Can BRT solve the transport crisis in Dhaka city?

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Abstract
Transport situation in Dhaka City, the capital of Bangladesh, has recently reached in a crisis situation – road congestion and emissions is spreading and the transport system is unable to meet the demands. Because of unavailable and overcrowded bus service, the cheapest form of public transport, the high dependence on walking and rickshaw in a city of 12 million is a symptom of inefficient and ineffective transport systems and operations. The expected addition of another 12 million people over the next 15 years will make the transport conditions almost unbearable, unless urgent measures are taken. So, policy measure for transport of the city should be directed towards tackling the large amount of travel demand and reducing congestion. Based on the secondary information, this paper has been initiated to come up with some guidelines for providing sufficient transport supply. For this purpose, successful bus rapid transit (BRT) systems of developing countries especially Bogota and Curitiba have been studied to gain lessons for the possibility of BRT in Dhaka. The study found that BRT is the most suitable form of public transport for Dhaka City to tackle the public transport crisis.

Introduction
Dhaka, the capital city of Bangladesh contains 12 million populations within 2,000 sq. k.m. land area. Transport environment of the city is characterized by traffic congestion and delays, inadequate traffic management, public transport crisis, unaffordable and inaccessible public transport for may people, high accident rates, and increasing air pollution problems (DUTP, 1998). The crisis in public transport is largely the result of growing concentration of population and economic activities, and inadequate public transport systems. The population of Dhaka City grew at an annual rate of 6.4 % whilst the vehicle population grew even faster, at an estimated rate of 8.9 % per year between 1992 and 1999 (ESMAP, 2002). However, the projected population of the city is to be about 16 million by the year 2015 and around 24 million by 2021 (DDC, 1998); will make the situation more critical if appropriate measures are not taken to tackle the increasing travel demand.

The paper is based on secondary information and the required information has been collected from related journals, published and unpublished materials of different agencies. The purpose of this research is to explore the transport crisis of the city and how the crisis situation could be solved. The study also further examines to come up with some guidelines for sufficient transport supply and wheather the bus rapid transit (BRT) system is possible to solve the transport crisis of the city. Successful BRT systems in cities of developing countries especially Bogota and Curitiba have been studied to gain lessons for the possibility of replicating BRT systems within the settings of Dhaka City.

Transport Crisis in Dhaka City
The transport problems of the city have recently reached in a crisis situation; streets are choked with traffic, inadequate and overcrowded buses, poor public transport service, and unaffordable and inaccessible public transport for the majority of

people (DDC, 1998). Bus speed reduces to less than 10 km per hour because of mix-traffic flow, uncontrolled number of rickshaw and baby-taxi and their indiscriminate operations. Usually taxi and baby-taxi are reluctant to go for shorter distance or certain areas of the city and to use meter for charging. Beside these, absence of a good scheduled bus system or other mass transport, inadequate sidewalks and pedestrian facilities, absence of road signs and markings, general lack of regard for traffic regulations, weak institutional arrangement for planning, modes and sub-modes act independently of each other, and very small bus fleet size are also the common problems. The poor institutional and regulatory framework, reluctance to enforce existing legislation, and lack of enforcement reduce the capacity of existing roads (DMDP, 1995). Further, the road hierarchy is poorly established and most new development is taking place without any coherent road system.

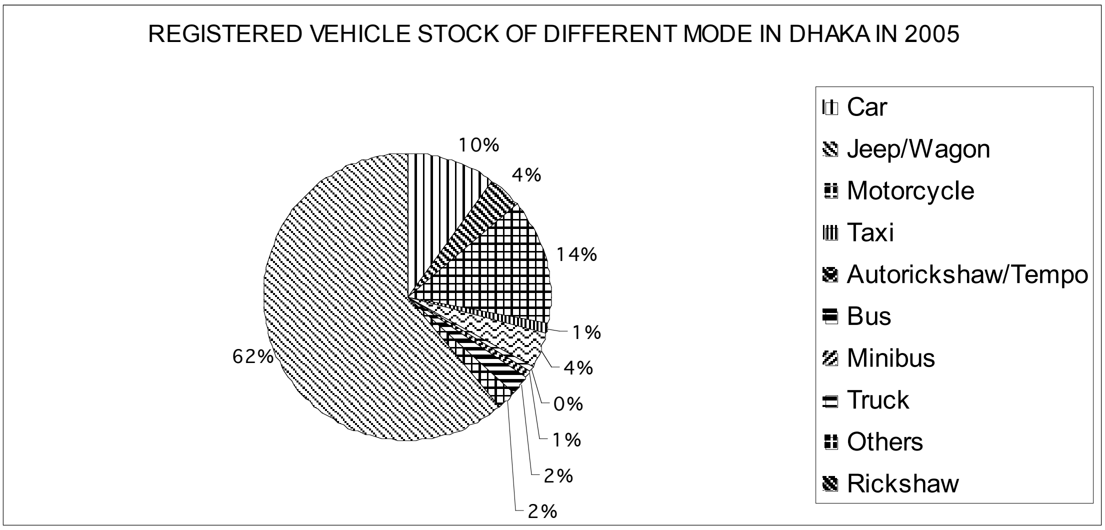
Traffic congestion and air pollution are the major problems of Dhaka City. Mixed traffic flow, poor driver behaviors and road blockage by haphazard parking, insufficient transport capacity and insufficient operation are the major causes of congestion (DDC, 1998). As there is no proper parking place, cars parked on busy streets occupying much of the carriage way. Inadequate traffic management, inefficient road use, and poor operating conditions waste up to 50 % capacity of the roads (BCL, 2005). Slow moving vehicles such as rickshaws, ply with fast moving automobiles, getting in their way and forcing them to slow down. Buses stop illegally wherever they feel they can pick up a few people and pedestrians cross busy streets blocking the movement of vehicles behind them or bringing them to a complete halt.

