities with less than one million inhabitants, located in Asia and Africa (UNDESA, 2018). Rapid growth of population causes negative impacts on urban residents especially by creating transport related challenges including pollution, congestion due to not having suitable public transportation system, climate change and lack of accessibility for the poor (Gwilliam, 2002). For the majority of residents, road-based public transport (bus and paratransit) is the only means to access employment, education, and public services. In medium and large developing cities, such destinations are beyond viable walking and cycling distances while vast numbers of individuals have limited access to automobiles. Therefore, in many cities' effective road-based public transport is central to economic growth of developing cities (Pojani & Stead 2015). Unfortunately, the current state of road-based public transport services in many developing cities does not serve the mobility needs of the population adequately. Formal bus services are often unreliable, inconvenient, uncomfortable, or even dangerous. Metro systems are usually the most expensive form of public transport in terms of construction and operation. Bus Rapid Transit (BRT) is an urban transport solution for many of countries around the world because it is much less costly and less time consuming to build, less space consuming to operate compared to rail-based Mass Rapid Transit (MRT) (ITDP, 2017). Building a heavy urban rail system can cost 10 times as much as building a BRT system (Suzuki, 2013). Installation of BRT needs only two years where as building an underground metro takes a decade (Suzuki, 2013). Moreover, BRT vehicles can run on natural gas, electricity, or biofuels. Now more than 170 cities in the world have BRT; among them 48 cities are from Asian and developing countries (ITDP, 2017; Global BRT data, 2018).

For Dhaka city RSTP (2015) recommends five Mass Rapid Transit (MRT) Lines (MRT Line 1, 2, 4, 5 & 6) and two Bus Rapid Transit (BRT) Lines (BRT Line 3 & 7) in greater Dhaka city region i.e. area under the jurisdiction of Dhaka Transport Coordination Authority (DTCA). BRT Line 3 will operate from Gazipur in the north to Kodomtoli Circle in the south, covering a total distance of approximately 42 km. Under Greater Dhaka Sustainable Urban Transport Project (GDSUTP) part of BRT Line 3 is being implemented along National Highway-3 from Shahjalal International Airport Roundabout up to Gazipur terminal near Joydebpur Railway Station with a total length of 20 km (GDSUTP, 2016).

Many other cities of Bangladesh being in the category of medium sized towns from a global perspective and hence having potential to expand in the fastest growing urban agglomeration, do not have any strong public transport system at all. But government of Bangladesh is committed through national and sectoral strategies and plans and international commitments, to provide efficient, accessible and affordable public transport options for the citizens of all the cities in Bangladesh. Considering socio-economic, demographic and urban characteristics of cities, in the world, having BRT there may be scopes for introducing high occupancy public transport system like BRT in other cities in Bangladesh. But question comes which cities should the government consider first. In fact, each year transport sector receives one of the largest shares of national annual budget. So, there is a dire need of prioritization of investment and development activities in urban transport sectors and optimization of their effects.

Moreover, in many cities of the world BRT and MRT are provided not only for a single city, but to provide strong connectivity between central city and surrounding urban centers in an urban agglomeration. (It does not only make rapid transit system viable and feasible, but also ensures growth and sustainability of small and medium urban centers and controls scattered or leap frog land use development and urban sprawl). Suzuki (2013) also shows that BRT networks generally encourage suburbanization by improving accessibility to different parts of a region. If urban agglomeration, instead of single central city, is considered as an initial sign of potential to have BRT, number of cities in Bangladesh competing for having BRT further increases. As per Census 2011, currently Bangladesh has 43 cities with population above 100,000. Among them four cities, namely Dhaka, Chittagong, Khulna and Sylhet have population more than 500,000 (see

Appendix A). If population of urban agglomeration, defined here as population in surrounding municipalities in the district, is considered, the number rises to 10.

Now to assess the merit of these cities to have advanced form of public transit i.e. BRT, a large volume of data including ridership, is required. But no systematic transport data is available for cities in Bangladesh, except that for Dhaka. Hence, developing a rigorous methodology, right now, for prioritizing the cities in Bangladesh for having BRT may seem premature. Therefore, there is an imperative for an alternative, simple methodology using other available data to do primary ranking in this regard. This research would like to contribute to address the gap.

In this connection it should also be mentioned that cities having BRT have specific planning process, polices and agencies to regulate operations of BRT (Manasan, 1999; Rizvi, 2014 and World bank, 2009). Implementing a BRT network is part of an emerging public transportation policy around the world, which is different in details depending on each city's characteristics such as pathways, population, resources, and texture of the city (Salavati, 2016). Here again, there is neither any transport policy framework, nor any city focused scientific transport study for these cities (BUF, 2011 and GOB, 2004).

Developing cities are advised to consider examples of transport solutions from both developing and developed contexts (Pojani & Stead, 2015). Economic and geographical features and the size of the cities play a substantial role in selecting policies. Implementation of a specific policy might be successful in a city, while it could not be that much helpful in another city with different characteristics (Talebian, 2014). Transportation policies implemented in different cities around the world could be considered as an important source for identification of effective transportation policies and methods. Study of the success and failure of BRT in foreign cities will be helpful to assess the potential for development of BRT and relevant policy framework for any other country (CityMetric, 2016 and Levinsion, 2003), like Bangladesh. But up to now, no attempt for using other cities' experiences has been made for cities in Bangladesh. This study also aims to propose a general policy framework to identify cities for providing BRT and operation and management of the BRT provided.

1.2 Objectives with Specific Aims

The main aim of the study is to assess the potential cities of Bangladesh for BRT development. The specific objectives are as follows-

- To classify the large cities of Bangladesh based on their potential to have BRT.
- To develop a policy framework for BRT development and operation in cities of Bangladesh based on success and failure of selected BRT in other similar cities in abroad.

1.3 Possible Outcomes

It is expected that, a list of potential cities of Bangladesh to have BRT will be prepared. It will be helpful for decision maker to choose the priority city for future investment. The policy of successful BRT case studies in cities abroad will be revealed to develop a policy framework for BRT in Bangladesh. This will guide future BRT implementation in a city.

1.4 Study Area

Census of Bangladesh 2011 has defined 43 cities, among all 64 districts, as city (see **Appendix A**). As cities under Dhaka, Gazipur and Narayanganj district namely Dhaka, Savar, Tongi, Gazipur, Kaliakair, Shreepur, Narayanganj, Shiddhirganj, Kadam Rasul and Tarabo cities are going to have BRT in near future (RSTP, 2016; DTCA, 2019), they are excluded from this study to find out potentiality of having BRT. Among Remaining 33 cities, Cumilla Adarsha Sadar and Cumilla Sadar Dakshin are considered as included in Cumilla city, Similarly Begumganj is considered as included in Noakhali city. Excluding these, other 30 main cities in 30 districts are considered for the study area (Figure 1.1).

1.5 Scope and Limitations of the study

The study is primarily based on data from secondary sources and personal observation of experts. Observation may vary from person to person and may affect the analysis. Moreover, BRT development fundamentally depends on modal characteristics, daily trips, ridership to the activity center, existing transport infrastructure etc. Since these data are not readily available for almost all cities, except Dhaka in Bangladesh right now, an alternative simple methodology using other available data is developed in this study to assess the merit of having BRT in other cities. As BRT is expected to provide better

connectivity between central and growing/surrounding urban centres, this study considered several variables related to surrounding urban centers i.e. considered urban agglomeration. However, as the functional relationship or linkages between central town of a district and its surrounding urban centers is not known, this study considered all municipalities in the district to find the population in the respective urban agglomeration.

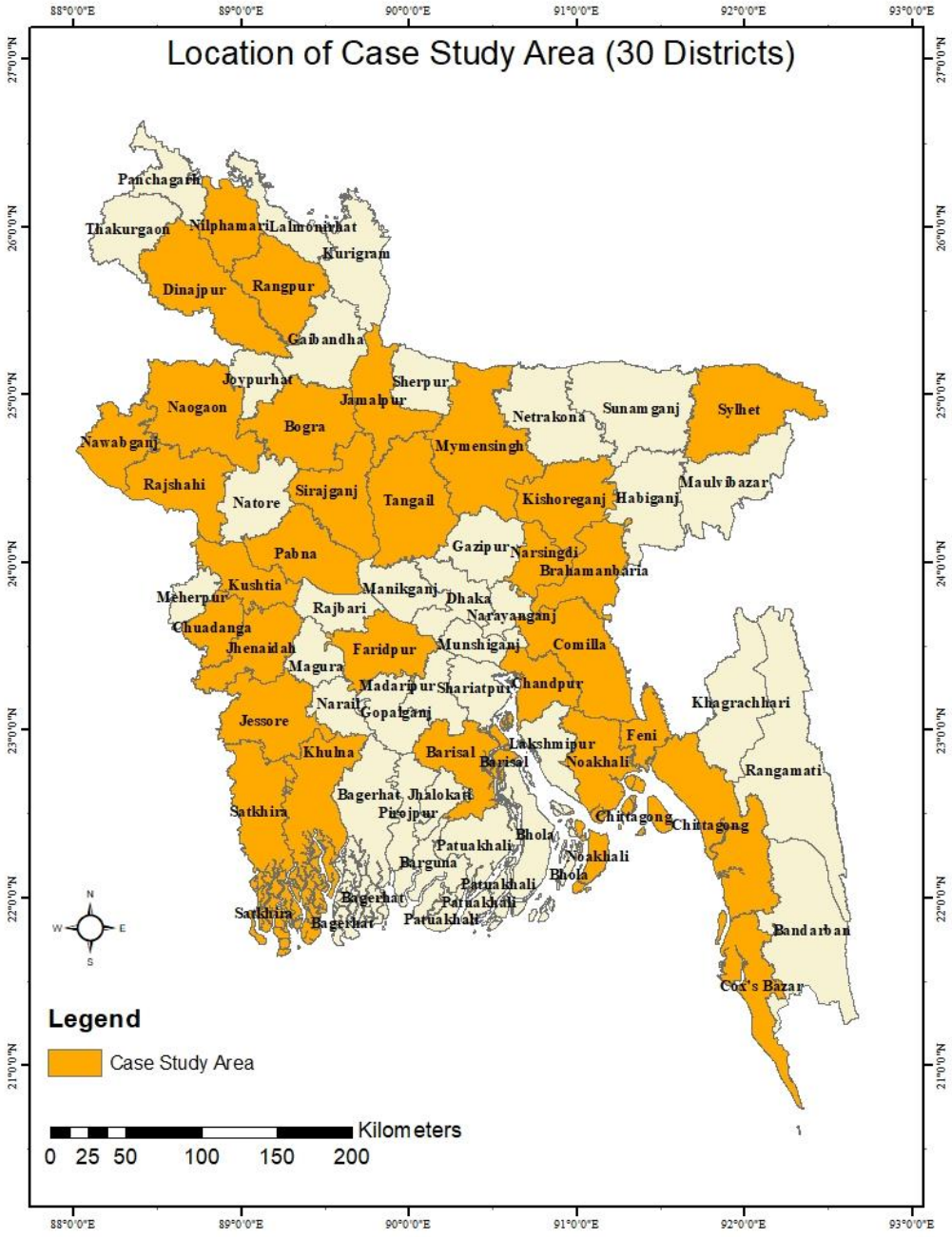


Figure 1.1: Location of Case Study area (30 Districts)

1.6 Outline of the Report

Chapter 1 Introduction: This chapter contains the general background and present status of the problem, objectives of the study, study area and the thesis organization.

Chapter 2 Literature Review: Evolution of BRT concept, Transport plans in Bangladesh and relevant Journals and Reports on BRT from home and abroad that were studied are represented in this chapter.

Chapter 3 Methodology: The overall design of the study and research methodology that were followed for this thesis is presented here. The tasks include the process of data collection and data analysis method.

Chapter 4 Identification of Factors: This chapter explains the suitable factors and criteria for identification of potential cities for BRT in Bangladesh.

Chapter 5 Identification of Potential Cities: Based on different criteria and their weightage, potential cities will be ranked for BRT development using AHP method in this chapter.

Chapter 6 Policy Direction for BRT Management in Bangladesh: Policy of successful BRT having cities around the world will be presented here. Suitable Policy for BRT development in Bangladesh will be recommended in this chapter.

Chapter 7 Conclusion: This chapter summarized the outcomes of the study. Direction for future research and major policy issues are also highlighted here.

Chapter 2
Literature Review

Chapter 2: Literature Review

2.1 Bus Rapid Transit (BRT)

Bus rapid transit is an emerging form of mass transit, which ties the speed and reliability of a rail service with the operating flexibility and lower cost of a conventional bus service (Deng, 2011). BRT is a such kind of bus system that has separated bus lane, that uses bus stations rather than bus stops, the fare collection system is pre-boarding like metro system and it has ITS which gives information to the passenger about next stop and upcoming bus (Suzuki, 2013). BRT is faster, safer, more efficient, and more user-friendly than traditional bus systems.

Design and operation system of BRT varies widely. So, it is difficult to provide a definition for BRT. However, the following descriptions together provide a good understanding of the scope of BRT. BRT is defined as –

- *"bus Rapid Transit can best be described as a combination of facility, systems, and vehicle investments that convert conventional bus services into a fixed-facility transit service, greatly increasing their efficiency and effectiveness to the end user"* (FTA, 2002).
- *"a flexible, rubber-tired form of rapid transit that combines stations, vehicles, services, running ways, and ITS elements into an integrated system with a strong identity" (*Levinson et al., 2003).
- *"a bus-based rapid transit system that can achieve high capacity and speed at relatively low cost by combining segregated bus lanes that are typically median aligned, off-board fare collection, level boarding, bus priority at intersections, and other quality-of-service elements (such as information technology and strong branding)" (*ITDP, 2017).

Bus system should have five essential elements to call it "rapid" bus transit (ITDP, (2017):

- Physically separated bus lanes to allow buses to avoid congestion;
- Stations and bus lanes aligned to the center of the street to avoid being delayed by turning vehicles and vehicles dropping off passengers or goods;
- Fares collected off the bus, to avoid delays caused by passengers paying on board;
- Boarding from a platform level with the bus floor to make boarding faster, and so that people in wheelchairs or with strollers can roll directly onto the vehicle;
- Turn restrictions and bus priority at intersections to reduce delay at intersections from red signals.

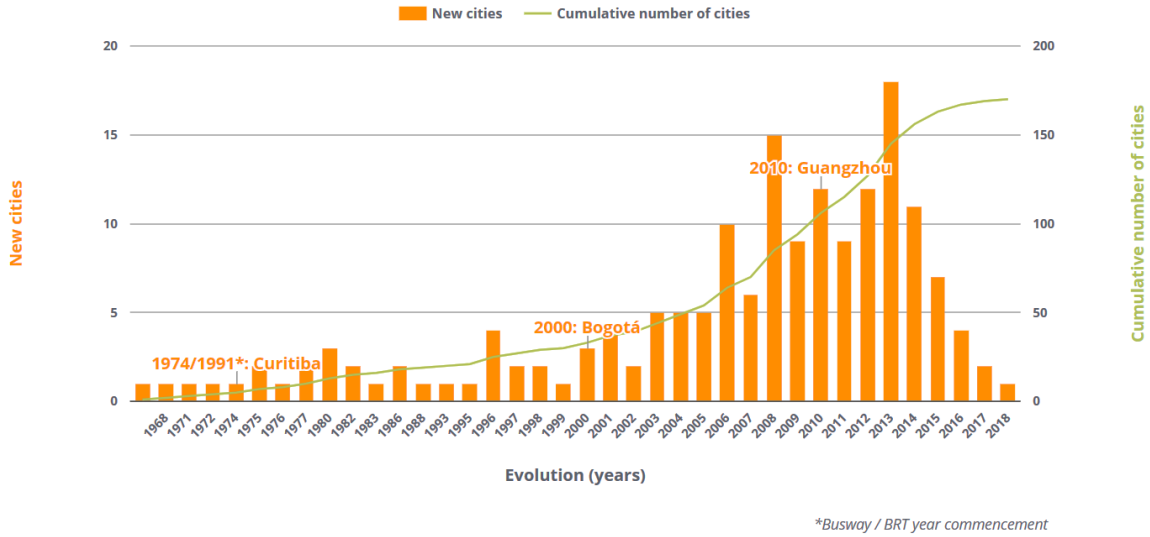
2.2 Worldwide Development of BRT

The origins of the BRT concept can be traced back to the first exclusive bus lane on a city street in Chicago in 1939. The modern concept of BRT was developed in the 1970s by Latin American planners, who sought a quick and relatively inexpensive way to speed up buses as the solution to deteriorating traffic conditions.

Table 2.1: Evolution of BRT and cities having BRT

Before 1970
•America (Chicago, 1939) America (Virginia, 1969
1971- 1980
•UK (Runcorn, 1971) •Brazil (Curitiba, 1974) •Brazil (Goiania, 1976) •U.S., Pittsburgh; Brazil, Porto Alegre(1977) •Brazil, São Paulo; Germany, Essen, (1980)
1981- 1990
•Canada (Ottawa, 1983) •Japan (Nagoya, 1985) •Australia (Adelaide, 1986) •Brazil (Mauá - Diadema, 1988)
1991- 2000
•1995: Leeds, UK; Quito, Ecuador; 1996: Oberhausen, Germany; Jonkoping, Sweden •1996: Vancouver, Canada; 1997: Dublin, Ireland; Miami & Orlando, US •1998: Taipei, Taiwan; Juiz de Fora, Brazil; 1999: Kunming, China; Joinville, Brazil •2000: Bogotá, Colombia; Twente, Netherlands
2001- 2010
•Guangzhou, Hefei, Yancheng, Zaozhuang, Jaipur, Bangkok, Londrina, Niterói, Sumaré, Barranquilla, Bucaramanga, Mexico City – Metropolitan Area,Johannesburg, Zhengzhou, Ahmedabad, Tabriz,La Rochelle, Castellón, Swansea, Guadalajara, Cleveland, Lagos, Changzhou, Chongqing, Dalian, Jinan, Xiamen, Tehran, Chiayi, Lille, Maubeuge, Toulouse, Natal, Cali, New York, Auckland, Lorient, Zurich, Istanbul, Guatemala, Merida, Eugene, Hangzhou, Douai, Lyon, Nantes, Kent, Luton, Uberlândia, Santiago, Pereira, Guayaquil, Concepción, Guadalupe, Mexico City, York Regional Municipality, Los Angeles, Beijing, Jakarta, Seoul, Almere, Las Vegas, Helsinki, Eindhoven, Gothenburg, León de los Aldama, Sydney - Metropolitan Area, Caen, Amsterdam, Nagoya, Nancy, Rouen, Utrecht
2011 to present
•Cape Town, Urumqi, Cambridge, Brasília, Buenos Aires, Medellín, Panama, Port of Spain – Arima, Rio de Janeiro, Changde, Kesennuma – Tome, Lianyungang, Rajkot, Yinchuan, Châlon-sur-Saône, Fareham – Gosport, Nîmes, Saint-Nazaire, Caracas, Montevideo, Winnipeg, Bhopal, Chengdu, Haifa, Indore, Isfahan, Lahore, Lanzhou, Belfort, Cannes, Metz, Strasbourg, Barquisimeto, Chihuahua, Gran San Salvador, Guarulhos, Juárez, Puebla, Gatineau, Pretoria, Surat, Taichung, Granada, Belém, Córdoba, Monterrey, Alexandria – Arlington, Fort Collins, Mississauga, San Bernardino, Islamabad – Rawalpindi, Pune - Primpi-Chinchwad, Subang Jaya, Yichang, Pachuca, Uberaba, Hartford County, Dar es Salaam, Le Mans, Acapulco, Cartagena, Hanoi, Buenos Aires - Metropolitan Area, Richmond, Amritsar

Source: www.brtdata.org



Source: www.brtdata.org

Figure 2.1: Change in Number of cities with BRT over time

According to Global BRT Data, after 2011, BRT got much more popularity and almost 64 cities have introduced from 2011 to till now. Average corridor length of total 170 BRT's are provided in **Appendix B**. Some BRT project evaluation reports (Deng, 2011) suggest that BRT can be uniquely and flexibly adapted to a multitude of urban environments and result in achievement of performance objectives, including higher ridership, higher speed, travel time saving, enhanced reliability and safety, and improved passenger comfort and convenience.

2.3 Review of Successful BRT around the world

Two main characteristics of a successful BRT should achieve are- First, the corridor is well designed, and that elements such as dedicated right of way, busway alignment, off board fare collection, intersection treatments, and platform level boarding are collectively considered and built into the design of a new system or corridor. Second, the corridor is well integrated, and is ideally linked to high density areas, promotes seamless transfers between modes, provides pedestrian access, secure bicycle parking, bicycle lanes and bicycle sharing integration, allowing it to attract and retain a variety of transport users and expand the catchment area of the BRT[ii]. In fact, Poku-Boansi (2018) has termed BRT systems as a governance reform project.

ITDP and the Sustainable Transport Award Committee select successful transportation projects each year[i]. Also, C40 Cities Climate Leadership Group has developed a series of

Good Practice Guides that focuses on the key elements to successfully develop a high-quality BRT system, leading to better economic, social, and environmental outcomes for cities[ii]. ITDP, STA and Good practice guides have been adopted following criteria for selecting successful BRT studies.

- Adopt holistic planning for a high-capacity BRT corridor
- Develop benchmarking and measure the impacts of BRT
- Focus on strong stakeholder engagement and communications
- Integrate BRT with other means of public transport and urban planning
- Utilize innovative financing mechanisms
- Reduction of transport related air pollution and greenhouse gas emissions

Reviewing BRT systems in Curitiba, Bogota, Ahmedabad, Guangzhou, Mexico City, Buenos Aires, Rio de Janeiro and Jakarta will provide valuable insights to current research. This section will detail the BRT system in these cities. Understanding their planning and implementation processes and the significant factors for their success or failure can be important lessons for our cities. Lessons learnt from these systems will then be analyzed in Chapter Six.

2.3.1 BRT Curitiba

Curitiba, Brazil, is often held up as an example of a successful BRT system, which integrates land use and transport planning to achieve environmentally friendly urban development (Smith & Raemaekers, 1998). In Curitiba, the first busway opened in 1974, operating in the high-demand, lower income district on the periphery of the city. Population number of Curitiba city in 2015 was around 1,879,355 people, Population density in this city was around 179.6 people per km^2 and GDP per capita in 2016 was around US$ 8,650 [iii]. Curitiba BRT has four types of bus which are express, feeders, neighborhood and direct. The “Express” buses (trunk buses) were designed focusing on high capacity and on-time operation rather than speed and the speediest buses are “Direct buses”, with a speed of 32kph[v]. Express bus uses articulated bus with 25-meter length and its capacity is 270 passengers. The operational system for this BRT operates 15 bus terminals, 11 corridors in which the length of each corridor is around 77km, 106 bus shelters in which the distance for each shelter is around 722.6 meter [iii]. In each terminal and shelter, real time information display is provided to facilitate travelers in finding the bus schedule (Levinson, 2003a). Operational average for this transportation is 19

km/hour. Headway of BRT or waiting average for this transportation is around three minutes. Average departure for this transportation in rush hour is around 67 units per hour. Only view routes have overtaking lanes which aim to overtake other vehicles (Muhtadi, 2017). Average numbers of passenger within rush hour are around 20,500 passengers per hour per direction. The total numbers of passenger in per day are around 566,500 passengers in which the average passengers in a year are around 169,950,000 [iii].

Service characters of Curitiba BRT are low cost and comfortable therefore it becomes the main option for traveler. It influences the displacement of private into public transportation which reaches 28%. In a year, it decreases the number of mobility up to 27 million in which it also decreases engine usage up to 27 million liters. Curitiba share model for transportation is 46% for public transportation, 26% for private vehicle and 28% for non-motorized vehicle (Muhtadi, 2017). About 70% of Curitiba's commuters use the bus system[v].

The private operating companies were forced to procure special, higher capacity buses to operate as "Express" buses on the trunk corridors by the municipality in 1974 when the first busway was opened[v]. Since then, the private bus operators have always financed the buses. Station maintenance has also been the responsibility of the bus operators, while the Municipality of Curitiba paid for the entirety of the infrastructure. They also covered maintenance of the roads. Boarding and fare payment inside tube stations was initiated along trunk lanes in 1991. The objective was to find a design that was functional, "clean", and unobtrusive. In 2012, the city initiated the integration with a bicycle network, expanded through the 2012 Bicycle Masterplan and also continues innovation in other parts of its transport sector: since 2014, they have been promoting 100% electric buses [ii].

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].

Source: www.brtdata.org

Figure 2.2: BRT Curitiba (Brazil)

Reason for success:

Curitiba's BRT system can be said to be one of the most successful because of its high ridership (Nasrin, 2015). The success of the BRT system is related to its integration in Curitiba's master planning and support from different stakeholders. Curitiba's BRT system uses bi-articulated buses and well-designed 'tube' stations to expand corridor capacity. The significant aspects of Curitiba's BRT relate not only to the BRT system itself but also its coordination with land use, enabling commercial/service development along the busways based on the Master Plan. As a result, Curitiba's bus transport system has become economically efficient and convenient for commuters.

