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ACHIEVING OPERATIONAL EFFICIENCY THROUGH INTEGRATION OF NON-MOTORIZED VEHICLE WITH IMPROVED BUS SYSTEM IN HERETOGENEOUS TRAFFIC CONDITION OF DHAKA

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ABSTRACT

Currently over 19 million people live in Dhaka, the capital city of Bangladesh, with annual growth rate of 4.2% and density of 47,000 people per square kilometer. The rapid rise of population along with mixed land use, growing motor vehical ownership rate and huge number of non motorized vehical on street resulted in huge travel demand, traffic congestion and air pollution..

Bus is still the main mode of public transportation in Dhaka, when metro rail (MRT-6) implementation is on-going. Like most other developing cities, public transport system at Dhaka lacks the much needed integration of an organized feeder service. The capital has an abundance of rickshaw in city roads since they are the most preferred mode of transportation especially for making short trips. Keeping in mind the escalation of multiple MRT and BRT projects, it would be ideal to use rickshaw as a feeder service of the public transport system. But over the last few years, the government of Bangladesh has implemented policies to phase out rickshaws from the major traffic spines of Dhaka City. The acceptability, rationality and implication of such 'solutions' are widely argued in Bangladesh. The argument is severe in Dhaka. The case study of this research considered social acceptability, economic response, fuel free ecofriendly characteristics and magnitude of role of rickshaw in sustaining the traffic and mobility needs of citizens.

With the backdrop and given the immense significance of the problem, this paper delineates an engineering design of non-motorized vehicle (NMV : rickshaw) integration to improved bus service system to increase its efficiency and focuses on challenges to be faced to implement it. A framework outlining improved physical design, infrastructure development and seamless flow of non-motorized transport is presented. The case studies for this research were conducted in Azimpur-Mirpur-Savar route considering it as an arterial road. A system has been designed whereby the rickshaws serve as feeder services to improved bus system for seamless flow passenger from any origin to bus station. Rickshaw will be restricted from major arterial and can only serve in collector and local road. Separate rickshaw lane near bus station (collector road), rickshaw parking space and pedestrian walkways facilities have been designed.

Keywords: *NMV integration, Feeder service, Sustainable, Heterogeneous traffic, Public transport.*

1. INTRODUCTION

Rickshaw is one of the principal means of transport in the urban areas of Bangladesh. But the capital city Dhaka is turning into chaotic, unsafe and immobile day by day due to chaotic management of rickshaws.

According to the Dhaka city corporations, there are 79,554 licensed rickshaws in the capital. However, the actual number is estimated to be around 1.1 million (Shafiq, 2017). According to the international standard, maximum 2.16 lakh vehicles can run in the city. But now, around 1.1 million rickshaws ply in the city daily along with the engine-driven vehicles. Sources of both city corporations said giving new licenses has remained stopped since 1980s. But there is a provision to renew the licenses after a scheduled period (Jibon, 2017).

Non-Motorized Vehicle (NMV) integration is one of the major issues regarding an efficient mass transit system. Some non-motorized profit can be monetize using methods commonly used by transportation agencies to evaluate policies and investments. These include congestion reductions, road and parking facility cost savings, consumer cost savings, energy conservation and emission reductions, and reduced accident risk to other road users. Thorough study is must for ascertain the number and pattern of vehicle for a city or town. But there is a crisis of study to ascertain the number and pattern of NMV in the city. Adaptive system of managing rickshaws are searched for many years and some measures have been taken by authority, albeit not very successfully. Restriction on rickshaw plying was imposed in some routes in the city in 2002. But the directive is debated among researchers, users, rickshaw pullers and even policy makers (Md. K. Rezaul, A.S Khandoker, 2019). To eliminate NMV from urban feeder roads or corridor cannot be a practical solution rather than to integrate it with mass transit system. Every location can be reached by walking, bicycles or rickshaws and is a fast and efficient means of transport particularly at the short distances. It is necessary for Dhaka to devise a functional and indigenous integration mechanism that is contextual to the traffic characteristics and travel demand while meditating the majority of the transport users. Public transport and NMV can be complementary. Integration of NMV with public transport can cancel out the negatives of both systems and provide efficient and sustainable door-to-door service to the bus or rail based commuters.
Conventional planning and evaluation practices tend to overlook or undervalue many non-motorized transportation benefits. Comprehensive evaluation methods are needed to identify the full benefits of policies and investments that improve non-motorized travel and encourage shifts from motorized to non-motorized modes. In this paper an attempt has been made to develop an effective NMV integration plan based on literature review and present scenario of transportation system of Dhaka city.