MODAL SHARE

There is a wide variety of transport modes available in Dhaka City and obviously the motorized is a small proportion (Rahman, 2003). Beside the pedestrians, other means of travel are bicycle, rickshaw, motorcycle, baby-taxi/tempo, minibus, bus, car, taxi, jeep/wagon etc. However, there is no MRT, LRT, or BRT systems and water transport within the city. Among the transport modes, bus is the most effective and economic mode of public transport in terms of energy consumption per passenger and per passenger km basis. Dhaka is one of the least motorized cities in the world with a total of 383,000 or approximately 30 motorized vehicles per 1,000 population, of which almost 70 %-80 % are old and defective (BRTA, 2007, DDC, 1998). Despite the very small number of motorized vehicles, Dhaka is one of the most polluted cities in the world because of high vehicular emissions. About 1,000 MT of pollutants are pumped everyday into the air of Dhaka, of which 70 % comes from transport sector (BCL, 2005; Khuda, 2001).

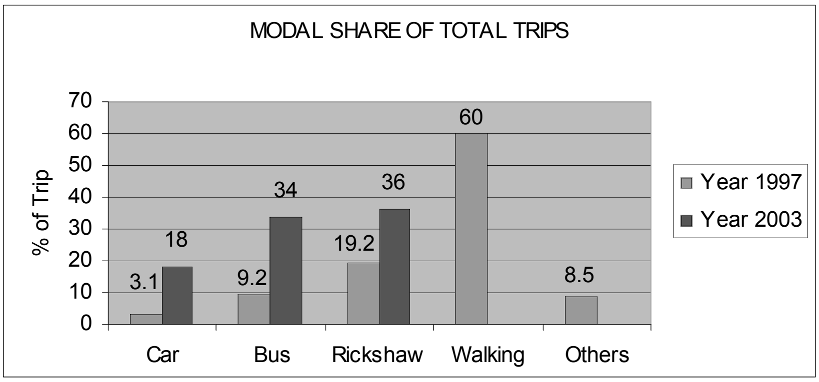
Dhaka City has only around 2500 buses as public transport whilst the current demand is more than 5,000. However, only 1,300 of the existing buses are playing of which less than 200 are of improved quality (Rahman, et. al, 1999). Public transport of the city is poor and disorganized with limited coverage (DMDP, 1995). Present public transport problems are the lack of integration between land use and transport system, lack of integration between different modes of transport, and increasing trend of private car. Because of inadequate and disorganized bus service, rickshaw has filled the vacuum and become popular mode among the middle and lower-middle income groups. Almost 600,000 rickshaws are available for hire which accounts more than 60 % of the total vehicles (BRTA, 2007). However, trip cost of rickshaw is significantly expensive than bus or tempo whilst considerably cheaper than the baby-taxi or taxi (Rahman, 2003). Average length of trip on rickshaw and NMT is small compared with the bus and motorized vehicles. Despite the unavailability of information on average trip distance by mode, it is evident that over the year trip length is increasing as the city size is growing. The average work trip has a size of 11 minutes only. Without major transport changes, in future most of the population would live near to workplace (DMDP, 1995).

Majority of the trips in Dhaka City are walking and NMT trips. Lots of researcher argued in favour of walking, cycling, and NMT for the health and environmental benefits. However, high dependence on walking and rickshaw in Dhaka is not for



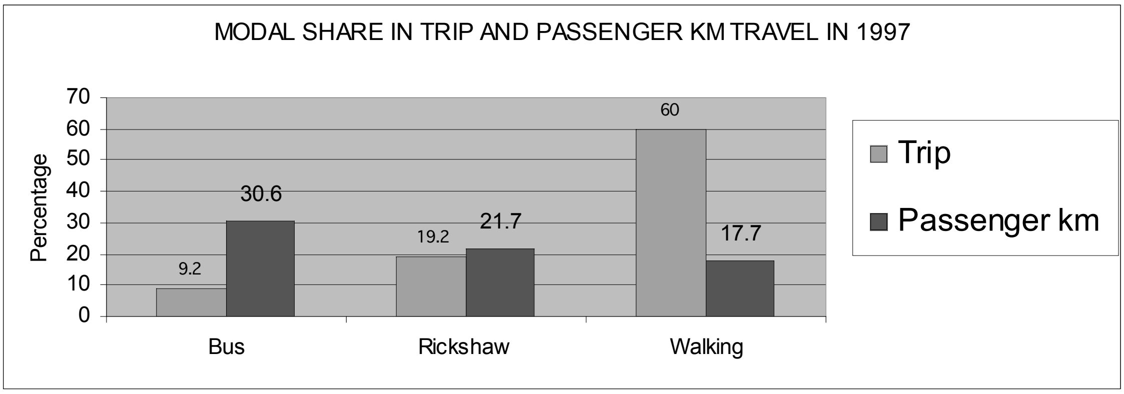
Source: BRTA, 2007.

Figure 1. Percentage of different modal vehicles of Dhaka City in 2005.



Note: Information on Walking and Others are not available in 2003.
Source: BRTA, 2003 and DDC, 1998.

Figure 2. Comparison of modal share of different modes in 1997 and 2003.



Source: DDC, 1998.

Figure 3. Modal share in trip and passenger km travelled in 1997.

these reasons; but for unaffordable and inaccessible bus service. Whatever the reason, there was a significant increase of trips on car, bus, and rickshaw between 1997 and 2003. There is no information available for trips made on walking and others for 2003. Whatever, lack of infrastructure facilities for walking, footpaths encroachment by traders, and consequently safety problems might be the reasons behind the strong decrease of walking. Despite the small number of bus trips, its contribution in passenger km is the highest. As the trip share is very minimal, car is not considered for the comparison of trip and passenger km for different mode in 1997 (Figure 3).

There were about 45,000 baby-taxi/tempos in 1997, which constitutes 19.5 % of motorized vehicles or more than 75 % of public transport vehicles. However, despite the large share in transport fleet the contribution of baby-taxi/tempo in trip making is only 1.4 % of the total (DUTP, 1998). On the other hand, contribution of bus is 16 % of public transport vehicles and 9.2 % of trips made on public transport.

CITY STRUCTURE AND ECONOMICAL CONTEXT

Dhaka's past growth and present urban configuration have been shaped by the city's relative susceptibility to flooding (DMDP, 1995). There is a preponderance of mixed use with high densities, a wide scattering of very poor slum areas and squatter settlements. Dhaka Metropolitan Development Plan (DMDP) indicated that transport would play a major role for Dhaka's growth. Without major transport changes, the future shape of the city will still be constrained by the need of most people to live near to their workplace. Around 53.62 % population of the city is with low income of Tk 5,000 per month (Euro 60 per month) and 22.8 % live below the absolute poverty level (DMDP, 1995). As the majority of the population are poor, any extensive outwards growth of the city will be a burden for their mobility and travel (DMDP, 1995).

