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EFFECTS OF ALTERNATIVE TRANSPORTATION OPTIONS ON CONGESTION AND AIR POLLUTION IN DHAKA CITY

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ABSTRACT: Transportation serves as channel for economic development of a country. Development of transportation facilities involve huge amount of resources and time. Also, in most the cases transportation investment are irreversible. To satisfy the future demand and maximize the benefit of investment in this sector, elaborate planning is deemed necessary. One of the major tasks of planning process is to assess future demand and comprehend the impacts of alternative decisions. This paper presents an assessment of future traffic demand and traffic related air pollution situation in Dhaka City. It also evaluates the impacts of alternative transportation options on traffic congestion and air pollution. The options examined in the study include banning of rickshaws and autorickshaws from the major roads of the city, improvement of bus service, bottlenecks and missing links in the road network of the city, and introduction of rail transit system.

KEYWORDS: Traffic Demand, Congestion, Air Pollution Impact.

INTRODUCTION

Cities act as prime movers of economic growth of any country. Bartone et al. (1994) suggest that about eighty percent of GDP growth in developing countries is expected to accrue from cities. Urban transportation system facilitates movement of goods and passengers which is essential for economic activities. When transportation system is unable to maintain a satisfactory level of service, several problems arise including congestion, delay and consequent emission of pollutants. In most cities, particularly in the developing countries, authorities often fail to cope with the pressure of increasing population growth and economic activities, causing uncontrolled urban sprawl, traffic congestion and environmental degradation. With growing population and diversified land-use activities, transportation system needs to be updated and readjusted regularly, which requires forecasting of future demand as well as identification of the most suitable solution among different alternative options. Also, development of any transportation facility requires substantial amount of time. Due to the large time lag between design and operation phases of transportation facilities, the changes in demand scenario during this period are required to be considered in the design.

One of the major reasons of urban dilapidation is the inability to understand the underlying factors causing the problem, which is particularly true for transportation system. To cope with the rapidly

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increasing transportation need, it is imperative to ensure proper use of available facilities and develop infrastructure ensuring optimum utilization of resources through proper planning. Comprehensive planning considering future demand and consequences of all the alternative options provides the best possible solution of the problem satisfying the constraints of resources. It is particularly true for developing countries like Bangladesh because of severe scarcity of resources.

Dhaka city, the capital of Bangladesh, accounts for more than twenty-five percent of gross national production of the country. With a population of about 10 million, which is increasing at about 7% per year, and population density of more that 20,000 per square kilometer, it has already become one of the most densely populated cities in the world. Severe traffic congestion is ubiquitous in the city. Also air pollution situation is among the worst in the world. To overcome the problem a wide range of solutions are being proposed by the experts. In most cases the solutions are provided on the basis of subjective evaluation thereby lacking objective measurement. Objective evaluation is imperative for judicious decision making. Traditionally, the objective evaluation is provided on the basis of transportation models. Unavailability of such models for Dhaka City is one of the major reasons of sluggish planning efforts in transportation and urban planning of the city.

This paper describes the development of a transportation planning model of Dhaka City and assesses of future transportation demand and traffic congestion and environmental consequences. It also analyzes the consequences of a few alternative solutions of transportation and environmental situation of the city. The alternative solutions analyzed in the paper include banning of rickshaws and autorickshaws from the major roads of the city, improvement of bus service as well as bottlenecks and missing links in the road network of the city, and introduction of rail transit system.

TRANSPORT SYSTEM AND TRAFFIC OF DHAKA CITY

Transport system of Dhaka is mainly road based. The road network basically determines the accessibility to the different locations of the metropolitan area. The road network of Dhaka city is composed of 199 kilometer of primary roads, 109 kilometer of secondary roads, 152 kilometer of collector roads, and about 2540 kilometer of access roads and others (Habib, 2002; Quium, 1995). With the exception of some planned residential areas, in most areas the roads are narrow and poorly aligned. At present all intersections are at grade intersections and major intersections are controlled either manually by traffic police or by traffic signals. At present two flyovers at Khilgaon and Mohakhali intersections are under construction and some others are proposed for construction at Jatrabari, Moghbazar, Malibagh, and Sonargaon intersections. The road network of the city has never been planned specifically in cognizance with the well-developed process of transportation planning. As a result, an irregular pattern of network, rather than a more efficient pattern such as grid or redial-circumferential pattern, has evolved (Ahsan, 1990).

