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**TECHNICAL NOTE**

# Possibilities And Challenges In Implementation Of Transit Oriented Development Along Proposed BRT Corridor In An Already Developed And Existing City – Case Study Dhaka-Gazipur BRT Line, Bangladesh

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**Abstract:** Cities in the developing world are faced with a challenge from the transport intensive land use development focused on personalized modes. Transit Oriented Development (TOD) is considered to be one of the most promising alternative city development strategies focusing on use of public transport. However, most of the high capacity public transport projects in cities of developing countries are coming up at a stage where the city corridors are already developed. Success of a public transport system depends on accessibility of passengers to its nodes. Field data collected from Gazipur Bangladesh shows accessibility to proposed BRT stations depends majorly on access road widths, besides it also depends on road condition, distance of access roads from BRT stations. Potential access roads are ranked with a scoring system and in-situ improvements are proposed to yield achievable results. Retrofitting improvement measures can enhance accessibility and increase ridership. To retain a sustainable path in urban transport, a city needs to improve its accessibility to Public Transport nodes that will ensure a viable public transport system, which is a prerequisite to a successful TOD.

**Keywords:** *Transport incentive, TOD, public transport, BRT system.*

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## 1.0 Introduction

### *1.0 Background*

Implementation of a new public transport system and simultaneous initiation of TOD planning process in cities with congested low capacity roads, unorganized public transport, and inefficient enforcement practice is a real challenge to the planners and government agencies in developing countries. A BRT system along with TOD planning process is being developed at Gazipur in Greater Dhaka area in Bangladesh. Traffic volume in the existing road is more than its capacity and shoulder spaces on both sides are occupied with hawkers and vendors. Both sides of the corridor are already developed with low rise high density residential, commercial, industrial and institutional land uses. Each components of TOD process including land use, commercial redevelopment, accessibility, parking and enforcement are studied separately. Accessibility component of TOD is studied in details and analysis of accessibility audit data shows passenger volume along proposed BRT corridor depends on access road widths, road conditions and inversely depends on its distance from BRT station. A methodology of prioritization of access roads for improvements of pedestrian and Non-Motorized Transport (NMT) and parking facilities is identified. Certain achievable improvements in access road infrastructure within limited right of way and resources are identified. Success of TOD planning process depends on a viable public transport system and viability of BRT depends on its ridership and improvements in accessibility network can improve BRT ridership. This study attempts to find out possible improvements in accessibility, parking and NMT facilities utilizing existing resources to ensure growth in BRT ridership and to achieve common TOD goals.

### *1.1 Methodology*

Land use study, redevelopment, accessibility, parking and enforcement, the five components of a TOD planning process was assessed with field data from an already developed road corridor, where BRT was proposed to be built. Scope of the study was to identify achievable improvements in the proposed BRT corridor to ensure increased ridership demand. Land use data collected through primary surveys and secondary sources and analyzed to find out land use composition, public land holding and existing regulations. Land use proposals were developed such as additional zoning regulation for BRT overlay zone, land pooling, which are long term in nature.

Redevelopment of commercial, residential and mixed use projects was identified and development mix was derived through market survey and analysis, which can pool commuters to live along the BRT corridor. Redevelopment required consensus and sharing of land ownership among interested groups, which could be achieved through long term concerted effort. Accessibility audit survey was conducted for all access roads around each of the proposed BRT station. Data for various attributes of accessibility were analyzed to find out their relationship with ridership volume and improvements are proposed.

Parking accumulation and duration surveys were conducted along the entire BRT corridor and existing and project parking demand was analyzed. Off-street parking proposals for private cars, buses and heavy vehicles were developed.

Enforcement rules and regulations and agencies involved were studied and essential amendments were proposed along with capacity development and enforcement practices. Based on data analysis and improvement proposals for each five components of the TOD, the most achievable improvement proposals were identified and a prioritization process was developed to undertake projects to achieve common TOD goals.