Dhaka master plan emphasised on integrated transport network plan, improved public transport along with proper pedestrian facilities, improved road intersections and water transport facilities for metro Dhaka. Dhaka integrated transport studies (DITS) also gives priority to expand and upgrade public transport services, most particularly high capacity buses where traffic management measures rank second. Provision of better bus services will produce greater benefits than any other single measure (DMDP, 1995).

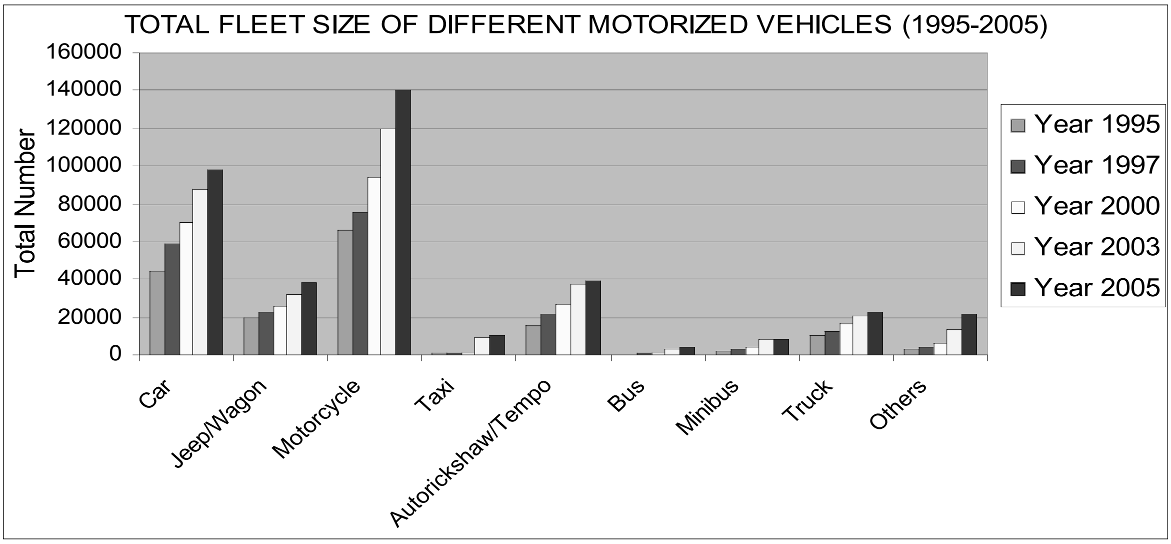


Figure 4. Different type of registered motorized vehicle units in 1997 and 2003.

VEHICLE GROWTH RATE

Number of registered vehicles in Dhaka has grown by 60 % from 1990 to 1996. The total number of motorized vehicles of Dhaka City in 2003 became more than double that of in 1995 with an annual growth rate is about 10 % (BRTA, 2003, BCL, 2005; Ahsan, et. al, 2006). The rate of vehicle ownership per capita is unlikely to change drastically, though some increase will occur over the next 20 years (Rahmatullah, 2005). As a result, it is anticipated that even though the number of privately owned vehicles may rise, a great part of the population will still remain dependent on public transport modes. A high percentage of poor people might be the reason behind this.

Figure 4 reveals a high number of car, baby-taxi, and motorcycle – all with very small passenger carrying capacity; whilst very few buses. Main reason for increasing vehicle ownership and trips are raising incomes, low quality of public transit services, and urban spatial decentralization (He, 2006). As motorcycles in the country are mostly registered only in Dhaka, it shows a high number. Except the bus and minibus, almost all types of vehicle had a high increase over the last ten years. Considering the public transport and private transport mode, during the same period, number of private vehicles had increased and public transport decreased. However, within the public transport, taxi had a dramatic increase whilst bus decreased more than half and a slight increase for minibus. Absence of transport policy to promote public bus service for middle and lower-middle class people is responsible for it. Despite the less contribution in trips and comparatively a very high fare rate, the numbers of baby-taxi are increasing dramatically. Among the motorized vehicles, in 2003, the highest increase (22 %) was for baby-taxi; whilst for bus, which is barely needed for Dhaka, was only 4 %.

How to Solve the Transport Crisis?

Congestion gives rise a negative externality as any increase in the number of vehicles using the road slows down other users of the road. Baby-taxi and taxi are occupying major portion of the city streets and carrying a small portion of trips or passengers km. Government could restrict these small occupancy vehicles and private cars and introduce large size buses, the cheapest form of public transport in Dhaka city, at affordable fare and thus possibly could solve both the congestion, and travel and access problems of the city.

Transport planning policies and perceptions in Bangladesh are more concentrated on motorized traffic, whilst NMT is seen as hindering motorized traffic flows. Such an approach is completely inconsistent with the realities of transport situation and travel pattern of the city where almost 70 % trips are either walking or NMT. The policy should be directed towards promoting walking and cycling along with the low-cost bus service accessible for all. The following measures might help to address the existing transport crisis situation of Dhaka City:

- It is time to think about restriction on private car use or small-occupancy vehicle through road use charging. Otherwise, having the GDP growth rate and increasing trend of population and per capita income may increase car ownership in the near future, and city streets will be clogged permanently for the whole day. Major polluter must pay for the pollution or social cost and that money should be earmarked for air pollution reduction.
- Reduce dependency on fuel use by promoting NMT and introducing fuel efficient vehicles; and reduce vehicle emissions and air pollutions by introducing improved transport systems, and cleaner fuel or alternative fuels.
- Ensure efficient traffic management to reclaim the full potential capacity of the existing road space. Strict enforcement of existing traffic laws and regulations and if necessary,

enact new laws. Meaningful coordination is needed among different transport agencies and departments.

- Restructure the bus operations from a large number of small and individual operators into a smaller number of large operators. Give priority to public transport by improving the public transport infrastructure, optimizing the structure of public transport operation, priority use of road for public transport, and developing the sector reform (Pucher and Kurth, 1996; He, 2006).
- Need to promote NMT and provide facilities for safe and comfortable walking and cycling. Develop a program for encouraging people to "walk from choice rather than from necessity".
- Develop public transport and implementation of a well-organized bus service and an integrated mass rapid transit system. Introduce mass transit in major corridoors that serve basic access requirements to major areas of development. Only the mass-transit systems are able to meet the increasing travel demand of large population size with minimum fare cost and pollution.