Metropolitan Dhaka has traditionally been served by a wide variety of transport modes. These modes can be broadly classified into two groups, the Motorized transport (viz. bus, mini-bus, truck, car, auto-rickshaw, auto-tempo, motorcycle, etc.) and Non-motorized transports (viz. rickshaw, rickshaw van, bicycle, push cart, etc.). Estimation from the data provided by Statistical Year Book of Bangladesh (BBS, 2001) reveals that the motor vehicle fleet in Bangladesh is growing at an average rate of 7% per year. DUTP (1998) suggests that the vehicle population on road is growing at an average rate of 10% annually. Estimate of different types of vehicle population are shown in Table 1, which is based on annual vehicle registration information from Bangladesh Road Transport Authority (BRTA).

Table 1. Estimated number of motor vehicles

Vehicle Type	Year 1996			Year 2003	
	Whole Country	Dhaka		Whole Country	Dhaka
		Number	%		
Car	98,854	23,241	24	1,54,70 0	41,500
Jeep	30,597	12,705	42	42,800	20,000
Bus/Minibus	30,428	3,610	12	43,500	5,800
Trucks	48,734	3,858	8	72,800	6,500
3 Wheelers	79,293	27,443	35	1,19,50 0	16,500
2 Wheelers	1,96,012	40,127	20	3,11,00 0	69,500
Total	4,83,918	1,10,984	23	7,44,30 0	1,59,8 00

Source: BBS (2001), and DUTP (1998)

Reliable estimate of non-motorized vehicle fleet is more difficult to obtain. Dhaka City Corporation (DCC) limits the number of license issued to rickshaw owners to about 70,000. However, unofficial estimates claim that the number of rickshaws plying in Dhaka city is more than three times the figure mentioned above (DUTP, 1998).

ROAD TRANSPORT MANAGEMENT IN DHAKA CITY

Dhaka has a multi-modal transport infrastructure, which caters to the needs of intra-city and inter-city passenger and freight traffic. Most of intra urban traffic is handled by road based transport system. Rail, water, and air transport system primarily cater to the inter-city travel.

Although water transportation is involved in peripheral movement in certain parts of the city, its role in urban transport is insignificant. The agencies that are involved in providing, operating and maintaining transport infrastructure and services in the city include Dhaka City Corporation (DCC), Bangladesh Road Transport Corporation (BRTC), Bangladesh Road Transport Authority (BRTA), Dhaka Transport Coordination Board (DTCB) and Traffic Police.

Evidently, government agencies are the main provider of transport infrastructure and services. Two major factors have contributed to such a situation: the relatively high investment requirement and high-risk involvement in the provision and management of infrastructure. Consequently the private sector had been discouraged from entering into this area. But the scenario has changed dramatically in the past two decades and private bus services have become the backbone of mass transit system of Dhaka city. In the case of transportation services, government exercises control through regulatory mechanisms of vehicle registration, fitness check, route permits, and price level fixation in order to protect people from being exploited by the private operators.

TRAVEL CHARACTERISTICS OF PEOPLE OF DHAKA CITY

According to DITS (1993), on an average transport expenditure of people of Dhaka is around 12% of total household monthly income. Expenditure on transport services in Greater Dhaka, based on Household Interview survey (DITS, 1993), is about Tk. 1,100 crore (US$ 280 million) annually.