2. INTEGRATION OF NON MOTORIZED TRANSPORT WITH PUBLIC TRANSIT SYSTEM: RICKSHAW

The role of rickshaw in transportation sector of Dhaka city, the potential of rickshaw and improved bus transit system as a combined mode and the policy & benefits of modal integration has been recognised in literature.
Rickshaw, bicycle and walking are common forms of non-motorized transportation observed in the traffic composition of Dhaka, where Rickshaw is the most common and immensely used NMV mode for people of all ages. Factors contributing to rickshaw popularity include its socio-economic contribution as middle class and lower middle class people primarily depend on rickshaw for short trips; extensive physical network structure and access equity as almost all local and collector roads are accessible by rickshaw and fuel free nature yielding environmental sustainability. Most of the factors also correspond to transport sustainability for which the role of NMV in achieving such transport sustainability is tenable, especially in developing cities of Asia. Like many developing countries of Asia, the mixed land use distribution and lack of effective public transit mode of Dhaka resulted in short trip lengths, around 2 to 2.5 km (DUTP 1998 & Bari,M & Efroymson, D, 2007)) and where NMV already has a dominant share in the overall traffic composition. For balanced system

development public transport along with increasing motorized vehicle cannot be viable alternative to non-motorized transport in Asian cities (H. Kubota, T. Kidokoro, 1996). For achieving sustainable transportation and reduced climate change effects in developing countries a modal shift to zero emission vehicle like NMV is highly recommended by World Bank (World Bank-GEF, 2003).

2.1 Social Significance

Rickshaws plays a major socio-economic role at transportation sector in Dhaka. They are the preferred travel mode by vulnerable social groups - women, children and the elderly – due to their safety, security and comfort perspective. In addition, they provide an alternative to more costly motorized para-transit like taxis and auto rickshaws. Figure 1 shows the relation between trip distribution and household income. For low income group walking, rickshaw and bus are major mode of travel where rickshaw trips slightly decline with increase of income but still it is the highest modal share.

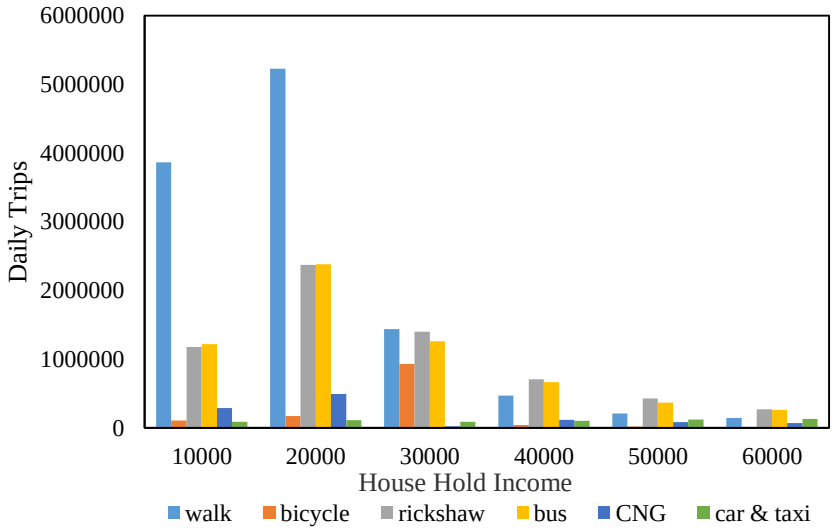

Figure 1: Trip distribution of different household income group
(Source: Derived from RSTP 2015 and critical analysis)

2.2 Sustainability Issue

Rapid increase of travel demand accelerates the demand for fuel in the transport sector which resulted in huge environmental pollution in developing countries (Singh, 2006). Cheaper fuel and fuel efficient technologies are not readily available in developing countries. The percentage of total consumption of petroleum products in India is about 50% (Singh, 2006) and in Bangladesh is about 54% (Rahman, 2009). The energy consumption per passenger-km is 0.91 mega joules (MJ) for light rail, 0.92 MJ for the average bus, 1.7 MJ for motorcycle, and 2.1 MJ for the average car (Banister et al., 1997). The estimated carbon footprint of the non-motorized transport is very low compared with all modes of motorized transport (ADB, 2010). Hence, future urban transportation policy should be oriented towards the promotion of mass public transport along with NMVs.