MASS RAPID TRANSIT SYSTEMS: THE INSTRUMENT TO SOLVE THE TRANSPORT CRISIS

Mass Rapid Transit is a form of public transport which is organized to transport large numbers of people at speed through the city. Common 3 mass rapid transit systems are-- Heavy Rail Metro (Metro), Light Rail Transit (LRT), and Bus Rapid Transit (BRT). The Steering Committee of the Strategic Transport Plan (STP) for Dhaka Urban Transport Plan (DUTP) has characterized 4 transport strategies; named 'auto/roadway emphasis', 'bus/transit emphasis', 'auto/roadway & bus/transit mix', and 'continuation of existing/recent practices'. 'Auto/roadway emphasis' is characterized as increasing automobile travel with high provision of infrastructure projects along with some improved bus services but no rapid transit system; where as 'bus/transit emphasis' generally characterized as significantly improved bus services and an extensive mass rapid transit system in conjunction with heavy reliance on pedestrian, cycling and rickshaw travel and limiting the increasing automobile travel through charging mechanisams (Rahmatullah, 2005). However, "Trying to solve traffic jams building more road infrastructure is like trying to put out a fire with gasoline." said *E. Penalosa.*

The STP of Dhaka suggested giving emphasis on public transport. Therefore, the primary emphasis moved towards public transit systems and using the most efficient means whereby the increasing travel demand could be met and tackled the transport crisis of the city. Once the need for a mass rapid transit system had been established, in order to make the public transit system more efficient, a number of corridors were required to be reserved for the major mass transit lines. The STP also recommended for a considerable investment in mass rapid transit both MRT and BRT and a lower investment in highways (Rahmatullah, 2005). There is no doubt that Dhaka needs mass rapid transit to tackle the serious transport crisis; however, choice for investing on MRT is questionable and needs further research before the final decesion is being made.

BRT system is a bus service that operates like a suburban rail system and gives priority to bus commuters. It is like "think rail, use buses". Articulated buses operate on exclusive bus-ways, using one or two lanes in each direction. These lanes can run in the middle of the road or along the service roads. Since traffic in most Asian cities is characterized by conflicts between buses, other motorized vehicles such as cars, motorcycles, baby-taxies, along with rickshaws and cycles and parked vehicles on the road, therefore design of BRT in Asian cities requires segregating traffic into various dedicated lanes. Buses, MVs and NMVs each should be provided with a physically segregated path. Segregated parking spaces and infrastructure for hawkers can be provided along the corridor to prevent encroachment on the carriage way, bus lanes or NMV paths (Tiwari, 2006). Since every bus commuter is also a pedestrian, the system must address the needs of pedestrians also. The station of BRT is a critical element. When the bus arrives, two doors of bus open simultaneously with those of the station, and a hundred passengers can walk in and out. The bus floor is at the same level as the station, making the inflows and outflows faster. Major benefits of BRT systems are efficient usage of urban road, save energy, reduce CO_2 emissions, lower investment, easily construction and shorter implementation time, and social equity (He, 2006).

BRT vs. LRT or MRT

Over the last twenty years, the (re)introduction of trams (or light rail) as a suggested 'solution' to delivering public transport at a lower cost than heavy rail in the low to medium density trafficked corridors have been observed. Bus-based transitways are often compared with light rail and frequently criticised in favour of light rail on the grounds of their lack of permanence because of the opportunity to convert the right-of-way to a facility for cars and trucks (Smith and Hensher, 1998). For many years the arguments for and against light rail and bus-based transitway systems have persisted, with light rail often the victor on ideological grounds (Hensher, 1999). The majority of bus-based schemes in most countries have generally been tried on a smaller scale than is necessary to give real advantages to buses (Richmond, 1998). *David A. Hensher* (1999) pointed that it is not valid to compare the impact of short bus lanes with longer dedicated-way transit systems.

A study of public transport options in Canberra suggested that a bus-based transitway is more cost efficient than light rail. All operating and maintenance costs excluding depreciation and interest are (in $1992) $ 3-$ 3.5 per vehicle km for a bus-based transitway and $ 3-$ 5 per vehicle km for light rail, and capital costs are approximately 50 % lower for a bus-based transitway (Hensher, 1999). On construction costs, an integrated BRT system in Sydney can be expected to cost, at grade (in $ 2004 M/km), from $ 0.12 M/km with shared use of existing road, $ 1.1 M/km with widening of an existing road and $ 1.7 M/km in an exclusive corridor. In contrast LRT under the same three corridor contexts is respectively $ 3.6 M/km, $ 2.20 M/km and $ 2.12 M/km (Hensher, 1999).

A comparison of the life cycle costs of providing bus services compared to light rail in Los Angeles LRT Blue Line leads to a conclusion that for the same level of funding, Los Angeles can either afford to build and operate the Blue Line for 30 years or operate 430 buses for 33 years, including the cost of building the operating divisions to support these new buses. For the same cost, however, the buses would produce over four-and-one-half times as many passenger kilometres and carry over nine times as many passengers (Rubin, 1991).

However, strong views exist on the merits of light rail as a preferred alternative to dedicated bus-based transitway systems. Why did many of these cities supporting and building light rail not consider having a very flexible bus system on the dedicated alignment which has the capability of offering much better door-to-door service than a very inflexible fixed rail system? The answers are relatively simple - the adage that 'trains are sexy and buses are boring' (quoted from the Mayor of Los Angeles) says it all (Hensher and Waters, 1994).

David A. Hensher (1999) argued that the decision to go with rail transit appears to have little economic or social basis. When the evidence suggests that one can move three times as many people by dedicated bus-based transitway systems for the same cost or the same number of people for one-third of the cost as light rail, one wonders about the rationality of urban planning.

Very few light rail systems have proven 'successful' on the criteria used to justify their construction and operation such as reducing car use, raising fundamental questions about the viability of public transport in general and light rail in particular (Hensher, 1999). Nevertheless, the BRT systems can provide an equivalent capacity to an LRT system, at a fraction of the capital costs.

