ACCESSIBILITY NETWORK DEVELOPMENT FOR TOD ALONG PROPOSED BRT CORRIDOR IN DHAKA

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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, and therefore, implementation of track based systems are hugely costly. Success of a public transport system depends on accessibility of passengers to its nodes or stations. Field data collected from Gazipur (Dhaka) Bangladesh shows that accessibility to proposed Bus Rapid Transit (BRT) stations depends majorly on the network of access road of different geometry (width), besides its condition and distance of access road 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 safety while causing increased ridership of BRT. To ensure sustainability of public transport (BRT in this case), city needs to provide accessibility to Public Transport nodes, which is a prerequisite to successful TOD.

KEY WORDS

Transit Oriented Development (TOD), Accessibility, Non-Motorized Transport (NMT), Bus Rapid Transit (BRT)

1. INTRODUCTION

1.1 Background

Implementation of a new public transport system and simultaneous implementation of TOD concept, in cities with congested low capacity roads, unorganized public transport, and inefficient enforcement practices, is a real challenge to both the planners and city government agencies in developing countries. A BRT system along with TOD planning process is under implementation at Gazipur in Greater Dhaka area in Bangladesh. Traffic in the existing corridor runs more than its capacity and shoulder spaces on both sides are occupied with hawkers and parking of all types of vehicles. Both sides of the corridor are already developed with low rise high density residential, commercial, industrial and institutional land uses. Each component of TOD process including land use planning, commercial redevelopment, and simultaneous provision of accessibility network, parking and enforcement are studied for the project separately. In this paper, accessibility component of TOD is studied in details, and analysis of accessibility audit data shows that passenger volume along BRT corridor depends on access road geometry (width), condition and inversely related to its distance from BRT station. A methodology of prioritization of access roads for improvements to facilitate pedestrian use, Non-Motorized Transport (NMT) movement and parking, 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, in this case, depends on its ridership ensured through improvements in accessibility network. This study attempts to find out possible improvements in accessibility network including parking and NMT facilities utilizing existing resources to ensure growth in ridership of the BRT system.

1.2 Literature Review on Transit Oriented Development

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"(*1*) 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"(*2*).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. 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 was formed to monitor, implement and update the Master Plan. In 1973 the first line of median busway of 20 Km was implemented in Curitiba (*3*). Mixed High-Rise Residential, Medium-to-High-Density Residential, Medium-Density Residential, Low-Density Residential are shown in the Figure 1 below.