### *1.2 Literature Review*

Transit Oriented Development (TOD) was conceptualized in developed countries to prevent city sprawl and reduce dependency in car ownership. Peter Calthorpe first coined the term Transit oriented Development in "The New American Metropolis" published in 1993. TOD was defined generally as "a mixed use community that encourages people to live near transit services and to decrease their dependence on driving" (Calthorpe, 1993). Later TOD analyst explained, "Transit Oriented Developments have the potential to provide residents with improved quality of life and reduced household transportation expense while providing the region with stable mixed-income neighborhoods that reduce environmental impacts and provide real alternatives to traffic congestion" (Ditmarr and Ohland, 2004). TOD planning process was implemented successfully in Rosslyn Ballston Corridor in Arlington Virginia USA, Curitiba Brazil, and Singapore Metropolitan area. During 1960 to early 1980 Curitiba grew at a rapid rate. In 1964 Curitiba prepared a Preliminary Urban Development Plan which evolved to "Curitiba Master Plan" in 2 years and which guided the city development for 30 years (Transit Cooperative Research Program, 2013). It included promotion of a linear urban city growth by integrating public transport, road network development and land use along key "structural axes". As land use and transportation are integrated, a government agency Instituto de Pesquisa Planejamento Urbano de Curitiba (IPPUC) was formed to monitor, implement and update the Master Plan.

Unified Traffic and Transportation Infrastructure Planning and Engineering Centre (UTTIPEC, 2013), the urban transport wing of Delhi Development Authority, developed TOD guidelines for Delhi and Delhi Metro Rail Corporation (DMRC) also adopted TOD strategy. UTTIPEC defined TOD as Transit Oriented Development (TOD) is essentially any development, macro or micro that is focused around a transit node, and facilitates complete ease of access to the transit facility, thereby inducing people to prefer to walk and use public transportation over personal modes of transport

A study aims to examine the relationship between quality of life (QOL) and bid rent among socioeconomic groups living near rapid transit stations in Bangkok. The levels of various residential QOL indicators were classified into access, amenity, and safety elements. These indicators and their values by socioeconomic groups were examined in station and no-station areas using data from a questionnaire survey of local residents in

Bangkok. The QOL indexes and bids for rent were estimated by socioeconomic group and by residential location. The results showed that low-income residents, who most frequently use mass transit, have higher QOL in station areas than in no-station areas, and high-income residents, who rely more on cars, have the highest bid rent (Kazuki et.al, 2016).

### *1.2.1 TOD and Accessibility*

Benefits of TOD in developed cities in the post implementation stage are studied to find out the parameters that influence public transport ridership. Arefeh & Lei (2014) observed that the analysis results indicate that people living in TOD areas tend to drive less, reducing their VMT by around 38% in Washington, D.C. and 21% in Baltimore, compared to the residents of the non-TOD areas even with similar land use patterns [6]. Papa & Bertolini (2014) found out a significant direct relationship between the index measuring degree of TOD and accessibility, in line with the expectations expressed in the international literature. Accessibility values, on the other hand, do not react either to density or compactness of development (Papa and Bartolini, 2014).

Jindrich & Martin (2016) tested two of the basic parameters of TOD and their impact on public transport use - destination accessibility and distance to transit. An additional test was the impact of the distance to streetcar stop as a more comfortable public transport mode, and frequency of connections. The analysis was carried out in neighborhoods in two Czech mid-size cities. Results indicate a larger influence of frequency of connections and distance to transit than destination accessibility. Accessibility in these Czech cities is already developed.

Giuseppe (2016) listed the primary components that constitute TOD vary from several definitions, but, in essence are: (a) transits accessibility – neighborhood development around transit hubs; (b) walkability – pedestrian-friendly street network that connect local destinations within walking distance of transit stops; (c) Diversity – mix of uses, densities and housing types in the same district; (d) articulated density for mass transit – infill and redevelopment along transit corridors within existing neighborhoods..

It is mentioned in the Transit Oriented Development Guidance Document published by Ministry of Urban Development (MoUD) Government of India (GoI) that a fundamental rule for TOD is to plan for long-term spanning a horizon of 10-20 years and interventions related to improving accessibility to transit stops and stations offer ‘quick-wins’( time frame of 2-3 years). These interventions are generally identified in the TOD plan as incremental additions for creating complete TOD projects. Some of these immediate projects may include (Ministry of Urban Development, 2016):

- Multimodal integration for various modes including direct access between feeder buses, auto rickshaws, cycle rickshaws and transit stations;
- Upgraded pedestrian infrastructure including footpaths, street furniture, designated waiting areas;
- Improved station facilities including passenger amenities;
- Bicycle rental or public bicycle sharing systems near transit stations;
- Park-and-ride lots at strategic transit locations; or
- Identify staff resources for managing TOD projects

Planning for TOD along proposed BRT line from Dhaka to Gazipur Bangladesh was considered as case study. Primary and secondary data for all possible parameter influence proposed ridership in BRT were collected, analyzed and findings were used to develop improvement proposals.