2.3.2 BRT Bogota

Bogota, Colombia was recognized as the first ever winner of the Sustainable Transport Award for its TransMilenio Bus Rapid Transit System, which began operation in 2000 [i]. It was adapted by Bogota city as a part of a long-term sustainable transport strategy to encourage the use of public transport, walking, cycling. Population of Bogota in 2018 was around 8,181,047 people. Population density was around 3347.4 person/km2. GDP per person in 2016 was around US$ 5,806 [iii]. Average numbers of passenger within rush hour are around 49,000 passengers per hour per direction. The total numbers of passenger in per day are around 2,192,009 passengers in which the average passengers in a year are around 657,602,700 [iii]. The TransMilenio comprises dedicated busway, articulated buses, enhanced stations, smart card-based post -paid fare collection system in order to avoid long queue at station, advanced control system, distinctive image as well as an affordable cost for low-income users. The TransMilenio trunk services run on exclusive busway in the center of the city and integrated ticketing system with other big, medium

and small buses. This system fulfils 80% the demand of city transportation (Muhtadi, 2017). TranMilenio operates under partnership mechanism between state and private company. The state is responsible to develop and maintain infrastructures (through Urban Development Institute) and the private company is responsible for planning, management and service control. To maximise reduction in transit service cost per passenger kilometer, larger buses were installed and the number of buses was reduced. As a result, transport capacity, which was 30,000 persons/h per direction before implementation, increased to 49,000 persons/h [v].

Source: www.brtdata.org

Figure 2.3: TransMilenio BRT Bogota, Colombia

Reason for success:

Strong control by a single public entity enables well-coordinated bus operation[v]. TransMilenio S.A. is a single state stock company carrying out planning, management, and operation control of the TransMilenio bus system. It also operates the control center and controls the number of buses. All bus operating companies provide bus operations based on TransMilenio S.A.'s direction and are paid per operating km. This strong control by a single public entity has led to the successful operation of TransMilenio. Integrating bicycle infrastructure with mass transit, connection with the existing road transport system and leadership of Mayor Enrique Peñalosa, has made Bogotà a model livable city.

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].

2.3.3 BRT Ahmedabad

Ahmedabad's Janmarg BRT is the first full-featured BRT in all of India commenced on 2009. The system's name is Janmarg and won the 2010 Sustainable Transport Award [i]. City has population of 5,726,000 people, population density 4,060 persons/ km^2 and GDP as per 2016 was US$ 1,710 [iii]. Average numbers of passenger within rush hour are around 1,780 passengers per hour per direction. The total numbers of passenger per day are around 130,000 passengers in which the average passengers in a year are around 39,000,000 [iii]. Janmarg incorporates several sophisticated features of a high-level BRT system, including- median busways with strong longitudinal segregation and good pavement structure; changes in road geometry to accommodate new traffic patterns, including split flyovers, as well as new pedestrian and bicycle facilities; real bus stations, located in the median, with prepayment and level access to the buses; renewed vehicle fleets with special design, including wide doors on both sides; and frequent service to improve passenger convenience [vi]. The system also includes electronic fare collection, centralized control and user information systems. All these elements are classified as high-end, making Janmarg the first full BRT system in India. The system is projected to save 288,000 metric tons of CO2 each year [i], in part because it will prevent passengers from switching from bus to motorcycles or private cars and motorcycles in the years to come. The system also incorporates high-quality pedestrian facilities throughout the city as well as bicycle lanes.

Source: www.staward.org

Figure 2.4: Janmarg BRT, Ahmedabad, India

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

Reason for success:

Strong leadership, adequate coordination among stakeholders, good technical planning and careful implementation has made Ahmedabad BRT successful[vi].

2.3.4 BRT Guangzhou

Guangzhou's innovative 22.5 km long BRT corridor opened in February 2010 and is an example of holistic planning, with the BRT at the center of a multimodal transport network that integrates other urban design elements. The corridor's success was also recognized by the Institute for Transportation and Development Policy's Sustainable Transport Award in 2011[i]. Population number of Guangzhou city in 2013 was around 6,780,000 people, Population density in this city was around 1,764 people per km2 and GDP per capita in 2015 was around US$ 7,925[iii]. Guangzhou BRT does not have integrated terminals, 1 corridor in which the length of corridor is around 22.5 km, 3 transfers route, 26 bus shelters in which the distance of each shelter is around 808.8 meter. Fare ticket for standard service is US$ 0.3. Speed average in the city centre is 24.8 km/hour [iii]. It has fully segregated BRT lanes with world's highest BRT bus volumes (350 buses per hour in a single direction, system location in a high-density area and station size based on passenger demand; flat-rate subsidized bus fares and discounted smart cards; direct access to metro or rail stations; bridges from bus stations connecting directly to adjacent buildings; bike parking and public bike sharing available at or near BRT stations (more than 5,000 bikes)[ii,iii]. Average numbers of passenger within rush hour are around 27,000 passengers per hour per direction. Average passengers in a year are around 225,000,000[iii]. Guangzhou City share model for transportation is 32% for public transportation, 21% for private vehicle and 47% for non-motorized vehicle Numerous characteristics for Guangzhou city are cycling lanes are continuously provided along the bus corridors and it also supported with 5,500 park area for bicycle nearby the bus shelter area (Muhtadi, 2017).

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[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

Source: www.staward.org

Figure 2.5: Guangzhou BRT (China)

Guangzhou launched a bike sharing system with 5,000 bikes and 113 stations, primarily along the BRT corridor. It has also launched a spectacular greenway project along a polluted former canal which is part of a wider project to build dozens of kilometers of high-quality greenways throughout the city. This project created a 4km off-street bikeway and walkway combined with parks and plazas and areas for children to play alongside the water [i].

Reason for success:

Guangzhou's BRT system is particularly successful because of the holistic and detailed planning process. The city considered very carefully how the new BRT corridor would fit in with people's expectations and needs, as well as with existing modes of transit e.g. existing bus routes, walking and cycling options in the city, etc. Bike sharing along with park and ride facility and a "greenway" combining bike lanes, walkways, parks and playgrounds on either side of the BRT corridor were a part of BRT policy [i, iii].

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

2.3.5 BRT Mexico City

Mexico City, the largest city in North America, won the 2013 Sustainable Transport Award for its Bus Rapid Transit (BRT) system [i]. It also includes cycling and walking infrastructure, parking program, and revitalization of public spaces. Population number of Mexico City in 2010 was around 8,851,080 people, Population density in this city was around 2,451 people per km2 and GDP per capita in 2016 was around US$ 8,209 [iii]. The name of BRT in Mexico City is Metrobus. The operational system of this BRT is operated since 2005 and it is operated by company named METROBUS. Metrobus has 12 integrated terminals, 7 corridors in which the length of each corridor is around 140 km, 240 bus shelters in which the distance of each shelter is around 665 meter. Average numbers of passenger within rush hour are around 12,000 passengers per hour per direction. The total numbers of passenger in per day are around 1,240,000 passengers in which the average passengers in a year are around 372,000,000[iii]. Mexico City share model for transportation is 77.9% for public transportation, 20.7% for private vehicle and 1.4% for non-motorized vehicle[iii]. Speed average in the city centre is 18 km/hour. Average departure for this transportation in rush hour is around 77 units per hour. Only view routes have overtaking lanes which aim to overtake other vehicles.

Source: www.staward.org

Figure 2.6: BRT Mexico City (Metrobus)

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

Reason for success:

The BRT system of Mexico is successful because of integration of public bike system (Ecobici) and revitalized public spaces and plazas. Also, Mexico City Government's planning, coordination and management as well as financing of construction and maintenance of the corridor infrastructure made the system successful [vi].

2.3.6 BRT Buenos Aires

Buenos Aires, the capital and largest city in Argentina has population of 2,891,082 people, population density 50.7 persons/ km^2 and GDP as per 2016 was US$ 12,440 [iii]. For its success promoting urban mobility, reducing emissions, and improving safety, Buenos Aires won the 2014 Sustainable Transport Award [i]. Average numbers of passenger within rush hour are around 49,000 passengers per hour per direction. The total numbers of passenger per day are around 2,192,009 passengers in which the average passengers in a year are around 657,602,700 [iii]. In 2013, the city launched two new corridors of their BRT system, Metrobus: the 23 km corridor of Metrobus Sur and the 3.5 km corridor of 9 de Julio. In addition, the city has transformed dozens of blocks in city center into a pedestrian-friendly environment, encouraging walking and cycling, and plans to continue this process in the next year. These changes are bringing big changes to Buenos Aires and promoting a culture that prioritizes people over cars [i]. Avenue 9 de Julio, known as the "widest avenue in the world" with more than 20 lanes of car traffic, underwent an impressive "transit makeover" which is part of a citywide Sustainable Mobility Plan initiated in 2009. The city replaced car lanes with bus-only lanes and created a high-quality, median-aligned bus corridor with 17 stations, accommodating 11 bus lines.

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[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

Source: www.staward.org

Figure 2.7: 9 de Julio BRT Buenos Aires, Argentina

Reason for success:

Stakeholder engagement has been crucial for the city's successful BRT delivery, enabling it to overcome initial negative publicity [ii]. The BRT system now consistently rates among the best initiatives launched by the city administration, with positive impacts on everyday life.

2.3.7 BRT Rio de Janeiro

In 2014, the city received a Sustainable Transport Award for its second of four BRT systems, Transcarioca. Population of Rio de Janeiro in 2015 was around 6,476,631 people, population density in this city was around 2,209 people per km2 and GDP per capita in 2015 was around US$ 8,539[iii]. The name of BRT in Rio de Janeiro (Brazil) is BRT Rio. The operational system of this BRT is operated since 2011 and it is operated by company named SMRT. BRT Rio has 8 integrated terminals, 17 corridors in which the length of each corridor is around 168 km, 49 transfers route, 240 bus shelters in which the distance of each shelter is around 700 meters. In each terminal and shelter, real time information display is provided to facilitate travelers in finding the bus schedule Fare ticket for standard service is US$ 1.16. Ticket of BRT Rio is integrated with all corridors in Rio de Janeiro. Operational average for this transportation is 21.8 km/hour Average departure for this transportation in rush hour is around 382 units per hour. Only view routes have overtaking lanes which aim to overtake other vehicles. Average numbers of passenger within rush hour are around 65,400 passengers per hour per direction. The total numbers of passenger in per day are around 3,178,600, passengers in which the average passengers in a year are around 953,580,000 [iii]. Rio de Janeiro share model for

transportation is 48.7% for public transportation, 19.5% for private vehicle and 31.8% for non-motorized vehicle. In 2009, the city put in sharrows (shared car and bike roads) connecting the metro line to the bikeway[iv]. At the same time, they opened a new bike sharing system with 8 stations and 80 bikes. This bike sharing system, originally called SAMBA but now BiciRio, expanded over the next few years with a doubling of stations and bikes in 2012. In 2012, the city built 300 km of new bike lanes and released the first official bike map to promote access to the city's expanding bike opportunities.

Source: www.brtdata.org

Figure 2.8: BRT Rio de Janeiro (Brazil)

Reason for success:

Rio de Jeneiro BRT has proved so successful because it was part of Rio's holistic planning exercise for the corridor and a strong overarching transport improvement plan for the city. There is a bike-sharing program implemented in Rio de Janeiro that makes it easy for travelers to the BRT Rio stop (Muhtadi, 2017). It connects high density areas around the city.

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

2.3.8 BRT Jakarta

Population number of Jakarta (Indonesia) in 2011 was around 9,607,787 people, Population density in this city was around 3,830 people per km2 and GDP per capita in 2016 was around US$ 3,570 [iii]. The name of BRT system and its operator in Jakarta is Transjakarta. It was opened in 2004 in which it has 240 BRT shelters, 12 corridors with its length is around 206.75 km. Average numbers of passenger within rush hour are around 3,600 passengers per hour per direction. The total numbers of passenger in per day are around 370,000 passengers in which the average passengers in a year are around 114,783,774 [iii]. The capacity of TransJakarta corridor one is only 3,600 persons/hour/ direction. One of the main reasons for Transjakarta's low capacity is the relatively small size of its buses. Jakarta BRT does not have any bike sharing policy along BRT Corridor that made it less successful. But Transjakarta has integrated medium sized bus operators, small bus operators and LRT (ITDP, 2019). Many of the important features added to Transjakarta's system like having dedicated bus lanes, off-board fare purchasing and advance ticketing (ITDP, 2019). Transjakarta has been nominated for 2020 Sustainable Transport Award because of its continuing success [i].

Source: www.itdp.org

Figure 2.9: Transjakarta (Indonesia)

Reason for success:

Integration with bus and paratransit operators made Jakarta BRT system successful. Also 3 in 1 policy helped to reduction of car congestion and ridership of BRT.

[i] Source: Sustainable Transport Award, available at www.staward.org [accessed on 5 July. 2019].
[ii] Source: Good Practice Guide: BRT, C40 Cities Climate Leadership Group, available at www.c40.org [accessed on 5 July. 2019].
[iii] Source: Global BRT data, available at www.BRTdata.org [accessed on 18 Mar.2019]
[iv] Source: Rio de Jeneiro, available at www.itdp.org [accessed on 11 July. 2019].
[v] Source: Bus Rapid Transit (BRT): Toolkit for Feasibility studies, available at www.sti-india-uttoolkit.adb.org [accessed on 13 July, 2019].
[vi] Source: World Resources Institute, available at www.wri.org [accessed on 5 July. 2019].

2.4 BRT based connectivity in cities

Continued growth of urban areas, including many CBDs and suburban and regional centers, requires more transport service (Levinson, 2003b). BRT plays an important role as the rapid mass transit feeder, serving passengers from suburban residential areas to the business area in the CBD. A typical alignment of BRT corridor is shown in Figure 2.10, which shows connectivity of CBD and the satellite city in a suburban area.

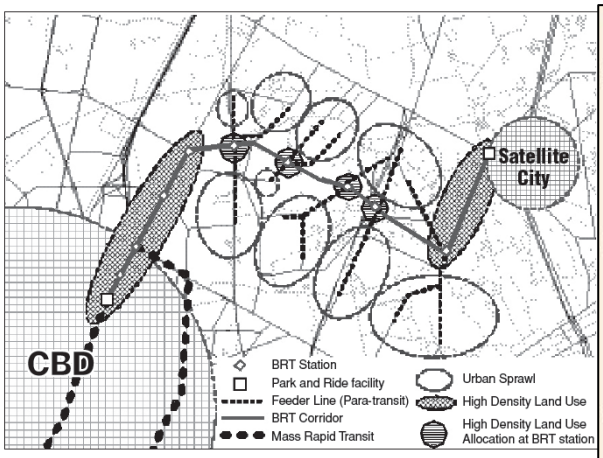
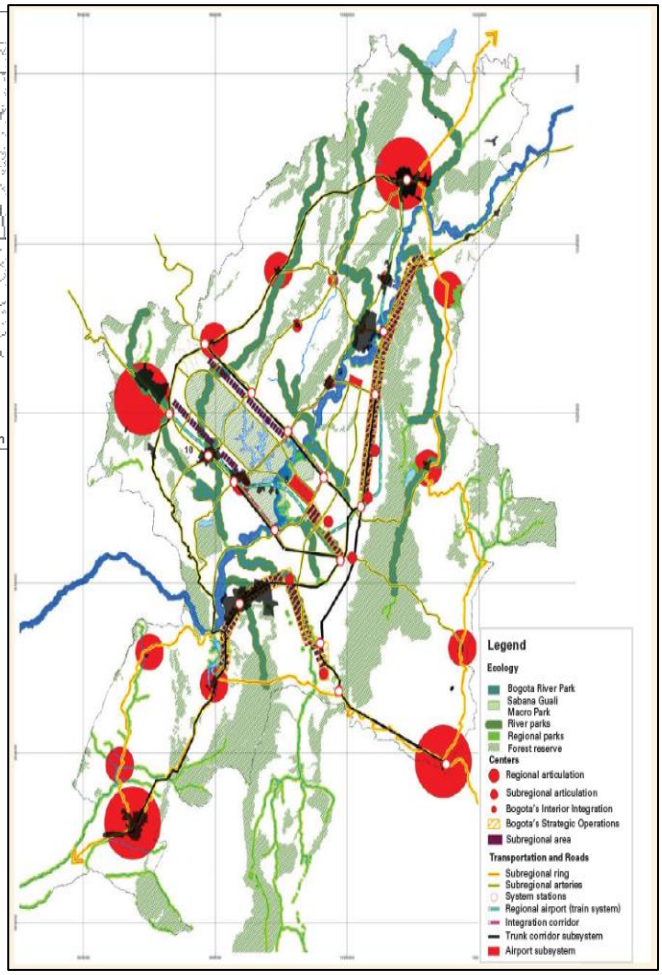


Figure 2.10: Typical BRT Network connecting Satellite city

Source: Satiennam, 2006

Bogota is developing a high-capacity Transit system, which will be integrated with other public transit modes, including regional trains and extended BRT lines (Suzuki, 2013). Bogota's Regional Connectivity model in shown in Figure 2.11. Same type of regional connectivity with BRT network can be found in Ottawa, Hanoi city etc. also.



Source: Suzuki, 2013

Figure 2.11: Bogota's regional connectivity model

2.5 Review of BRT related studies from abroad

An extensive literature review has been carried out to get the basic understanding and to acquire knowledge on finding criteria for introducing BRT in potential cities. Relevant research approach and their findings are as follows:

Levinson (2003) said size of urban areas, concentration of population and activities in key corridors, and strength of the CBD have important bearing on the transit market in general and BRT in particular. BRT systems are found in urbanized areas of more than 750,000 people and (in the United States and Canada) areas with downtown employment that exceeds 75,000 (Levinson, 2003). There may, of course, be special situations in smaller urbanized areas that make BRT desirable. Factors include (1) the intensity and growth prospects and patterns of the urbanized area; (2) the existing and potential future demand for public transportation; (3) expansion of the urbanized area; (4) street width continuity, capacity, and congestion; (5) opportunities for off-street running ways; (6) bus operating speeds and reliability; (7) locations of major employment centers and residential developments in relation to potential BRT routes; (8) community attitudes; and (9) community resources. Community willingness to support public transportation, foster transit-oriented development, and enforce bus lanes is essential. Finally, the report has suggested that the following three conditions should be in place when BRT is being considered:

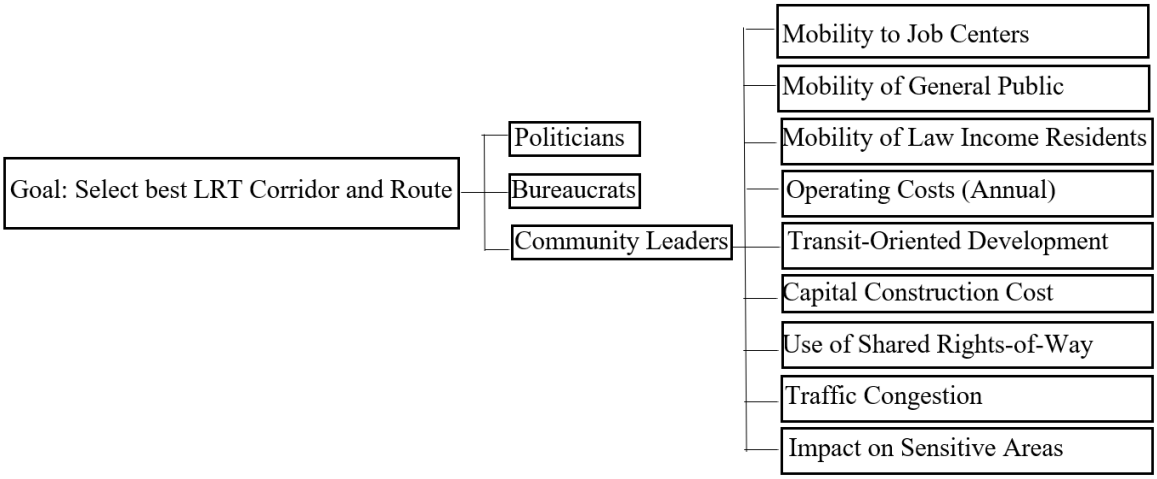
(1) the proposed location is a large city with a strong CBD, an urbanized area, or an activity center with dense patterns that facilitate transit use;

(2) there are current total passenger flows that might support high service frequencies that are characteristic of rapid transit, and

(3) there is a sufficient "presence" of buses where bus lanes or busways are being considered.

Banai (2006) used Analytic Hierarchy Process (AHP) for multicriteria analysis to assess light rail transit (LRT) corridor and route alternatives. Main objective was to understand decision making process of LRT corridor and route selection process in Memphis, Tennesse. Three broad criteria and nine sub criteria were used to determine the best LRT corridor alternative: (1) mobility to job centers, (2) TOD impact, and (3) operating cost. First, the relative importance of the criteria was determined. A rating scale was then

developed to evaluate alternatives. Politicians, bureaucrats, community leaders, and the general public were interviewed.



Source: Banai, 2006

Figure 2.12: Criteria Used in Selecting best LRT Corridor and route for Memphis

Kittelson & Associates (2007) has provided a general guideline for BRT practitioners for BRT development. They have included some key steps for developing and analyzing BRT service alternatives.

1. Establish the Need: Considerations include existence of (a) slow and unattractive local bus service; (b) peak-period congestion on major roadways; (c) continued (or anticipated) growth in CBD employment, urban population, and transit ridership; and (d) community desire to improve transit.

2. Identify the Market: Current and future land use and demographic characteristics should be clearly identified. Market segments include riders diverted from local bus and automobiles as well as new trips. Similarly, current and future transit ridership profiles - including origin-destination patterns, expected BRT ridership, and maximum load section (point) volumes-should be determined. Candidate markets include corridors with sufficient ridership potential to allow frequent all-day service (preferably at headways not greater than 10 to 12 minutes). A strong CBD and high-density corridors are supportive of BRT.

3. Select Type of Running Way; Selecting the type of BRT running way depends upon (a) availability of off-street right-of-way within the proposed BRT corridors; (b) width,

continuity, and operational characteristics of arterial streets; and (c) the ability to integrate BRT operation with existing transit service.

4. Recognize Public Preferences: Community and agency preferences regarding BRT routes should be taken into account. The public's preference for a special BRT vehicle should have the support of the transit agency responsible for operating the BRT service.

5. Integrate BRT with Existing Bus Services: Existing bus routes on streets in or serving a BRT corridor may need to be restructured. Local routes should feed rather than duplicate the BRT service. Where BRT operates on busways, terminals or outlying stations can serve as focal points for connecting bus services.

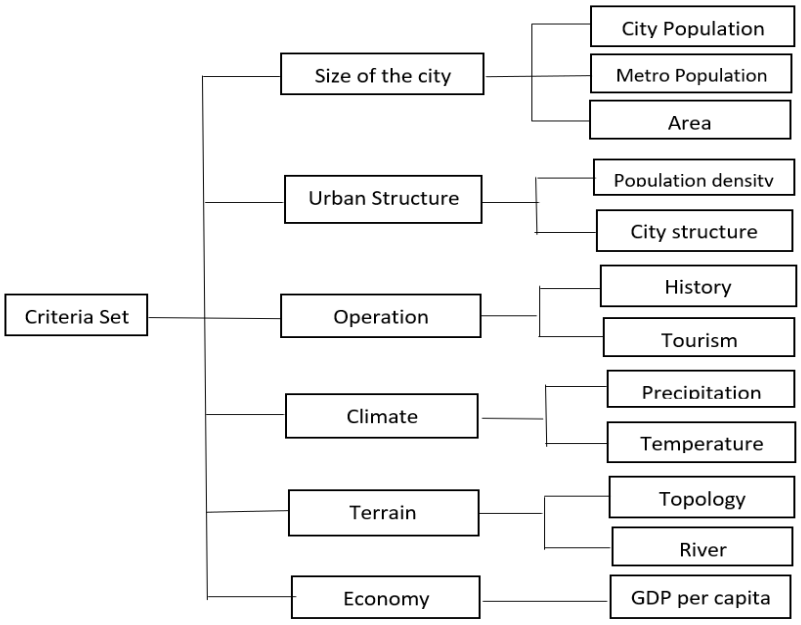
6. Consider Funding Availability: Available resources for capital, operating, and maintenance requirements are essential. The funding available for BRT may influence the type and extent of BRT features and the staging of BRT service implementation. Where funding is limited, BRT may have to operate on city streets rather than on off-street busways (at least initially). Similarly, existing vehicles might have to be used initially (although distinctively colored).

7. Explore Development Opportunities: Opportunities for land development near BRT stations should be explored. They can have bearing on (a) the extent of the BRT system, (b) the location and design of stations, (c) the type of running way selected, and (d) ridership.

MDTA (2011) has conducted a countrywide Bus Rapid Transit study for Maryland. A preliminary screening methodology was developed for the first 20 initial BRT corridors to provide regional connectivity. The methodology attempted to normalize certain attributes of some corridors relative to others. The four screening criteria developed for this stage of the study represented these corridor attributes; they are – (1) Existing daily bus trips, (2) Percent of corridor within a 1/2-mile radius having BRT-supportive density under future conditions, (3) Presence of major attractors/activity centers and (4) Regional transit connectivity. The total scores for each corridor were calculated in two different ways: 1) assuming equal weights for all four criteria and 2) assuming different weights for each criterion. Population and employment density and the number of major attractors and activity centers received the highest weights because these criteria provide strong justifications for offering and supporting BRT service. Daily bus trips received the lowest

weight because data on existing daily ridership was unavailable by corridor segment at the time of the evaluation.