2.3 Modal Dominance

The latest BRT study (Advance Logistics Group Study, 2011) estimated that on an average day 21 million trips are taking place in Dhaka metropolitan area (Hoque et al., 2012). Despite the rapid growth of motorized traffic in Dhaka, non-motorized transport (walking and rickshaw in particular) still remains the dominant mode for the city dwellers who are mostly middle and low income groups. Rickshaw accounts for 34% of all person trips in Dhaka, which was 19% in 1998 and 61% of all rickshaw trips are made by people of middle income levels. Again, 40% of rickshaw trips are made by

women, children or people with goods, while other 20% of users are students (Louis Berger Group and BCL, 2005). With due attention, it can be the most demanding mode of transport in future Dhaka, particularly to the poor segment of the travellers.

2.4 Demand Responsive and other Operating Utility

The demand responsiveness nature, route choice flexibility and ease accessibility & widespread coverage of rickshaw compared to other para-transit like taxi or CNG, Car or Public Transit makes it more desirable as primary mode of travel for daily short trips (trip length ranges 3-4 Km or less) and supporting mode for long distance trips (trip to and from bus and metro station). In Dhaka, the majority of trips are short and local which accounts for three-quarters of total trips, with average trip lengths around 3.8 km (Hoque M. M. et al, 2014). For short distance trips, rickshaw is competitive in terms of overall travel time (when walking, waiting and transit time is taken into account) and is cheaper than traveling by auto-rickshaw, taxi or car. It can provide door to door services and high service frequency which promises the opportunity to integrate rickshaw as a feeder service to public transit system.

2.5 Increased coverage and efficiency of public transit system

The quality of public transport is determined not only by the quality of the main transport mode, but also by the before (access) and after (egress) modes. Access and egress are the weakest links in a public transport chain. The comprehensive interconnectivity of public transit and NMV is important to realize a trip and also to determine the availability and convenience of public transport (Krygsman, 2004). Initiatives aimed at improving access and egress hold potential to significantly reduce public transport trip time and are inexpensive options compared to the expensive infrastructure and vehicle enhancement alternatives frequently considered. Systematic modal integration has several benefits with regard to public transport which are crucially important for Dhaka. In Dhaka, non-motorized transport (walking, rickshaw, and bicycle) is currently a major component of the transport system. Murray et al (1998) estimates a 400m walk to public transit stops as the distance most people can walk comfortably under normal condition. Use of NMV as a feeder mode has seen to increase coverage of public transport as well as decrease the journey time.

2.6 Road Space Efficiency

The rise of automobiles i.e. car, CNG are significant in Dhaka city. Private cars take over 60-65% space of roads in the capital, while public transports use 7% only ((Rimon, 2017). But still the total number of automobiles are less than half (17%) that of NMV. However, the total road space occupied by car and CNG is almost equals to that of rickshaw (34% road space for automobiles compared to rickshaw's 38%), which means that the NMV uses half the road space than that of a car while transporting more people per vehicle than cars across all urban areas in Bangladesh (Rahman M. M. et al, 2008). The space efficiency of NMV gives operational flexibility and ease access to narrow roads. These features give the opportunity to connect public transit stations at major arterial road with single NMV lane serving as feeder.

2.7 Initiative towards Integration between Public Transit with NMV and Walk Mode

As a sustainable and environment friendly mode of transportation, cities in developed countries as well as developing countries are recently promoting non-motorized transportation as a successful urban development model. Cities with old concept of urban sprawl and car dependency exhibits paradigm shift towards transit oriented mixed land use development, where public transit mode (bus or metro) serve as main transit mode and NMV serves as feeder to the public transits. In Western Europe and Japan, the bicycle is the fastest growing and predominant access mode to suburban railways (Replogle 1992). In India, bicycles play a major role in access to commuter railways (Tiwari 2002). The Bogotá sustainable urban development models in recent years promoting NMV and public transport while restricting cars transport, which is considered by many researchers like Hidalgo (2002), Bari (2003) and Joewono & Kubota (2005) as highly successful. This model is under active consideration for implementation in a number of African developing cities like Cape Town Dakar and