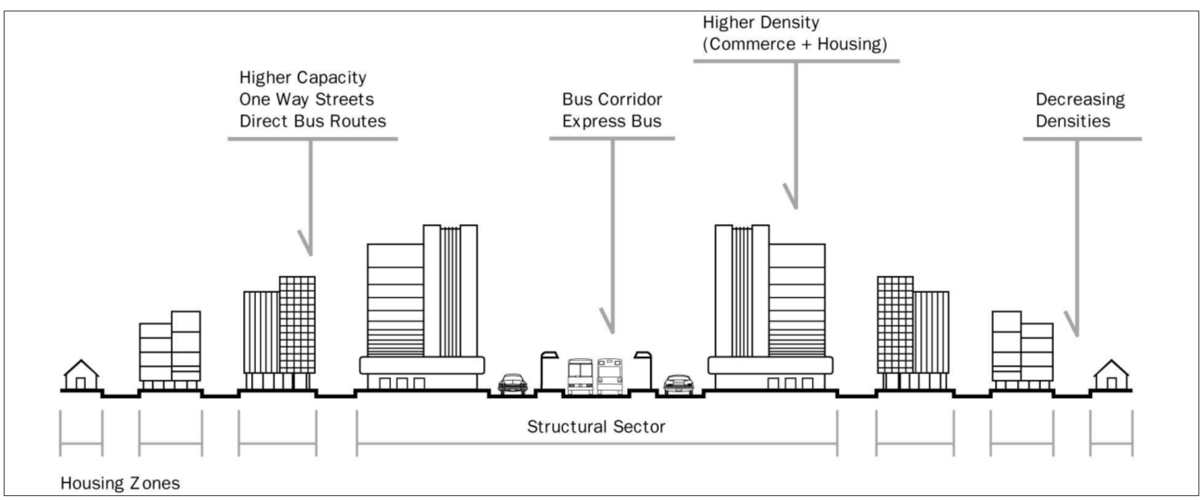

FIGURE 1 Structural axes of high intensity development in Curitiba

Unified Traffic and Transportation Infrastructure Planning and Engineering Centre (UTTIPEC), 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), which 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 variety of high-density, mixed use, mixed income buildings, within a short distance of a rapid public transport network, and higher density or taller buildings, within pre-specified zones near transit stations are to encourage more people to use public transport and limit urban sprawl (*4*).

Each of the examples of TOD is generally implemented and realized over 20 to 40 years period and when both land use and public transport system were designed concurrently. However, examples of TOD in cities of developing country as a part of the implementation of new proposed public transport system is unavailable.

2. BRT CORRIDOR STUDY

2.1 Population and Traffic

The proposed BRT line in Dhaka is passing through Gazipur City Corporation (GCC) area north of Dhaka City Corporation area in Bangladesh. GCC 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 is proposed to have 25 stations planned from Dhaka Airport to Gazipur Terminal, out of which 5 stations are located in North Dhaka City Corporation area and rest of 20 stations in the GCC area. BRT line is proposed along the existing Dhaka-Mymensingh Road, which is a four lane divided carriageway with operating traffic volume exceeding its daily capacity. Two exclusive BRT lanes are proposed at the centre of the carriageway, and the elevated sections are proposed at locations with constrained ROW along the corridor and at some of the major intersections.

For the purpose of delineating the TOD study influence area, 500 metres on both sides of the proposed BRT corridor along Dhaka-Mymensingh Road is analyzed. The population of the area of 500 metre on both sides of the Dhaka-Mymensingh Road is estimated to be 287,191, who are considered to be the residents 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 sq.km.

As per the land use survey data analysis, the composition of land use in the study influence area along the Dhaka-Mymensingh Road corridor is summarized below.

- 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.

The land use distribution is quite supportive to the proposed TOD objectives, while the new BRT Line 3 is under implementation. 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% and the rest of the land are privately owned and subdivided with smaller plot sizes. Due to lack of enforcement of building rules over the years and other local conditions, 51% of access roads are observed to have widths less than 5 metres and 41% of access roads have widths from 5 to 10 metre. Most of the potential developable land in the influence area is inaccessible due to less width of access roads.

Traffic and pedestrian volumes of the road corridor along Dhaka-Mymensingh Road (BRT corridor) is collected by conducting primary surveys. The existing road is a four-lane divided carriageway and it carries 60,000 Passenger Car Unit (PCU)/day. The existing traffic composition on the Dhaka-Mymensingh Road 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

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. A study in Bangladesh University of Engineering and Technology (BUET) derived the relationship of income level and modal choice in Dhaka (*5*). Table 1 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. Details of the walk trip percentages in Greater Dhaka are presented in Table 2.

TABLE 2 Walk Trips in Dhaka

Average Household Income (BDT/month)	Walk Trips	Trips by other Transport Mode
<2,000	84.0%	16.0%

Average Household Income (BDT/month)	Walk Trips	Trips by other Transport Mode
2,000-9,999	67.0%	33.0%
10,000-29,000	40.0%	60.0%

Source: Md Shafiqul Mannan & Md Masud Karim

Middle income people and garment factory workers population are found to be predominant along the BRT corridor and it is observed that walk is the most preferred among the access modes for reaching existing bus stops on the main Dhaka-Mymensingh Road.