Talebian (2014) distinguished successful cities around the world with respect to transportation and similar city to Isfahan, Iran in his study. Cities categorized as well-above average and above average in Global Cities Initiative (GCI) and Haghshenas & Vaziri's Urban sustainable transportation indicators were used and total 83 cities were selected for the study (Talebian, 2014). By reviewing transportation policy literature and negotiating with experts, main characteristics of 83 cities which were effective in selection of transportation policies were specified. Considering particular features of Isfahan, the most important similarity criteria were categorized into 6 main categories and 12 subcategories. Using AHP and pairwise comparison method, weights and the relationships among the criteria were evaluated. 15 experts, including university professors studying relevant fields, and transportation planning specialists in municipality of Isfahan, were asked to do the pairwise evaluation. Foreach pairwise comparison, geometric mean of 15 numbers in the questionnaires was considered as the final value for each pairwise comparison. The weight of each criterion was calculated using AHP method by Super Decision software.



Source: Talebian, 2014

Figure 2.13: Criteria used in Sustainable Transportation Policies Identification for Isfahan

Those characteristics of the cities which are determinant in selection of transportation policies were introduced and the weights that transportation experts assign to each characteristic were presented. Then, the most similar city to Isfahan was selected, based on similarity criteria and weights. Finally, the selected cities were studied and the most repeated policies were distinguished and suggested for implementation in Isfahan. Policies which were more frequent and repeated more than three times in the case study areas were recognized to be introduced as appropriate policies for evaluation and implementation in Isfahan. Policies were categorized into three groups, including private transportation, public transportation, and non-motorized transportation. The policies implemented in successful cities are parking pricing, Intelligence Transportation Systems (ITS), car-sharing and carpooling, and using small cars etc.

Salavati (2016) wanted to define appropriate criteria for the systematic approach to evaluate and prioritize multiple candidate corridors for public transport investment in Isfahan, Iran. In this regard, 137 questionnaires were completed by experts, directors, and policymakers of Isfahan to identify goals and objectives in the field of urban transportation. 12 criteria were described in this paper, such as- alleviating traffic congestion in city streets and highways, traffic safety improvement especially pedestrian safety, and reliability improvement in transportation systems regarding schedule adherence, trip comfortability, accessibility to transportation systems, attractiveness of the transportation system, facilitation of a sense of living in a modern city, mode choice diversity in city trips, efficient response to transportation demand, reducing energy consumption in city transportation sector, reducing travel time, and trip cost. In the next step, objectives were prioritized by a multi-criteria decision-making method using AHP. Afterward, for the main 35 corridors of the city, available information, including trip demands toward main destinations of studied corridors derived from Isfahan comprehensive transportation studies and number of passengers of bus lines, were collected. Finally, 3,906 taxi passengers were interviewed at the end points of each corridor. Proper alternatives were offered as feasible policies of public transportation for the studied corridors.

2.6 Review of Literature on Dhaka, Bangladesh

2.6.1 Review of high capacity public transport related studies for Dhaka

A few studies have been conducted in Bangladesh related to Mass rapid transit. Some of the studies are briefly presented below.

Ahsan (1990) studied on Mass Transit in Metropolitan Dhaka. He observed that public transport plays a significant role in metropolitan's transport system. In developing countries, bus transit with combination of various vehicles sizes and services in playing an increasingly major role in urban passenger transportation. The study investigated the status of the public transport systems in metropolitan Dhaka. Particular attention has been given to examine the necessity of a functional and cost effective 'Mass Transit' system.

Karim (1998) discussed about the Light Rail Transit (LRT) system as a mass transit option for Dhaka city. He said, "It is quite difficult to imagine that basic transport services can be provided for a metropolis with 10 million people without reliable mass transit system. To cope with the problems of increasing transportation demand, traffic congestion, deteriorating environmental quality, and inadequate traffic safety measures Light Rail Transit can be a probable solution." He also mentioned that although transport demand requires the development of rail mass transit system, financial restraints normally rejects the option and sometimes economic reason asks for better alternative solutions.

Hoque and Hossain (2003) suggested to introduce Tramway in Dhaka. They emphasized on the augmentation of mass transit system is a necessity to ensure mobility need, road safety, and liable urban environment for Dhaka city in future. Rail based tramways, with description of its inherent cost and service characteristics have highlighted as a potential option for improvements of existing public transport system.

Amin and Kabir (2004) have been conducted a study titled on "Evaluation of Bus Rapid Transit as A Mass Transit Option for Dhaka City: Case Study of Route No.9 and 11". This study aims at introducing a mass rapid transit option of relatively low cost and fast implementation time, which would be able to cope with the physical and economic condition of Dhaka City. The study was undertaken to focus the comparison among various mass transit options and to identify a mass rapid transit option as well as to assess its physical and economic evaluation in the context of Dhaka City.

Mahmud and Anwar (2012) have been conducted a study on "A Preliminary Feasibility Study of Bus Rapid Transit System in the Context of Present Road Network in Dhaka". They said existing mass transit system in metropolitan Dhaka is mainly characterized by large bus, mini bus and human hauler/auto-tempo. But, to meet the future demand MRT and BRT will be needed as proposed in STP. As per their study, in spite of having huge benefit and large potentials, Insufficient Road Width, Insufficient Space for BRT Station, Uncontrolled and Excessive Access Road are being some of the conflicting and constraining issues for implementing BRT in Dhaka. The widening of road, Efficient pedestrian movement, Segregated bus lane, encouraging consolidation of the industry into larger operating units etc. have been suggested in this study for the successful implementation of BRT system.

Nasrin (2015) combined a mixed qualitative and quantitative methodology to understand potential uptake of BRT by commuters in Dhaka for their work trip in her PhD thesis titled "Acceptability of Bus Rapid Transit (BRT) to Commuters in Dhaka" BRT systems in model cities of Curitiba, Bogota, Santiago, Jakarta, Beijing, Ottawa and Brisbane were reviewed in this research. Their success factors, for BRT planning and implementation, were grouped into four broad interrelated categories. This review provided a strong foundation to investigate the challenges that may be faced when planning and implementing a system in Dhaka. Quantitative analysis was conducted by developing mode choice models for Dhaka with RP and PMS data.

Rahman (2017) studied Dhaka-Narayanganj and Dhaka-Gazipur these two routes to analyze the mode choice behavior of the commuters who regularly travel to Dhaka from its suburban areas using public transportation. The study found that suburban commuters spend a substantial amount of time for access and egress. Unlike intra-urban travel where most of the people get access to the main mode by walking or NMT (Nonmotorized Transport), for suburban travelers, MT (Motorized Transport) modes play an important role both in access and egress. Rail travelers usually travel longer distance and egress end and they are more likely to choose MT as egress mode than bus travelers. For the main mode choice binary logistic regression and for the access and egress modes Multinomial Logistic Regression (MNL) have been applied in this study.

2.6.2 Existing Transport Plans of Dhaka

Bangladesh has a wealth of experience in development planning having formulated and implemented several medium terms and short-term development plans. Development is an integrated and continuous process necessitating a long-term perspective.

The "Outline Perspective Plan of Bangladesh 2010-2021: Making Vision 2021 A Reality" has three targets to fulfill in the transport sector with the policy that an attractive Bus Rapid Transit (BRT) system should be introduced in the medium term.

The following are the long-term transport plans for Dhaka:

Long Term Transport Plans for Dhaka:

- ¶ Dhaka Integrated Traffic Study (DITS)- 1994
- ¶ Strategic Transport Plan (STP)- 2004– accepted in 2008
- ¶ Dhaka Urban Transport Study (DHUTS)-2010
- ¶ Revised Strategic Transport Plan (RSTP)- 2015

2.6.2.1 Dhaka STP (Strategic Transport Plan)

The Strategic Transport Plan (STP) was prepared in 2004 by Dhaka Transport Coordination Board (DTCB) under the Ministry of Communication with assistance from the World Bank. The STP laid out a 20-year (long-term) transport plan for the greater Dhaka area and its transport strategy outlined a balance between public transport, private transport, and anticipated future demand forecast. The plan is divided into four 5-year periods commencing in 2005 and ending in 2024. The urban development scenario selected in the STP was the "Growth Pole Scenario" which included the concept of satellite suburban cores. These suburban cores would be built up with housing and working space and connected with CBD by UMRTs.

Proposed projects:

The STP suggested a number of important transport components, including strategic road links, expressways, the Mass Rapid Transit (MRT) System, and a Circular Water-way for Dhaka. Many of the STP roads were derived from the earlier DMDP and besides these inherited proposals new arterial roads were also recommended by STP. These new

road links when fully completed will form the major arterial road network for Dhaka and facilitate smooth traffic movement along east-west and north-south directions.

The STP also recommended three Bus Rapid Transit (BRT) lines and three Metro Rail (MRT) lines. However due to shorter lead-in time for design, financing and the construction, it was proposed that the BRT lines should be constructed before the proposed Metro Rail system.

The STP recommended three elevated expressways which are as follows:

- ¶ Gulistan-Jatrabari Flyover: This project was developed and proposed by Dhaka City Corporation (DCC) to be implemented as a PPP project (BOT basis). It will be a 10 km. dual 2-3 lane expressway. The project work is currently in progress and was programmed for completion by mid-2013.
- ¶ The Elevated Expressway: This is a 20 km elevated expressway proposed by Roads & Highways Department (RHD), and was to be developed in 2-phases.
- ¶ In Phase-I, the Gulistan to Mohakhali section
- ¶ In Phase-II, from Mohakhali flyover to the north section as a dual 3-lane expressway.
- ¶ Mogh Bazar-Mouchak Flyover: This project is being developed by Local Government Engineering Department (LGED) with financing from the Kuwait Fund. The STP suggested that this scheme should include connection somewhere in the area of Paribagh and Bangla Motors before the project plans are finalized.

Implementation plan

The implementation plan, which commenced in 2005 and ends in 2024, is divided into four five-year plans. The key aspects of the various phases are summarized in Table 2.2. Figure 2.14 shows the locations of the proposed MRT and BRT alignments.

Table 2.2: Implementation of the proposed projects

Phase	Period	Proposed Project
1	2005-2009	¶ Concentrating efforts on optimal use of existing resources and improvement of current transport services ¶ Implementing transport management measures for major routes, including first BRT line ¶ Formulating guidelines for development of Mass Rapid Transit system, including BRT and MRT system

2	2010-2014	¶ Completing three major elevated highways, based on PPP and financing plan ¶ Continuing development of BRT line network and opening of 16 km of Line 3 ¶ Final design of initial MRT line (Line 5) and financing plan ¶ Full rationalization of regular bus services to supplement Mass Rapid Transit system
3	2015-2019	¶ Final design of second and third MRT lines (Line 4, Line 6) and financing plan ¶ Completing construction of MRT Line 5
4	2020-2024	¶ Completing construction of MRT Line 4 and Line 6

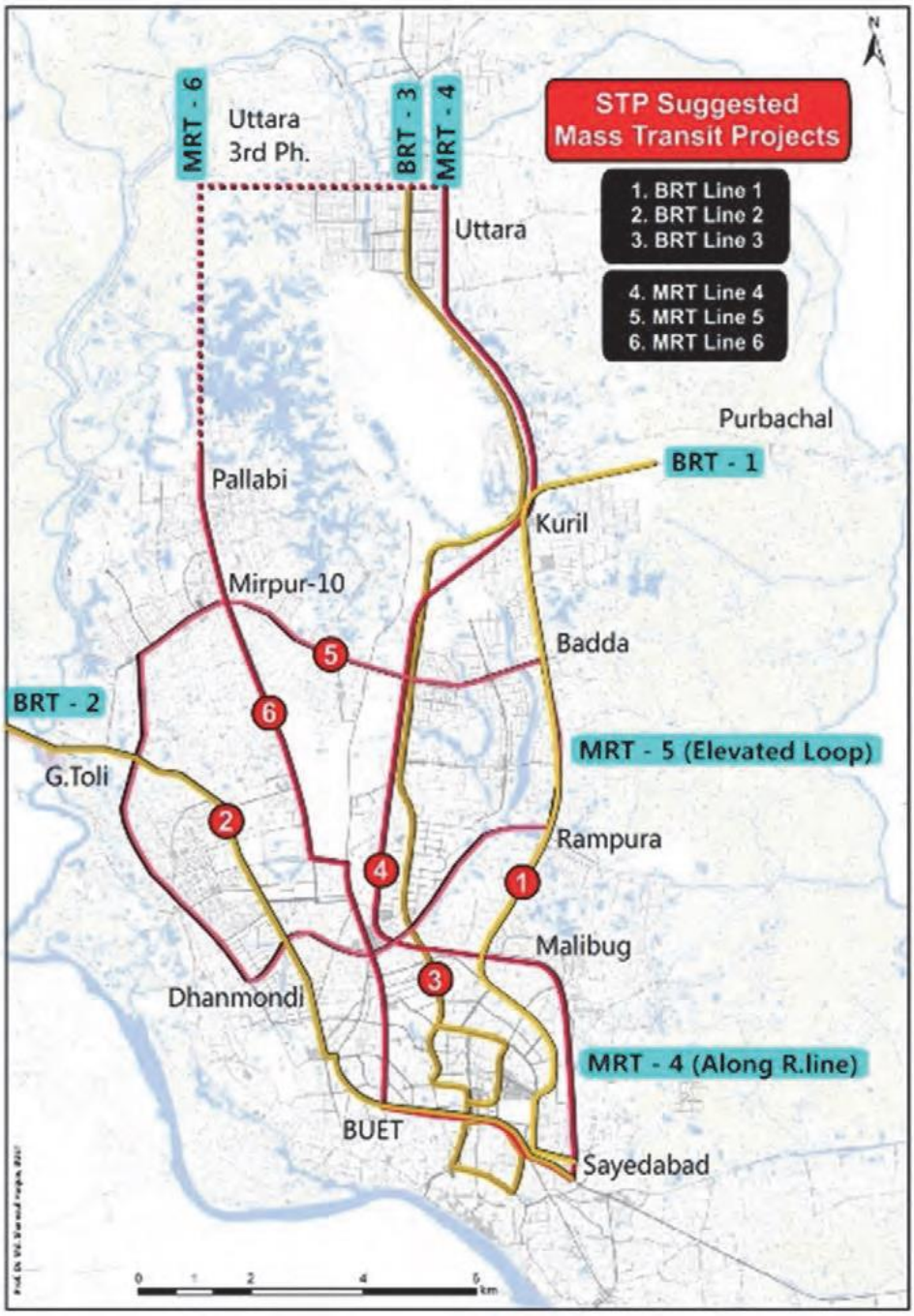


Figure 2.14: MRT and BRT Alignment

2.6.2.2 Dhaka Urban Transport Network Development Study (DHUTS), 2010

The Dhaka Urban Transport Network Development Study (DHUTS) was conducted in 2010 by JICA to formulate the urban transport network in Dhaka up to 2025. The DHUTS featured strategy and implementation plans including the public transportation development plan, the road network development plan, the traffic management plan, and the institutional development.

The urban transport development policies of DHUTS are:

- ¶ Introduction of mass transit system based on the present public transport system hierarchy;
- ¶ Developing an intermodal public transport system consisting of the proposed Dhaka MRT and bus and para-transit systems for efficient integration and interconnection between different public transport elements;
- ¶ Recognizing that transport cost of public bus is comparatively cheaper than the other modes for low-income peoples; and
- ¶ The Mass Rapid Transit (MRT) system in order to solve traffic congestion in the Central Business District (CBD) needs to be developed to promote new urban development to accommodate increasing population and to promote appropriate urban development.

Proposed projects in DHUTS:

Public Transport Development Plan:

The four key policies for public transport development plan were recommended by DHUTS. These included:

- ¶ The introduction of mass transit system based on hierarchy of public transport system;
- ¶ Building an integrated public transport system;
- ¶ Public transport for low income sectors; and
- ¶ A public transport system that promotes urban development.

In addition, the Mass Rapid Transit system (MRT) plan was recommended in order to accommodate future population increases. A total of eight MRT lines will be constructed

by 2050 according to DHUTS. Of the proposed MRT lines, Line 6 was especially recommended as the most urgent project.

Figure 2.15 shows the MRT network proposed in the DHUTS.

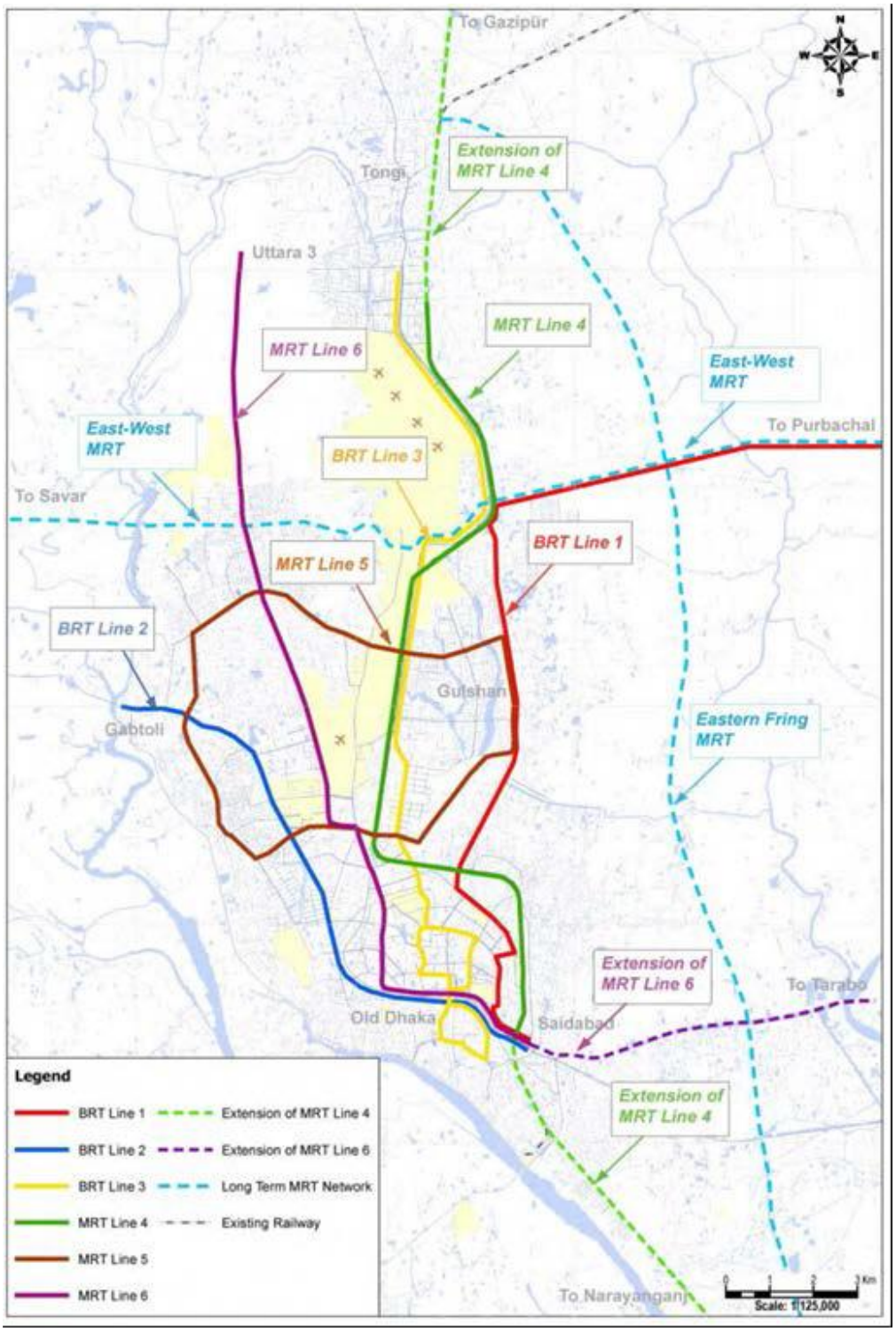


Figure 2.15: Mass Rapid Transit Plan by DHUTS

Road Network Development Plan:

The DHUTS showed the road network development plan, which included the improvement of existing road networks, improvement of missing links, the development of grid type road networks, provision of urban expressway networks, and improvement of inner ring roads. The recommended road network development plan based on above policies is shown in the Figure 2.16 below.

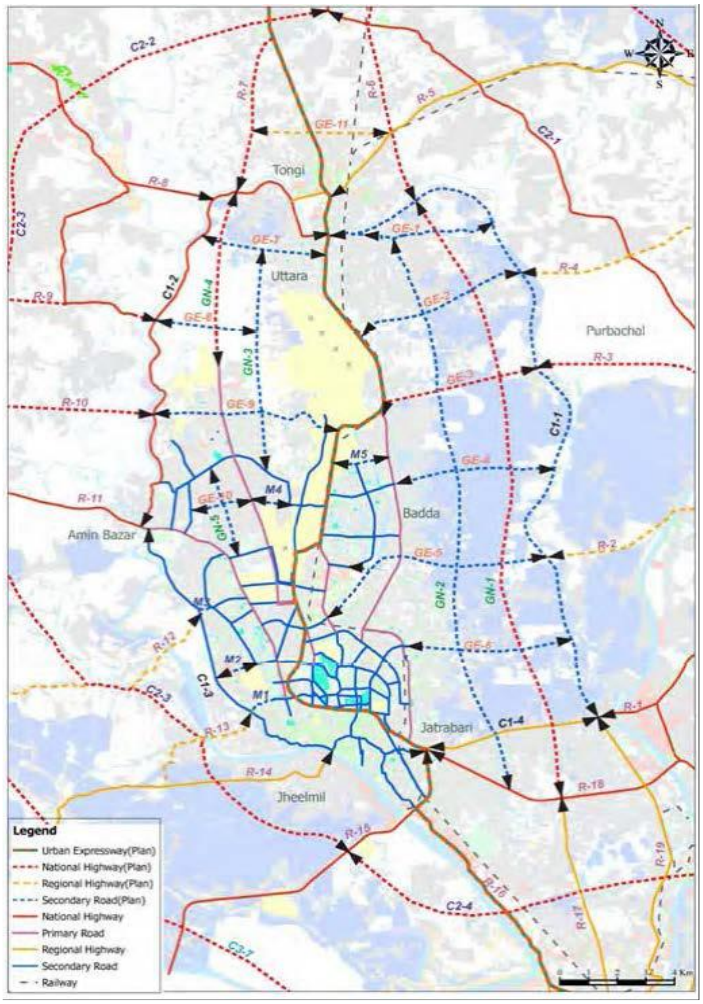


Figure 2.16: Network Plan by DHUTS

The principals of the road network development plan for DCC and DMA are;

- ¶ To improve city based on hierarchical and functional road network;
- ¶ To improve the primary road network to link between CBD of Dhaka and urban cores, satellite communities and division centers;
- ¶ To improve links within the urbanized area in order to prepare efficient road network;
- ¶ To develop the grid type road network for newly development areas taking into consideration the geographic feature of the Eastern Fringe Area;
- ¶ To construct the Urban Expressway to form a backbone road network in the center of Dhaka; and
- ¶ To improve the Inner Ring Road to serve traffic from Dhaka to regional centers in RAJUK area but also in Bangladesh.

Institutional Development:

The DHUTS recommended the establishment of the Dhaka Mass Transit Authority (DMTA). The DMTA was expected to assume the functions of the Dhaka Transport Coordination Board and to determine public transport projects including the MRT and BRT systems. The establishment of the MRT operating company (DMTC) was also recommended.

The high priority projects proposed in DHUTS are:

- Public Transport Projects
- MRT Line 6 Project
- BRT Line 3 Project
- Road Projects
- Eastern fringe road project
- Southern section of middle ring road
- Flyover projects
- Traffic Management
- Comprehensive traffic management project
- Organizational development for DMTA and DMTC

2.6.2.3 Revised Strategic Transport Plan (RSTP), 2015-2035

The population growth and urbanization of GDA have changed much more rapidly than the forecasts predicted in the STP:

- The Growth Pole Scenario which proposed in the STP has not occurred;
- The existing Dhaka phase 2 has moved on to the next phase, Phase 3A;
- Only one BRT line and one MRT line are still in design stage;
- Construction of the BRT Line 3from Gazipur to International airport is expected to start in late 2014 with bus operation starting in mid-2015;
- MRT Line 6 is at the detail design stages and will start operate in 2019.
- Construction of flyovers proposed in the STP has been completed without complimentary transport infrastructures with the result that traffic congestion beyond the flyovers is still congested.

It has been acknowledged that the socio-economic environment and urban transport environment is quite different from the supposed environments in STP. Consequently, the JICA RSTP study team revised and updated the STP based on the latest transport environment and conditions. Figure 2.17 summarizes the transport proposals included in the STP.