> *'... it should be noted that despite the current wave of LRT proposals, and the considerable resources which have been invested in various LRTs (Manila, Hong Kong, Rio de Janeiro etc.), the consultants know of no LRT in a less-developed country which outperforms the busways surveyed in terms of productivity (passenger volumes x speeds)' (Cornwell and Cracknell, 1990, pg. 200).*

While LRT costs much more than BRT, it cost less than building or extending metro lines. Studies of existing BRT systems around the world demonstrate that they can provide excellent express service at a fraction of the cost of new metro construction (Pucher, Park, and Kim, 2005). For example, Park and Han (2003) estimated that the cost of constructing new LRT lines ranges from $ 20 million to $ 50 million per km, compared to a range of $ 80 million to $ 100 million for metro lines. However, for LRT lines that are fully underground, the cost difference is much less. For example, the LRT line being constructed in the southern Korean port city of Busan is costing $ 63 million per km (Kang, 2005). The LRT line is cheaper substitutes for metro extensions. The Seoul Metropolitan Government estimates that the full-scale metro version of the northeastern rail line would cost $ 107 million per km, almost twice as much as the LRT version of the same line, and more than 10 times as expensive as the per-km cost of BRT (Pucher, Park, and Kim, 2005).

The advantage of light rail on operating costs per passenger km is eroded. The total operating costs per passenger of LRT are typically higher than the typical bus-based transiway, where comparisons are possible. The most cost-effective LRT is 60-80 % higher on unit operating costs than a bus-based transitway (Hensher, 1999). Bus-based transitway systems are simpler to operate and maintain than LRT systems, the latter typically attracting a sizeable support system such as an operations control centre and maintenance facilities (Hensher, 1999). Bus-based transitway systems can be shorter in length than LRT and permit far more flexible operation (Hensher, 1999). The extension and continual upgrading of BRT is likely to be the most cost-effective approach to providing the additional public transport services needed throughout the greater metropolitan area (Pucher, Park, and Kim, 2005).

Planning and construction time for BRT is 12-18 months; where for Metro is 3–30 years (Wroblewski, 2005). BRT is a much cheaper and quicker way to provide express public transport services than metro expansion, which can take many years to construct and requires much more capital investment (Pucher, Park, and Kim, 2005). Distinctive vehicle design for BRT buses is a feature of many North and South American BRT systems (TRB, 2003). BRT has become a more attractive mode of choice than rail in Australia (Currie, 2005).

According to *David A. Hensher (1999)*, "The potential for dedicated bus-based infrastructure along major corridors with efficient interchanges and bus distribution deep into suburbia is recognised as having such potential, yet has been neglected internationally (with few exceptions such as Ottawa and Curitiba) relative to light rail". The Ottawa, Curitiba, Bogota and Brisbane experiences are worthy of special investigation. They appear currently to offer the best examples of how a bus-based system can be a major alternative to light rail in terms of the wider range of criteria used to justify a rail-based public transport system (Hensher, 1999).

Lessons from the Successful BRT Systems

During the 1960's and 1970's major Latin American Cities were growing rapidly and choose Metro Rail solutions for their public transport needs (Kasih, 2006). However, many cities were unable to expand their Metro network as needed because infrastructures of metro systems require high investments. Only Mexico City had a widespread Metro network by 1990, but the Metro investment contributed significantly to the country's foreign debt. In the 1970's, Curitiba was also looking at rail based solutions for the growing transport problems; however, having the financial constraints, the city decided to innovate (Kasih, 2006). A low-cost-high-quality transport service was created by using bus technology, which was financially a sustainable system. Land use development and transport planning were perfectly integrated in Curitiba (Kasih, 2006). However, the Curitiba experience could not be replicated in Latin America for many decades. There are several reasons behind this that need to be understood by planners. A system like Curitiba is only possible if undertaken before the city spreads out. It is almost impossible to restructure when too many operators provide the transport services in a city. Cities like Porto Alegre and others implemented bus priority systems with somehow lower standards than Curitiba. After more than 2 decades, Quito was the first Latin American City tried to replicate the Curitiba experience by using an expensive technology. Almost 3 decades later of Curitiba, the "impossibility of implementation paradigm" was broken with TransMilenio in Bogota (Kasih, 2006). TransMilenio was not only able to break the paradigms, but also introduced "state-of-the-art technologies" never used before in public transport in developing countries and proved that the major barrier for BRT implementation is "lack of political will".

Suddenly, several BRT systems are being implemented based in the TransMilenio model. With TransMilenio, most Latin American Cities are looking into BRT systems to solve their transport problems (Kasih, 2006). However, barriers still exists and continues after operation and it is up to transport professionals to break them. Corruption rumors were used to stop the operation of a BRT system in Ciudad Juarez and private vehicles owners convinced the newly appointed mayor to open the busway to private traffic in Quito (Kasih, 2006). Most transport professionals are convinced about the benefits of BRT systems; however, they still encounter political opposition that would prefer to implement more expensive solutions. About 20 Chinese cities are actively planning or implementing BRT systems with varying approaches, viz. full-fledged BRT system, or incremental implementation of BRT elements (He, 2006). Jakarta built Asia's first 'closed' BRT system (Hook, 2004). Bangkok and even Delhi also established BRT systems very recently.

BOGOTA, COLOMBIA

Bogota, the capital of Colombia, from it's founding in 1538 until today has been growing steadily and shaping its identity (Wroblewski, 2005). The city had one of the most disorganized and atomized public transport systems in Latin America. BRT is a proven system that changed the face of Bogota from a hopelessly congested and polluted city of 8 million to a model transport system. It is the idea of *Enrique Penalosa*, who was the mayor of the city from 1998 to 2001. His model is people oriented which is providing a new way for organizing transport in many world cities. It restricts the use of private cars, and gives priority to children and public spaces. The transformation of Bogota was completed just in three years. During this time, hundreds of kilometres of sidewalks, bicycle paths and pedestrian streets were built to give space to the BRT and people.