A study in Indian Institute of Technology (IIT) Delhi found out in an urban condition, 500 metre is an ideal distance for a walk trip to the public transport stop/station (*6*). Thus, people living within 500 metre of the public transport node have the highest accessibility using walk mode and as the distance increases, passengers start using some feeder service or other different modes (*6*).

Another study found out that condition for pedestrians in Dhaka are extremely poor. Many roads have no footways, and those where provided, are difficult to use due to obstructions, uncovered drains, low hanging wires, hawkers and parked vehicles (*7*).

3. ACCESSIBILITY AUDIT SURVEY AND ANALYSIS

Accessibility for the proposed BRT station areas is evaluated through quantitative measures of the ease of accessing a BRT station/stop through different prevailing modes, namely walk, cycle rickshaw, auto-rickshaw and private car. Accessibility audit survey was conducted for each feeder road around each BRT station, and including all interconnecting roads within 500 metres on either side of the BRT corridor. The accessibility audit captured the key data influencing the accessibility such as the location relative to the nearest BRT station, road surface type, road quality and conditions, obstructions in the access road, drainage, availability and condition of street lighting, and other condition influencing safety and security of pedestrians, maintenance of the access road, and facilities for NMT.

In total there are 19 BRT stations and one terminal BRT station located in the BRT corridor falling within GCC area. There are 170 feeder roads exists along the Dhaka - Mymensingh Highway that provides access from the influence area of the BRT corridor to the various BRT stations. 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. Out of the 170 feeder roads in the BRT corridor, 42% feeder roads are found to be located within 100m 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, where 90% road surface is damaged, have no drainage and no pedestrian facilities. 25% of the access roads are fair, where 50% surface is found with potholes and walking/NMT movement is possible. 30% of access roads are good condition, where the road surface is paved and pedestrian/NMT movement is smooth.

Actual measurement of access road widths, pedestrian counts are obtained from the field and included as analytical input. Average distance of all existing access roads (d1, d2, d3…….dn) from the BRT station within an area with 500 metre radius are collected and analyzed, as shown in Figure 2. Average access road widths and road condition for each of the BRT stations are collected from survey.

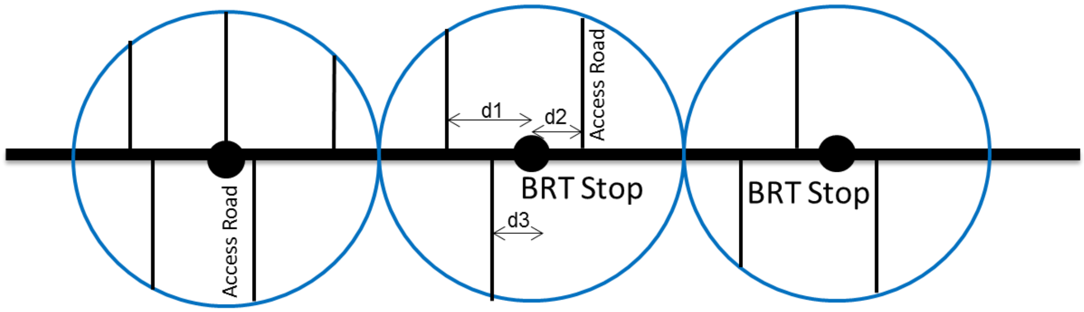

FIGURE 2 Schematic drawing showing distances of access roads from BRT stations used in Accessibility Audit

Access network within the influence area of the BRT corridor is found to be related to the observed attributes, and are analyzed to establish explainable relationship. It is found that access road width, and its condition positively relate to walking as access mode, and distance of access roads from BRT stations is inversely related to use of walk mode for access to BRT stations.

Figure 3 graphically presents the relationships of pedestrian volume near to proposed BRT stations with access road width, access road condition and with the average distance of the access roads from the BRT stations, showing the likely use of access network for walk mode when BRT will be in operation.