## 2.0 BRT Corridor Study

### *2.1 Population and Traffic*

The proposed BRT line is passing through Gazipur City Corporation (GCC) area near Dhaka Bangladesh. Gazipur has a total area 332.19 sq.km with a population of 1,899,290 according to the 2011 Census. The average population density is 5895.0 persons per sq.km. The BRT corridor has 20 stations planned from Tongi to Gazipur Terminal. BRT line is proposed along the central verge of existing Dhaka-Mymensingh Road, which is a four lane divided carriageway.

Based on map study, major commercial, industrial, institutional, residential and office activities and associated land uses are found to be located within a 350 to 400 metre along both sides of the proposed BRT corridor, development density reduces after 400 metre. Walk and NMT trips are also found to be taking place within 500 metre range. For the purpose of delineating the TOD study influence area, 500 metre on both sides of the proposed BRT corridor along Dhaka-Mymensingh Road is analyzed. The population of the area of this buffer zone is estimated to be 287,191 persons are resident within the BRT corridor influence area, which is 15.1% of the GCC population. Average population density is estimated to be 17,224 persons per square km.

Land verification survey was conducted using existing plot level vector data and Google image in the background during March-April 2016 by planners and assistants. As per the land use survey and data analysis, the composition of land use in the study area along the Dhaka-Mymensingh Road corridor is consist of residential use 741.68 hectares (44.2%), industry 155.28 hectares (9.3%), vacant land 138.09 hectares (8.2%), commercial 116.37 hectares (6.9%), water bodies 104.25 hectares (6.2%), research institute 99.40 hectares (5.9%), road network 79.73 hectares (4.8%), agriculture 76.77 hectares (4.6%), etc.

Government land constitutes only 1.5% of the total land in the BRT influence area with an average plot size less than 0.05 hectare. Road spaces in the BRT influence area is less than 5%. Rest of the land are privately owned and subdivided with smaller plot size. Potential developable land in the influence area is inaccessible due to less width of access roads. Traffic and transportation surveys were conducted in April 2016 at various locations along the corridor using manual classified traffic count method with enumerators and supervised by engineers. The existing road is a four-lane divided carriageway and it carries 60,000 Passenger Car Unit (PCU)/day. The existing traffic composition shows cars (21%), heavy vehicles (31%), buses (16%), light commercial vehicle (16%), three-wheeler (4%), two-wheeler (2%) and Cycle Rickshaws (10%).

## *2.2 Travel Characteristics*

Based on a study in Bangladesh University of Engineering and Technology (BUET), it is found that about 60% of daily trips are walk trips in Dhaka and rest of the trips are made by different modes of transport and NMT. The study derived the relationship of income level and modal choice in Dhaka (Mannan & Karim, 2001). Table 1 below shows average income level and modal choice of people in Greater Dhaka.

Table 1: Travel Characteristics in Dhaka

| *Average Household Income (BDT/month)* | *Cycle Rickshaw* | *Taxi* | *Bus* | *Auto-Tempo* | *Car* | *Motor Cycle* | *Bicycle* | *Water Transport* |
|---|---|---|---|---|---|---|---|---|
| <1,500 | 23.6% | 0.9% | 43.5% | 4.4% | 0.0% | 0.0% | 5.1% | 22.6% |
| 1,500-1,999 | 26.4% | 1.2% | 38.6% | 5.5% | 1.5% | 0.6% | 5.8% | 20.4% |
| 2,000-2,999 | 33.0% | 1.8% | 36.3% | 5.2% | 1.6% | 0.5% | 5.0% | 16.7% |
| 3,000-4,999 | 40.9% | 1.4% | 39.3% | 4.8% | 0.7% | 2.1% | 3.0% | 7.9% |
| 5,000-9,999 | 52.0% | 2.8% | 28.1% | 4.7% | 2.5% | 3.6% | 1.7% | 4.6% |
| 10,000-29,999 | 57.6% | 4.6% | 16.8% | 2.8% | 9.9% | 5.2% | 0.8% | 2.4% |
| >29,999 | 40.9% | 7.0% | 7.0% | 1.0% | 39.1% | 4.2% | 0.2% | 0.7% |