Accra. Bogotá approach demonstrated how NMVs, pedestrian mobility and public transport facilities could be integrated for the development of sustainable transport system and is worthy of exploring to cities like Dhaka (Bari, 2003). The integration lessons from Delft, Netherlands, Tama New Town in Tokyo, which provides for pedestrian and bicycle access to town centres and railway stations completely segregated from vehicular road traffic, also gives literature background to develop efficient physical NMV integration plan with public transit system in heterogeneous traffic condition like Dhaka (World Bank 2002).

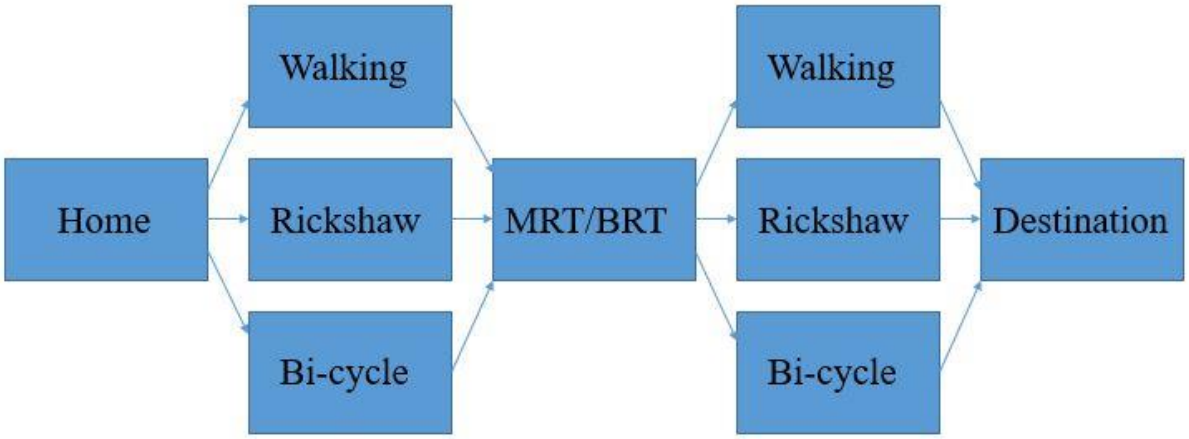

Figure 2: NMV integration with Public Transit System (BRT/MRT) Representation

2.8 Rickshaw Ban Policy and End Resul

Rickshaw restriction have been implemented by many cities i.e. Jakarta, Manila, Delhi, Dhaka etc. for either reducing congestion (smooth flow of motorized traffic) or enhancing the city image by eliminating traditional modes from the entire city or from certain roads. But evidence shows that, the purpose of smooth flow of motorized traffic or to get rid of congestion, is not served by simply restricting rickshaws (Gallagher, 1992; Barakat, 2004).

According to the recommendation of Dhaka Urban Transport Project (DUTP) (1998) and the National Land Transport Policy (2004), Dhaka City Corporation (the city government), in 2002 adopted plan to eliminate rickshaws from eight major roads of Dhaka, comprising a total of 120 km. The objective was to improve traffic flow, more space for motorized transport and creating some separate lanes for rickshaws. As a result, average monthly travel expenditure increased by 10%, travel hardship exaggerated for women and children, frequency reduced for social/recreational trips and inefficiency occurred in making a short trip. A comparative scenario between pre-rickshaw ban (2000) and post-rickshaw ban (2005) shows that, in automobile movement marginal improvement of speed (3.6%) and reduced travel time (5.7%) has been found but average travel times for buses have declined by 26.1% (Bari, M & Efroymson, D., 2007). Observing socio economic implication of such policy World Bank in 2005 revised its patronage to rickshaw restriction in Dhaka (DUTP, 2007).