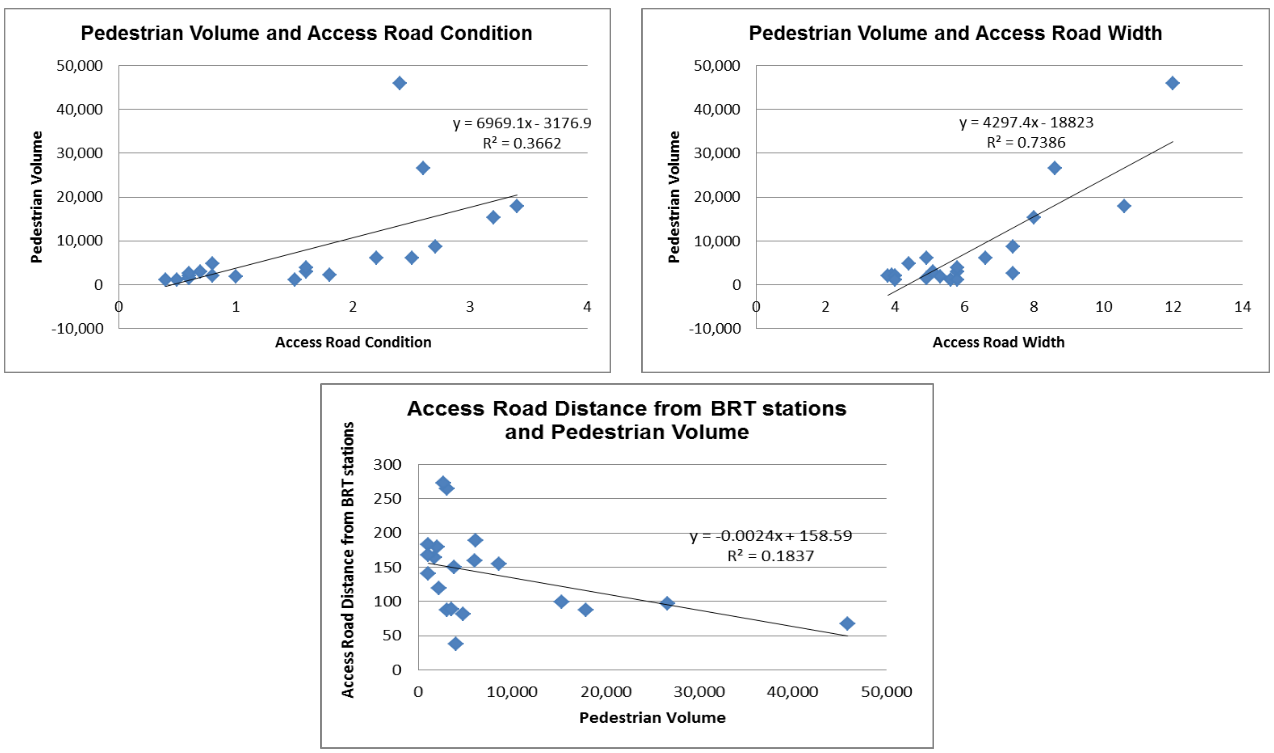

FIGURE 3 Pedestrian volume dependencies on access road width, road condition and access road distance from BRT stations

This indicates that to increase ridership in BRT stations, the most significant effect can be achieved by increasing the access road width.

In an existing city, widening the access roads to improve ridership to the BRT system will involve land acquisition and cost intensive improvements. Access road widening can be taken up as a 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 maximum accessibility benefits.

For the purpose of accounting for all the attributes of accessibility, field data were converted to a 5 point scale. Each attribute was rated as 1 for very bad, 2 for bad, 3 for fair, 4 for good, and 5 for very good. The attributes identified in the assessment/survey were the access road width, road condition, road surface type, availability of NMT parking space, and distance from BRT station.