*Source: Md Shafiqul Mannan & Md Masud Karim; "Current State of the Mobility of Urban Dwellers in Greater Dhaka" 2001*

People with monthly income less than Bangladeshi Taka (BDT) 2,000 make 84% of walk trips and 16% of trips are by other transport modes (Mannan & Karim, 2001) Middle income people and garment factory workers population are found to be predominant along the BRT corridor and it is observed that walk trips are most preferred among the access trips for existing bus stops on the main Dhaka-Mymensingh Road.

A study in Indian Institute of Technology (IIT) Delhi found out 500 metre is an ideal distance for a walk trip to the public transport stop/station in an urban condition (Advani & Tiwari, 2005). People living within 500 metre of the public transport node have the highest accessibility. If the distance increases, passengers start using some feeder service or different mode (Advani & Tiwari, 2005). Another study found out condition for pedestrians in Dhaka are extremely poor. Many roads have no footways, and those that are provided are difficult to use due to obstructions, uncovered drains, low hanging wires, hawkers and parked vehicles (Gallagher, 2016).

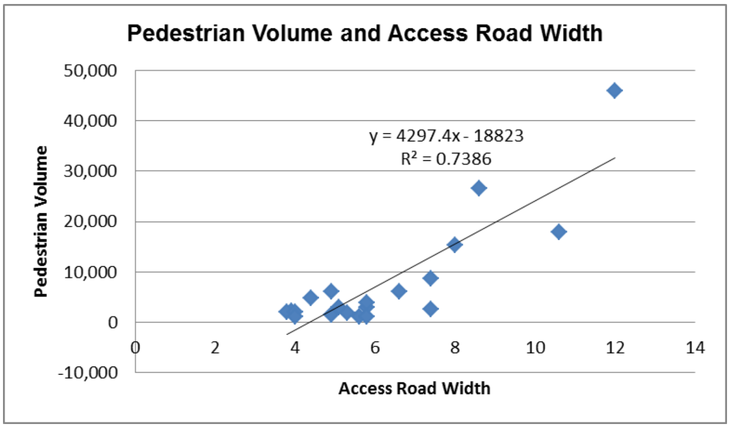
## 3.0 Accessibility Audit Survey and Analysis

Accessibility audit survey was conducted in June 2016 using manual survey method by engineers walking along the feeder roads and collecting information for accessibility parameter. The objective of the accessibility audit is to find out the availability and level of congenial attributes that affect the ease of access for passenger located within the BRT stations influence area. The accessibility audit captured the key data influencing the accessibility such as road width, road surface type, road quality and conditions, obstructions in the access road, drainage, availability and condition of street lighting, and existing NMT facilities.

Out of the 170 feeder roads in the BRT corridor, 42% feeder roads are found to be located within 100 metre from a BRT station. 43% of feeder roads, within 100 m from BRT stations, have road width less than 5 metre and 44% of the feeder roads have road widths from 5 to 10 metre. Only 3% of feeder roads are having sufficient space for pedestrians. There are no segregated NMT lanes and no formal parking areas for NMT. 45% of the access roads are in bad/very bad stage, 25% of the access roads are fair and 30% of access roads are found in good condition.

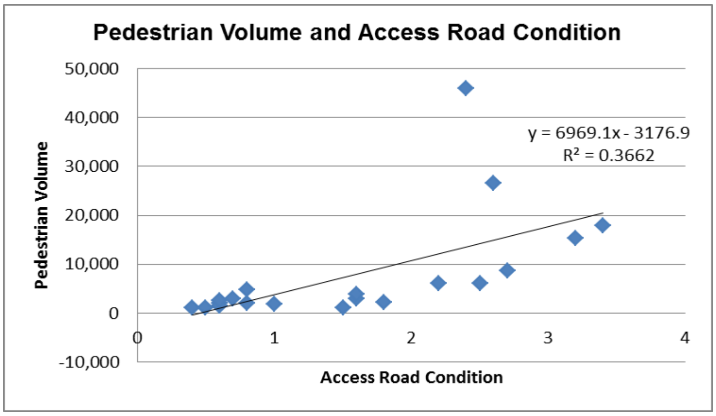
Observed accessibility attributes are analyzed to establish explainable relationship. Actual numeric values were used for road widths, daily pedestrian volume near to the proposed BRT stations and access road distance from the proposed BRT stations. Road condition was rated as 1 for very bad (uneven surface, very frequent potholes), 2 for bad (uneven surface, frequent potholes), 3 for fair (uneven surface, some cracks), 4 for good (even surface, few cracks), and 5 for very good (even surface, no cracks).

