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Development of Non-Motorized Transport as a Sustainable Initiative

Dr. Purnima Parida, Dr. M Parida and Dr. Najamuddin

Abstract

Non-motorized modes include trips made by walk, bicycle and cycle rickshaw. These modes are essential part of the sustainable and suitable transport modal mix on consideration of energy, self reliance, environmental concerns, affordability, employment and safety. The important issues are those of giving due recognition to the Non-Motorized Transport (NMT) in planning, policies, investments, transport and traffic management, institutional structures and regulatory procedures. The present trend in the developed countries of encouraging non-motorized modes is a learning experience for the developing countries. The future transport system to be developed should have a blend of transit modes and NMT, but with a major role assigned to non-motorized transport.

1. INTRODUCTION

If transport is to become sustainable so that it does not harm the environment or use resources that cannot be replenished, there have to be more public transport, more walking and bicycling. Half of the effort towards achieving sustainable transport would come from technological improvements of cars and trucks, fuels and infrastructure. Half would come from making transport smarter by using vehicles more efficiently (fewer empty vehicles, and cars carrying just one person), by shortening journeys (more compact towns and cities and more local production) and by enhancing the role of non-fossil fuel dependent transport modes. A sustainable transport system should provide access to people, places, goods, and services in an environmentally responsible, socially acceptable, and economically viable manner. Mobility for communication and for enabling social contacts as well as movement of people and goods is to be considered as a means rather than as an end in itself.

India is the second largest populated country in the world. The total urban population of India burgeoned over the past five decades. In 1951 the population of the country was 360.11 million, which has increased to 1,027 million in 2001. In the year 2002, 58.8 million vehicles were running on Indian roads. The annual rate of growth of motor vehicle population in India has been about 10 percent during the last decade. The issue is not the number of vehicles in the country but their concentration in a few metropolitan cities. It is alarming to note that 32 percent of these vehicles are plying in metropolitan cities alone, which constitute about 11

***Dr Purnima Parida**, is Senior Scientist, TPE Division, Central Road Research Institute, New Delhi.*
***Dr. M Parida**, is Professor, Civil Engg. Department, Indian Institute of Technology, Roorkee.*
***Dr. Najamuddin**, is Professor Emeritus, Architect and Planning Department, Institute of Technology, Roorkee.*

percent of the total population. During the year 2000, more than 6.2 million vehicles were plying in mega cities (Mumbai, Delhi, Kolkata, and Chennai) alone, which constitute more than 12.7 percent of all motor vehicles in the country. Interestingly, Delhi, which contains 1.4 percent of the Indian population, accounts for nearly 7 percent of all motor vehicles in India. Economic growth has brought about a spurt in vehicle ownership and the fast pace of urbanization has led to tremendous growth in urban traffic. While vehicle ownership has increased 125 folds in the last 50 years during the same period road infrastructure has expanded only four times. The growth of road length, vehicles and population in India, since 1951, is given in Table 1. The widening gap between supply and demand has manifested itself in many forms of increased traffic congestion, increased air and noise pollution, accidents, delays and subsequently wastage of Fuel.

Table 1 Growth of in Population and Transport Sector in India

Year	Population (million)	Vehicular Growth (Million)	Road Length (Million–Km)
1951	360.1	0.3	0.4
1961	430.9	0.7	0.7
1971	548.2	1.9	0.9
1981	683.3	5.3	1.5
1991	846.3	20.3	2.0
2001	1027.0	46.0	3.4

2. ENVIRONMENTAL CONCERNS OF URBAN TRANSPORT

Urbanization has a strong interrelationship with the travel demands in the country. Higher incomes, mobility, expanding cities and the proliferation of employment centers have increased the demand for motorized transport, resulting in a disproportionately high concentration of vehicles in urban centers. Consequent to the boom in automobiles in the urban areas the pollution level in the air has gone up. A study by Central Pollution Control Board reveals that the air pollution share of transport have gone up from 20 percent to 70 percent in the last four decades. The frequent traffic jams, increase in idling time of vehicles at intersections aggravate the pollution levels further. The contribution of motor vehicles on total pollution in Delhi has increased from 23 percent in 1970-1971 to 63 percent in 2000-2001. Cars and two-wheelers contribute to 11.5 percent and 77.7 percent of the total transport related air pollution. The largest share of transport activity is by road. Road transport is responsible for over 80 percent of fossil fuel energy consumption and responsible for around 64 percent of the total air pollution load.

A Nationally Coordinated Project on Urban Transport Environment Interaction was undertaken at Indian Institute of Technology, Roorkee for studying traffic noise and air pollution at identified locations in the major cities of India (Delhi, Jaipur, Allahabad, Chandigarh and Lucknow) and to analyze the trend of various air pollutants and noise pollution. Air pollution parameters measured were Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), and Suspended Particulate Matter (SPM).

Observed values of 24 hour average pollutant concentrations for a few locations in Delhi are given in Table 2. Sulphur dioxide levels are within prescribed limit.