NMV bans, which has been made over the years in different cities of Asia, experienced failure and decision reversal in most of the cases. Long after the ban, about 70% of residents in the low income neighbourhoods of New Delhi and Jakarta favour reintroduction of NMV (GTZ, 2009). In contrary, some cities have started favouring policies towards NMV movement- Bogota, Colombia from 2004;Yogyakarta, Indonesia from 2005 and few cities in India (Delhi, Agra, Chandigarh and Vrindavan) since 2002 (Gadepalli. S, 2006; Hidalgo. D, 2004; Zudianto, H. & Parikesit. D, 2009).

Rickshaw ban policy is a failure because it focuses on private motorized vehicles but not on broader mobility needs. But it is also true that the allowance to grow rickshaw without incorporating them in the overall transport system in a planned manner creates a chaotic traffic situation. Therefore rather

than simply pursuing policies to eliminate NMV, a better approach should be to integrate motorized and non-motorized vehicles as complementary rather than competitive forces in meeting the comprehensive transport demand. Rickshaws could play an important role of transport in Dhaka if they are modernized, planned properly, and the required facilities are provided (Rahman, et al. 2008; Gallagher, 1992; Rahman, 2011).

2.9 Principles of modal integration:

To implement integrated transportation system, the following aspects should be achieved in a project or in an area, preferably as many as possible:
• An integrated network,
• Integrated schedules,
• Physical transfer facilities,
• A common ticketing or fare integration system

3. OBJECTIVE:

The main purpose is to develop a plan for the integration of rickshaws with a pre developed improved bus system and thus promoting energy efficient and sustainable travel. The scope of the paper are:
(a) Explore the ability of rickshaws to serve as a feeder service of improved bus systems which is justified by literature review;
(b) Proposing a design for improved bus station that could assist for NMV integration by ensuring easy transfer between rickshaws and bus through their close/weather protected physical location;
(c) Integrated pedestrian walking facilities plan and
(d) Investigation on fare integration opportunity

4. METHODOLOGY

In this research, literature review has been done to understand standard NMV integration with public transit provision, previous studies and experiences of NMV integration. For traffic study data and distribution of traffic in future, Dhaka Strategic Transport plan (RSTP) by DTCA and Survey Report of Dhaka Metro Rail by DTCB has been considered as secondary data sources. According to literature rickshaw integration plan with improved bus system has been developed and presented with AUTOCAD drawing. In this paper, it has been assumed that rickshaw movement is not allowed in the study area Azimpur–Mirpur-Savar corridor, which is considered as an arterial road. Separate NMV lane is considered in collector road (collector road: which ends in arterial road), where NMV is used as feeder service to improved bus system and no lane restriction is imposed on local roads. 100% modal shifting is assumed from conventional bus and other para-transit to improved bus system on the study corridor.

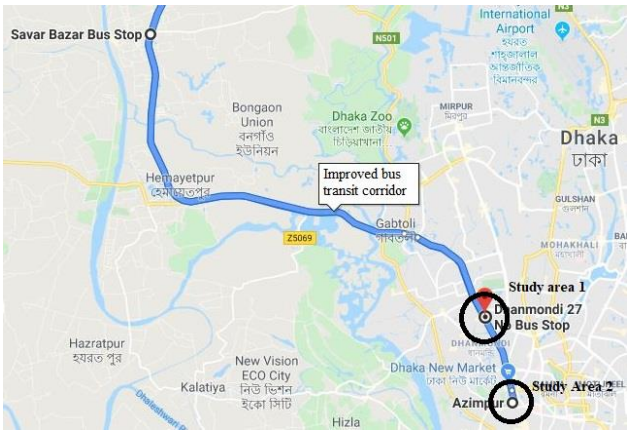

Figure 3: Azimpur–Mirpur-Savar route (major arterial) and study area (Azimpur and Dhanmondi 27)

5. STUDY AREA: AZIMPUR-MIRPUR-SAVAR CORRIDOR

Due to time and resource constraints, two potential integration area for NMV and improved bus system have been studied and one integration plan is presented in this paper. While selecting the locations, the socio-economic condition, demography, urban structure, and traffic situation have been considered as selection criteria. One location is in an unplanned and low-income residential area, developed along the major corridor of mixed traffic (azimpur); and the other location is a planned and high-income residential area with higher car ownership rate (Dhanmondi 27).