Correlation coefficient (Pearson product-moment correlation coefficient) for two set of values, eg, daily pedestrian volume data near to proposed BRT stations and access road widths is found to be 0.85 and correlation coefficient for daily pedestrian volume data near to proposed BRT stations and access road conditions is found to be 0.69. As correlation coefficients are close to +1 in both the cases and are found to be positively correlated. Correlation coefficient of daily pedestrian volume data near to proposed BRT stations and access road distance from BRT stations is found to be -0.42 and as the value is close to -1 it is found that the data set are negatively correlated. Figure 1 (a) and (b) graphically presents the relationships of pedestrian volume near to proposed BRT stations with access road width and access road condition.




$y = Pedestrian\ volume\ per\ day\ \ near\ to\ proposed\ BRT\ station$
$x = Width\ of\ Access\ Road$

Figure 1 (a): Pedestrian Volume dependencies on Access Road Width




$y = Pedestrian\ volume\ per\ day\ \ near\ to\ proposed\ BRT\ station$
$x = Access\ Road\ Condition$

Figure 1 (b): Pedestrian Volume dependencies on Access Road Condition

Analysis results show that increase in access road width can increase BRT ridership. However, in an existing city, increasing access road widths to improve ridership to the BRT system involve land acquisition and high cost intensive investment. Access road widening can be taken up as long term goal. However, to improve accessibility in "in-situ" condition, it is important to prioritize the potential access roads where improvements can be taken up immediately, which can yield accessibility benefits the most.

Access road width, road condition, availability of NMT parking space, and distance from BRT station were analyzed to be selected attributes. Analytical values of for each of these attributes were documented for each of the proposed 20 BRT stations. As all the attributes have different importance in accessibility, weights are used in combining the scores of various attributes, as shown in Table 2. Weightages used in the table is developed through deriving average of all weightages provided by experts and other stakeholders.

Table 2: Weightages for access attributes

| | |
|---|---|
| Pedestrian Volume | 30% |
| Access Road Width | 35% |
| Road Condition | 10% |
| Availability of NMT Parking space | 15% |
| Distance from BRT station | 10% |

BRT ridership is found to be depend on wider access road, good pavement condition, availability of parking space, already existing pedestrian volume and inversely proportional to the distance of the access road from BRT station. Ridership pull factor for passengers to come to BRT stations is derived based on relationships of studied attributes of accessibility and presented in terms of Final Score (weighted score), as given below.

$$Final\ Score = [(Wt\ Ave\ Pedestrian\ volume) * (Wt\ Ave\ Access\ Road\ Width) * (Wt\ Ave\ Road\ Condition) * (Wt\ Ave\ Availability\ of\ NMT\ Parking\ Space)] / [(Wt\ Ave\ Distance\ from\ BRT\ station)^2] \quad (1)$$

The results (Final Score) of the weighted attributes for different stations are summarized in Table 3 and graphically presented in Figure 2.