A wide variety of transport modes are available to meet the travel needs of the people of Metropolitan Dhaka. Table 2 provides a summary of trips in Dhaka by different modes of travel. According to DUTP (1998), on the basis of number of trips, walking is the dominant mode with a modal share of 60 percent, which is followed by rickshaw (19%). However, in terms of passenger-kilometer travel, bus travel dominates carrying about 46 percent of the total travel length, which is followed by rickshaw (16%), walk trips (12%), and private car (8%). Monayem (2001) suggests that the role of tempo is relatively insignificant constituting about 5 percent of the total trip length. With respect to passenger-kilometer, among the motorized transport in Greater Dhaka buses carry the largest volume with about 20 million passenger-kilometers per day while motorcycle runs the lowest volume (35 thousand passenger-kilometers). On the other hand, among non-motorized transports, rickshaws contribute the highest average passenger-kilometers per vehicle per day (115 kilometers), and bicycle runs the lowest average passenger-kilometers (16 kilometers). Again, if only mechanized transports in central metropolitan area of Dhaka are considered, bus carries the highest passenger-km per day comprising about 39.8% of total passenger-km while car carries the lowest passenger-km (11.9% of total passenger-km). Hoque and Alam (2002) reports that rickshaw shares 40% to 45% of total vehicular-trips which is followed by bus, auto rickshaw and car sharing 27%, 15% and 10% of the trips, respectively.

Table 2. Metro-Dhaka: Person trip by modes

Mode	No. of Person Trips		Avg. Trip Length per Day (km)	Passenger – km	
	'000/day	%		'000/day	%
Car	576	4.0 (10.5)	10.4	5,990	11.9
Bus	1,482	10.2 (27.0)	13.5	20,007	39.8
Auto Rickshaw	845	5.8 (15.2)	12.8	10,816	21.6
Rickshaw	1,927	13.3 (35.0)	4.3	8,286	16.5
Others	675	4.7 (12.3)	7.5	5,066	10.1
Subtotal	5,505	38.0 (100)	9.1	50,165	100.0
Walk	9,000	62.0	1.0	9,000	(15)
Total	14,505	100	4.1	59,165	(100)

Source: (Hoque and Alam, 2002)

METHODOLOGY OF ANALYSIS

For the purpose of analysis, a transport-planning model has been developed. The overall structure of the model is congruent with the traditional four stage modeling framework in terms of the sequence of the structural form which includes Trip Generation and Attraction, Trip Distribution, Modal Split and Trip Assignment steps. The model incorporates both supply and demand side variables, which facilitates investigation of a wide range of plans. The general structure of the strategic model is shown in Fig. 1.

The demand for travel varies by person-type in terms of socio-economic variables like income, employment opportunities, residential and educational facilities, etc. The developed model has the ability to correlate travel demand with socio-economic variables endogenously. On the other hand, effects of transportation system variable are considered in terms of travel time, cost, comfort, etc. Any change in the network layout, capacity and service availability is reflected through these variables. The basic components of the model are described below and illustrated in Fig. 1.

- Trip generation and attraction: Estimates trip generation and attraction volume on the basis of zonal population, employment, income, etc. Systematic category analysis approach is used for this purpose.
- Trip distribution: Estimates the OD matrix using synthetic gravity model on the basis of generalized cost considering time, cost and

comfort in addition to trip generation and attraction factors. The parameters of the model are endogenously calibrated to fit to the existing pattern of trips.

- Modal split: Logit choice model is used to estimate modal share. The model is calibrated using data of personal interview survey (Jaigirdar, 1998).
- Trip assignment: 'User Equilibrium Trip Assignment Technique' is used for route choice to estimate the traffic volume on the road links.

In order to obtain the equilibrium solution, the model is iterated until satisfactory equilibrium point is reached (Alam, 1992). For the purpose of analysis, the study area is divided into 90 Transportation Analysis Zones (TAZ), which correspond to the administrative zones called wards. Such a zoning system facilitates utilization of secondary data.