Access road where NMT parking space is available with government land is given higher score and with private land is given lower score.

The various attribute scores were then added to determine an overall score for each feeder road. As all the attributes have different importance in accessibility, the weights are used in combining the scores of various attributes, as shown in Table 3.

TABLE 3 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%

Ridership of proposed BRT is expected to depends 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.

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

The results (Final Score) of the weighted attributes for different stations are summarized in Table 4.

TABLE 4 Weighted Average Final Scores and Ranking of BRT Stations

BRT Station No.	Weighted Average Scores for BRT Station					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

BRT Station No.	Weighted Average Scores for BRT Station					Final Score	Ranking
	Road Condition	Access Road Width	Availability of NMT Parking space	Pedestrian Volume	Distance of Access Roads from BRT station		
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

Final score for the BRT stations for improvements in accessibility network based on its importance and possibilities are presented in Figure 4.

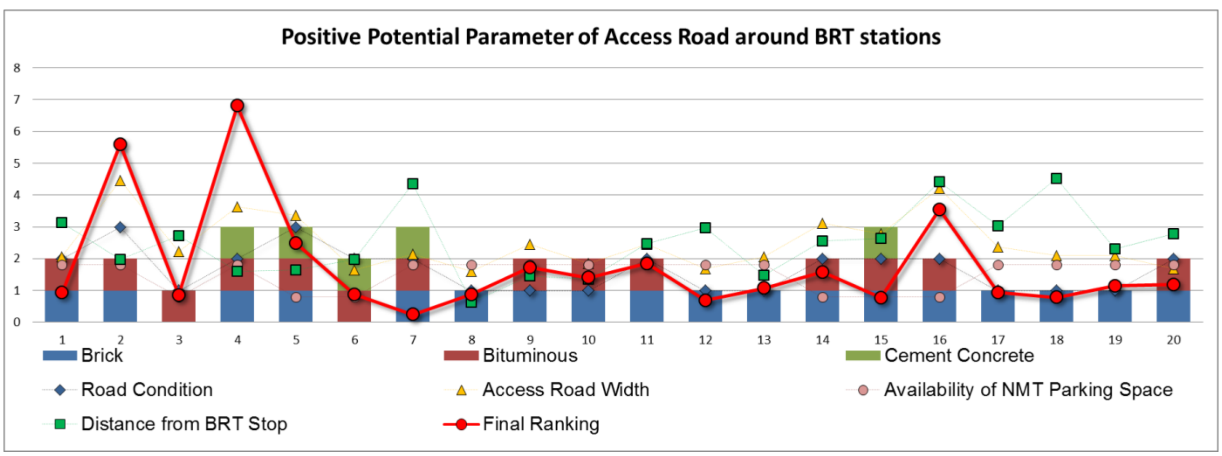

FIGURE 4 Graphical presentations of weighted average scores and final ranking of access roads

This graph shows that BRT station 2, 4, 5 and 16 are candidate stations where the existing accessibility network has certain attributes, which can be improved with minimum alternations and investments for maximum benefit 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. IMPROVEMENTS FOR ACESSIBILITY NETWORK

4.1 Improvements of Access Roads (8-15m wide)

Improvements are identified for access roads near the BRT stations as per ranking derived in the previous section. Stations with higher ranking (2, 4, 5, and 16) have more scope of improvements in its accessibility network. The BRT corridor is elevated at station 2 location and its improvement proposals include signalization of junction with pedestrian phase to allow pedestrians to cross the Dhaka-Mymensingh Highway. Pedestrian crossing is proposed to be at-grade between the footways and the central island. BRT station can be accessed via escalators, elevators or stairs to access the station concourse and platform level. The pedestrian crossings will be a minimum of 3m to 5m wide depending on the pedestrian demand. The stop-line for motorized traffic will be with set back from the pedestrian crossing and the area between the stop-line and pedestrian crossing will be used for queuing NMT vehicles. This will provide access of NMT vehicles with priority over other traffic.