Table 3: Weighted Average Scores and Final Ranking of Access Roads

| *BRT Station No.* | *Weighted Average Scores* | | | | | *Final Score* | *Ranking* |
|---|---|---|---|---|---|---|---|
| | *Road Condition* | *Access Road Width* | *Availability of NMT Parking space* | *Pedestrian Volume* | *Distance of Access Roads from BRT station* | | |
| 1 | 0.200 | 0.722 | 0.270 | 0.235 | 0.313 | 0.938 | 12 |
| 2 | 0.300 | 1.563 | 0.270 | 0.687 | 0.197 | 5.608 | 2 |
| 3 | 0.100 | 0.781 | 0.120 | 0.067 | 0.271 | 0.857 | 16 |
| 4 | 0.200 | 1.268 | 0.270 | 1.025 | 0.160 | 6.814 | 1 |
| 5 | 0.300 | 1.179 | 0.120 | 0.589 | 0.174 | 2.487 | 4 |
| 6 | 0.200 | 0.575 | 0.120 | 0.083 | 0.197 | 0.884 | 14 |
| 7 | 0.200 | 0.752 | 0.270 | 0.115 | 0.437 | 0.246 | 20 |
| 8 | 0.100 | 0.560 | 0.270 | 0.077 | 0.163 | 0.878 | 15 |
| 9 | 0.100 | 0.855 | 0.270 | 0.115 | 0.176 | 1.729 | 6 |
| 10 | 0.100 | 0.649 | 0.270 | 0.184 | 0.186 | 1.405 | 8 |
| 11 | 0.200 | 0.855 | 0.270 | 0.146 | 0.248 | 1.857 | 5 |
| 12 | 0.100 | 0.590 | 0.270 | 0.077 | 0.298 | 0.691 | 19 |
| 13 | 0.100 | 0.722 | 0.270 | 0.058 | 0.177 | 1.075 | 11 |
| 14 | 0.200 | 1.091 | 0.120 | 0.331 | 0.256 | 1.582 | 7 |
| 15 | 0.200 | 0.973 | 0.120 | 0.231 | 0.263 | 0.779 | 18 |
| 16 | 0.200 | 1.474 | 0.120 | 1.500 | 0.212 | 3.555 | 3 |
| 17 | 0.100 | 0.826 | 0.270 | 0.038 | 0.303 | 0.936 | 13 |
| 18 | 0.100 | 0.737 | 0.270 | 0.101 | 0.452 | 0.785 | 17 |
| 19 | 0.100 | 0.737 | 0.270 | 0.038 | 0.232 | 1.142 | 10 |
| 20 | 0.200 | 0.590 | 0.270 | 0.038 | 0.228 | 1.180 | 9 |

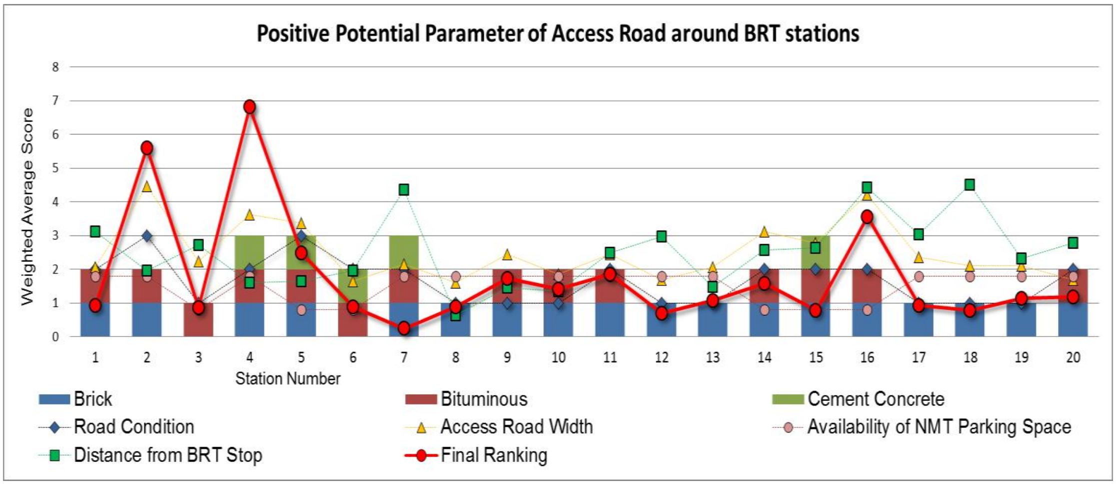



Figure 2: Graphical Presentations of Weighted Average Scores and Final Ranking of Access Roads

This graph shows that BRT station-4 ranked 1st, station-2 ranked 2nd and station-16 ranked 3rd, are candidate stations where the existing access roads have certain attributes which can be improved with minimum alternations and maximum output can be expected in terms of increased ridership. Essentially, access road widths of these stations vary from 8 metre to 15 metres. These roads have shoulder spaces but they are not used effectively and there are no defined pedestrian path and no demarcated NMT parking spaces. Rest of the access roads in the study area have widths less than 5 metre and used by pedestrian and NMT only.