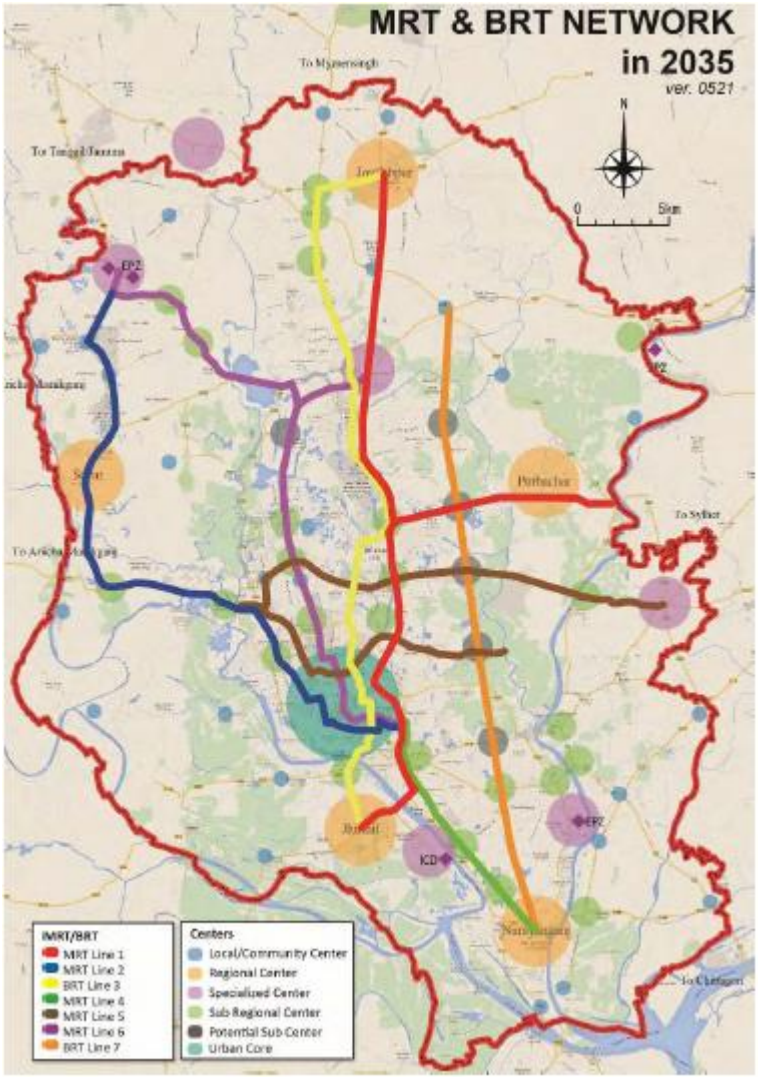


Figure 2.17: Proposed Transport System in RSTP

Transport mode integration Policy as per RSTP: RSTP has listed several transport policies including integration of mass transit along with NMTs. Some of these are as follows:

Policy 37: The Government will study to provide segregated or mixed NMT path network with full connectivity, commercial centers, and communities. This project will include the implementation of the proposed measures.

Policy 56: The Government will encourage the designation of some areas and streets as "motorized-free zones". These areas may be designated for specific times or days and the built environment will be developed and improved to encourage walking and NMT services.

Policy 57: For the more distant future, the Government will investigate the potential for the introduction of a Congestion Charging System for specific areas of the metropolitan area in order to control vehicular traffic at specific hours of the day. At the same time a parallel public awareness program will be introduced to inform the public that revenues from the Congestion Charging System will be reinvested in the public transport system.

Policy 70: Bicycles will be recognized as a mode of transport and separate lanes and crossings will be provided within the city in order to make bicycle journeys safe and pleasant.

2.7 Summary of the Literature review

Literature shows that BRT has got much more popularity after 2011 and the demand is increasing in developing countries. Cities are very diverging in terms of demographic, economic and social criteria. But successful BRT having cities around the world have strong political will to implement BRT as a Public Transport solution (e.g. Curitiba, Bogota etc.). Proper design, Integration with land use and transportation policies, coordination among different agencies, public participation etc. are also major reasons for being successful (e.g. Guangzhou, Mexico City, Rio de Janeiro etc.). BRT is important for urban as well as regional connectivity. Many cities like Bogota, Hanoi, Ottawa are having regional connectivity through BRT. Many transport plans have been prepared namely STP, DHUTS, RSTP in Bangladesh for providing efficient connectivity to the Dhaka city only. RSTP has revised STP and it has introduced one more BRT named BRT Line-7 which will connect Narayanganj, Dhaka and Gazipur District as a regional transport. Many academic studies also have been done in different period. Most of them suggests BRT as a public Transport solution for Dhaka city. But in spite of having large potentials, Insufficient Road Width, Insufficient Space for BRT Station, Uncontrolled and Excessive Access Road are being some of the conflicting and constraining issues for implementing BRT in Dhaka (Mahmud and Anwar, 2012). But there is not much literature on the selecting criteria to assess the merit of providing BRT in a city. Only a few has been found and those are reviewed here. Many of the studies on BRT from abroad talks about the efficiency of the systems. In Bangladesh context studies regarding BRT is further few. Most of the studies on public transport are about mode choice behavior. However, recent transport plans and studies for Dhaka have reflected a good focus on BRT.

Chapter 3
Methodology

Chapter 3: Methodology

3.1 Introduction

Methodology outlines here the techniques for the collection of data and the procedures applied for the execution of the study. It expresses a systematic way through which any study can be done in a fruitful way. This chapter outlines the overall design of the study and research methodologies that have been followed to achieve the objectives set out in Chapter one. It also describes data collection procedures at different stage of the research work. Data analysis procedures and techniques are also presented here.

3.2 Outline of the Research Methodology

Following processes/methods were applied for achieving the target which is set out as objective in the introduction chapter.

- At the very beginning of the research work, an extensive literature review has been carried out to know the criteria, nature, recommendations etc. of previous research, project reports conducted in home and abroad on criteria setting, research method, policy etc. to acquire knowledge for the basic understanding on the topics.
- In order to find out the potential cities for introduction of BRT, 30 cities of Bangladesh have been reviewed in terms of population, area, density, economy, transport sector etc.
- Information and data related to policy, institutional framework, management and maintenance practices have been collected from secondary sources like Global BRT Data, RHD, LGED, BRTA, World Bank, previous research survey report, published articles and internet browsing.
- Consultation with experts has been carried out to set criteria and priority matrix. All the data has been analyzed with AHP Method in order to get potential cities of Bangladesh for BRT development.
- Finally, in line with research findings and the relevant guidelines, policy framework has been proposed for BRT development in Bangladesh, which will fulfill the last objective of the study.

3.3 Detailed Methodology and Data Collection of the Study

According to the flow chart of the methodological framework of this study, detailed methodology and procedure of data collection are discussed in this section. This qualitative research will be based on secondary data and limited primary data to understand the criteria for potential cities for BRT in Bangladesh.

3.3.1 Primary Data Collection

The primary data was collected by using the following instruments:

Consultation with the Experts:

Consultation was done with experts in transport authority, academia and practitioners. It has been done in two stages. At first a list of potential factors affecting choice (or not choice) of BRT in a city has been identified based on literature review. The list is shared with experts to get their feedback regarding the validity of the factors in the context of Bangladesh. The experts were interviewed personally and via electronic mail.

Table 3.1: Organizations of Expert Panel Selected for AHP

Organizations
Dhaka Transport Coordination Authority (DTCA)
Bangladesh Road Transport Authority (BRTA)
Rajdhani Unnayan Kartripakkhya (RAJUK)
Local Government Engineering Department (LGED)
Asian Development Bank (ADB)
Jahangirnagar University (JU)
BRT Line-3 and MRT Line-1 project officials

After finalizing factors, the consultants were again contacted for putting their priority to criteria. Thus 10 priority matrix was obtained. See **Appendix C** for the list of experts.

3.3.2 Secondary Data Collection

For foreign BRT having cities data on city population, density, length of BRT corridor, passengers per day using BRT, BRT operating agencies, policies were collected from BRT database, online government documents/census and journals. Data for cities of Bangladesh were collected from census, LGED, RHD. Table 3.2 provides a list of secondary data collected.

Table 3.2: Type and sources of secondary data

Sl. No.	Data type	Data Source
1.	BRT Having city population, density, length of BRT corridor, passengers per day using BRT for 170 BRT having cities	GlobalBRTData
2.	BRT operating agency	Hossain (2005), ITDP (2017)
3.	City population, Density, Density of District (Sadar upazila)	District Statistics, 2011
4.	Average density of 'A' category municipalities in the district of Bangladeshi cites	BBS (2018)
5.	Industrial Employment, Number of Industry in the district	Economic Census, 2013
6.	No. of growth center	LGED Digital Maps
7.	Upazila wise Activity Center information of Bangladesh	District Statistics, 2011
8.	Traffic volume national highway (NH), regional highway (RH) and zilla road (ZR)	RHD Road database
9.	District wise Registered motor vehicles	BRTA (2019)
10.	Upazila wise poverty rate (Head count ratio)	BBS (2009)

3.4 Data Analysis

To optimize resource allocation, policymakers need to identify proper corridors to implement a public transportation system (Salavati, 2016). Such decision-making for public transportation like BRT involves great technical and social complexity that leads to obstacles in the decision-making and demand strategic choices by the decision makers (Salavati, 2016). Applying a multi-criteria decision making (MCDM) method is a way to overcome this issue. A popular method of MCDM used by many researchers worldwide is the Analytic Hierarchy Process (AHP). AHP is the only multicriteria evaluation method with which the error in judging the relative importance of factors by means of relative measurement can be detected and corrected with new observation, reflection, and discussion (Banai, 2006). It has been introduced as a fast, easy, and effective technique for the decision-making process that has a powerful ability to handle planning problems with a systematic approach (Saaty, 1996). It allows complex problems with multiple and sometimes conflicting criteria to be addressed. Among the advantages of using AHP for decision- making is that it offers the opportunity to consider the different importance of criteria and, consequently, to assign different weights so that some criteria dominate the decision.

The basic AHP properties are outlined below (Banai, 1998):

(a) Hierarchical Structure: The systemic concept of a hierarchy is used to structure a multicriteria evaluation problem. The criteria, the sub criteria (if any), and the alternatives are represented at the various levels of a typical AHP hierarchy of interrelated of factors. The factors at each lower level are compared with respect to the factors at the higher level of the hierarchy. First, the relative importance of the criteria is determined, followed next by the importance of the sub criteria, and finally down to the lowest level in the hierarchy in which the alternatives are rated.

(b) Paired Factor Comparison: At the core of the AHP is a systematic procedure for determining the relative importance of factors through their paired comparisons and by using a ratio scale. The weights of n factors, A_1, A_2, ..., A_n are denoted by a vector

$w = (w_1, w_2, \ldots, w_n)$

Paired comparisons of the factors are performed in a matrix

$$A = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ . \\ . \\ . \\ A_n \end{array} \begin{array}{c} \begin{array}{cccccc} A_1 & A_2 & A_3 & \ldots & A_n \end{array} \\ \begin{bmatrix} w_1/w_1 & w_1/w_2 & w_1/w_3 & \ldots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & w_2/w_3 & \ldots & w_2/w_n \\ w_3/w_1 & w_3/w_2 & w_3/w_3 & \ldots & w_3/w_n \\ . & . & . & & . \\ . & . & . & & . \\ . & . & . & & . \\ w_n/w_1 & w_n/w_2 & w_n/w_3 & \ldots & w_n/w_n \end{bmatrix} \end{array}$$

The matrix A is reciprocal ($a_{ij} = 1/a_{ji}$), consistent ($a_{ij} = a_{ik}/a_{jk}$), and all its diagonal entries are one ($a_{ii} = 1$). The coefficients (or entries) of A give the relative magnitudes of the n factors ($a_{ij} = w_i/w_j$) when the vector of weights $w = (w_1, w_2, ..., w_n)$ is known. However, if the weights are not known, they can be recovered by solving the well-known characteristic value problem. That is A is (post) multiplied by w and the result is stated in proportion to w itself, with n as a scalar.

$A \cdot w = n \cdot w$

Since A has unit rank (there is only one independent row of A), all of its characteristic values λ_i ($i = 1 \ldots, n$) are zero except one $\lambda_{max} \neq \lambda_i = 0$. The system $A \cdot w = n \cdot w$ is stated in the form

$A \cdot w = \lambda_{max} \cdot w$

The weights of the factors compared pairwise in matrix A are thus determined by the normalized principal characteristic vector of A. The vector of weights w is recovered from any column of A. A unique solution is obtained upon normalization of the columns of A (each w_i entry is divided by the column total $\sum w_i$ for i = 1,..., n).

(c) Calculus of Consistency: When the vector of weights w is known, matrix A is consistent. That is, $a_{ij} \bullet a_{jk} = a_{ik}$

However, when w is unknown and the coefficients of A are estimates of the relative weights, then the condition of consistency may not hold. That is, $a_{ij} \bullet a_{jk} \neq a_{ik}$. A small perturbation in the values of the coefficients of A implies a small perturbation in l_{max} When A is consistent, $l_{max} = n$. But, in general, $l_{max} \geq n$. The closer the value of l_{max} is to n, the more consistent are the estimated coefficients of A and therefore the better the estimated solution vector w. Hence, deviation from consistency is measured by an index: $CI = (l_{max} - n)/(n-l)$.

If $CR \leq 0.1$, level of inconsistency is acceptable and tolerable. Otherwise, degree of inconsistency is high and the decision makers might have to re-estimate the elements of comparison matrix for better consistency.

Table 3.3: Random Index Values

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	.58	.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.58

This value is compared with its average value for a randomly-generated reciprocal matrix of the same size as A. The comparison indicates whether the ratio estimates in the pairwise comparison matrix A are closer to being logically consistent or are closer to being random. Saaty (1995) has suggested an upper limit of 10 percent as a measure of good consistency. When this 0.10 threshold is exceeded, the ratio estimates are revised to improve consistency. Thus, a procedure is provided that offers a gauge on consistency of judgment when violated in multicriteria evaluation in the face of limited information, data imperfection, factor diversity, and uncertainty.

(d) Synthesis: Once the relative weights of the factors at the various levels of the hierarchy- from the criteria to the alternatives- are determined, the results are aggregated in a weighted summation procedure in which the scores of the alternatives are computed. Pairwise comparisons are used to determine the relative importance of each criterion. Available values for the pairwise comparisons are members of the set: {9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9}. The pairwise comparisons are arranged in a matrix.

Table 3.4: The Fundamental Scale for Pairwise Comparisons

Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Element ***a*** and ***b*** contribute equally to the objective

3	Moderate importance of one over another	Slightly favor element ***a*** over ***b***
5	Strong importance	Strongly favor element ***a*** over ***b***
7	Very strong importance	Element ***a*** is favored very strongly over ***b***
9	Extreme importance	The evidence favoring element over ***a*** over ***b*** is of the highest possible order of importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed. For example, 4 can be used for the intermediate value between 3 and 5
1/3, 1/4 , 1/5, 1/6, 1/7, 1/8, 1/9	These values represent the opposite of the reciprocal whole numbers. For example, if "9" means that x is much more important than y, "1/9" means that x is much less important than y.	

Note: Element a and b are any two of the criteria.

For data analysis at first, experts will provide their judgement as per fundamental scale for Pairwise Comparisons. Priority vector and weightage will be calculated through AHP analysis. Then actual values of the finally selected variables for the studied cities will be collected. As different city will have different data these will be categorized into five range and scored as 0.2, 0.4, 0.6, 0.8 and 1 according to their merit. Then the scores will be multiplied by the respective weightages. Thus, for all variables a city will have weighted value and when these respective weighted values of a city are summed up, a composite score for each city is found which indicated overall merit of the city to have BRT.

3.5 Weakness of AHP Method and measures taken in this study to overcome weakness

Although AHP method has many advantages AHP relies on decision-makers' pairwise comparisons. Problems can arise if some of these comparisons are not performed well (Emrouznejad & Marra 2017). For example, the decisionmaker's arbitrary judgement can lead to some inconsistency. It is assumed that the reliability of the decision taken depends on the consistency of the decision-makers pairwise judgement.

To overcome the inconsistency experts from different academic field and profession are interviewed in this study. Experts working on Urban and Regional Planning field, Transport Studies department in international university, Government authorities and Transport Specialist from international agencies, Mass rapid transit design Consultants currently working for MRT Line in Bangladesh have been interviewed. The list of Expert panel is given in **Appendix C**.

Chapter 4
Identification of Factors

Chapter 4: Identification of Factors

The aim of this research is to define a set of criteria to identify potential cities for BRT development in Bangladesh. Criteria are objective measures of the goal to measure how well each alternative achieves the goal. Implementing a BRT network is part of an emerging public transportation policy around the world, which is different in details depending on each city's characteristics such as population, density, employment pattern, resources, and texture of the city.

By keeping the guidelines discussed in section 2.5 into consideration variables were selected. All variables were selected in two steps for identifying the major factors: 1) collecting appropriate variables from the literature and also based on preliminary discussion with experts, and (2) extracting major variables from this list using an expert survey (Figure 4.1). By reviewing literature, main characteristics of cities which are effective in selection of factors are specified.

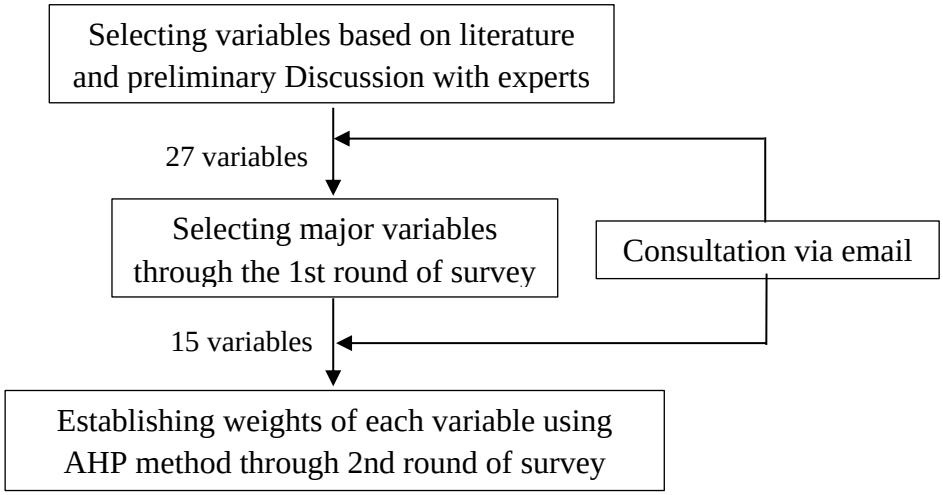


Figure 4.1: Variable and data collection process with multiple surveys

Considering particular features of Bangladeshi cities, the most important factors are categorized into 5 main categories and shown in Table 4.1. There are 27 variables under these 5 categories. Consultation with expert groups via emails helped to both select and label these variables.

Table 4.1: 27 variables selected from literature

Category	Variable	Reference
1. Demography	Population	Levinson, 2003a
	Population Density	Suzuki, 2013
	District Sadar upazila population Density	Preliminary Discussion with Expert

Category	Variable	Reference
	A' category municipality Population	Preliminary Discussion with Expert
	Average Density of 'A' category municipality	Preliminary Discussion with Expert
	Share of population Engaged in industrial activity	Gwilliam (2002), Suzuki (2013)
	Non-agricultural Employment growth rate	Gwilliam (2002), Suzuki (2013)
2. Regional/ Surrounding Context	Number of Surrounding Urban Centers	Gwilliam (2002), Suzuki (2013), Levinson (2003b)
	Number of A' and 'B' type municipalities	Preliminary Discussion with Expert
	Number of Growth Centers	FTA (2009), Levinson (2003b)
	Urban Centers with Industrial employment	FTA (2009)
3. Transport	Number of Airport	Gwilliam (2002), Levinson (2003b)
	Number of Railway Station	Gwilliam (2002), Levinson (2003b)
	RHD Road length	Preliminary Discussion with Expert, Levinson (2003b)
	Upazila Road length	Preliminary Discussion with Expert, Levinson (2003b)
	Motorised Passenger Traffic	Preliminary Discussion with Expert
	Right of Way (ROW)	Kittelson & Associates (2007)
	Commercial Vehicle per day (CVD)	Preliminary Discussion with Expert
	Local bus route	Kittelson & Associates (2007)
	Registered Motor vehicles	Kittelson & Associates (2007)
4. Major Activity center/ land use	Number of EPZ/Economic Zone	Gwilliam (2002), Levinson (2003b), Kittelson & Associates (2007)
	Number of University	Gwilliam (2002), Levinson (2003b), Kittelson & Associates (2007)
	Tertiary Education Center	Kittelson & Associates (2007)
	Number of Major Hospital	Gwilliam (2002), Levinson (2003b)
5. Economy	Poverty rate	Hidalgo (2005)
	Number of Non- agricultural Establishment	Gwilliam (2002), Suzuki (2013)
	Non- agricultural Establishment in 'A' category municipality	Gwilliam (2002), Suzuki (2013)

The second step was to establish the appropriate criteria for selection of potential cities from Bangladesh. Factors mentioned above were shared, via email, with the experts, policy makers and practitioners. Total 10 Experts were interviewed (see **Appendix C**). At this stage they were given option to (i) accept, (ii) reject or (iii) accept with suggested

changes in the name/focus or category. Thus, the number of the key variables were reduced to 15 from 27 as follows: three for Demography, two for Regional/surrounding context, five for Transport, three for Major activity center/ land use and two for Economy. (Table 4.2). Reason for selecting 15 variables are given in **Appendix D.** These 15 variables were selected for 2nd round of survey using AHP.

Table 4.2: Fifteen variables were extracted for Analytical Hierarchy Process (AHP) analysis from the survey

Category	Variable
1. Demography	Average Population density of 'A' Category Municipalities
	Share of population Engaged in industrial activity
	Annual growth rate of population engaged in non-agricultural activity
2. Regional/ Surrounding Context	Number of 'A' & 'B' type municipalities
	Number of Growth Centers on or within 500 meter of RHD/Upazila road
3. Transport	Presence of Airport in the district
	No. of Upazilas having Railway station
	Motorized Passenger Traffic volume in the RHD road
	Average Commercial Vehicle per day (CVD) in the Upazila road
	Total No. of Registered motor vehicles in the district
4. Major Activity center/ land use	Number of EPZ, Economic Zone in the District
	Number of Universities, Tertiary education & Vocational centers
	Number of Specialized Hospitals
5. Economy	Inverse of Head count ratio (HCR) rate in the district
	Number of Non-agricultural establishments

These criteria can be described as bellows:

Category 1: Demography

Demographic features are fundamentally important factors which directly affect selection of transportation policies. Transportation demand, and consequently, social, environmental and economic effects of transportation are direct functions of the number of people living in the city. Total population is the most important factor associated with public transport use. It should be mentioned here that this study has already identified several district towns of Bangladesh, based on their total population, to assess their merit for having BRT. Now to compare their merit, demographic variables in the potential BRT

operation areas - consisting of central divisional/district town and surrounding town centers – are to be studied. It will help to assess and compare the potential market for BRT in each city and its surrounding/regional context.

Variable 1.1: Average Population density of 'A' Category Municipalities: While total urban population is an indicator of urban public transport use, population density gives more vivid picture about the location and intensity of (demand for) use. The higher the average density of surrounding urban centers, the higher the potential of BRT demand. That is why, this variable has been selected. Most of the experts have chosen, i.e. accepted, the variable (See **Appendix D**).

Municipalities in Bangladesh are categorized into 'A', 'B' and 'C' categories based on the revenue generation of respective municipality. Based on preliminary discussion with experts it has been found that Category 'B' and 'C' municipalities are either too small or in many cases unscientifically identified as town. Hence, they are more rural than urban in nature. So, they may not be the extreme ends of a BRT corridor, rather they can be intermediate stops, at best. So, average population density of 'A' category municipalities is only considered.

Variable 1.2: Share of population Engaged in industrial activity: People engaged in industry are regular commuters. So, the more is the share of population engaged in industry in a district, the more will be the potential users of BRT. Moreover, higher populations share is also a proxy for strength of industrial sectors in the district, in other words in the activity centers surrounding the district/divisional towns.

Variable 1.3 Annual growth rate of population engaged in non-agricultural activity: Higher share of people engaged in industry is not enough, unless there is an increasing growth of such population in the centers or surrounding the central city i.e. district/divisional town. This variable captures the growth. However, due to absence of data to calculate the growth of persons engaged in industrial activities in two consecutive years, this study considers growth of population engaged in non-agricultural activities. On one way, this variable increases the spectrum of persons who are more likely to be regular commuters.

Category 2: Regional/ Surrounding Context

A BRT system is not for providing connectivity only between two points - a central city and a peripheral activity center. Rather it is supposed to accessibility to transport for people living in other centers in between. So, high density of population in main urban centers is not enough. Rather total number of different urban centers is also important. The more the number of centers, the higher will be the number of potential stops/stations, consequently higher will be the potential of BRT development. This category of variables puts light into this fact.

Variable 2.1: Number of 'A' & 'B' type municipalities: 'A' type municipalities may be an extreme end of the BRT corridor - central city being at the other end. 'B' type municipalities located on the corridor may be stops in between. Depending on the situation 'B' type municipalities may also be at the end of a corridor. So, the higher the number of such, 'A' and 'B' type, municipalities, the higher the merit of a district/divisional in Bangladesh to have BRT. It should be mentioned in this regard, if 'C' type municipalities are also thought as potential stops in BRT corridor, number of stops will be so high that it might make BRT service ineffective or unfeasible.

Variable 2.2: Number of Growth Centers on or within 500 meter of RHD/Upazila road: In Bangladesh Growth centers, i.e. government selected important (in terms of revenue, trading volume etc.) rural markets are the hubs of rural economy outside the urban centers. Buyers-sellers and other users of these rural markets, on or within 500 meter of BRT corridor, may be potential users of BRT. So, this variable has been selected. It should be mentioned that it is most likely that for BRT corridor national, regional or district roads maintained by Raods and Highways Department (RHD) or upazila road maintained by Local Government Engineering Department (LGED) will be used. Unless essentially required or economically feasible new roads will not be constructed nor any road lower than the stated types will be used. Hence, here in this variable instead of BRT corridor road type i.e. RHD/Upazila road is mentioned.

Category 3: Transport

This category of variable is not about understanding infrastructure design requirements of BRT. Rather it deals with selected transport related aspects which may have

implications for BRT market at a regional context. However, variables related to number of traffic would be indicative of travel or ridership demand along the corridor.