A bus rapid transit (BRT) system of Bogota, called TransMilenio, was launched in December 2000. TransMilenio uses 165 passenger buses through exclusive corridors on a contractual agreement with private operators (Wroblewski, 2005). The 100-km long network manages to transport 35,000 people per hour per direction. The buses run in the middle of avenues so that vehicles entering and exiting driveways or delivery vehicles do not become obstacles. This needs just one station, instead of one in each direction. Bogota generates about 18 million total trips per day where about 9.5 million trips (68 %) are on public transport; of which TransMilenio first phase serves 800,000 trips (Wroblewski, 2005). The stations are located every 500 m with pedestrian/bicycle access through overpasses, tunnels or signalized intersections and bicycle parking facilities (Wroblewski, 2005). Cost for first phase of TransMilenio was $ 250 million.

BRT has ability to carry passenger volumes never thought possible without a Metro. TransMilenio transports more passengers per kilometer per hour than 90 % of rail systems in the world at a similar speed (Wroblewski, 2005). Bogota banned all old buses on the BRT corridor and removed old bus routes. This reduced average trip time and air pollution, and increased safety (92 % less fatalities) (Hook, 2004). Ticketing and operation of TransMilenio is private while infrastructure is public. It uses performance based contracts under competitive bidding (Kasih, 2006). Bus operators' share of the revenue is divided according to the number of kilometers driven. A system of penalties is put in place for poor service or air quality violations. High level of service at low cost is available; only US$ 0.40 fare covers capital investment cost, operating and maintenance cost, and administrative costs of BRT. Larger capacity vehicles can add capacity when lane width is not available. TransMilenio buses have 4 doors of 1.1 meters wide, which reduces average boarding time per passenger from 3 seconds to 0.3 seconds. Whatever, a long bus require long stations, and most of the TransMillenio stations are 48 meter long (Wroblewski, 2005; Hook, 2004).

CURITIBA, BRAZIL

The BRT does make a city move faster and it happened not just in Bogota; there is also Curitiba in Brazil. Curitiba is a city of 1.6 million and located 400 km south-west of Sao Paulo. Long before *Mr. Penalosa* began changing the face of Bogota; Curitiba had rejected the metro and LRT systems because they were too expensive. Instead, in 1975, the city decided to spruce up the bus system and design it on the lines of a surface rail system with exclusive right of way and elevated platforms. The BRT, in fact, has it's origin in Curitiba. Curitiba introduced a bus priority system at a cost of US$ 54 million, 300 times less than a subway and also less expensive than light rail (Herbst, 1992). The integrated transport network has 72 km of exclusive bus lanes, 2,000 buses and 233 'tube stations' where passengers pay the fare and board buses via ramps. Boarding and alighting is considerably speeded up with passengers paying fares using smartcards at a turnstile at the end of a clear tube and then waiting inside, entering the bus from sliding doors in the tube. Curitiba's buses transport 1.3 million passengers per day which is four times the number of subway passengers in Rio de Janeiro, a city of 10 million residents and more than six times the size of Curitiba (Hensher, 1999).

Curitiba implemented a master plan in the late sixties which restricted high-density growth to several slender corridors radiating from the city centre. The traditional core has given way to a cluster of high rises and scattered outlying development with all tall buildings arrayed along five transportation axes. Express bus-based transitways occupy the median of each road. To achieve this, the city brought or condemned a substantial amount of land along the transport axes and enacted zoning regulations that restricted high-density development to a two- to four-block corridor on both sides of the road. *Flower Street*, an auto-free downtown pedestrian zone was created, banishing cars in a 17-block area (Hensher, 1999). Hensher (1999) mentioned that political stability has enabled the planning and innovation in Curitiba to deliver the results. The effective use of bus-based transitways is dependent on an integrated regulatory regime.

A three-tiered bus system, arguably one of the most efficient in the world, was introduced in Curitiba which allows passengers to transfer without charge from the red express services along the axes to the yellow feeder services that circulate through outlying districts and bring passengers to transfer stations, and to the green inter-district buses that travel in concentric circles to connect outlying areas (Hensher, 1999). A computerised traffic control system gives priority to buses. According to *J. E. D. Richmond* (1998), transfers are a major constraint on the use of public transport. Bogota, Curitiba, Quito all have free transfer from feeder buses operated by the same authority (Hook, 2004). Since then bus travel times have been dropped drastically, with significant reductions in congestion, noise, and air pollution.

The current maximum volume carried on an efficient bus-based transitway (i.e. with an average speed greater than 20 km/h) is 11,000 pax/h in Curitiba, and where volumes exceed this, the average bus speed drops towards that of the surrounding traffic flow. It remains to be seen whether the Curitiba 'surface subway' and the new systems in Sao Paulo will be capable of both moving 22,000 pax/hr volume and maintaining average speeds in excess of 25 km/h, as predicted (Hensher, 1999).

The bus-based transitway systems in Bogota and Curitiba provide an illustration of the strengths of this transport mode. The experience of Bogota and Curitiba supports the contention that, under appropriate regulation, organisation and capital investment, bus based transit systems are capable of transporting large volumes of passengers at reasonable speeds for minimal capital and operational costs.

Possibility of BRT in Dhaka City

Bangladesh needs focus on solving urban transportation problems by improving the public transit service. BRT has been seen as a 'creative, emerging public transit solution' which can be cost effective in addressing urban congestion (Currie, 2005). Hensher (1999) argued that BRT has become the most efficient, affordable above all sustainable mass transport system. Cost-effectiveness and flexibility of BRT makes it suitable form of urban transport (He, 2006). Transport facilities should be provided keeping in mind the population growth, economic development, and future travel demand of the city. Buses and minibuses provide the cheapest and most flexible way of meeting heavy demand. Systems using shared-size transit buses, each with a capacity of about 80 passengers, are able to carry up to 10,000 passengers an hour per lane in mixed traffic. Systems using larger buses with a capacity of 120 or more and operating in the same conditions can carry up to 15,000 passengers an hour. If priority measures are put into place, these volumes can be increased to 15,000 passengers an hour for standard buses and in the region of 20,000 for the larger buses; peak-hour volumes of 23,000 passengers an hour have been achieved by buses operating in reserved lanes (World Bank, 1986:33).

BRT has been a huge success story in the Colombian capital. Because of the flexibility, ease of implementation and image of a modern information technology based system, several Latin America and Chinese cities are adopting BRT rather capital intensive Metro systems. This appears to be the perfect solution for overcrowded Dhaka city seeking cheaper and more efficient public transport system. According to *G. Tiwari* (2006), since mid seventies when the first BRT appeared in Curitiba, the system design has been evolving as per the local needs of road users, institutional mechanisms and financial structures. International BRT experience and practice are important for Bangladesh. It is time to open the BRT Era in Bangladesh.