The existing shoulders on either side of the main road and the wide access roads will be reconstructed with paver blocks. 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, and also to prevent illegal parking and use of the footway by motorized vehicles. Figure 5 presents the layout of footpaths, pedestrian crossings, NMT pick-up drop-off bays, off-street NMT parking arrangements, etc in the accessibility network of a BRT station.

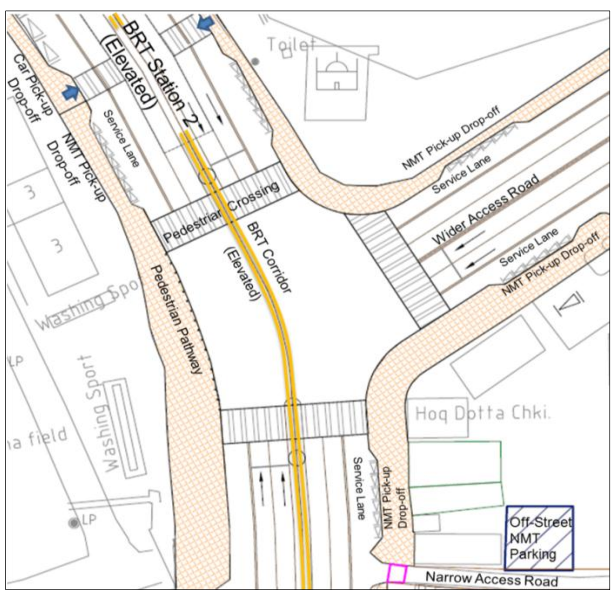

FIGURE 5 Accessibility improvements for wider access roads (8-15 M wide)

4.2 Parking

Instead of on-street parking, pickup and drop-off spaces for NMT and vehicular modes are provided near the stations. Off-street car parking spaces for NMT and private vehicles are identified and provided within 500 metres of each BRT station. Multi-storeyed car park buildings (off-street parking) with commercial spaces at ground floor are proposed at BRT station 4 and 16 which have wider vehicular access roads. One of the requirements of improved accessibility is to shift all unauthorized parking of heavy vehicles (trucks and buses) along the shoulders of Dhaka-Mymensingh Highway along the entire BRT corridor. In addition to providing multi-storeyed (off-street) car parking with commercial developments, which shows return more than 12%, possibilities of developing separately truck and bus terminals were explored under PPP mode with financial analyses. These terminal facilities for truck and bus near Voghra junction can be developed by GCC and operated with an O&M Contract. Figure 6 shows multistoried car parking, bus parking and heavy vehicle parking proposals.

FIGURE 6 Proposed multi-storeyed car parking, bus parking and heavy vehicle parking

Heavy vehicle parking needs a larger area of operation and an area of 15 hectare is found within 1 km of the BRT corridor which can accommodate 2000 trucks. It can be developed through government agencies. Only Light Commercial Vehicles (LCV) may be allowed to access the industry along the BRT corridor for day time delivery only. Bus parking area of 5 hectare is identified near BRT station 16, which will accommodate 500 buses. This off-street bus parking facility can be developed as a bus terminal through government funding.

4.3 Redevelopment of Commercial Spaces

The survey data revealed that 1277 on-street vendors operate along the BRT corridor. Vendors occupy shoulder space, which creates friction at the edges and one of the major cause of congestion along the corridor. 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 developments as residential, office and other uses based on its demand. On-street vendors are also accommodated in these multi-storeyed commercial redevelopment schemes. The remaining space for the commercial and residential use is utilized as revenue source to set up a PPP project scheme. Commercial redevelopment projects near BRT stations 2, 4 and 16 are found to be viable with 12%, 24% and 25% IRR.

4.4 Improvements for Access Roads (<5 M Wide)

Improvement of road surface and provision of pedestrian and NMT facilities are included for the access roads, which are 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 in Dhaka use cycle rickshaw even for a distance of 200m.