5.1 Location A: Azimpur

Azimpur is the starting point of Azimpur-Mirpur-Savar corridor. The right-of-way (ROW) of this corridor at Azimpur station is about 88 feet and provides three lanes in each direction. There exists a very busy and congested traditional bus station, a shopping centre called Dhaka new market nearby and also lots of busy hawker markets at Nilkhet end. This area basically deals with students and mid income people daily. The existing average vehicle composition at azimpur-new market circle is determined by field survey which shows the dominance of NMV mode on that area in figure-3.

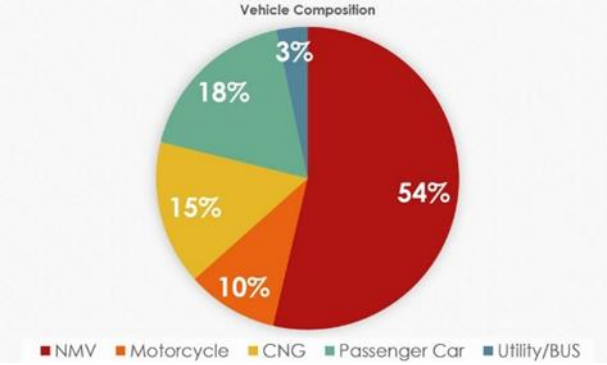

Figure-3: Classified vehicle count of sample data field at Azimpur station area

5.2 Location B: Dhanmondi 27

Dhanmondi 27 is located between dhanmondi 32 and Asad Gate on the azimpur- mirpur- savar corridor. This is a T section. The ROW of the corridor at dhanmondi 27 involves a road width of about 80 feet (29-30.5 m) and provides three lanes in both directions. This place is used as bus stoppage. Road users are mostly employees of mid income. The existing vehicular composition at Dhanmondi-27 circle is derived from Strategic Transportation Plan (RSTP) 2015, which shows the dominance of bus mode on mirpur route and less modal share of NMV in arterial route in Figure-4.

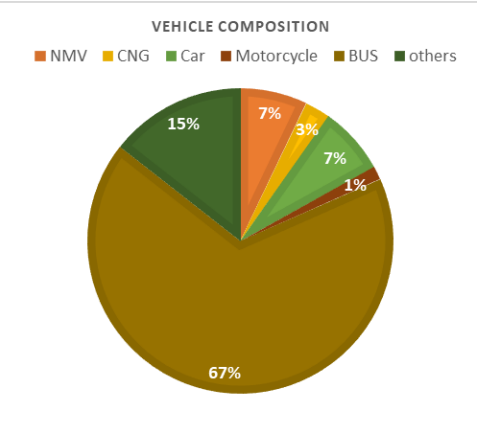

Figure-4: Vehicular composition at Dhanmondi 27
(Source: Derived from RSTP 2015 and critical analysis)

5.3 Traffic Demand:

The traffic demand for dedicated bus lane along 25 km Azimpur-Mirpur-Savar route is estimated by using conventional four step demand forecasting model, which has been commonly utilized and found to be effective in many cities around the world. For demand forecasting process circular area of 2 km radius around improved bus corridor was considered and demand was found 4.4 million daily household trips in 2018, with an increment of 5% rate considered (Rahman, 2018). Estimation of demand along study corridor is beyond the scope of this paper.