Variable 3.1: Presence of Airport in the district: A major transport hub like Airport can be a very big traffic attraction point. The users of the airport are supposed to of higher affordability who would expect better mobility service to and from the airport, even at a higher price than regular public transport option and at a lower price than the private service options like microbus or car. In fact, passengers having larger luggage may opt for private options and rest airport users, including companions flocking to the airport to receive or say bye to the air-passenger are expected to use the BRT.

Variable 3.2: No. of Upazilas having Railway station: Like the previous variable, railway stations can generate more passenger, and can be a major employment hub. Hence it will may be an important factor for BRT development. If a district has more railway stations than other district, then the district or central town of the former district, i.e. the one having more railway stations, will more potential user attracting points which ultimately will increase the merit of that district to have a BRT service. Questions may come, if all the railway stations will be connected by BRT in reality or not. Answer is the purpose of this study is to assess the potential of a district town to have BRT from an overall perspective. So, details like actual BRT corridor is not considered. Moreover, only this variable is not going to influence the entire process of prioritization. There are other variables and all of them are weighted as per experts' opinion in a scientific way i.e. AHP.

Variable 3.3: Motorized Passenger Traffic volume in the RHD road: This is more likely that BRT corridor extending away from the central or district town to other important urban centers would follow the alignment of national, regional or district roads i.e. roads under the jurisdiction of Roads and Highways Department (RHD). If data on number of commuters using these roads were available, assessing the potential of BRT would have been much easier. However, in absence of such data motorized passenger traffic volume on National highway, Regional highway and District road, would act as a proxy variable. It is assumed that more traffic volume on road will lead more demand on that road.

Variable 3.4: Average Commercial Vehicle per day (CVD) in the Upazila road: As there is a little possibility that BRT corridor may also follow the alignment of upazila roads, under the jurisdiction of Local Government Engineering Department (LGED), traffic volume along the road may also an important proxy variable. Moreover, rural growth centers and big markets are either located on this road or in some cases of union roads which feeds into upazila road. So, other than taking data on motorized vehicle, which may be much low in many cases, commercial vehicle per day (CVD) is considered to understand the number of potential BRT rider. Moreover, per day average commercial vehicle on upazila road would also reflect the economic potential of upazila.

Variable 3.5: Total Number of Registered motor vehicles in the district: It is assumed that the more motor vehicles are plying in the district, the more is the potential BRT riders. Experience and discussion with the experts reveal that district towns have the most of the motorized vehicles in the district. Hence, while the previous two variables reflect on the BRT market in the potential corridor outside the central city, this variable reflect on the same in central city.

Category 4: Major Activity center/ land use

Like major airport and railway stations, there may be major activities or land uses which will generate substantial traffic. The more is the number of such centers or land uses, the more will be the points having concentrated demand for BRT use in the district. If users of these points are channelized through potential BRT corridor it will increase the viability of BRT in the district.

Variable 4.1: Number of Export Processing Zone (EPZ), Economic Zone (EZ) in the District: Hundreds of thousand people are employed in each of the EPZs located in different parts of the country. Government is planning to build 100 EZs, also expected to generate more than hundred thousand employment in each of them, in different districts. So, these EPZs and EZs will have a substantial impact on the direction of trips in a district. Hence their number in a district is considered as a variable.

Variable 4.2: Number of Universities, Tertiary education & Vocational centers: Unlike school goers or in some cases college goers, students attending university or tertiary of vocational education centers are independent trip makers. Hence, their number is an important factor affecting public transport or BRT

ridership. Study (Kittelson & Associates, 2007) also shows that a large university or other outlying major activity center may support a BRT route or system.

Variable 4.3: Number of Specialized Hospitals: Local medical centers will cater for the need of minor diseases and those are located nearby the localities. But for addressing not addressed at local level medical centers like union or upazila health complex, people have to go to specialized hospitals. Although they are not in many in number in the country, they serve patients from different parts of a district or a region. Number of persons accompanying them will also be more. So, a good number of traffic will be attracted towards this higher order hospitals. Except the patients in emergency condition, rest hospital goers are likely to use public transport, at least for considerable part of their journeys. So, this variable is considered.

Category 5: Economy

The link between trip rate and economy of a city and financial condition of the citizens are well established. This category of variables tries to catch the economic potential of a district.

Variable 5.1: Inverse of Head count ratio (HCR) rate in the district: Although the cost of public transport is lower than private transport, it requires a minimum level of financial condition of the people to ride a transport that will charge them. Otherwise they will make a smaller number of trips and if make trips will remain mostly on foot. So, average household income of the people in a district or GDP of the district could be a good variable. However, in absence of such data the reverse Head Count Ratio (HCR) is considered. HCR is the proportion of a population below the poverty line. So, the inverse of HCR in one sense represents the economic condition of the district.

Variable 5.2: Number of Non-agricultural establishments:

People engaged in farm activities are less likely to make more trips than those engaged in formal, industrial, service activities. So, number of persons engaged in non-agricultural sector is an important variable. But in absence of recent data for this variable, number of non-agricultural establishments has been considered.

Chapter 5
Identification of Potential Cities

Chapter 5: Identification of Potential Cities

5.1 Introduction

Analysis and interpretation of data collected through expert survey and secondary sources forms an imperative part of a research. Data analysis reveals uncovered patterns and trends to provide the researcher with the required information. Data analysis helps in drawing conclusions about a research, and in the process, supports decision making process. This chapter focuses on the priority determination of the factors governing potential cities for BRT development through analysis and interpretation of collected data.

5.2 Expert Opinion

In order to evaluate the factors, AHP was conducted with several experts including transportation planner, civil engineer, economist, urban planner and practitioners. Their judgments provided a basis for quantitative assessment of these factors to identify the resolution of the problem. In the next stage, a pair-wise comparison matrix is used to compare the factors with each other. The exact number of people to be interviewed for AHP has not been mentioned in any guideline by Thomas L. Saaty (1977), the inventor of the AHP. For the purpose of this research, 10 experts from different organizations have been interviewed. Each of the members of expert panel was asked to put scores beside the factors in a checklist according to their personal judgments. The checklist was arranged in such a way that only two factors would be compared at a time, thus resulting in pair-wise comparisons. Detailed information of the expert panel is given in **Appendix C** and the weights provided by them are given in **Appendix C-1**.

5.3 Priority Determination of the Factors

Analytic Hierarchy Process (AHP) is used to determine the priority or weights of the factors. At first, a pair-wise comparison matrix is developed considering all the factors. A reciprocal matrix is generated from the judgment values provided by the experts. Judgment values range from 1 to 9, where 1 denotes equal importance and 9 denotes extreme importance of a factor over another factor (Chapter 3). The significance of a factor over another factor increases as rating increases. Procedures for calculation and analysis of data to find out the priority vectors of the factors have been described below.

5.3.1 Development of Pair-wise Comparison Matrix

A pair-wise matrix is developed with the help of the judgment values provided by the experts. This produces a reciprocal matrix, and the sum of the values in each column is recorded. Table 5.1 shows that Demography has been given preference over Transport and Major activity center/ land use. On the other hand, Demography has been given equal importance to Economy in defining a potential city for BRT development.

Table 5.1: Development of Pair-wise Comparison Matrix

Broad Category	Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy
Demography	1	0.33	3	8	1
Regional/ Surrounding Context	3	1	3	5	1
Transport	0.33	0.33	1	1	0.33
Major Activity Center/ Land use	0.13	0.20	1	1	0.20
Economy	1	1	3	5	1
Sum	5.458	2.87	11.00	20.00	3.53

Source: Expert survey, 2019

Normalization of the matrix and determination of the priority vectors of the factors are the subsequent steps after developing the pair-wise comparison matrix.

5.3.2 Matrix Normalization and Priority Vector Determination

In order to normalize the matrix, each entry of the column is divided by the column total. The result is the normalized matrix score. When each entry is normalized in this manner, the sum of each column becomes unity.

Table 5.2: Normalization of Pair-wise Matrix

Broad Category	**Demography**
Demography	0.183
Regional/ Surrounding Context	0.550
Transport	0.061
Major Activity Center/ Land use	0.023
Economy	0.183
Sum	1

For example, first column total is 5.458. Therefore, normalized value is 1/5.458 or 0.183 (Table 5.2). Summing up the entries of each normalized row and subsequently dividing

each row total by the number of factors generates the priority vectors of the factors (Table 5.3).

Table 5.3: Priority Vectors of Selected Factors

Factor	Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy	Row total	Priority Vector
Demography	0.183	0.116	0.273	0.400	0.283	1.255	0.251
Regional/ Surrounding Context	0.550	0.349	0.273	0.250	0.283	1.704	0.341
Transport	0.061	0.116	0.091	0.050	0.094	0.413	0.082
Activity Center/ Land use	0.023	0.070	0.091	0.050	0.057	0.290	0.058
Economy	0.183	0.349	0.273	0.250	0.283	1.338	0.268
Total							1.00

5.3.3 Consistency Ratio

Among the several benefits of AHP, consistency ratio is exceptional. Consistency checking through the determination of consistency ratio is a cross-checking method to verify whether the data are consistent and whether the judgment needs to be revised. If consistency ratio exceeds 0.1, data are not consistent and the judgments need to be revised (Saaty, 1995). To obtain the consistency index of the judgments, each column of the pair-wise comparison matrix is multiplied by their corresponding weights in the first place. Then, sum of the row entries is divided by the corresponding weights. The value achieved in this process is called consistency measure and summation of consistency measure is denoted as l_{max}.

l_{max} = 5.458×0.251+ 2.87×0.341+ 11.00×0.082+ 20.00×0.058+ 3.53×0.268

=5.361

Consistency Index (CI) is calculated by the equation $CI=(l_{max} - n)/(n-1)$; where n is the total number of factors. In case of this matrix, n=5. Consistency Ratio (CR) is obtained by dividing the Consistency Index with the Random Index (RI) value. Random Index values are developed by Saaty, 1995.

Table 5.4: Consistency Ratio of the Judgments

Broad Category	Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy	Priority Vector	Consistency Measure
Demography	1	0.33	3	8	1	0.251	1.370
Regional/ Surrounding Context	3	1	3	5	1	0.341	0.977
Transport	0.33	0.33	1	1	0.33	0.082	0.908
Major Activity Center/ Land use	0.13	0.20	1	1	0.20	0.058	1.161
Economy	1	1	3	5	1	0.268	0.945
						l_{max}	5.361
						For n=5, CI =	0.0902
						RI=	1.12
						CR=	0.0806 (8%)

In table 5.4, since Consistency Ratio is less than 0.1 hence the level of inconsistency is acceptable. Priority vector and Consistency Ratio are calculated for the rest of the experts' judgments following the same procedure.

5.3.4 Ranking of the Factors

Factors are ranked according to judgments given by the experts. Table 5.5 demonstrates the ranking of the factors according to expert judgments. Table 5.5 reveals that Regional/ Surrounding Context is defined by 4 experts as the most important factor governing potential cities for BRT development. Economy has got more priority to 3 experts. So, there is a lack of unanimity among the experts regarding the importance of factors for determining bus stop location. This is also true for other factors. So, there is a variation of the ranking of factors given by experts. But a consensus is necessary to achieve the overall priority vector. Geometric mean is applied widely in such instances. AHP method supports group decision making through consensus by calculating geometric mean of priority vector derived from individual pair-wise comparisons.

Table 5.5: Priority vector of the Factors According to Experts' Judgments

Factors		Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy	Sum of Priority Vectors
Priority vector	Expert 1	0.047	0.109	0.175	0.225	0.444	1
	Expert 2	0.159	0.313	0.136	0.133	0.260	1
	Expert 3	0.032	0.103	0.279	0.272	0.314	1
	Expert 4	0.068	0.098	0.116	0.298	0.420	1
	Expert 5	0.318	0.181	0.274	0.080	0.147	1
	Expert 6	0.251	0.341	0.082	0.058	0.268	1
	Expert 7	0.122	0.351	0.122	0.197	0.209	1
	Expert 8	0.076	0.107	0.134	0.374	0.309	1
	Expert 9	0.354	0.211	0.232	0.128	0.076	1
	Expert 10	0.144	0.336	0.175	0.171	0.173	1

As for example, overall priority for demography has been calculated in following way: Priority vectors of demography are 0.047, 0.159, 0.032, 0.068, 0.318, 0.251, 0.122, 0.076, 0.354 and 0.144.

Geometric mean of those values,

$GM=\sqrt[10]{}$ (0.047 × 0.159 × 0.032 × 0.068 × 0.318 × 0.251 × 0.122 × 0.076 × 0.354 × 0.144)

= 0.157

Overall priority vectors of all the factors have been calculated from geometric mean and shown in Table 5.6.

Table 5.6: Overall Priority of the Factors

Factors	**Overall Priority**	**Remarks**
Economy	0.262	Most significant factor
Regional/ Surrounding Context	0.215	Second most significant factor
Major Activity Center/ Land use	0.193	Third most significant factor
Transport	0.173	Fourth most significant factor
Demography	0.157	Least significant factor
SUM	**1**	

From the expert judgments Economy is the most significant factor in determining potential cities for BRT development, whereas Demography is least significant factor.

5.3.5 Ranking of the Sub Factors

Ranking of sub factors of Demography, Regional/Surrounding Context, Transport, Major activity center/ Land use and Economy have been done by following the same procedure and can be found in **Appendix C-2**. Priority vector of the sub factors are provided in Table 5.7.

Table 5.7: Priority vector of the Sub-Factors

Factors	Sub Factors	Priority vector of Sub Factors (ii)
Demography	Avg. Population density of 'A' Category Municipalities	0.255
	Share of population Engaged in industrial activity	0.474
	Growth rate of population engaged in non-agricultural activity	0.271
	Total	**1.0**
Regional/ Surrounding Context	Number of 'A' & 'B' type municipalities	0.424
	Number of Growth Centers on or within 500 meter of RHD/Upazila road	0.576
	Total	**1.0**
Transport	Presence of Airport in the district	0.327
	No. of Upazilas having Railway station	0.274
	Motorized Passenger Traffic volume in the RHD road	0.110
	Avg. CVD in the Upazila road	0.170
	Total No. of Registered motor vehicles in the dist. (Last 10 years)	0.119
	Total	**1.0**
Major Activity Center/ Land use	No. of EPZ, Economic Zone in the District	0.240
	No. of Universities, Tertiary education & Vocational centers	0.266
	No. of Specialized Hospitals	0.494
	Total	**1.0**
Economy	Inverse of Poverty rate in the district	0.632
	No. of Non-agricultural establishment	0.368
	Total	**1.0**

5.4 Grouping of Selected Factors

The factors are in different unit. So, weighted index method has been applied in order to convert the values to the same unit. For this, values of each factor have been classified into five equal classes (Table 5.8). Equal interval method has been used for classification

of values. This classification scheme divides the range of attribute values into equal sized sub ranges.

Table 5.8: Score Classification for every variable

Factor	Subfactors	Score Classification				
		0.2	0.4	0.6	0.8	1.0
Demography	Avg. Population density of 'A' Category Municipalities	<2000	2001-4000	4001-6000	6001-8000	>8000
	Share of population Engaged in industrial activity (in %)	<10	10.1-20	20.1-30	30.1-40	>40
	Annual growth rate of population engaged in non-agricultural activity (in %)	<2.50	2.51 to 5.0	5.1 to 7.5	7.51 to 10.0	>10.1
Regional/ Surrounding Context	Number of 'A' & 'B' type municipalities	<2 or, =2	3-4	5-6	7-8	>8
	Number of Growth Centers on or within 500 meter of RHD/Upazila road	0-15	16-30	31-45	46-60	>60
Transport	Presence of Airport in the district	0	N/A	N/A	N/A	>1 or, =1
	No. of Upazilas having Railway station	<2 or, =2	3 to 4	5 to 6	7 to 8	>9 or, =9
	Motorized Passenger Traffic volume in the RHD road	<100,000 or, =100,000	100,001-200,000	200,001-300,000	300,001-400,000	>400,000
	Avg. CVD in the Upazila road	< 100 or, =100	101-200	201-300	301-400	>400
	Total No. of Registered motor vehicles in the dist. (Last 10 years)	<20,000 or, = 20,000	20,001-40,000	40,001-60,000	60,001-80,000	>80,000
Major Activity Center/ Land use	No. of EPZ, Economic Zone in the District	<2	3-4	5-6	7-8	>8
	No. of Universities, Tertiary education & Vocational centers	0-40	41-80	81-120	121-160	>160

Factor	Subfactors	Score Classification				
		0.2	0.4	0.6	0.8	1.0
	No. of Specialized Hospitals	0-100	101-200	201-300	301-400	>400
Economy	Inverse of Poverty rate in the district	>40	31 to 40	21 to 30	11 to 20	<10 or, =10
	No. of Non-agricultural establishment	<65,000	65,001-130,000	130,001-195,000	195,001-260,000	>260,001

5.5 Calculating Composite Index for Each City

After calculating priority vector of each factor and subfactors, they have been multiplied in order to get corresponding weight of the factors (Table 5.9).

Table 5.9: Weighted Index of Sub factors

Factors	Priority vector of Factors (i)	Sub Factors	Priority vector of Sub Factors (ii)	Weighted Index (i)×(ii)
Demography	0.157	Avg. Population density of 'A' Category Municipalities	0.255	0.040
		Share of population Engaged in industrial activity	0.474	0.074
		Growth rate of population engaged in non-agricultural activity	0.271	0.043
Regional/ Surrounding Context	0.215	Number of 'A' & 'B' type municipalities	0.424	0.091
		Number of Growth Centers on or within 500 meter of RHD/Upazila road	0.576	0.124
Transport	0.173	Presence of Airport in the district	0.327	0.056
		No. of Upazilas having Railway station	0.274	0.047
		Motorized Passenger Traffic volume in the RHD road	0.110	0.019
		Avg. CVD in the Upazila road	0.170	0.029
		Total No. of Registered motor vehicles in the dist. (Last 10 years)	0.119	0.021
Major Activity	0.193	No. of EPZ, Economic Zone in the District	0.240	0.046

Factors	Priority vector of Factors (i)	Sub Factors	Priority vector of Sub Factors (ii)	Weighted Index (i)×(ii)
Center/ Land use		No. of Universities, Tertiary education & Vocational centers	0.266	0.051
		No. of Specialized Hospitals	0.494	0.095
Economy	0.262	Inverse of Poverty rate in the district	0.632	0.166
		No. of Non-agricultural establishment	0.368	0.096

Score has been assigned for each city (Table 5.10) and data of respective city has been provided in **Appendix E.** Calculated weighted index and respective score was then multiplied to get the composite index for each city. Then the multiplication result for each factor has been added up to determine the composite index for each city (Table 5.11).

Table 5.10: Score assigned for each city

Sl. No.	City/ District	Demography			Regional/Surrounding Context		Transport					Major Activity Center			Economy	
		Avg. Population density of Category 'A' Municipalities	Share of population Engaged in industrial activity (in%)	Annual growth rate of population engaged in non-agricultural activity (in %)	Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road	Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)	No. of EPZ, Economic Zone in the District	Number of universities, tertiary education & vocational centers in the district	Number of specialized hospitals or centers higher than upazila health complex in the district	Inverse of Poverty headcount ratio (%)	No. of Non-agricultural establishment
1	Chattogram	0.6	0.6	0.8	1.0	1.0	1.0	0.6	0.8	0.4	0.4	0.8	1.0	1.0	0.8	1.0
2	Khulna	-	0.4	0.6	0.2	0.6	0.2	0.2	0.4	0.4	0.4	0.2	0.6	0.4	0.4	0.6
3	Sylhet	0.2	0.4	0.6	0.2	0.6	1.0	0.4	0.4	0.2	0.6	0.2	0.4	0.2	0.6	0.6
4	Rajshahi	0.2	0.2	0.6	1.0	0.6	1.0	0.6	0.4	0.2	0.6	0.2	1.0	0.4	0.4	0.6
5	Bogura	0.4	0.4	0.8	0.6	0.8	0.2	0.6	0.8	0.4	0.8	0.2	0.8	0.4	0.8	0.8
6	Mymensingh	0.6	0.4	0.8	1.0	0.8	0.2	0.8	0.4	0.6	0.6	0.4	0.6	0.6	0.2	1.0
7	Barishal	0.2	0.4	0.6	0.6	0.6	1.0	0.2	0.4	0.4	0.4	0.2	0.6	0.4	0.2	0.4
8	Rangpur	-	0.2	0.6	0.2	0.6	0.2	0.4	0.4	0.2	0.6	0.2	0.6	0.4	0.2	0.6
9	Cumilla	0.4	0.4	0.4	0.8	1.0	0.2	1.0	0.6	0.6	0.6	0.2	0.8	0.6	0.4	0.8
10	Jashore	0.6	0.4	0.4	0.8	0.6	0.2	0.4	0.4	0.6	0.4	0.2	0.8	0.4	0.4	0.6
11	Cox's Bazar	1.0	0.2	0.6	0.4	0.4	1.0	0.4	0.2	0.6	1.0	0.2	0.6	0.4	0.4	0.4
12	Brahmanbaria	0.8	0.2	0.6	0.4	0.4	1.0	0.2	0.4	0.4	0.2	1.0	0.2	0.4	0.6	0.4
13	Dinajpur	0.4	0.2	0.6	0.6	0.6	0.2	0.6	0.6	0.4	0.2	0.2	0.2	0.4	0.4	0.8
14	Narsingdi	0.8	0.6	0.6	0.4	0.4	0.2	0.8	0.4	0.4	0.8	0.2	0.8	0.4	0.6	0.4
15	Chapai Nawabganj	0.4	0.2	0.8	0.4	0.4	0.2	0.2	0.2	0.6	0.2	0.2	0.4	0.4	0.6	0.4

Sl. No.	City/ District	Demography			Regional/Surrounding Context		Transport					Major Activity Center			Economy	
		Avg. Population density of 'A' Municipalities	Share of population Engaged in industrial activity (in%)	Annual growth rate of population engaged in non-agricultural activity (in %)	Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road	Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)	No. of EPZ, Economic Zone in the District	Number of universities, tertiary education & vocational centers in the district	Number of specialized hospitals or centers higher than upazila health complex in the district	Inverse of Poverty headcount ratio (%)	No. of Non-agricultural establishment
16	Chandpur	0.4	0.4	0.6	0.6	0.4	0.2	0.2	0.2	0.4	0.2	0.2	0.4	0.2	0.2	0.4
17	Tangail	0.6	0.4	0.6	1.0	0.6	0.2	0.2	0.6	1.0	0.2	0.2	0.4	0.4	0.6	0.8
18	Sirajganj	0.6	0.6	0.4	0.4	0.4	0.2	0.6	0.6	0.4	0.6	0.2	0.6	0.6	0.4	0.6
19	Feni	0.6	0.4	0.6	0.6	0.4	0.2	0.2	0.4	0.6	0.4	0.2	0.2	0.2	0.6	0.4
20	Naogaon	0.6	0.2	0.6	0.4	0.4	0.2	0.2	0.4	0.2	0.6	0.2	0.6	0.4	0.8	0.6
21	Jamalpur	0.4	0.2	0.8	0.6	0.4	0.2	0.6	0.2	0.2	0.4	0.2	0.4	0.4	0.2	0.6
22	Pabna	0.4	0.4	0.6	0.8	0.6	0.2	0.4	0.6	0.4	0.6	0.2	0.6	0.4	0.4	0.6
23	Nilphamari	0.4	0.2	1.0	0.4	0.4	1.0	0.4	0.2	0.4	0.4	0.2	0.4	0.2	0.4	0.6
24	Noakhali	0.6	0.2	0.8	0.8	0.4	0.2	0.4	1.0	0.4	0.4	0.2	0.4	0.4	1.0	0.6
25	Chuadanga	0.4	0.2	0.6	0.4	0.4	0.2	0.4	0.4	0.8	0.4	0.2	0.2	0.2	0.6	0.2
26	Faridpur	0.4	0.4	0.4	0.4	0.6	0.2	0.4	0.4	0.4	0.2	0.2	0.4	0.4	0.4	0.4
27	Satkhira	0.4	0.2	0.6	0.2	0.6	0.2	0.2	0.6	0.4	0.8	0.2	0.4	0.4	0.2	0.4
28	Jhenaidah	0.4	0.2	0.4	0.6	0.4	0.2	0.2	0.6	0.4	0.4	0.2	0.4	0.4	0.6	0.4
29	Kushtia	0.6	0.4	0.4	0.4	0.4	0.2	0.6	0.2	0.6	0.6	0.2	0.6	0.4	1.0	0.4
30	Kishoreganj	1.0	0.2	0.6	0.4	0.6	0.2	0.6	0.2	0.8	0.2	0.2	0.4	0.4	0.6	0.6