Cycle Rickshaw is a widely used mode of transport in Bangladesh and it is an essential component to support last minute connectivity. Actual number of cycle rickshaw in Greater Dhaka area probably exceeds 330,000 (*7*). For access roads with 5 metre or less width, the details of the off-street and on-street NMT parking facilities are shown in the Figure 7.

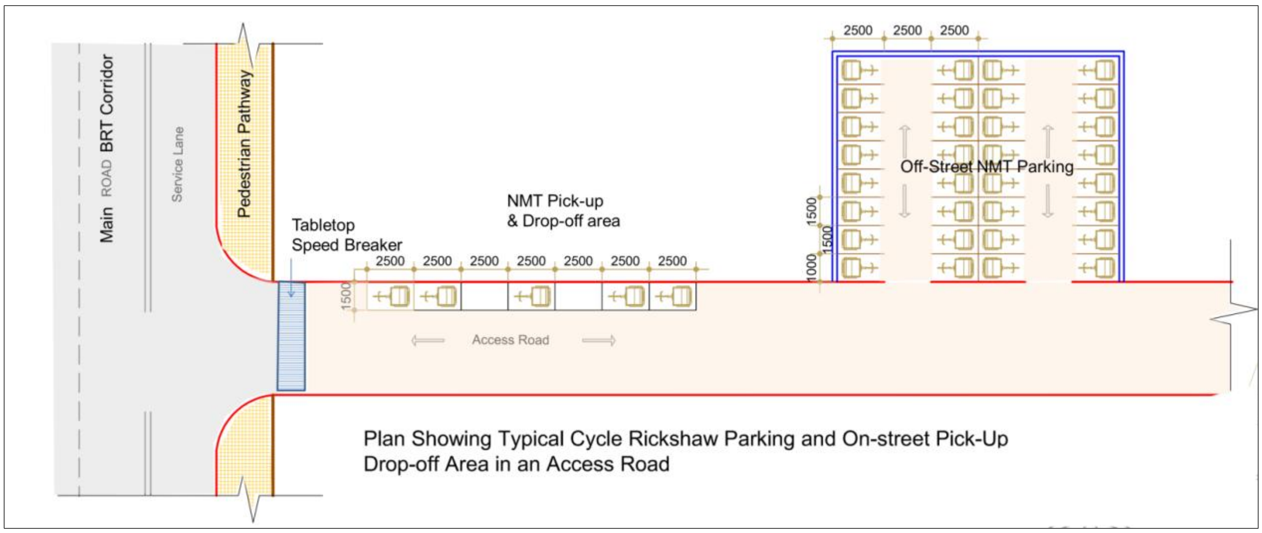

FIGURE 7 Accessibility improvements for access roads (<5 M Wide)

Pick-up and drop-off facilities for cycle rickshaws are provided as parallel parking of cycle rickshaws 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 identified along the access roads of each of the BRT stations. Constant supply of cycle rickshaws at the pick-up and drop-off locations from the nearest off-street parking sites will meet its peak hour demand.

4.5 Enforcement

To ensure uninterrupted access to the BRT stations by all access modes will be possible through very strict enforcement along the BRT corridor for parking along the road edge by cars and other heavy vehicles. Capacity of the enforcement agencies like 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, as required, to facilitate uninterrupted functioning of accessibility network of the BRT system.

5. CONCLUSION

Implementation of TOD along the BRT corridor in an already developed existing city is not an easy project. Based on the study and analysis it is found that access road network width is one attribute that affects the accessibility network influencing the ridership of BRT. Thus, improvements of accessibility network for easy reach to the stations are the most essential component of a successful 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, planners of the GCC. Legal department is to be involved in amendments/introduction of traffic rules and regulations suiting to the needs of implementing and operations of proposed public transport system, i.e. BRT system with TOD goals.

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