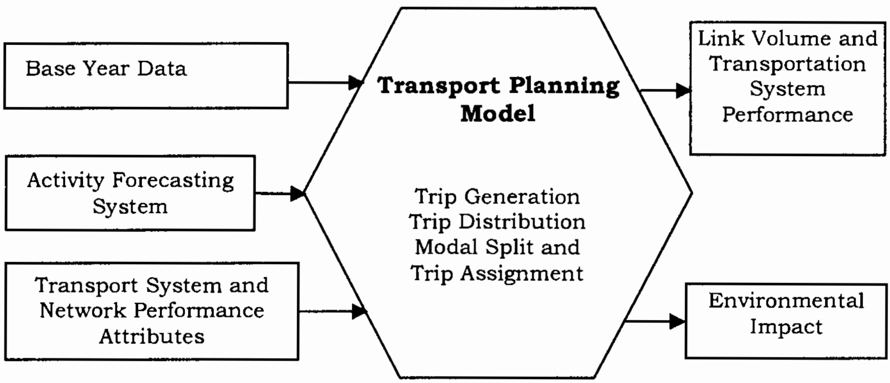

Fig. 1. Overall Structure of Transportation Planning Model

ANALYSIS OF TRANSPORTATION DEMAND

Utilizing the model described above, future transportation demand is analyzed under "business as usual" situation, which serves as the base for different estimates. The increase of transportation demand is assessed considering the current growth trend in population, economic activities and transportation supplies.

With increasing population, demand for travel also increases. The travel demand is normally expressed in terms of Vehicle-Kilometer (veh-km) travel and Vehicle-Hour (veh-hr) travel. Total veh-km travel provides information regarding the travel need but total veh-hr travel includes transportation system deficiencies with the travel demand. The changes in population and travel demand during peak period with time are shown in Fig. 2. Total peak period demand, in terms of vehicle-km per day, will increase by 76 percent from 1.35 million veh-km in 2002 to about 2.37 million veh-km in 2020. On the other hand, the total peak period traffic demand, in terms of veh-hr per day, will increase by more than 300 percent from 0.06 million veh-hr in 2002 to 0.25 million veh-hr in 2020. Although both the measures demonstrate exponentially increasing tendency, total veh-hr travel demand increases at a higher rate total veh-km travel demand. Such trend indicates transportation system supply deficiency. With increasing demand, the traffic volume in different road links approaches the capacity and consequently congestion incurs. Traffic congestion consumes extra time and results in higher order increase rate of veh-hr travel demand.

IMPACT ON VOLUME-CAPACITY RATIO AND AVERAGE SPEED

With increasing travel demand, transportation network performance deteriorates, which is demonstrated by reduced average speed and increasing volume-capacity ratio. As shown in Fig. 3, in the base year of 2002 more than 60 percent of total road ways of the network remain congested, carrying traffic with volume-capacity ratio greater than 1.25, and 47 percent of total road length of the network carry traffic with average speed bellow 15 kilometer per hour during peak period. However, 51 percent of this 47 percent (24 percent of total) carry peak period traffic with average speed less than 5 kilometer per hour. In 2020, the volume of congested road is likely to increase to about 85 percent, and the proportion of roadways having average speed of less than 5 km per hour is likely to increase to 60 percent of the total roadways.

IMPACTS ON AIR POLLUTION

The urban transportation activities affect the environment mainly in term of air pollution. In this study, motor vehicle emissions of SOx, NOx and CO during peak hour have been estimated. The emissions during peak hour of different years are shown in Fig. 4. At present the average peak period emission rates of SOx, NOx and CO are 0.26, 0.79 and 13.44 ton per hour, respectively. If no measures are taken to improve the situation by 2020 the emission rates of SOx, NOx and CO is expected to increase to 1.25, 4.11 and 61.68 ton per hour, respectively, during the peak period.