Table 5.11: Composite Score of each city

Sl. No.	City/ District	Demography			Regional/Surrounding Context		Transport					Major Activity Center			Economy		Composite score= ∑Weighted Index ×
		Avg. Population density of 'A' Category	Share of population Engaged in	Annual growth rate of population engaged in non-agricultural	Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500	Presence of Airport in the district	No. of Upazillas having Railway station	Motorized Passenger Traffic volume in the	Avg. CVD in the Upazilla road	Total No. of Registered motor vehicles in the	No. of EPZ, Economic Zone in the District	Number of universities, tertiary education	Number of specialized hospitals or	Inverse of Poverty headcount ratio (%)	No. of Non-agricultural establishment	
1	Chattogram	0.024	0.044	0.034	0.091	0.124	0.056	0.028	0.015	0.012	0.008	0.037	0.051	0.095	0.133	0.096	0.849
2	Khulna	-	0.030	0.026	0.018	0.074	0.011	0.009	0.008	0.012	0.008	0.009	0.031	0.038	0.066	0.058	0.398
3	Sylhet	0.008	0.030	0.026	0.018	0.074	0.056	0.019	0.008	0.006	0.013	0.009	0.020	0.019	0.100	0.058	0.463
4	Rajshahi	0.008	0.015	0.026	0.091	0.074	0.056	0.028	0.008	0.006	0.013	0.009	0.051	0.038	0.066	0.058	0.546
5	Bogura	0.016	0.030	0.034	0.055	0.099	0.011	0.028	0.015	0.012	0.017	0.009	0.041	0.038	0.133	0.077	0.614
6	Mymensingh	0.024	0.030	0.034	0.091	0.099	0.011	0.038	0.008	0.017	0.013	0.018	0.031	0.057	0.033	0.096	0.600
7	Barishal	0.008	0.030	0.026	0.055	0.074	0.056	0.009	0.008	0.012	0.008	0.009	0.031	0.038	0.033	0.038	0.435
8	Rangpur	-	0.015	0.026	0.018	0.074	0.011	0.019	0.008	0.006	0.013	0.009	0.031	0.038	0.033	0.058	0.358
9	Cumilla	0.016	0.030	0.017	0.073	0.124	0.011	0.047	0.011	0.017	0.013	0.009	0.041	0.057	0.066	0.077	0.609
10	Jashore	0.024	0.030	0.017	0.073	0.074	0.011	0.019	0.008	0.017	0.008	0.009	0.041	0.038	0.066	0.058	0.493
11	Cox's Bazar	0.040	0.015	0.026	0.036	0.050	0.056	0.019	0.004	0.017	0.021	0.009	0.031	0.038	0.066	0.038	0.466
12	Brahmanbaria	0.032	0.015	0.026	0.036	0.050	0.056	0.009	0.008	0.012	0.004	0.046	0.010	0.038	0.100	0.038	0.480
13	Dinajpur	0.016	0.015	0.026	0.055	0.074	0.011	0.028	0.011	0.012	0.004	0.009	0.010	0.038	0.066	0.077	0.453
14	Narsingdi	0.032	0.044	0.026	0.036	0.050	0.011	0.038	0.008	0.012	0.017	0.009	0.041	0.038	0.100	0.038	0.499

Sl. No.	City/ District	Demography			Regional/Surrounding Context		Transport					Major Activity Center			Economy		Composite score= ∑Weighted Index ×
		Avg. Population density of 'A' Category	Share of population Engaged in	Annual growth rate of population engaged in non-agricultural	Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500	Presence of Airport in the district	No. of Upazillas having Railway station	Motorized Passenger Traffic volume in the	Avg. CVD in the Upazilla road	Total No. of Registered motor vehicles in the	No. of EPZ, Economic Zone in the District	Number of universities, tertiary education	Number of specialized hospitals or	Inverse of Poverty headcount ratio (%)	No. of Non-agricultural establishment	
15	Chapai Nawabganj	0.016	0.015	0.034	0.036	0.050	0.011	0.009	0.004	0.017	0.004	0.009	0.020	0.038	0.100	0.038	0.403
16	Chandpur	0.016	0.030	0.026	0.055	0.050	0.011	0.009	0.004	0.012	0.004	0.009	0.020	0.019	0.033	0.038	0.336
17	Tangail	0.024	0.030	0.026	0.091	0.074	0.011	0.009	0.011	0.029	0.004	0.009	0.020	0.038	0.100	0.077	0.554
18	Sirajganj	0.024	0.044	0.017	0.036	0.050	0.011	0.028	0.011	0.012	0.013	0.009	0.031	0.057	0.066	0.058	0.467
19	Feni	0.024	0.030	0.026	0.055	0.050	0.011	0.009	0.008	0.017	0.008	0.009	0.010	0.019	0.100	0.038	0.414
20	Naogaon	0.024	0.015	0.026	0.036	0.050	0.011	0.009	0.008	0.006	0.013	0.009	0.031	0.038	0.133	0.058	0.465
21	Jamalpur	0.016	0.015	0.034	0.055	0.050	0.011	0.028	0.004	0.006	0.008	0.009	0.020	0.038	0.033	0.058	0.385
22	Pabna	0.016	0.030	0.026	0.073	0.074	0.011	0.019	0.011	0.012	0.013	0.009	0.031	0.038	0.066	0.058	0.486
23	Nilphamari	0.016	0.015	0.043	0.036	0.050	0.056	0.019	0.004	0.012	0.008	0.009	0.020	0.019	0.066	0.058	0.431
24	Noakhali	0.024	0.015	0.034	0.073	0.050	0.011	0.019	0.019	0.012	0.008	0.009	0.020	0.038	0.166	0.058	0.556
25	Chuadanga	0.016	0.015	0.026	0.036	0.050	0.011	0.019	0.008	0.023	0.008	0.009	0.010	0.019	0.100	0.019	0.369
26	Faridpur	0.016	0.030	0.017	0.036	0.074	0.011	0.019	0.008	0.012	0.004	0.009	0.020	0.038	0.066	0.038	0.399
27	Satkhira	0.016	0.015	0.026	0.018	0.074	0.011	0.009	0.011	0.012	0.017	0.009	0.020	0.038	0.033	0.038	0.349
28	Jhenaidah	0.016	0.015	0.017	0.055	0.050	0.011	0.009	0.011	0.012	0.008	0.009	0.020	0.038	0.100	0.038	0.410
29	Kushtia	0.024	0.030	0.017	0.036	0.050	0.011	0.028	0.004	0.017	0.013	0.009	0.031	0.038	0.166	0.038	0.512
30	Kishoreganj	0.040	0.015	0.026	0.036	0.074	0.011	0.028	0.004	0.023	0.004	0.009	0.020	0.038	0.100	0.058	0.487

Composite Scores are shown in Figure 5.1. Chattogram has highest score (0.849) and other cities lie in between 0.336 and 0.614 (i.e. score of Chattogram is like an outlier and it has to be addressed separately). Chattogram has very much potential and developing BRT network has become overdue for the city. Other cities still have potential for BRT development in near future.

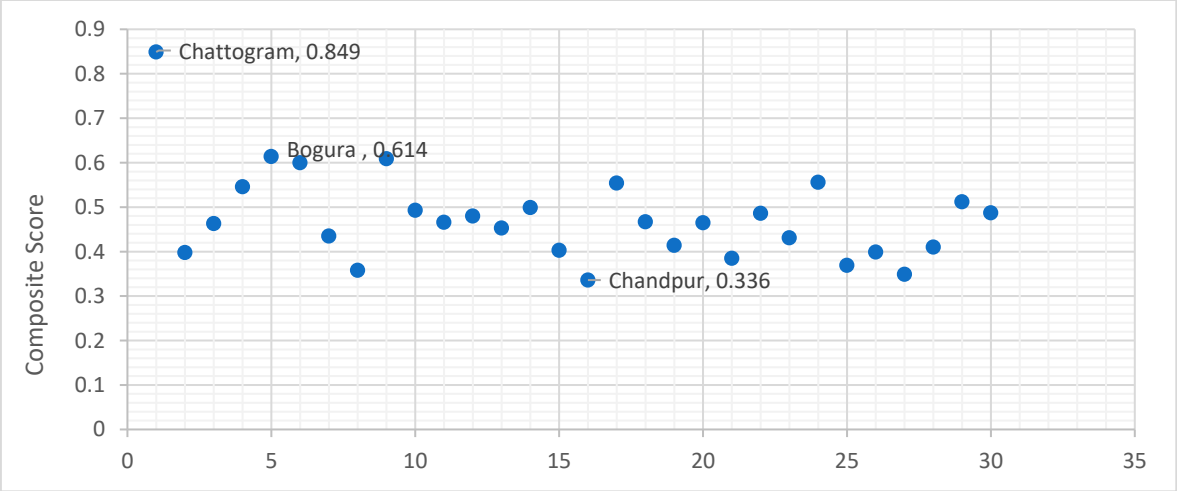


Figure 5.1: Composite Scores of Cities

Composite scores can be grouped into three equal distributed range and shown in Table 5.12. 10 cities fall under Composite Score range 0.336 to 0.429, 14 cities fall under Composite score range 0.429 to 0.521 and 6 cities fall under Composite score range 0.521 to 0.614.

Table 5.12: Priority Rank group

City/ District	Composite Score	Categorization as per Score	Remarks
Bogura	0.614	1	Currently Requiring BRT
Cumilla	0.609		
Mymensingh	0.600		
Noakhali	0.556		
Tangail	0.554		
Rajshahi	0.546		
Kushtia	0.512	2	Requiring BRT in near future
Narsingdi	0.499		
Jashore	0.493		
Kishoreganj	0.487		
Pabna	0.486		
Brahmanbaria	0.480		
Sirajganj	0.467		
Cox's Bazar	0.466		

Naogaon	0.465		
Sylhet	0.463		
Dinajpur	0.453		
Barishal	0.435		
Nilphamari	0.431		
Feni	0.414	3	Yet to Require BRT
Jhenaidah	0.410		
Chapai Nawabganj	0.403		
Faridpur	0.399		
Khulna	0.398		
Jamalpur	0.385		
Chuadanga	0.369		
Rangpur	0.358		
Satkhira	0.349		
Chandpur	0.336		

Priority based map for Potential cities for BRT development has been shown in Figure 5.2.

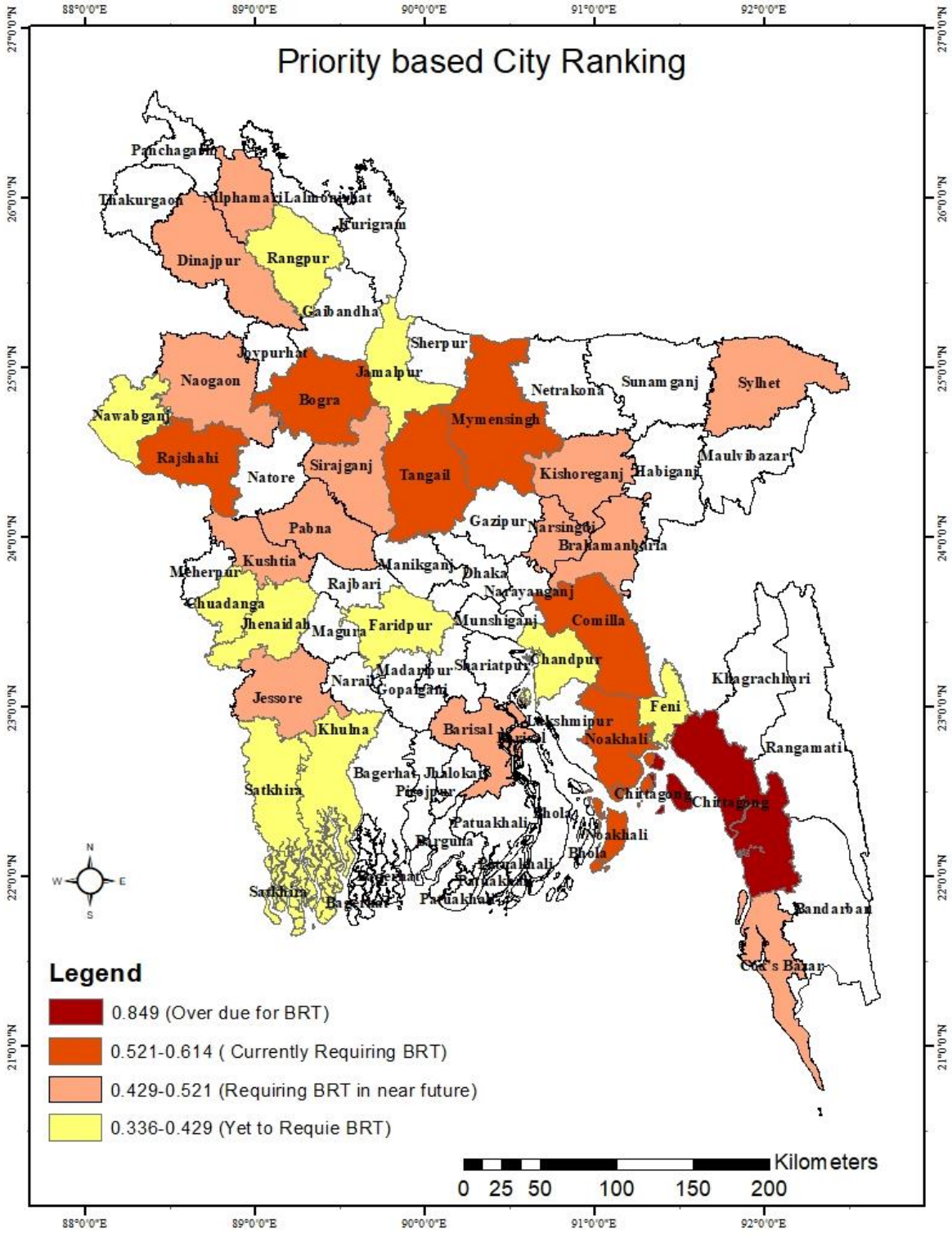


Figure 5.2: Priority based map of potential cities for BRT Development

Chapter 6

Policy Direction for BRT Development in Bangladesh

Chapter 6: Policy Direction for BRT Development in Bangladesh

While urban transportation systems are managed in a variety of ways in different cities, successful BRT systems tend to exhibit certain characteristics and organizational forms (ITDP, 2017). An overview of world BRT systems in Chapter two has identified factors leading to their success. For implementing BRT in cities of Bangladesh, it is very important to analyze other BRT projects to identify their factors for successes and failings. In this chapter, lessons from successful cities' BRT examples are analyzed and discussed.

6.1 Analyzing factors leading to Success of BRT around the world

It has been found in Chapter Two (Section 2.3) that strong administrative capability and political willingness helped Bogota, Jakarta, and Curitiba to achieve successful BRT systems. For example, Jamie Learner, Enrique Penalosa, and Sutyiso – who were mayors of their cities when BRTs were introduced - had strong administrative power and positive attitudes that reformed the BRT system and urban structures in Curitiba, Bogota and Jakarta respectively (Ardila-Gomez, 2004; Matsumoto, 2007; Nasrin, 2015). If executives in power were not interested in the project, then TransMillenio would not have come into reality. After Penalosa's term ended, subsequent mayors, continued the TransMilenio project by planning and beginning to implement its second stage (Ardila-Gomez, 2004). Therefore, with strong political effort, TransMilenio continued to expand as planned. It might have been that if Penalosa remained as mayor for longer, the BRT system's expansion would have received more momentum (Ardila-Gómez, 2004; Hidalgo & Yepes, 2005). Table 6.1 shows most of the successful cities are having a BRT authority or Public Agency for institutional management of the system. Table 6.2 summarizes key factors for the success of BRT systems in those cities.

Table 6.1: Institutions Managing BRT systems of successful BRT having cities

Sl. No.	City	Institutions Managing BRT Systems
1	Curitiba	Bus Authority
2	Bogota	BRT Authority
3	Ahmedabad	BRT Authority
4	Guangzhou	BRT Authority
5	Mexico City	BRT Authority

Sl. No.	City	Institutions Managing BRT Systems
6	Buenos Aires	Bus Authority
7	Rio de Janeiro	Transport Department
8	Jakarta	BRT Authority

Source: ITDP (2017)

Route planning is very important for the success of BRT systems. Furthermore, it is essential to integrate land use and transit. If BRT is constructed along low density areas then it will not have enough patronage to sustain the system and people will not benefit from it (Nasrin, 2015). Curitiba's BRT is a very good example of planning. Being constructed along the city's structural axes and high-density corridors, people can easily shop, work and use services. Curitiba's Master Plan integrated transportation with land use planning (Goodman et. al., 1998). Land within two blocks of the transit arteries has been zoned for mixed commercial-residential uses. Higher densities are permitted for office space. Beyond these two blocks, zoned residential densities taper with distance from transitways. Land near transit arteries is encouraged to be developed with community-assisted housing. Very limited and time-restricted public parking is available in the downtown area, and private parking is very expensive.

Finally, service planning and integration with other services are also important. Most employers offer transportation subsidies to workers, especially low-skilled and low-paid employees, making them the primary purchasers of tokens (Goodman et. al., 1998). Integration of BRT with other modes makes transit convenient to use. In Bogota, each BRT corridor is built along main road of the city (Muhtadi, 2017). In Bogota, integration between BRT and non-motorized transport (NMT) (mainly bicycle) made TransMilenio convenient to use for commuters. In Ahmedabad, high-quality pedestrian facilities throughout the city as well as bicycle lanes with BRT lane has been provided. Guangzhou BRT system is incorporated with bike sharing system. It has recently included a 4km off-street bikeway and walkway combined with parks and plazas and areas for children to play alongside the water along BRT lane. It also has vehicle license control policies as a result this policy makes private vehicle ownership more costly. Mexico City has also integrated public bike system (named Ecobici) and revitalized public spaces and plazas with BRT corridor (Muhtadi, 2017). In Buenos Aries the city replaced car lanes with bus-only lanes. Bike-sharing program has been introduced in Rio de Janeiro and it connects high density areas around the city with BRT. In Jakarta, BRT integration with commuter

rail and local buses improves overall convenience of transit. '3 in 1' policy has been introduced on several roads to minimize traffic congestion and to increase BRT ridership. The essential elements of BRT are running way, convenient station design and location, proper fare structure, and proper service and route planning (Nasrin, 2015). These elements have existed in selected cities. BRT sustains sufficient patronage to run cost effectively (Ardila- Gómez, 2004). Curitiba BRT has 4 types of bus which are express, feeders, neighborhood and direct. Express bus uses articulated bus with 25-meter length and its capacity is 270 passengers. Ahmedabad BRT has several sophisticated features of a high-level BRT system, including- median busways with strong longitudinal segregation and good pavement structure; changes in road geometry to accommodate new traffic patterns. Buenos Aires BRT corridor design includes pedestrian-friendly environment policy by encouraging walking and cycling. Bus design is very important for a BRT system. Buses should have high capacity with adequate access. Initially, buses used on TransJakarta had only a single door for boarding and alighting, causing significant delay and overcrowding on the station and inside buses (Matsumoto, 2007). Eventually the bus fleet was changed, with vehicles having two or three doors.

Public participation in the project is equally, if not more, essential. BRT needs to be marketed to the general public well ahead of opening, for people to understand it. In Bogota, at all stages during planning, implementation and construction, the public was educated about the progress of BRT and how it should be used (Nasrin, 2015). Capacity of a BRT system relies mostly on station operation. Curitiba's tube-like station created a state-of-the-art-image, making for one of its success factors. Stations should enable enough passengers to wait comfortably for buses without having safety and security concerns. To provide identity and branding, in Curitiba, buses are uniquely identified by route and function, while in Jakarta each corridor has separate colored buses that make TransJakarta distinctive above others. Factors leading to success of global cities are summarized in Table 6.2. All the successful BRT having cities have strong administrative capability and political will as a key factor. Coordination among different organizations are also an important factor for success of BRT in a city. The main differences among Jakarta and other cities were the institutional set-up and the contracting procedures. Jakarta split equipment and operation between two different agencies.

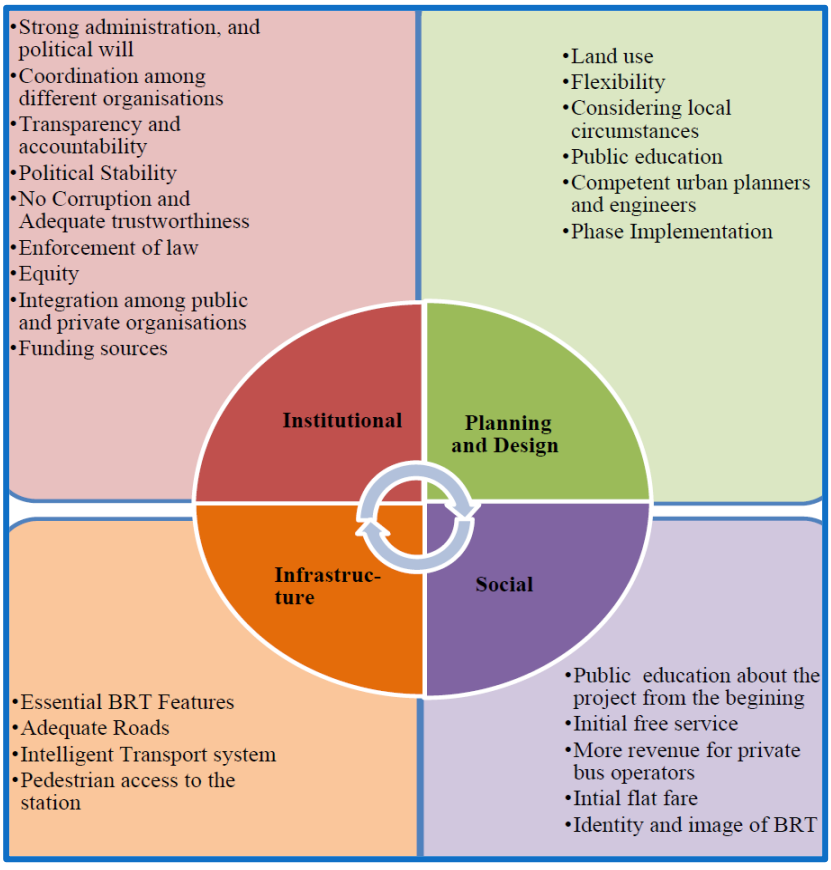
Table 6.2: Factors leading to success of BRTs around the world

Sl.No.	Factors	Curitiba	Bogota	Ahmedabad	Guangzhou	Mexico City	Buenos Aires	Rio de Janeiro	Jakarta
1	Strong administrative capability and political will	Y	Y	Y	Y	Y	Y	Y	Y
2	Separate Public Agency for Institutional management	Y	Y	Y	Y	Y	Y	Y	Y
3	Coordination among different organisations	Y	Y	Y	Y	Y	Y	Y	P
4	TOD zoning policy around the stations	Y	Y	Y	Y	Y	Y	Y	Y
5	High-quality pedestrian facilities	Y	Y	Y	Y	Y	Y	Y	P
6	Bike sharing policy along BRT Corridor	Y	Y	Y	Y	Y	Y	Y	N
7	Complementary policies to reduce car traffic	Y	Y	Y	Y	Y	Y	Y	Y
8	Essential BRT Features	P	Y	Y	Y	P	P	P	Y
9	Public Participation in BRT	Y	Y	Y	Y	Y	Y	Y	Y
10	Identity and Image of BRT	Y	Y	Y	Y	Y	Y	Y	Y
11	High-quality passenger information at stations	Y	Y	Y	Y	P	P	P	P

(Y = Fully Considered, P= Partially Considered, N= Not Considered)

Source: Deng et al., (2013); Goodman, et al. (1998); ITDP (2017); Kamrowska-Zaluska (2017); Suzuki et al., (2013); Good Practice Guide (2019) accessed on 5 July from www.c40.org ; Global BRT data accessed on 18 Mar, 2019 from www.brtdata.org ; Sustainable Transport Award accessed on 5 July, 2019 from www.staward.org ; Transforming Urban Transport – The Role of Political Leadership accessed on 01 Nov, 2019 from www.transformingurbantransport.com ; Far East Mobility- BRT & Urban Transport Planning accessed on 15 Oct, 2019 from www.fareast.mobi.

There was an apparent lack of coordination between these agencies (ITDP, 2007). Essential BRT features such as- High-quality passenger information at stations are partially present in Curitiba, Mexico City, Buenos Aires and Rio De Janeiro. Earlier Curitiba had manual ticketing system. In 2000, electronic ticketing system has been introduced in Curitiba, but not all stations are having this facility. Bogota, Ahmedabad and Guangzhou BRT have all factors for being successful. Jakarta BRT does not have any bike sharing policy along BRT Corridor. Nasrin (2015) has divided BRT success factors into four broad categories: institutional, planning and design, social and infrastructural factors. However, all factors are interrelated.



Source: Nasrin, 2015

Figure 6.1: BRT Success Factors as per Nasrin, 2015

Similarly, A seven-point theoretical framework for key barriers to successful BRT has been used in a study of Nguyen and Pojani (2018) which is shown in Table 6.3. The categories covered in the framework are: (1) institutional and legislative context; (2) political leadership and commitment; (3) management of competing modes; (4) public participation; (5) funding and coordination; (6) physical design; and (7) image promotion.