"We enjoy walking and being with people. Our city design should facilitate this" said *E. Penalosa*. So, it is our responsibility to design city in this way. W. Hook (2004) mentioned to get people to switch from private vehicles to buses, a new bus-way must increase bus speeds over current levels and the capacity of the busway must be sufficient to handle the travel demand at a high speed. He also pointed that the busway needs to be designed carefully based on the projected demand for bus passengers and the quality of bus service must also be improved. The guided bus technology used in Adelaide which results in high and safe operating speeds (with reasonable ride comfort) with maximum running speeds of up to 100 km per hour. The Sydney Transitways with a short stop spacing of 861 m and mixed-traffic on-street operation explains their low average scheduled speeds (29-34 kmp). While this is the lowest speed of the BRT systems, it is still more than double typical average operating speeds for buses running on-street in mixed-traffic in Australian conditions (Currie, 2005).

MAJOR CORRIDORS

Though the bus route lists of Bangladesh Road Transport Authority (BRTA) shows a total of 34 routes in Dhaka City, including the sub-routes of different main routes it becomes 46 in total of which 13 routes are not presently in operation (BRTA, 2002; Amin, et al. 2005). In order to develop the strategic road network of the city as well as those which could provide major connections to the growth poles/ satellite cities around Dhaka, an attempt was made by the Steering Committee for Strategic Transport Plan (STP) of the Dhaka Urban Transport Plan (DUTP) to identify the arterial road networks of the city which carry most of the North-South and East-West traffic. A brief analysis of the road network (Figure 5) reveals that there are about 5 major North-South corridors whilst several missing links in the East-West direction, which need to be built on a priority basis to provide alternative route for movement (Rahmatullah, 2005).

Demand analysis of passengers movement by the Steering Committee of STP revealed that at least five lines (Figure 8) of total length around 76 km would be needed to cover most of the city (Rahmatullah, 2005). However, STP suggested 2 corridors of them for Metro; which is not financially viable compared to the BRT, already discussed in previous sections. Furthermore, the guidelines for introducing urban rail transit are given in terms of city population size (at least 5 million), corridor traffic demand (approximately 100,000 trips a day with peak hour bus traffic of 15,000 per direction), level of city economy (at least US$ 1,000 per capita of national income) and administrative capability for construction and management, which mostly apply to many of the Southeast Asian cities (Iwata, 1995:560). A corridor of about 5 km, for example, between Khilkhet and Kaptan Bazar, attracts flows of upto 2,300 pcu/hr and heavy public transport flows of almost 40,000 passengers per hour (pph) (Rahmatullah, 2005). Despite this corridor can fulfill the city population size and traffic demand, city economy is far below than the given figure. Thus, the research recommends all the 5 lines (Figure 6) as BRT corridors. After the implementation of these 5 BRT lines in first phase, if demand continues and performance evaluation reveals financially viable system then further extension could be possible later on. Whatever, the detailed study for each proposed BRT lines are needed; which is unfortunately beyond the scope of this paper.

SYSTEM DESIGN

Three aspects of geometric design viz. exclusive bus lane, location and design of bus stops, and non-motorized vehicle lane are essential for system efficiency of BRT (Tiwari, 2006). Creating exclusive lanes for buses minimizes conflicts with other vehicles and therefore improves bus movements. Exclusive bus lanes can be provided either as curb-side lanes or central lanes physically segregated from the rest of the traffic (Tiwari, 2006). Curb-side bus lanes cannot get speeds up significantly even at very low demand levels. The central lanes of a corridor have minimum conflict with turning vehicles or slow moving vehicles. There is least probability that the volume of turning traffic from innermost lane will come in conflict with it. Most successful BRT systems use the center lanes (Hook, 2004). These central lanes can be reserved for buses. In centrally placed bus lane layout the bus lanes for both directions are separated by a median. Bus shelter can be on the right or on the left; but, putting station in the middle consumes less road space and eases transfers (Hook, 2004). As bus shelters are close to existing intersections, extra pedestrian crossing will not be required (Tiwari, 2006). “Closed” BRT systems have much higher capacity but require a feeder system with transfers compared to the “Open” systems (Hook, 2004).

The corridor width (right of way) varies from 51 m to 29 m (Tiwari, 2006). There should be separate lanes for buses, MVs, NMVs and pedestrian. Whenever possible service lanes are also provided along the corridor. Exclusive lanes for bicycles and rickshaws and pedestrians along with spaces for hawkers are also essential. Hawkers and roadside vendors provide services to bus commuters and pedestrians therefore designed spaces would discourage them from ‘encroaching’ upon the carriage way. Tiwari (2006) argued that this improves capacity of the lanes designed for motorized vehicles and increases safety of bicyclist and pedestrians. A 2.5 m wide physically segregated NMV track should be provided on both sides and throughout the length of the corridor. The NMV track should be provided as close to the carriageway as provided (segregated by a 0.3 m wide median. Since rickshaws and cycle-vans may also use the cycle track, a minimum width of 2.5 m is required for two rickshaws each to overtake (or to pass when approaching in the opposite direction) (Tiwari, 2006). The texture, colour and width of cycle track should remain consistent throughout the zone clarifying the right of way condition in favor of the cyclist (Tiwari, 2006). If hawker spaces are integrated with the pedestrian waiting areas then the carriageway is left free for moving vehicles. These geometric details are the first stage required for BRT. These have to be combined with optimal signal cycle to improve the throughput of all vehicles as well as provide safe pedestrian crossings. In general, following lane widths are recommended while creating exclusive lanes (Tiwari, 2006):

- MV lane width on main carriageway 3 m (minimum) for maximum speed < 50 km/h;
- Recommended lane width for buses 3.3 m (3 m minimum) for maximum speed < 50 km/h;
- Recommended width of NMV track is 2.5 m (1.5 m minimum); and
- Separate service lane (3.75 m minimum).

Source: Amin, et al. 2005; Rahmatullah, 2005.

Figure 5. Existing bus routes map of Dhaka City.

Source: Rahmatullah, 2005

Figure 6. Proposed major mass transit corridors of Dhaka City.