## 4.0 Improvements for Accessibility Network

### *4.1 Improvements for Access Roads (8-15 M Wide)*

Improvements are proposed for access roads near the BRT station-4, 2 and 16. Improvement proposals at BRT station-2 (Elevated) include signalization of at-grade Tongi junction with pedestrian phase to allow pedestrians to cross the Dhaka-Mymensingh Highway.  The pedestrian crossings will be a minimum of 3m to 5m wide depending on the pedestrian demand. Guard rails will be installed along the edge of footpath along main road and access roads to protect pedestrians and to channelize pedestrian movement to the cross-walk. Figure 3 presents the layout of footpaths, pedestrian crossings, NMT pick-up drop-off bays, off-street NMT parking arrangements for 8 to 15 metre wide access roads.

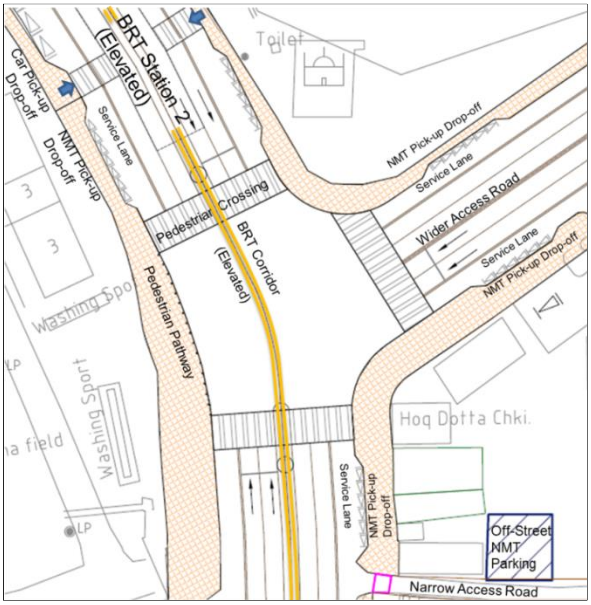


Figure 3: Accessibility Improvements for Wider Access Roads (8-15 M wide)

### *4.2 Parking*

Pickup and drop-off spaces for NMT and cars are proposed near to the BRT stations. Off-street car parking and NMT parking are identified and proposed within 500 metres of each BRT station. Multi-storeyed car park buildings with commercial spaces at ground floor are proposed at BRT station 4 and 16 which have wider vehicular access roads. Pre-tax Financial Internal Rate of Return (FIRR) was analyzed to be 12%, where land is assumed to be provided by the government. Off-street truck and bus parking cum terminal facilities are proposed near Voghra junction. An area of 15 Hectare is identified within 1 Km of the BRT corridor for the proposed truck parking lot, which can accommodate 2000 trucks. Truck movement is proposed to be restricted from 9:00 pm to 6:00 am along the BRT corridor. Light Commercial Vehicles (LCV) will be allowed for day time delivery. Bus parking area of 5 Hectare is proposed near BRT station 16, which will accommodate 500 bus parking. Off-street truck and bus parking space can be developed through government funding.

### *4.3 Redevelopment of Commercial Spaces*

As per observed data, it is found that 1277 on-street vendors operate along the BRT corridor. It occupies shoulder space, creates friction at the edges and causes congestion. Three existing low rise commercial market sites are identified along the corridor near to BRT station 2, 4 and 16. Redevelopment schemes for these sites include multi-storeyed buildings with commercial spaces at ground, first and second floor; and rest of the eight floors are proposed as residential and other uses. On-street vendors are accommodated in these multi-storeyed commercial redevelopment schemes. Rest of the commercial, residential spaces can be sold in market for revenue generation. Commercial redevelopment projects near BRT stations 2, 4 and 16 are found to be viable with pre-tax FIRR 12%, 24% and 25%, where land is assumed to be provided by government agencies.