Table 6.3: Theoretical framework of Key barriers to Successful BRT

Key barriers to Successful BRT	
1. Institutional and Legislative Context	¶ Unaligned interests of involved city officials and stakeholders. ¶ Uncoordinated, decentralized municipal transport departments ¶ Limited in-house technical capacity. ¶ Foreign consultancy services unfamiliar with the local culture, legislation, and political system. ¶ Lack of specialized BRT agencies with coordinating and ruling capacity.
2. Political Leadership and Commitment	¶ Lack of commitment of city leaders ¶ Risk of discontinuation in case of electoral changes. ¶ Conflicts with stakeholders.
3. Management of Competing Modes	¶ Competition and opposition to BRT from private motorized vehicles ¶ Lack of complementary policies to reduce car traffic. ¶ Opposition to BRT from existing transit operators (bus and rail). ¶ Competition and opposition from myriad small enterprises (paratransit). ¶ Cycling lobbies might view BRT as their contestant for scarce road space. ¶ Lower image than rail-based urban transport. ¶ Opposition from retail shop owners.
4. Public Participation	¶ Lack of communication, transparency, and media or community engagement. ¶ Lack of public education activities on the advantages of BRT (e.g., over rail), on what to realistically expect, and on how to use the system once it is built. ¶ Lack of negotiation and/or compromise with the car lobby.
5. Funding and Coordination	¶ Large upfront public investment. ¶ No novel funding sources. ¶ Poor incentives for operators. ¶ Inadequate funding or very tight financial planning. ¶ Maintenance provisions sometimes not built into the financial plan. ¶ High land acquisition/compensation costs. ¶ Strained negotiations with land and building owners. ¶ Low BRT fares are unlikely to cover high purchase costs of land while high fares lead to decreases in ridership.
6. Physical Design	¶ Poorly designed BRT system. ¶ Poor physical integration with other modes. ¶ Lack of access from low-income neighborhoods. ¶ Neglect of existing bus routes. ¶ Development of isolated corridors with integration deferred to a later stage. ¶ No scheduled reviews and revisions of BRT once in operation.

Key barriers to Successful BRT	
7. Image Promotion	¶ No distinctive image, confusing maps and wayfinding, little information on/off-line. ¶ Lack of awareness raising among users on the benefits of BRT over rail.

Source: Nguyen and Pojani (2018)

By reviewing factors behind successful BRT and these two frameworks we can group (i) strong political leadership, administration, coordination among organizations, political stability, accountability, law enforcement, capability to arrange funding for BRT into Governance category; (ii) BRT design, competent urban planners and engineers, land use, integration with transport and land use policies, essential BRT features, ITS, pedestrian access to the roads etc., can be grouped into Urban Planning and Design category; and (iii) Distinctive image and identity of BRT, public awareness, public education about the project etc, can be grouped into Social factor category. If these three factors are met, then government can implement BRT infrastructure.

6.2 Consideration of Success Factors with Respect to BRT in cities of Bangladesh

The challenges and opportunities of the BRT system in Bangladesh can be derived based on the findings from success factors discussed above. The analysis will give an indication about the strategies Bangladeshi cities should follow and the necessary changes for successful BRT implementation in cities of Bangladesh.

Table 6.4: Success factor with respect to Implementation of BRT in Cities of Bangladesh

Success Factors	Current Circumstances
1. Governance	¶ **Lack of Political will:** STP plans are not implemented as planned due to lack of political will.
	¶ **Lack of Coordination:** Bangladesh Government does not have a system for coordinating development plans and budgets in a fragmented institutional framework and also lack of coordination in different government agencies exists here.
	¶ **Lack of Funding Policy:** The lack of an integrated transport policy and planning framework for prioritizing investments.
	¶ **No Separate Authority:** BRTA is responsible for co- ordinating, developing and managing, or participating in the development and management of, road transport and traffic systems including BRT,

	whether in Bangladesh or elsewhere, and DTCA is the implementation agency of BRT.
2. Urban Planning and Design	¶ **No Planned Road:** Both motorized and non-motorized vehicles are in operation on each and every road, except some NMT restricted routes in Bangladesh.
	¶ **No Integrated Planning:** There is no Transport and Land use integrated plan. Implementation of TOD may improve urban environment.
	¶ **Poorly Designed road:** Most of the roads and terminals of Bangladesh are poorly designed. That causes huge traffic congestions.
	¶ **Absence of Route Number:** Most buses are not identified by route number.
3. Social factor	¶ **Public Participation:** Several FDG, Consultation meeting has been conducted with mayors, councilors and residents.
	¶ **Image Promotion:** Passenger information, in terms of route maps, schedules, or service time coverage, is virtually non-existent.

Source: Azra (2016); DTCA (2019); GDSUTP (2016); Nasrin (2015); Nigar (2013); Road Transport and Traffic Act (2011); Smith (2009)

6.3 Recommendation

The following recommendations can be provided for successful implementation of BRT in cities of Bangladesh.

1) **Governance:** Selecting best approach and policy for a city depends upon power of authority, the legislative context at a regional and national level, citizen engagement, availability of project funding, relationship with bus operators and other agencies etc. Success of BRT depends on coordination amongst all relevant agencies and strong political will (Nasrin, 2015). Cities such as Bogota and Curitiba have benefited from highly motivated political leaders who prioritized public transport (ITDP, 2017). So, A strong political can be suggested for effective implementation of BRT in any cities.

As per Proposed Road Transport and Traffic Act- 2011, BRTA is responsible for co-ordinating, developing and managing, or participating in the development and management of, road transport and traffic systems including BRT, whether in Bangladesh or elsewhere. Also responsible for performing the duties of a Regional Transport Authority where there is no such authority, and if it thinks fit or if so required, perform those duties in respect of any route or matter common to two or more regions, or the routes or areas subject of franchise, or BRT service and competitive bids. DTCA is the

implementing agency for BRT. But a separate Authority will be needed for successful implementation of BRT. Successful implementation of BRT system may lead to economic growth of our country.

2) **Urban Planning and Design:** Good design standard such as- physically separated bus lanes in the median of the roadway, high floor bus stations and wheel chair-usable pedestrian ramps, high-floor buses, pre-board fare payment with turnstiles using electronic smart-cards are integrated in most of the successful cases. User friendly Design standard can be recommended for successful BRT. TransJakarta BRT was supplemented by '3-in-1'policy. '3-in-1' policy was extended for functioning during the evening hours, respectively, from 16:00-19:00. This interaction of BRT and '3-in'1'policy contributed to a general reduction of congestion level during peak hours on BRT corridors. Bangladesh Government has plan to designate some areas and streets as "motorized-free zones". These areas may be designated for specific times or days and the built environment will be developed and improved to encourage walking and NMT services. Effective implementation of these kind policies may lead to successful BRT in cities. According to AHP analysis in this study, Economy is the most significant factor and Regional/ Surrounding Context is the second most important factor. BRT will provide regional connectivity within employment centers. Transit-Oriented Development (TOD) along BRT corridor can be recommended as for providing access between destinations and workplaces.

3) **Social factor:** Public participation was one of major factors of all successful BRT system. There should be a law for public consultation to integrate public with the transport infrastructure implementation.

Chapter 7
Conclusion

Chapter 7: Conclusion

Mass Rapid Transit, especially BRT plays the principle role in transportation system by carrying large number of passengers in each trip. Couple of studies have been conducted focusing on feasibility of first or last mile linkages to the Bus Rapid Transit system in Dhaka. But no study has been conducted yet on exploring its potentiality in other cities of the country. This study is an attempt to initiate an exploratory research in this regard.

A total number of 30 cities of Bangladesh has been studied. The study has enlisted five major factors, namely, Demography, Regional/Surrounding Context, Transport, Major Activity Center/ Land Use and Economy. Relevant data and information have been collected for the considered factors and their sub factors. Analytic Hierarchy Process (AHP) has been applied for prioritizing the factors.

This study shows that, Chattogram has highest composite value (0.849) and it has very much potential but developing BRT network has become overdue for the city. Other cities still have potential for BRT development in near future. As per analysis Bogura, Cumilla, Mymensingh, Noakhali, Tangail and Rajshahi city needs BRT immediately.

On important issues that need mentioning is that, transportation policies implemented in cities around the world do not have the same transferability potential and its case should be considered in final decisions. The successes depend on the institutional strength, co-ordination, steady political support and, above all, control over the allocation of land, which tend to be lacking.

The method developed in this study would be a guidance for the concerned authority to review their selection procedure and to make necessary changes regarding potential city to develop BRT. Further research can be done emphasizing on route or corridor selection and detailed design for BRT development in priority cities. The methodology developed in this research can be applied not only for BRT system but also for other types of public transport service.

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APPENDIX A

City ranking according to population:

Sl. No.	Cities	Population	Ranking (According to Population)
1.	Dhaka	8906039	1
2.	Chattogram	2592439	2
3.	Khulna	664728	3
4.	Sylhet	526412	4
5.	Rajshahi	451425	5
6.	Tongi	406420	6
7.	Bogura	400983	7
8.	Mymenshingh	389918	8
9.	Barishal	339308	9
10.	Rangpur	307053	10
11.	Savar	296851	11
12.	Comilla Adarsha sadar	296010	12
13.	Narayanganj	286330	13
14.	Sirajganj	167200	14
15.	Jessore	237478	15
16.	Cox's Bazar	223522	16
17.	Gazipur	213061	17
18.	Brahmanbaria	193814	18
19.	Dinajpur	191329	19
20.	Narsinghdi	185128	20
21.	Chapai Nawabganj	180731	21
22.	Chandpur	171065	22
23.	Tangail	167412	23
24.	Shiddhirganj	256760	24
25.	Kadam Rasul	166291	25
26.	Kaliakair	163498	26
27.	Feni	156971	27
28.	Tarabo	150709	28
29.	Naogaon	150549	29
30.	Jamalpur	150172	30
31.	Pabna	144442	31
32.	Saidpur	133433	32
33.	Begumganj	132948	33
34.	Noakhali	130842	34
35.	Chuadanga	128865	35
36.	Sreepur	126249	36
37.	Faridpur	122425	37
38.	Bhairab	118992	38
39.	Satkhira	113322	39
40.	Comilla Sadar Dakshin	111891	40
41.	Jhenaidah	110541	41
42.	Kushtia	108423	42
43.	Kishoreganj	103798	43

Source: Population and Housing Census, 2011, Urban Area Report- National Report; Volume 3, August 2014.

Highlighted cities are under Dhaka, Gazipur and Narayanganj districts. As BRT is already implementing in these districts, these cities will be excluded in the analysis.

APPENDIX B

Average corridor length of 170 BRT's

Cities size class	Population Range	Bangladesh		170 BRT Cities		Avg. BRT corridor length (Km)
		No. of Cities	Name of Cities	No. of Cities	Name of cities	
C1	100,000-199,999	26	Brahmanbaria, Dinajpur, Narsinghdi, Chapai Nababganj, Chandpur, Tangail, Kadam Rasul, Kaliakair, Feni, Tarabo, Naogaon, Jamalpur, Pabna, Saidpur, Begumganj (Chowmuhoni), Noakhali, Chuadanga, Sreepur, Faridpur, Bhairab, Satkhira, Comilla Sd. Dakshin, Jhenaidah, Kushtia, Kishoreganj	18	Kent, Almere, Liège, Fareham - Gosport, Castellón, Kesennuma - Tome, Fort Collins, Enschede, Eugene, Nîmes, Le Mans, Cannes, Jonkoping, Cambridge, Metz, Rouen, Caen, Nancy	20
C2	200,000-299,999	7	Savar, Comilla, Narayanganj, Jessore, Cox's Bazar, Gazipur, Shiddhirganj	17	Nantes, Strasbourg, Haifa, Chiayi, Pachuca, Sumaré, Gatineau, Merida, Orlando, Swansea, Granada, Lille, Richmond, Eindhoven, Oberhausen, Criciúma, Luton	17
C3	300,000-399,999	3	Mymensingh, Barishal, Rangpur	6	Cleveland, Zurich, Alexandria - Arlington, Uberaba, Utrecht, Pittsburgh	14
C4	400,000-499,999	3	Rajshahi, Tongi, Bogra	6	Niterói, Lyon, Pereira, Port of Spain - Arima, Toulouse, Miami	18
C5	500,000 - 999,999	2	Khulna, Sylhet	26	Concepción, Lianyungang, Johannesburg, Ottawa, Hartford County, Stockholm, Natal, Chihuahua, Panama, Amsterdam, Acapulco, Yancheng, Pretoria, Mississauga, Subang Jaya, Guadalupe, Winnipeg, Uberlândia, Helsinki, Las Vegas, Essen, Juiz de Fora, Londrina, Quebec, Gothenburg, Bucaramanga	23
C6	1,000,000 - 1,999,999			33	Brisbane, Indore, Caracas, Xiamen, Curitiba, Bhopal, Isfahan, Recife, Quito, Puebla, Guatemala, Auckland, Guadalajara, Porto Alegre, Belém, Hanoi, Goiânia, Changde, Montevideo, Juárez, Córdoba, Guarulhos, Rajkot, León de los Aldama, Barquisimeto, Barranquilla, Adelaide, Campinas, Monterrey, Yinchuan, Yichang, Cartagena, York Regional Municipality	24
C7	2,000,000 - 2,999,999	1	Chittagong	22	Dalian, Brasília, Buenos Aires, Greater Manchester, Kunming, Taichung, Guayaquil, Taipei, Fortaleza, Medellín, Urumqi, Belo Horizonte, Cali, Tabriz, Changzhou, Nagoya, Zaozhuang, Hefei, Paris, Gran San Salvador, San Bernardino, Lanzhou	33
C8	3,000,000 – 4,999,999	1		10	Santiago, Pune - Primpi-Chinchwad, Sydney - Metropolitan Area, Surat, Hangzhou, Dar es Salaam, Jinan, Los Angeles, Islamabad - Rawalpindi, Cape Town, Jaipur	37
M*	5,000,000 and above	1	Dhaka	22	Lagos, Mexico City - Metropolitan Area, Chongqing, Buenos Aires - Metropolitan Area, São Paulo - Metropolitan area, Istanbul, Beijing, São Paulo, Seoul, Jakarta, Mexico City, New York, Bangkok, Tehran, Bogotá, Lima, Chengdu, Lahore, Guangzhou, Rio de Janeiro, Zhengzhou, Ahmedabad	73

M*= Mega city

City size and Population range is as per Population and Housing Census-2011, BBS.

APPENDIX C

Consultation of 10 persons:

Sl. No.	Name of Consultants and Designation
1	Dr. Md. Akter Mahmud Professor, Department of Urban & Regional Planning, Jahangirnagar University (JU)
2	Shafiq-Ur Rahman Professor, Department of Urban & Regional Planning, Jahangirnagar University (JU)
3	Dr. Suman Kumar Mitra Assistant Project Scientist, Institute of Transportation Studies (ITS)
4	Sitangshu Shekhor Biswas Deputy Director Bangladesh Road Transport Authority (BRTA)
5	Abul Monzur Mohammed Sadeque Executive Engineer, Local Government and Engineering Department (LGED)
6	Mr. Md. Anisur Rahman Project Director, Clean Air and Sustainable Environment CASE-DTCA and Traffic Engineer Project, Dhaka Transportation Co-ordination Authority (DTCA)
7	Stephen Moriarty Urban Planner and Former Team Leader Greater Dhaka Sustainable Urban Transport Project (GDSUTP)
8	Md. Jahurul Haque Ex Chief Town Planner, RAJUK DTL, GDSUTP and Senior Transport Planner, MRT Line-1
9	Md Nurullah Superintending Engineer Local Government and Engineering Department (LGED)
10	Mohammad Nazrul Islam Transport Specialist Asian Development Bank (ADB)

Appendix C-1

AHP Check List/Instrument

Name of Interviewee: _____

Designation/Affiliation: _____

Contact: Phone: _____E-mail: _____

Note:
Pairwise comparisons are used to determine the relative importance of each criterion. Available values for the pairwise comparisons are members of the set: {9, 8, 7, 6, 5, 4, 3, 2, 1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9}. The pairwise comparisons are arranged in a matrix.

Table 1: The Fundamental Scale for Pairwise Comparisons

Note: Element *a* and *b* are any two of the criteria.

Intensity of Importance	**Definition**	**Explanation**
1	Equal importance	Element ***a*** and ***b*** contribute equally to the objective
3	Moderate importance of one over another	Slightly favor element ***a*** over ***b***
5	Strong importance	Strongly favor element ***a*** over ***b***
7	Very strong importance	Element ***a*** is favored very strongly over ***b***
9	Extreme importance	The evidence favoring element over ***a*** over ***b*** is of the highest possible order of importance
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed. For example, 4 can be used for the intermediate value between 3 and 5
1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9	These values represent the opposite of the reciprocal whole numbers. For example, if "9" means that x is much more important than y, "1/9" means that x is much less important than y.	

Now please rank following criteria and variables, keeping in mind the research context, according to your opinion:

Table 2: The Pairwise Comparison Matrix Template for broad criteria

Variables	Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy
Demography	1				
Regional/ Surrounding context		1			
Transport			1		
Major Activity Center/ Land Use				1	
Economy					1

Now please rank specific variables under each category of broad criteria

Table 3: Demography

Variables	Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
Avg. Population density of 'A' Category Municipalities	1		
Share of population Engaged in industrial activity		1	
Growth rate of population engaged in non-agricultural activity			1

Table 4: Regional/surrounding context

Variables	Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
Number of 'A' and 'B' type municipalities	1	
Number of Growth Centres on or within 500 meter of RHD/Upazila road		1

Table 5: Transport

Variables	Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 yrs)
Presence of Airport in the district	1				
No. of Upazilas having Railway station		1			
Motorized Passenger Traffic volume in the RHD road			1		
Avg. CVD in the Upazila road				1	
Total No. of Registered motor vehicles in the dist. (Last 10 years)					1

*For motorised Passenger Traffic only (Large Bus, Mini Bus, Micro Bus, Car & Motor Cycle)

Table 6: Major Activity Center/Land Use

Variables	No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
Number of EPZ, Economic Zone in the district	1		
Number of universities, tertiary education & vocational centers		1	
Number of specialized hospitals			1

Table 7: Economy

Variables	Inverse of Poverty rate in the district	No. of Non-agricultural establishment
Inverse of Poverty in the district	1	
No. of non-agricultural establishments		1

Expert 1: Dr. Md. Akter Mahmud

Professor, Dept. of Urban & Regional Planning,
Jahangirnagar University

Broad Category		Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	0.20	0.50	0.13	0.11
Regional/ Surrounding Context	2	5.00	1.00	0.50	0.33	0.20
Transport	3	2.00	2.00	1.00	1.00	0.50
Major Activity Center/ Land use	4	8.00	3.00	1.00	1.00	0.33
Economy	5	9.00	5.00	2.00	3.00	1.00

CR=10%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.33	3.00
Share of population Engaged in industrial activity	2	3.00	1.00	4.00
Growth rate of population engaged in non-agricultural activity	3	0.33	0.25	1.00

CR=9%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	0.20
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	5.00	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	1.00	4.00	4.00	3.00
No. of Upazilas having Railway station	2	1.00	1.00	9.00	3.00	3.00
Motorized Passenger Traffic volume in the RHD road	3	0.25	0.11	1.00	0.25	0.20
Avg. CVD in the Upazila road	4	0.25	0.33	4.00	1.00	1
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.33	0.33	5.00	1.00	1.00

CR= 5%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	3.00	3.00
No. of Universities, Tertiary education & Vocational centers	2	0.33	1.00	0.50
No. of Specialized Hospitals	3	0.33	2.00	1.00

CR= 6%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	0.25
No. of Non-agricultural establishment	2	4.00	1.00

CR= Not needed for two variables

Expert 2: Shafiq-Ur Rahman

Professor, Dept. of Urban & Regional Planning,
Jahangirnagar University

Broad Category		Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	0.33	0.50	2.00	1.00
Regional/ Surrounding Context	2	3.00	1.00	3.00	2.00	1.00
Transport	3	2.00	0.33	1.00	0.50	0.50
Major Activity Center/ Land use	4	0.50	0.50	2.00	1.00	0.33
Economy	5	1.00	1.00	2.00	3.00	1.00

CR = 10%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	3.00	2.00
Share of population Engaged in industrial activity	2	0.33	1.00	1.00
Growth rate of population engaged in non-agricultural activity	3	0.50	1.00	1.00

CR = 2%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	0.50
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	2.00	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	3.00	5.00	2.00	4.00
No. of Upazilas having Railway station	2	0.33	1.00	3.00	0.50	2.00
Motorized Passenger Traffic volume in the RHD road	3	0.20	0.33	1.00	1.00	1.00
Avg. CVD in the Upazila road	4	0.50	2.00	1.00	1.00	2.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.25	0.50	1.00	0.50	1.00

CR = 6%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	0.50	0.25
No. of Universities, Tertiary education & Vocational centers	2	2.00	1.00	0.33
No. of Specialized Hospitals	3	4.00	3.00	1.00

CR= 2%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	3.00
No. of Non-agricultural establishment	2	0.33	1.00

CR= Not needed for two variables

Expert 3. Dr. Suman Kumar Mitra

Assistant Project Scientist,
Institute of Transportation Studies (ITS)

Broad Category		Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	0.14	0.14	0.13	0.13
Regional/ Surrounding Context	2	7.00	1.00	0.25	0.33	0.17
Transport	3	7.00	4.00	1.00	1.00	1.00
Major Activity Center/ Land use	4	8.00	3.00	1.00	1.00	1.00
Economy	5	8.00	6.00	1.00	1.00	1.00

CR= 8%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.17	0.20
Share of population Engaged in industrial activity	2	6.00	1.00	2.00
Growth rate of population engaged in non-agricultural activity	3	5.00	0.50	1.00

CR= 3%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	0.20
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	5.00	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	1.00	7.00	4.00	5.00
No. of Upazilas having Railway station	2	1.00	1.00	6.00	3.00	6.00
Motorized Passenger Traffic volume in the RHD road	3	0.14	0.17	1.00	1.00	3.00
Avg. CVD in the Upazila road	4	0.25	0.33	1.00	1.00	1.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.20	0.17	0.33	1.00	1.00

CR= 8%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	1.00	1.00
No. of Universities, Tertiary education & Vocational centers	2	1.00	1.00	0.50
No. of Specialized Hospitals	3	1.00	2.00	1.00

CR= 5%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	4.00
No. of Non-agricultural establishment	2	0.25	1.00

CR= Not needed for two variables

Expert 4: Sitangshu Shekhor Biswas
Deputy Director, Bangladesh Road Transport Authority (BRTA)

Broad Category		Demography	Regional/ Surrounding Context	Transport	Major Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	1.00	0.50	0.17	0.17
Regional/ Surrounding Context	2	1.00	1.00	1.00	0.25	0.33
Transport	3	2.00	1.00	1.00	0.50	0.25
Major Activity Center/ Land use	4	6.00	4.00	2.00	1.00	0.50
Economy	5	6.00	3.00	4.00	2.00	1.00

CR= 4%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.50	0.50
Share of population Engaged in industrial activity	2	2.00	1.00	0.50
Growth rate of population engaged in non-agricultural activity	3	2.00	2.00	1.00

CR= 5%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	0.50
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	2.00	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	3.00	3.00	4.00	5.00
No. of Upazilas having Railway station	2	0.33	1.00	1.00	0.50	1.00
Motorized Passenger Traffic volume in the RHD road	3	0.33	1.00	1.00	0.33	1.00
Avg. CVD in the Upazila road	4	0.25	2.00	3.00	1.00	1.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.20	1.00	1.00	1.00	1.00

CR= 6%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	4.00	3.00
No. of Universities, Tertiary education & Vocational centers	2	0.25	1.00	0.50
No. of Specialized Hospitals	3	0.33	2.00	1.00

CR= 2%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	0.50
No. of Non-agricultural establishment	2	2.00	1.00

CR= Not needed for two variables

Expert 5: Abul Monzur Mohammed Sadeque
Executive Engineer, Local Government and Engineering Department

Broad Category		Demography	Regional/ Surrounding Context	Transport	Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	1.00	2.00	3.00	3.00
Regional/ Surrounding Context	2	1.00	1.00	0.50	2.00	1.00
Transport	3	0.50	2.00	1.00	3.00	3.00
Major Activity Center/ Land use	4	0.33	0.50	0.33	1.00	0.33
Economy	5	0.33	1.00	0.33	3.00	1.00

CR= 7%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	1.00	3.00
Share of population Engaged in industrial activity	2	1.00	1.00	2.00
Growth rate of population engaged in non-agricultural activity	3	0.33	0.50	1.00

CR= 2%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	2.00
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	0.50	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	1.00	3.00	3.00	1.00
No. of Upazilas having Railway station	2	1.00	1.00	3.00	3.00	2.00
Motorized Passenger Traffic volume in the RHD road	3	0.33	0.33	1.00	0.33	0.33
Avg. CVD in the Upazila road	4	0.33	0.33	3.00	1.00	0.33
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	1.00	0.50	3.00	3.00	1.00

CR= 5%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	0.33	0.33
No. of Universities, Tertiary education & Vocational centers	2	3.00	1.00	0.50
No. of Specialized Hospitals	3	3.00	2.00	1.00

CR= 6%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	2.00
No. of Non-agricultural establishment	2	0.50	1.00

CR= Not needed for two variables

Expert 6: Mr. Md. Anisur Rahman
Project Director, Dhaka Transportation Co-ordination Authority (DTCA)

Broad Category		Demography	Regional/ Surrounding Context	Transport	Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	0.33	3.00	8.00	1.00
Regional/ Surrounding Context	2	3.00	1.00	3.00	5.00	1.00
Transport	3	0.33	0.33	1.00	1.00	0.33
Major Activity Center/ Land use	4	0.13	0.20	1.00	1.00	0.20
Economy	5	1.00	1.00	3.00	5.00	1.00

CR= 8%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.33	0.50
Share of population Engaged in industrial activity	2	3.00	1.00	2.00
Growth rate of population engaged in non-agricultural activity	3	2.00	0.50	1.00

CR= 1%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	4.00
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	0.25	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	1.00	3.00	4.00	4.00
No. of Upazilas having Railway station	2	1.00	1.00	4.00	4.00	4.00
Motorized Passenger Traffic volume in the RHD road	3	0.33	0.25	1.00	2.00	4.00
Avg. CVD in the Upazila road	4	0.25	0.25	0.50	1.00	2.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.25	0.25	0.25	0.50	1.00