ALTERNATIVE PLANNING OPTIONS AND THEIR CONSEQUENCES

A range of opinions exists regarding solutions of the traffic problem of Dhaka City, which includes measures regarding network improvement, traffic management, and mass transit. In this study, the consequences of a few of such measures are analyzed with respect to their impacts on traffic congestion and air pollution. The measures analyzed include elimination of rickshaw and autorickshaw from major roads of the city, improvement of bus service, minor improvements of the road network of the city network, and introduction of specific rail corridor.

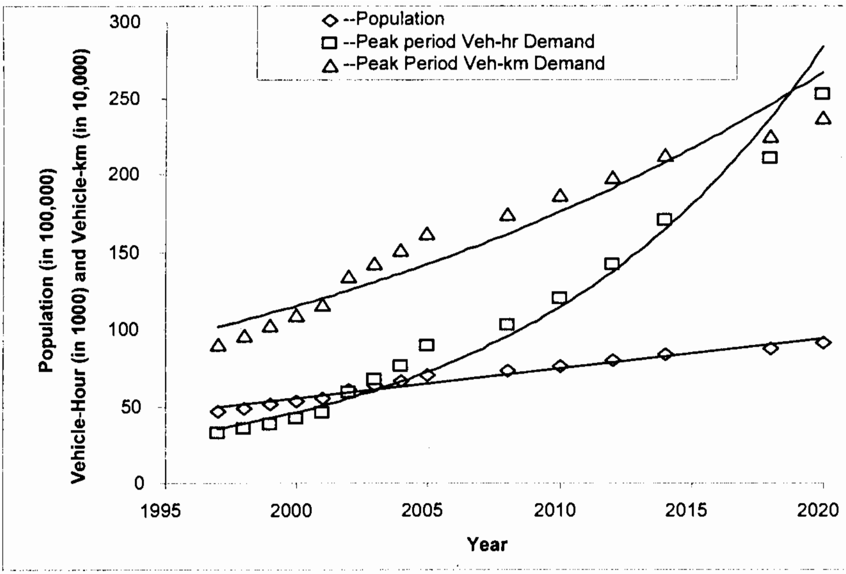

Fig. 2. Changes in peak period travel demand and population with time

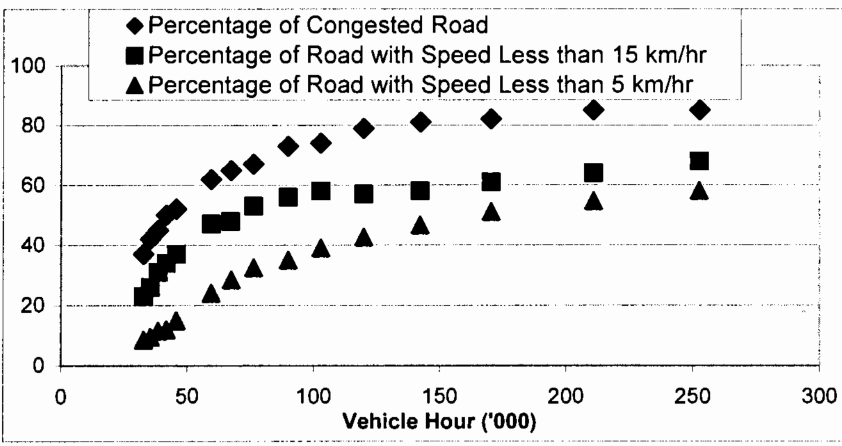

Fig. 3. Impact of travel demand on congestion

The results of the analysis suggest that elimination of rickshaw from major roads will reduce the percentage of congested roadways carrying peak hour traffic with volume-capacity ratio greater than 1.25, from 47% to 14% in 2002 and from 85% to 61% in 2020. It reduces the percentage of total roadway length carrying peak hour traffic with average speed less than 15 kilometer per hour, from 62% to 21% in 2002 and from 68% to 46% in 2020. Elimination of rickshaw will also result in reduction of pollutant emission by about 30 percent in 2010 and 55 percent in 2020. But it would result in the increase of demand for bus and car by more than 50 percent and 25 percent, respectively.