Most passengers walk to reach bus stops, and 500 meter is considered a convenient walking distance for human beings (Unterman, 1984). Bus stops must be located where it is safe and convenient for bus commuters to reach. A study on bus routes and stoppages (Amin, et. al. 2005) found majority of the bus riders in Dhaka City use a particular bus services for the cheaper fare and walk to or from the bus stop. The study also found that the majority of the stops are not located within a comfortable walking distance. Most of the users have to walk for 15-20 minutes or 1-1.5 km and wait for a perid of 20-30 minutes for a bus. Tiwari (2006) recommends a minimum distance of 500 m between the bus shelters. Bus stops locations must minimize the delays faced at junctions. Bus stop platform design should minimize boarding and alighting time. Bus shelters at junction can be located before the junction or after it. However, a simulation by G. Tiwari (2006) showed locating the shelter before the junctions gives better results. This is because when buses arrive at a junction the probability of getting a red light is always higher than green therefore when bus shelters are placed before the traffic signals the red phase is utilized for boarding and alighting thus minimizing delays. Otherwise buses have to stop twice, once at red light and again at the bus shelter after the junction.

BRT can have additional efficiency by changing the bus designs which can carry more people, boarding and alighting is made efficient by wider doors and low floor-same height as bus stop platforms. Many cities have recognized the institutional mechanisms and evolved public private partnerships for better regulations, licensing procedures and improved services. BRT efficiency has further been improved by making use of information technology for better passenger information system, route tracking, and vehicle maintenance and safety systems (Tiwari, 2006). These different stages of BRT can be introduced in phases, with each stage adding to the benefits of earlier system.

CHALLENGES

To start with a BRT system, it would have to redesign existing roads along the proposed BRT corridor to have dedicated bus lanes, install intelligent signaling systems and build bus shelters. The basic changes required include provision of a segregated lane for slow-moving vehicles in addition to service roads. Then, at least one lane can be reserved for buses, while the other two can be for cars, and other motor vehicles. The main challenge to start BRT is the political will and leadership skill for sustainable transport and livable city. "Often Third World upper classes oppose bus-systems because they would rather use the road space for their cars. Generally they prefer subways and metros because they imagine that by putting the poor underground, traffic problems will go away. Then rail systems are chosen in Third World cities, limited funds permit building only a couple of lines and that serves not more than 15 percent of daily trips" says Penalos, who himself scrapped proposals for a LRT system and a metro before implementing BRT in Bogota (Wroblewski, 2005).

Often, few people of Dhaka say "we don't have enough wide roads for BRT in Dhaka. So, we can go for underground metro". However, this dilemma could be well explained by the following quotation of *E. Penalosa* as "It is often said that there is not enough space in a given road for an exclusive bus lanes. Perhaps it should be rather said that there is not space for cars but only for buses. That is, if democracy and the public good are to prevail." The reality is, we do have major corridors with sufficient road width to provide BRT systems.

National level policies and incentives for sustainable urban planning and transport planning is a must. BRT plans need to be matched with land use planning and it is necessary to combine transit-oriented development and NMT. Whatever, BRT system will not work alone. Other public transport improvements like franchising of other bus routes are also needed. BRT systems should be integrated with other mode like normal bus services and pedestrians. Furthermore, the city needs capacity building and institutional cooperation.

Urban planning and development management in Dhaka is fragmented and uncoordinated. RAJUK (Dhaka Development Authority) is now regarded as one sectoral agency amongst many. There is no high level coordination between agencies at central government or metropolitan level, or indeed between private and public sector agencies.

Conclusions

The problem of traffic congestion and uncontrolled vehicle emissions make life miserable and causing threat to health and economic loss as well. Public transport service and air quality situation of Dhaka City is continuously deteriorating every year and imposing huge cost on the society. Though there is little information on human health, there is clear evidence that the air quality in Dhaka is harmful for the city dwellers and it is causing not only discomfort but also several diseases including allergy and asthma (Khatun, 2002). Such a problem needs immediate attention from the policy makers. As vehicle and emissions is a major contributor to air pollution, it is possible to improve air quality by reducing the vehicle stock through improving the public transport system service. Government should strengthen vehicle emission standards, regulations, enforcement and measures to reduce fuel demand and improve traffic conditions. Improved public transport facilities of the city could solve the transport and congestion problems, as well as improve the air quality. However, a strong political will or commitment of the government is needed for this. Better traffic management and discipline in roads is a must for reducing congestion; and only the prompt and proper enforcement can ensure these. The policy strategies should be directed not only to reduce vehicular emissions and pollution but also to reduce traffic congestion and to meet the travel demands of the city dwellers.

A quality public transport is necessary but only it is not sufficient for Dhaka. Use of car and small occupancy vehicle must be restricted. Higher frequency of bus service is necessary to reduce the waiting time of passengers. New bus route designing, increasing the number of buses and introducing buses in different routes as per demand, appropriately locating the stops to improve their coverage area are needed to improve the bus service situation. Bus links among different nodes should be as straight as possible and bus stops should be within walking distance. These efforts will lead to a sound public transport service and also meet the increasing travel demand of Dhaka City.

There is a need for less expensive technology and consideration of more appropriate ways of addressing the transport problems of Dhaka. Experience in Bogota and Cruitiba demonstrates that BRT can be a viable solution with low cost in the cities around the world struggle with exploding populations of people and cars, insufficient transport supply and traffic management. The major advantage of BRT is that it is a decidedly cheaper option compared with other mass transit system. While the (elevated) metro costs an astronomical Rs 100 crore/km, the bus system works out to just Rs 6 crore to 10 crore/km in Delhi. The special buses are available for about Rs 35 lakh. The cost of travel is also considerably lower at Rs 1/km. Experience reveals that transport related accidents have dropped in the cities where BRT has been implemented. Therefore, BRT systems could be the first choice of transport options for Dhaka City. The BRT system provides a faster, higher quality service than existing buses, and can attract passengers. With level boarding platforms at BRT stops, getting on and off express buses will be easier, faster, and safer. Fewer buses are needed to handle the same transit passengers; and the buses are properly maintained and cleaner than traditional buses. However, Hook (2004) mentioned many of these measures can be implemented without BRT but BRT creates an opportunity to negotiate a better deal for bus passengers and air quality.

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