6. PROPOSED NMV INTEGRATION PLAN AT IMPROVED BUS STATION:

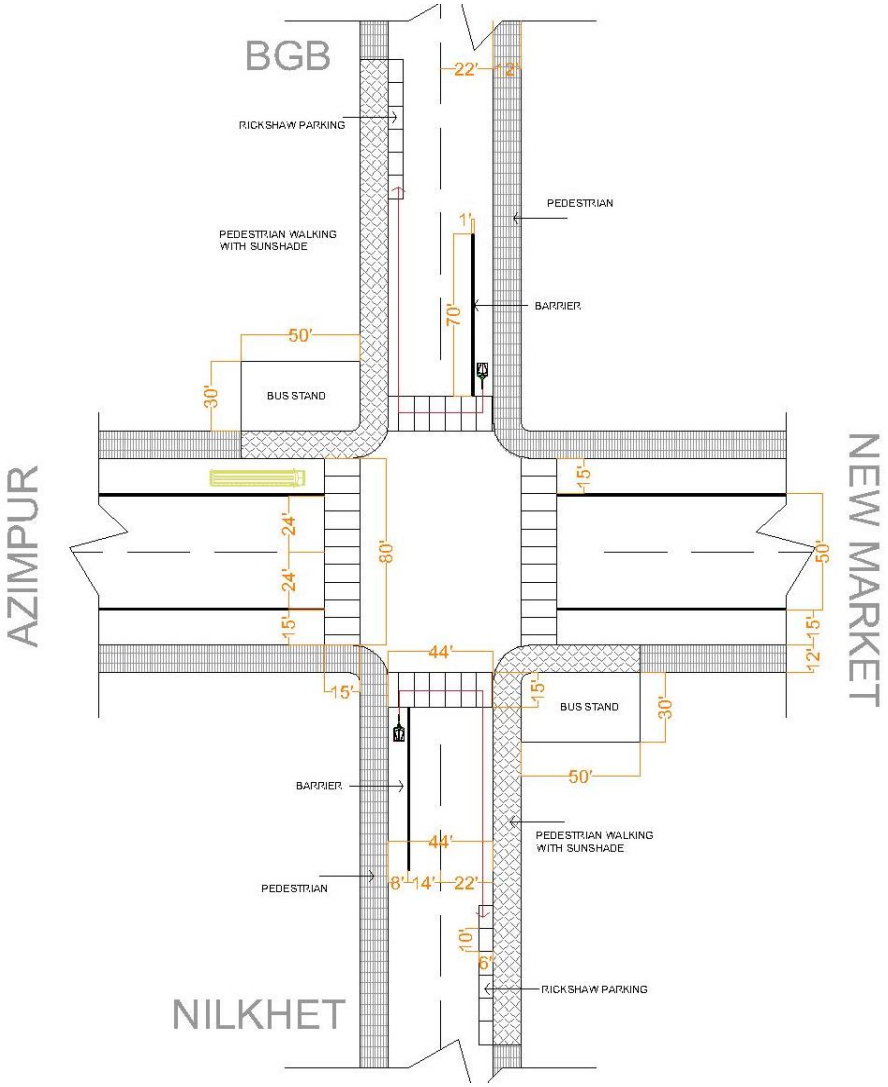

Figure 6: NMV integration plan with Improved Bus Station (Azimpur station)

6.1 Rickshaw Parking

To ensure least distance in modal interchange between bus and rickshaw, rickshaw parking is given in each approach road beside the arterial road. A parallel parking of 6-10 rickshaws on the left side of the road, at least 40 feet away from intersection has been designed (Figure-6 & 7). Two or more parking may create congestion so only one parking area is suggested. Parking is designed only for minor collector roads connected with major arterial, no rickshaw parking is allowed inside major arterial.

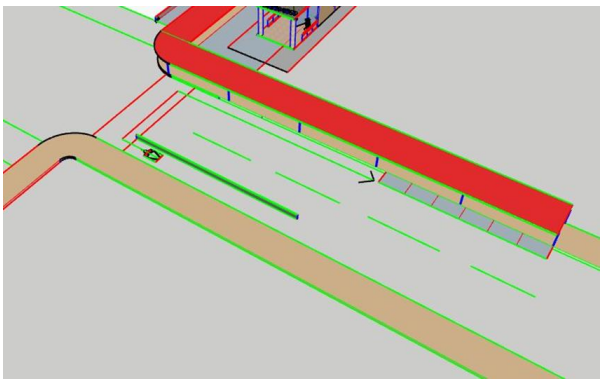

Figure-7: rickshaw barrier and rickshaw parking

6.2 Rickshaw Barrier Near Station

Physical barrier should be constructed for rickshaws approaching station to separate rickshaw flow from the other vehicle, as they will not cross the intersection to enter into major arterial. They will only drop passengers near the station and will go to the rickshaw parking if it has empty space to take return passenger or have to leave without any. An offset of 15 feet from the bus lane should be kept at the end of rickshaw barrier (figure 6 & 7)