### *4.4 Improvements for Access Roads (<5 M Wide)*

Improvement of road surface and provision of pedestrian and NMT facilities are proposed for the access roads less than 5 metre wide. Other than walking, the most important NMT mode in Dhaka is Cycle Rickshaw. It is found that cycle rickshaws do not have specified parking space and they clog the entry to the access roads for boarding alighting of their passengers. It is also important to note that people’s behavior in Dhaka to use cycle rickshaw even for distance less than 200 metre. Cycle Rickshaw is a widely used mode of transport in Bangladesh and it is an essential component to support last minute connectivity [13]. Details of the off-street and on-street NMT parking for access roads (<5 metre wide) are presented in the Figure 4.

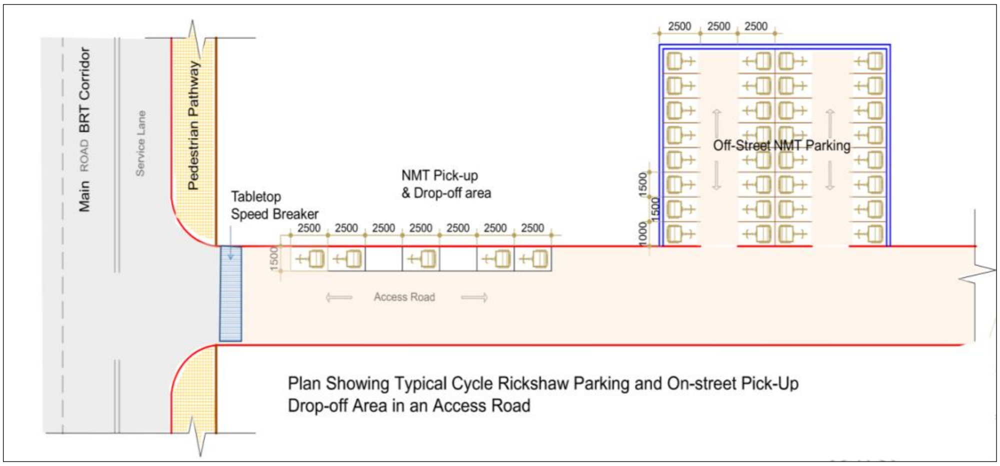



Figure 4: Accessibility Improvements for Access Roads (<5 M Wide)

Pick-up drop-off facilities for cycle rickshaws are proposed along the access roads near to the main corridor. Boarding alighting of cycle rickshaw passengers can be carried out at these locations away from the main corridor. Off-street cycle rickshaw parking spaces are proposed at each of the BRT stations. Constant supply of cycle rickshaws at the pick-up drop-off locations from the nearest off-street parking sites will meet its peak hour demand.

### *4.5 Enforcement*

Uninterrupted access to the BRT stations can be achieved through very strict enforcement along the BRT corridor. Unauthorized parking along the road edge by cars and other heavy vehicles need to be stopped. Capacity of the traffic police need to be upgraded to serve specifically to the need of enforcements related to the proposed BRT system. A system of issuing penalty for unauthorized parking, towing of parked vehicle in a no-parking area need to be implemented using hand held gadgets and wireless communication technology. Traffic rules and regulations need to be amended by the legal department to empower enforcement agencies and penalty system.

## 5.0 Limitations

The data collection and analysis conducted for the TOD project was oriented towards implementation plan for TOD and actions to be taken up by the local and central government agencies. Being a time bound project, the follow up analyses for the improvement measures proposed in the study were not worked out. Cost-benefit analysis can be taken up for each of the improvement proposals. Further studies can be undertaken using multivariate regression model with to find out contribution of each of the independent variables of accessibility, demographic and land use parameters put together.

## 6.0 Conclusion

Implementation of TOD along the BRT corridor in an already developed existing city is a complex process and it needs a concerted effort from various government agencies. Based on the study and analysis it is found that access road width is the major contributing attribute that influence BRT ridership. Thus, improvements of accessibility network for easy reach to the stations are the most essential component of a sustainable Public Transport system. To address the indiscriminate on-street parking along proposed BRT corridor, the planning and land development agencies need to adopt the recommended off-street parking proposals to accommodate the existing and future demands. Re-accommodation of existing street vendors in commercial redevelopment projects can be materialized through coordinated efforts of local government agencies, private developers, as well as NGOs and community organizations in close coordination with architects and planners. Legal department need to be involved in amendments/introduction of traffic rules and regulations to empower enforcement agencies for smooth operations of proposed public transport system with TOD goals.

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