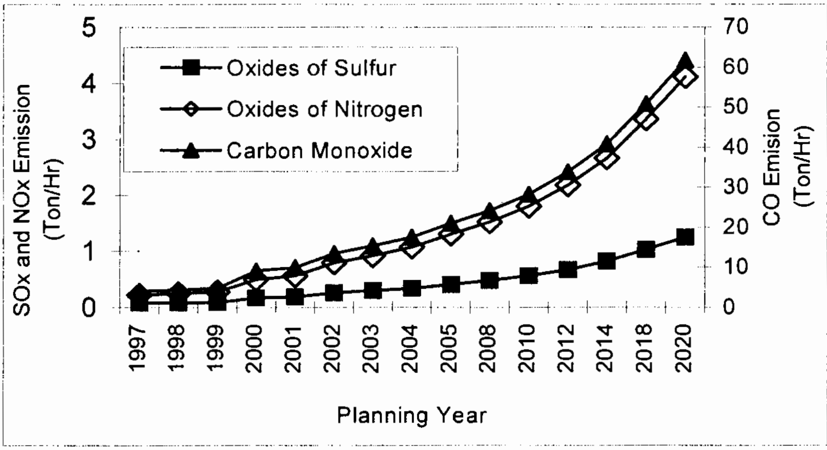

Fig. 4. Changes of emissions per hour during peak period with time

The analysis suggests that elimination of autorickshaw will have negligible impact on congestion but the impact on air pollution will be significant. It reduces congestion by about 8 percent and air pollution by about 30 percent. On the other hand, due to the elimination of autorickshaw, the demand for bus and car will increase by 20 percent and 10 percent, respectively.

In this study it is observed that substantial increase in the demand for bus services can be met by increasing the overall speed of the service. With only 2% increase in average speed of bus, modal share of bus increases by 6.70%, and peak period network average delay per kilometer travel, volume-capacity ratio and air pollution reduces by 5%, 5% and 4%, respectively.

The results also suggest that a few bottleneck points and missing links in the road network of the city exists. For example, elimination of bottleneck at Moghbazar intersection and opening of the roadway through Pilkhana would reduce city wide traffic congestion by about 8 percent and air pollution by about 6 percent which is mainly caused by the change of routes.

In case of rail transit option, it is proposed to utilize the existing rail line from Uttara to Kamalapur for commuting purpose. Results suggest that in the short run such rail transit system will increase the average speed of airport road by about 6 percent. To optimize its benefit, it is required to facilitate access modes to support rail transit system. Moreover, the introduction of such a system will cause changes in land use pattern, the effect of which will be evident in the long run.

CONCLUSIONS

Model based analysis of demand scenarios and consequences of alternative options play a significant role in the planning process. In this paper the future demand for transport facilities in Dhaka City has been analyzed. It is observed that in the next 15 years population of the city will increase by 50 percent with an increase in travel demand by about 70 percent and congestion by 250 percent. By 2020, it is anticipated that during the peak hours about 60 percent of the major roads will become highly congested with a speed of less than 5 km/hr.

In the study several alternative transportation options were evaluated to assess their impacts on congestion and air pollution of Dhaka City. Results suggest that banning of rickshaw and autorickshaw have the potential to improve the situation. However, in order to keep mobility at the current level it is required to increase the number of buses and cars by about 50 percent and 25 percent, respectively. Measures to improve modal share of buses were found to be highly cost effective and overall speed of the service found to be the most sensitive attribute. Speed can be improved by reducing waiting time at the bus terminals. This can be achieved by reducing the number of operators of bus services in the city through development of cooperatives, and allocation of specific space for each cooperative at the terminals. It was also observed that a significant benefit could be achieved through improvement of the bottleneck points and missing links in the road network of the city. With respect to rail transit, ancillary facilities such as access mode are required to be introduced in order to materialize its potential. Also analysis suggests that benefit of rail transit will be more evident in the long run through the changes in land use pattern.

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