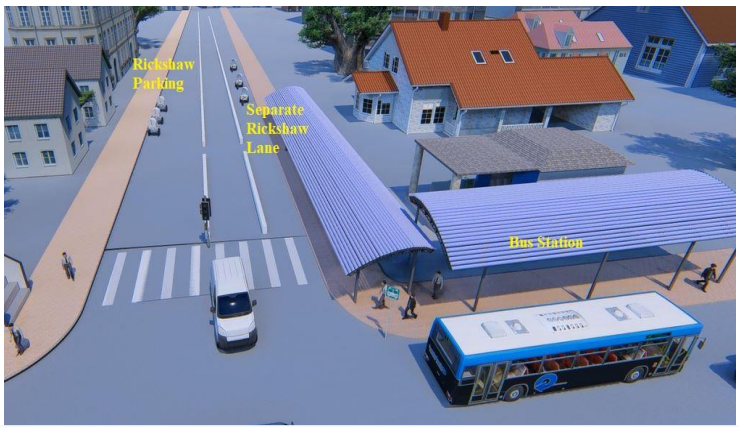

Figure-8: Demonstration of separate rickshaw lane, rickshaw parking, bus station and modal integration arrangement

6.3 PEDESTRIAN WALK-WAY AND SUN SHADE

• To ensure walking friendly environment for pedestrian foot-path of 10 feet width is considered near bus station and modal interchange area (Figure 7 & 8). No hawker, car parking and non-motor activities are not allowed near 20m of bus station.

• Footpath must be clean from garbage, brick/sand piles blocking the walkway

• A continuous sunshade from rickshaw dropping area to bus boarding/alighting area is provided.

As the dedicated bus lane is in curb side, foot over bridge is not needed. In collector road with NMV lane, Zebra crossing is used for pedestrian road crossing.

Figure 9: Pedestrian walkway facility near station

7. IMPLEMENTATION FRAMEWORK

Implementation of NMV integration in Dhaka is challenging because of the huge number of unregistered rickshaws, inadequate effective enforcement of law, absence of education and awareness among rickshaw pullers and unwillingness of pedestrians to follow rules. Engineering design can achieve limited success if these other conditions are not improved along with it.

Currently there are no designated rickshaw stand for picking up and dropping off passengers in Dhaka city. Rickshaws are found in 3 to 5 locations surrounding high ridership area like around shopping centres, bus stops and some are scattered in residential areas for potential passengers. If rickshaws are to act as feeder services for improved bus system, along with planning of bus stations to accommodate rickshaws, factors like discipline and organization of rickshaws in a tidy queue at station area and pre-determined fare structure to be addressed. Some shopping malls in Dhaka city have restricted zone for rickshaw queue but often they face a problem of ‘last-in first-out’ (when a rickshaw comes to drop passenger, came at last, but pick another passenger for another trip ahead of the waiting pullers); hence pullers will not follow the queuing.

Moreover, it should be noted that given the limited width of rights-of-way (ROW) of many roads in Dhaka city it might be very difficult to provide 40 or 50 spaces for rickshaws. Consequently, the rickshaws wait on streets occupying the carriage. Hence, the empty rickshaws are more problematic than a moving rickshaw because they occupy half of the carriage way. To stop extra rickshaws accumulating beyond the number of allowable limit should be executed through law enforcement as well as awareness generation among the pullers about the benefits they may get from following this. However, given the reality of more than three-quarter of existing rickshaws operating in Dhaka without a valid registration makes it difficult to enforce the law properly.

In Dhaka, almost 25 organizations are responsible for social and political activities rickshaw pullers including Dhaka Divisional Rickshaw and Van Owners Association, Bangladesh Rickshaw and Van Owner Federation, Metropolitan Rickshaw Owner League etc. These organizations must be afforded with responsibility to ensure awareness generation among rickshaw pullers. Again, rickshaw fare in a particular route or between major locations in Dhaka is already becoming determined at an acceptable rate through the market force itself, it would still create much bargaining between users and pullers and consequently end up creating delay in a queue. Pre-determined fare would be advantageous for smooth flow operation. Establishing large billboards with fare rates and periodic revision of fare rates is essential to keep this design functional.

8. CONCLUSION

Rapid urbanization, growth of vehicular population, unwarranted inflow of people in urban areas resulting in increase of urban poor are worsening the transport problem in Dhaka, like any other developing city in the world. But, it is a fact of life in Bangladesh that there are never, hardly ever, sufficient resources. So, to carry on progress in socio-economic field and prevent environmental pollution, a sustainable urban transportation system is required. The prerequisite for that is management and creating solutions for existing problems and implementation of them in infrastructure development and policy making.

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