CR= 6%

Major Activity Center/ Land use:

Major Activity		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	0.20	0.20
No. of Universities, Tertiary education & Vocational centers	2	5.00	1.00	0.50
No. of Specialized Hospitals	3	5.00	2.00	1.00

CR= 6%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	4.00
No. of Non-agricultural establishment	2	0.25	1.00

CR= Not needed for two variables

Expert 7: Stephen Moriarty
Urban Planner and Former Team Leader
Greater Dhaka Sustainable Urban Transport Project (GDSUTP)

Broad Category		Demography	Regional/ Surrounding Context	Transport	Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	0.50	1.00	0.50	0.50
Regional/ Surrounding Context	2	2.00	1.00	2.00	3.00	2.00
Transport	3	1.00	0.50	1.00	0.50	0.50
Major Activity Center/ Land use	4	2.00	0.33	2.00	1.00	1.00
Economy	5	2.00	0.50	2.00	1.00	1.00

CR= 4%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.13	0.14
Share of population Engaged in industrial activity	2	8.00	1.00	2.00
Growth rate of population engaged in non-agricultural activity	3	7.00	0.50	1.00

CR= 4%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	4.00
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	0.25	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	1.00	3.00	3.00	3.00
No. of Upazilas having Railway station	2	1.00	1.00	3.00	3.00	3.00
Motorized Passenger Traffic volume in the RHD road	3	0.33	0.33	1.00	1.00	2.00
Avg. CVD in the Upazila road	4	0.33	0.33	1.00	1.00	2.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.33	0.33	0.50	0.50	1.00

CR= 2%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	0.14	0.14
No. of Universities, Tertiary education & Vocational centers	2	7.00	1.00	0.50
No. of Specialized Hospitals	3	7.00	2.00	1.00

CR= 6%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	0.50
No. of Non-agricultural establishment	2	2.00	1.00

CR= Not needed for two variables

Expert 8: Dr. M. Jaharul Haque
Ex Chief Town Planner, RAJUK
Senior Transport Planner, MRT Line-1

Broad Category		Demography	Regional/ Surrounding Context	Transport	Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	1.00	0.50	0.20	0.20
Regional/ Surrounding Context	2	1.00	1.00	1.00	0.33	0.33
Transport	3	2.00	1.00	1.00	0.50	0.33
Major Activity Center/ Land use	4	5.00	3.00	2.00	1.00	2.00
Economy	5	5.00	3.00	3.00	0.50	1.00

CR= 4%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	2.00	3.00
Share of population Engaged in industrial activity	2	0.50	1.00	2.00
Growth rate of population engaged in non-agricultural activity	3	0.33	0.50	1.00

CR= 1%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	2.00
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	0.50	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	2.00	2.00	2.00	2.00
No. of Upazilas having Railway station	2	0.50	1.00	3.00	3.00	2.00
Motorized Passenger Traffic volume in the RHD road	3	0.50	0.33	1.00	1.00	0.50
Avg. CVD in the Upazila road	4	0.50	0.33	1.00	1.00	2.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.50	0.50	2.00	0.50	1.00

CR= 7%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	0.50	0.33
No. of Universities, Tertiary education & Vocational centers	2	2.00	1.00	0.50
No. of Specialized Hospitals	3	3.00	2.00	1.00

CR= 1%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	3.00
No. of Non-agricultural establishment	2	0.33	1.00

CR= Not needed for two variables

Expert 9: Md Nurullah
Superintending Engineer
Local Government and Engineering Department (LGED)

Broad Category		Demography	Regional/ Surrounding Context	Transport	Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	2.00	2.00	3.00	3.00
Regional/ Surrounding Context	2	0.50	1.00	1.00	2.00	3.00
Transport	3	0.50	1.00	1.00	3.00	3.00
Major Activity Center/ Land use	4	0.33	0.50	0.33	1.00	3.00
Economy	5	0.33	0.33	0.33	0.33	1.00

CR= 5%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.17	0.20
Share of population Engaged in industrial activity	2	6.00	1.00	2.00
Growth rate of population engaged in non-agricultural activity	3	5.00	0.50	1.00

CR= 3%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	0.17
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	6.00	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	0.33	0.33	2.00	2.00
No. of Upazilas having Railway station	2	3.00	1.00	3.00	2.00	3.00
Motorized Passenger Traffic volume in the RHD road	3	3.00	0.33	1.00	1.00	2.00
Avg. CVD in the Upazila road	4	0.50	0.50	1.00	1.00	2.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.50	0.33	0.50	0.50	1.00

CR= 9%

Major Activity Center/ Land use:

Major Activity Center/ Land use		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	0.17	0.17
No. of Universities, Tertiary education & Vocational centers	2	6.00	1.00	0.50
No. of Specialized Hospitals	3	6.00	2.00	1.00

CR= 6%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	6.00
No. of Non-agricultural establishment	2	0.17	1.00

CR= Not needed for two variables

Expert 10: Mohammad Nazrul Islam
Transport Specialist, Asian Development Bank (ADB)

Broad Category		Demography	Regional/ Surrounding Context	Transport	Activity Center/ Land use	Economy
		1	2	3	4	5
Demography	1	1.00	0.33	1.00	1.00	1.00
Regional/ Surrounding Context	2	3.00	1.00	3.00	1.00	2.00
Transport	3	1.00	0.33	1.00	1.00	2.00
Major Activity Center/ Land use	4	1.00	1.00	1.00	1.00	0.50
Economy	5	1.00	0.50	0.50	2.00	1.00

CR= 8%

Demography:

Demography		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity
		1	2	3
Avg. Population density of 'A' Category Municipalities	1	1.00	0.20	1.00
Share of population Engaged in industrial activity	2	5.00	1.00	3.00
Growth rate of population engaged in non-agricultural activity	3	1.00	0.33	1.00

CR= 4%

Regional/ Surrounding Context:

Regional/ Surrounding Context		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
		1	2
Number of 'A' & 'B' type municipalities	1	1.00	0.20
Number of Growth Centers on or within 500 meter of RHD/Upazila road	2	5.00	1.00

CR= Not needed for two variables

Transport:

Transport		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
		1	2	3	4	5
Presence of Airport in the district	1	1.00	3.00	3.00	0.33	3.00
No. of Upazilas having Railway station	2	0.33	1.00	1.00	0.20	0.50
Motorized Passenger Traffic volume in the RHD road	3	0.33	1.00	1.00	0.14	0.33
Avg. CVD in the Upazila road	4	3.00	5.00	7.00	1.00	2.00
Total No. of Registered motor vehicles in the dist. (Last 10 years)	5	0.33	2.00	3.00	0.50	1.00

CR= 5%

Major Activity Center/ Land use:

Major Activity		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals
		1	2	3
No. of EPZ, Economic Zone in the District	1	1.00	1.00	0.33
No. of Universities, Tertiary education & Vocational centers	2	1.00	1.00	0.20
No. of Specialized Hospitals	3	3.00	5.00	1.00

CR= 4%

Economy:

Economy		Inverse of Poverty rate in the district	No. of Non-agricultural establishment
		1	2
Inverse of Poverty rate in the district	1	1.00	5.00
No. of Non-agricultural establishment	2	0.20	1.00

CR= Not needed for two variables

Appendix C-2

Table 1: Overall priority of sub factors of Demography

Demography					
Sub factors		Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity	Growth rate of population engaged in non-agricultural activity	**Sum of Priority Vectors**
Priority vectors	**Expert 1**	0.272	0.608	0.120	1
	Expert 2	0.548	0.211	0.241	1
	Expert 3	0.082	0.575	0.343	1
	Expert 4	0.198	0.312	0.490	1
	Expert 5	0.443	0.387	0.170	1
	Expert 6	0.164	0.539	0.297	1
	Expert 7	0.062	0.584	0.354	1
	Expert 8	0.539	0.297	0.164	1
	Expert 9	0.082	0.575	0.343	1
	Expert 10	0.158	0.655	0.187	1
Overall Priority		**0.255**	**0.474**	**0.271**	
Remarks		Least significant factor	Most significant factor	Second most significant factor	

Table 2: Overall priority of sub factors of Regional/ surrounding Context

Regional/ Surrounding Context				
Sub factors		Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road	**Sum of Priority Vectors**
Priority vectors	**Expert 1**	0.167	0.833	1
	Expert 2	0.333	0.667	1
	Expert 3	0.167	0.833	1
	Expert 4	0.333	0.667	1
	Expert 5	0.667	0.333	1
	Expert 6	0.800	0.200	1
	Expert 7	0.800	0.200	1
	Expert 8	0.667	0.333	1
	Expert 9	0.143	0.857	1
	Expert 10	0.167	0.833	1
Overall Priority		**0.424**	**0.576**	
Remarks		Least significant factor	Most significant factor	

Table 3: Overall priority of sub factors of Transport

Transport							
Sub factors		Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD	Avg. CVD in the Upazila road	Total No. of Registered motor	**Sum of Priority Vectors**
Priority vectors	**Expert 1**	0.337	0.359	0.045	0.122	0.137	1
	Expert 2	0.426	0.173	0.105	0.201	0.095	1
	Expert 3	0.386	0.365	0.094	0.090	0.065	1
	Expert 4	0.464	0.116	0.111	0.192	0.118	1

	Expert 5	0.265	0.308	0.075	0.119	0.233	1
	Expert 6	0.335	0.358	0.153	0.091	0.064	1
	Expert 7	0.329	0.329	0.128	0.128	0.086	1
	Expert 8	0.314	0.281	0.112	0.152	0.142	1
	Expert 9	0.165	0.379	0.207	0.158	0.092	1
	Expert 10	0.248	0.076	0.066	0.447	0.162	1
Overall Priority		0.327	0.274	0.110	0.170	0.119	
Remarks		Most significant factor	Second most significant factor	Least significant factor	Third most significant factor	Fourth most significant factor	

Table 4: Overall priority of sub factors of Activity Center/ Land use

Activity Center/ Land use					
Sub factors		No. of EPZ, Economic Zone in the District	No. of Universities, Tertiary education & Vocational centers	No. of Specialized Hospitals	**Sum of Priority Vectors**
Priority vectors	**Expert 1**	0.589	0.159	0.252	1
	Expert 2	0.137	0.239	0.623	1
	Expert 3	0.328	0.261	0.411	1
	Expert 4	0.623	0.137	0.239	1
	Expert 5	0.142	0.334	0.525	1
	Expert 6	0.090	0.354	0.556	1
	Expert 7	0.066	0.363	0.571	1
	Expert 8	0.164	0.297	0.539	1
	Expert 9	0.077	0.359	0.564	1
	Expert 10	0.187	0.158	0.655	1
Overall Priority		**0.240**	**0.266**	**0.494**	
Remarks		Least significant factor	Second most significant factor	Most significant factor	

Table 5: Overall priority of sub factors of Economy

Economy				
Sub factors		Inverse of Poverty rate in the district	No. of Non-agricultural establishment	**Sum of Priority Vectors**
Priority vectors	**Expert 1**	0.200	0.800	1
	Expert 2	0.750	0.250	1
	Expert 3	0.800	0.200	1
	Expert 4	0.333	0.667	1
	Expert 5	0.667	0.333	1
	Expert 6	0.800	0.200	1
	Expert 7	0.333	0.667	1
	Expert 8	0.750	0.250	1
	Expert 9	0.857	0.143	1
	Expert 10	0.833	0.167	1
Overall Priority		**0.632**	**0.368**	
Remarks		Most significant factor	Least significant factor	

APPENDIX D

Consultant's opinion:

Category of Factors	Sl. No.	Variable	Factors identified in the 1st stage				Result (Y/N)	Renamed Factors (If Renamed)	Expert's Comments (along with decision regarding acceptance/rejection, some experts also explained the reason for their decision. These explanations are summarized here)
			No. of experts* commented	No. of experts directly accepted the factor	No. of experts partially accepted the factor	Number of experts rejecting the factor			
a. Demography	1	Population	10	6	2	2	N		BRT system can be developed in less than 2 lac to mega cities with over 10 million inhabitants (ITDP, 2007).
	2	Population Density	10	10			N		BRT is running in Cities like Bogota with a population density of 240 inhabitants per hectare where as Kuala Lumpur has population density of 58.7 inhabitants per hectare. But higher population density can sustain the system.
	3	District Sadar upazila population Density	10	7	2	1	N		BRT provides mobility to City and Rrgion. Sadar Upazila will be very small interms of area and population. Low density neighborhoods are generally not ecnomicall viable for BRT Operation (ITDP, 2007).
	4	A' category municipality Population	10	7	3		N		Cities are categorized into 'A' , 'B' and 'C' category based on their revenue generation. This factor can be excluded.
	5	Average Population density of 'A' category municipalities	10	10			Y		The higher the average density of surrounding urban centers, the higher the potential of BRT demand.
	6	Share of population Engaged in industrial activity	10	7	3		Y		People engaged in industry are regular commuters. So, the more is the share of population engaged in industry in a district, the more will be the potential users of BRT.
	7	Non-agricultural Employment growth rate	10	10			Y	Y (Annual growth rate of population engaged in non-agricultural activity)	Due to absence of data to calculate the growth of persons engaged in industrial activities in two consecutive years, this study considers Annual growth rate of population engaged in non-agricultural activities.
b. Regional/ Surrounding Context	8	Number of Surrounding Urban Centers	10	7	3		N		This and next variable are similar. For BRT all urban centeres are not important. Large /higher order centers are importnat. Hence this variable can be excluded and next variable can be included.
	9	Number of A' and 'B' type municipalities	10	10			Y		A' and 'B' type municipalities can have regional connectivity through BRT.
	10	Number of Growth Centers	10	10			Y	Y (Number of Growth Centers on or within 500 meter of RHD/Upazila road)	Growth centers are the commercial hub of rural economy as well as destination place of many buyers and sellers. The more the number of growth centrers in the route of BRT, the higher the market viability of BRT
	11	Urban Centers with Industrial employment	10	6	3	1	N		If talked about uirban centres, other employment types along with industrial employment should be considered. Moreover, Industrial employemnt at district level is covered in variable no. 6 and 26. It is true that urban centres with more industrial emplyment, could be a higher order urban centres. If so, this issues will be covered by Var. no. 9. Besides var. 21 can also comp;lement, to some extent, the omission of this variable..

Category of Factors	Sl. No.	Variable	Factors identified in the 1st stage				Result (Y/N)	Renamed Factors (If Renamed)	Expert's Comments (along with decision regarding acceptance/rejection, some experts also explained the reason for their decision. These explanations are summarized here)
			No. of experts* commented	No. of experts directly accepted the factor	No. of experts partially accepted the factor	Number of experts rejecting the factor			
c. Transport	12	Number of Airport	10	10			Y	Y (Presence of Airport in the district)	Airports are employment hubs for service industry and also big traffic attraction point.
	13	Number of Railway Station	10	10			Y	Y (No. of Upazilas having Railway station)	Railway stations are employment hub for service industry and can generate more passenger.
	14	RHD Road length	10	3	3	4	N		RHD roads (national and regional highways) provides services mainly to interdistrict/regional/ national traffic. But BRT will more for city and surrounding city centres.
	15	Upazila Road length	10	3	3	4	N		Many of the upazila roads are not currently suitable for bus, let alone BRT, based mobility. Besides, they, in many cases, do/may not have deserving centres on both ends, or in between, of the road. So, only length of UPZ. Rd might be misleading.
	16	Motorised Passenger Traffic	10	10			Y	Y (Motorized Passenger Traffic volume in the RHD road)	For regional connectivity, BRT primarily will follow the alignment of national, regional or district roads. It is assumed that more traffic volume on road will lead more demand on that road.
	17	Right of Way (ROW)	10	10			N		There is a myth that BRT requires a great deal of road space and cannot be built in narrow roadways. Design solution exist for virtually every road space circumstance. Quito runs a BRT system through three-meter wide streets in its historical center (ITDP, 2007).
	18	Commercial Vehicle per day (CVD)	10	10			Y	Y (Average Commercial Vehicle per day (CVD) in the Upazila road)	In absence of representative dat, Per day average commercial vehicle on upazila road would reflect the economic potential of upazila or particular corridors in the upazila.
	19	Local bus route	10	7	3		N		Streets and corridors with existing long, heavily traveled bus routes are likely candidates for BRT. Unfortunately, such information is unavailable for upazila roads. So this variable has to be discarded. However, the ommission can, to some extent be offset, by inclusion of var. no. 16 and var. 18. and var. 20.
	20	Registered Motor vehicles	10	10			Y	Y (Total no. of Registered motor vehicles in the district)	More motor vehicles running in a district means more demand.

Category of Factors	Sl. No.	Variable	Factors identified in the 1st stage				Result (Y/N)	Renamed Factors (If Renamed)	Expert's Comments (along with decision regarding acceptance/rejection, some experts also explained the reason for their decision. These explanations are summarized here)
			No. of experts* commented	No. of experts directly accepted the factor	No. of experts partially accepted the factor	Number of experts rejecting the factor			
d. Major Activity center/ land use	**21**	Number of EPZ/Economic Zone	10	10			Y	Y (Number of EPZ, Economic Zone in the District)	EPZ's are major employment centers which plays as major attarcstion for BRT implementation.
	22	Number of University	10	10			Y	Y (Number of Universities, Tertiary education & Vocational centers)	Education is an important hub. Students can access to universities/colleges by BRT.
	23	Tertiary Education Center	10	10			Y		
	24	Number of Major Hospital	10	10			Y	Y (Number of Specialized Hospitals)	Hospitals are major trip attraction point. BRT can provide direct services among different Hospitals of a city.
e. Economy	**25**	Poverty rate	10	10			Y	Y (Inverse of Head count ratio (HCR) rate in the district)	HCR is the proportion of a population below the poverty line. So, the inverse of HCR in one sense represents the economic condition of the district which can by proxy of GDP of a district or city.
	26	Number of Non-agricultural Establishment	10	10			Y		People engaged in farm activities are less likely to make more trips than those engaged in formal, industrial, service activities. But in absence of recent data for number of persons engaged in non-agricultural sector, number of non-agricultural establishments has been considered.
	27	Non- agricultural Establishment in 'A' category municipality	10	6	2	2	N		The merit of 'A' category municipality can be assessed by var. nos. 5, 9.

APPENDIX E

1. Demography:

Sl. No.	City/ District	Avg. Population density of 'A' Category Municipalities	Share of population Engaged in industrial activity (in %)	Annual growth rate of population engaged in non-agricultural activity (in %)
1	Chattogram	4,256	24.3	9.34
2	Khulna	-	14.6	6.31
3	Sylhet	1,966	15.9	5.55
4	Rajshahi	1,990	6.3	7.49
5	Bogura	3,355	10.9	9.10
6	Mymensingh	4,393	11.2	9.34
7	Barishal	1,865	10.2	6.23
8	Rangpur	-	7.2	7.38
9	Cumilla	2,930	10.5	4.79
10	Jashore	5,632	10.3	4.44
11	Cox's Bazar	12,852	8.2	6.50
12	Brahmanbaria	6,767	9.8	6.70
13	Dinajpur	3,978	5.6	6.28
14	Narsingdi	7,672	23.0	6.83
15	Chapai Nawabganj	3,240	6.7	8.85
16	Chandpur	3,578	11.3	6.75
17	Tangail	4,953	11.6	7.11
18	Sirajganj	5,119	23.7	4.59
19	Feni	4,825	12.3	6.11
20	Naogaon	4,060	4.7	6.22
21	Jamalpur	2,680	6.2	7.72
22	Pabna	3,100	13.1	7.48
23	Nilphamari	3731	6.7	10.85
24	Noakhali	4,246	8.6	8.24
25	Chuadanga	2,819	6.1	7.07
26	Faridpur	3,727	10.1	4.89
27	Satkhira	3,499	5.7	5.06
28	Jhenaidah	2,043	7.4	4.20
29	Kushtia	4,909	10.3	3.05
30	Kishoreganj	8,380	9.1	6.50

2. Regional/Surrounding context

Sl. No.	City/ District	Number of 'A' & 'B' type municipalities	Number of Growth Centers on or within 500 meter of RHD/Upazila road
1	Chattogram	10	67
2	Khulna	2	35
3	Sylhet	1	38
4	Rajshahi	9	36
5	Bogura	6	50
6	Mymensingh	9	51
7	Barishal	5	35
8	Rangpur	1	35
9	Cumilla	8	66
10	Jashore	7	36
11	Cox's Bazar	4	28
12	Brahmanbaria	4	23
13	Dinajpur	6	34
14	Narsingdi	3	25
15	Chapai Nawabganj	4	19
16	Chandpur	6	25
17	Tangail	9	45
18	Sirajganj	4	29
19	Feni	5	23
20	Naogaon	3	29
21	Jamalpur	6	25
22	Pabna	8	32
23	Nilphamari	3	20
24	Noakhali	7	28
25	Chuadanga	4	17
26	Faridpur	3	33
27	Satkhira	2	31
28	Jhenaidah	5	25
29	Kushtia	4	21
30	Kishoreganj	4	43

3. Transport

Sl. No.	City/ District	Presence of Airport in the district	No. of Upazilas having Railway station	Motorized Passenger Traffic volume in the RHD road	Avg. CVD in the Upazila road	Total No. of Registered motor vehicles in the dist. (Last 10 years)
1	Chattogram	1	5	340,927	194	27,871
2	Khulna	0	2	107,967	131	22,927
3	Sylhet	1	3	189,304	95	48,024
4	Rajshahi	1	6	150,759	93	49,017
5	Bogura	0	6	338,249	174	73,627
6	Mymensingh	0	7	196,438	217	43,426
7	Barishal	1	0	137,035	143	28,546
8	Rangpur	0	4	168,210	97	48,351
9	Cumilla	0	9	287,186	231	50,418
10	Jashore	0	3	165489	231	26,347
11	Cox's Bazar	1	4	99,930	241	90,419
12	Brahmanbaria	1	0	175,468	164	19508
13	Dinajpur	0	5	268,110	151	13,540
14	Narsingdi	0	8	150,377	123	68,904
15	Chapai Nawabganj	0	2	89,271	223	9,294
16	Chandpur	0	0	49,597	116	9,158
17	Tangail	0	2	219,324	590	17,738
18	Sirajganj	0	5	201,211	156	53,117
19	Feni	0	2	178,607	227	29,189
20	Naogaon	0	2	142,930	90	56,280
21	Jamalpur	0	5	90,091	70	22,682
22	Pabna	0	3	204,740	102	47,673
23	Nilphamari	1	3	45,094	127	25,471
24	Noakhali	0	3	406,076	144	28,065
25	Chuadanga	0	4	200,000	394	32,628
26	Faridpur	0	3	160,871	154	18,938
27	Satkhira	0	0	200,300	154	61,768
28	Jhenaidah	0	2	226,361	118	37,437
29	Kushtia	0	5	96,691	240	51,274
30	Kishoreganj	0	5	65,766	363	19,918

4. Major Activity center/Land use

Sl. No.	City/ District	No. of EPZ, Economic Zone in the District	Number of universities, tertiary education & vocational centres in the district	Number of specialized hospitals or centers higher than upazila health complex in the district
1	Chattogram	7	193	509
2	Khulna	2	98	184
3	Sylhet	1	75	100
4	Rajshahi	1	199	137
5	Bogura	1	130	162
6	Mymensingh	4	109	282
7	Barishal	1	87	162
8	Rangpur	0	102	133
9	Cumilla	2	133	273
10	Jashore	2	145	112
11	Cox's Bazar	0	101	123
12	Brahmanbaria	9	29	169
13	Dinajpur	1	40	142
14	Narsingdi	0	121	119
15	Chapai Nawabganj	2	51	107
16	Chandpur	0	72	44
17	Tangail	2	43	179
18	Sirajganj	0	83	283
19	Feni	1	23	65
20	Naogaon	0	86	125
21	Jamalpur	2	69	130
22	Pabna	0	102	115
23	Nilphamari	1	59	59
24	Noakhali	1	45	126
25	Chuadanga	0	23	85
26	Faridpur	1	50	106
27	Satkhira	0	69	136
28	Jhenaidah	0	63	150
29	Kushtia	1	85	140
30	Kishoreganj	1	56	101

5. Economy

Sl. No.	City/ District	Inverse of Poverty headcount ratio (%)	No. of Non-agricultural establishment
1	Chattogram	12	380,550
2	Khulna	39	164,506
3	Sylhet	24	164,305
4	Rajshahi	31	153,865
5	Bogura	17	256,075
6	Mymensingh	51	270,462
7	Barishal	55	107,072
8	Rangpur	46	183,153
9	Cumilla	38	202,347
10	Jashore	39	182,749
11	Cox's Bazar	33	95,614
12	Brahmanbaria	30	113,812
13	Dinajpur	38	216,115
14	Narsingdi	24	107,152
15	Chapai Nawabganj	25	96,261
16	Chandpur	51	106,241
17	Tangail	30	225,154
18	Sirajganj	39	174,643
19	Feni	26	91,362
20	Naogaon	17	151,779
21	Jamalpur	51	159,156
22	Pabna	32	153,030
23	Nilphamari	35	132,102
24	Noakhali	10	151,659
25	Chuadanga	28	60,576
26	Faridpur	36	101,425
27	Satkhira	46	100,734
28	Jhenaidah	25	107,812
29	Kushtia	4	125,887
30	Kishoreganj	30	150,946