Table 2 Pollutant Concentrations at Selected Locations in Delhi, 2002

S No.	Locations	Pollutant Concentration (mg/m^3)		
		NO_X	SO_2	SPM
1.	Ashram Intersection	93.9	14.87	942.0
2.	DPS, Mathura Road	88.42	15.05	1064.0
3.	Jan path	63.67	12.3	949.24
4.	NOIDA Intersection	103.67	15.8	898.4
5.	Sarita Vihar	121.29	17.3	1026.0
6.	Nehru Place	76.57	16.9	1379.38
7.	Moolchand	89.08	17.8	1141.5
8.	RML Hospital	43.91	9.16	773.0

Table 3 Traffic and Pollution Levels For 2021

Year	Traffic	Noise (dBA)	Air Pollution (CO) (ppm)	% increase in Sound Pressure Level (SPL)
2001	6284	78.61	3.7	—
2011	9426	82.62	4.5	58
2021	14139	84.81	5.8	104

Locations with high traffic density experienced Nitrogen dioxide and SPM levels above the prescribed standards. Increased share of personalized vehicles and their absolute growth is a big challenge to different initiatives for improving transport infrastructure and reduce environmental pollution.

Using the traffic noise and air pollution models projections were made for a sample location in Delhi as given in Table 3. In the absence of appropriate mitigation strategies, vehicular pollution is likely to further deteriorate the ambient air quality in the country.

Vehicular pollution is responsible for a number of respiratory and other diseases. All over India, especially in metropolitan cities, people are suffering from different types of diseases as a result of vehicular pollution. Continued exposure to high levels of noise results in annoyance, fatigue and temporary shift of hearing may lead to permanent loss of hearing. There is increasing evidence that noise exposure causes physio-biological disturbances like changes in digestion, metabolism, blood circulation etc.

3. ENERGY LOSSES

Road transport is the backbone of economic development of India and meets the 75 percent of transport demand. Transport is the fastest growing energy sub-sector. The transport sector is the second largest consumer (50 percent) of commercial energy. It ranks first in the consumption of petroleum energy, consumes almost entire amount (98 percent) of the petroleum product in the form of petrol and diesel. Usage of petroleum energy in transport grew at 1.3 percent annually during 1971-1981; it has grown at 6-7 percent annually during 1991-1999, transport energy demand has grown at 1.2 times the GDP growth rate. Transport sector is the highest consumer of the fossil fuels but unfortunately the higher guzzler of the same. The usage is high due to the alarming increase in travel demand and growth of vehicles. The vehicle owners have to overcome congestion and delay on roads. There is considerable loss of fuel due to idling of vehicles at the traffic intersections, which results in increase of operating cost and wastage of precious fuel.

Central Road Research Institute, New Delhi conducted studies to estimate the fuel loss on a corridor and at the total signalized intersections of Delhi, the capital of India. The study results indicated that on a stretch of 1 kilometer at Chelmsford road connecting New Delhi Railway Station and outer circle of Connaught Place - a Central Business District, 66,000 vehicles ply in a day, on an average running speed of 18.60 km per hour. Stopped delays were observed to be as high as 158.82 second per vehicle. The low running speed and delay accrue a fuel loss of Rs.23,843,231 and Rs.7,180,694 annually.

At 600 signalized intersections of varying traffic volumes, 135 million Kilograms of CNG, 47 million Liters of Diesel, and 147 million Liters of Petrol worth Rs.9,945 million is being wasted during idling of vehicles waiting for green signal.

4. SUSTAINABLE STRATEGIES

Moving people and freight in an environmentally sustainable manner will be one of the biggest challenges for the 21st century. The first ever national urban transport policy of India (NUTP) puts it bluntly, "the use of cheaper non-motorized modes like cycling and walking has become extremely risky, since these modes have to share the same right of way with motorized modes. With each passing day the pedestrians and the non-motorized mode of transport are eased out of the system. In developing cities, average trips distances are extremely short. Often over 60 per cent of trips are less than 3 km long. In well planned German cities for example, over 80 per cent of trips less than 3 km would be made by walking or bicycling. According to GTZ in Bogotá for instance in 1998, 70 per cent of the private car trips were less than 3 km. Closer home, in Mumbai 57 per cent of work trips are 3 km or less. There is thus a tremendous scope for enabling this mode of transport. In fact the modal share of walking and non-motorized trips is higher than the private mode of transport for almost all the major Indian cities. In spite of the fact that non-motorized modes as a mode of commuting, constitutes such a high percentage in these cities, the government has no policy for enabling these modes of commuting.

4.1 Reinforcing Pedestrian Infrastructure

Increase in modal share of public transport increases walk trips. The basic objective of augmentation of public transport remains defeated until and unless a good network of pedestrian infrastructure is also developed. The explosion in popularity of the automobile in the last 50 years has shifted the focus of street design from pedestrian traffic to automobile traffic. The Five Year Plan outlays which are not sufficient are utilized in providing infrastructural facilities to more than 50 million vehicles and the safety of one billion pedestrians has got a back seat. In comparison to huge walk transport demand, pedestrian facilities in Indian cities are grossly inadequate. Lack of pedestrian facilities in Indian cities culminates in a high rate of pedestrian fatalities. The number of fatalities has increased from 15,000 in 1971 to about 1,00,000 in 2004. Nearly 50 percent of the road accident victims are pedestrians'

.The need of the hour is to recognize and encourage the most primitive mode of transport. To promote walk trips adequate pedestrian facilities need to be provided. If some of the motorized short distances trips can be made into walk trips it will go a long way in improving the economy and environment quality. Instead of considering the side walk network as a mere strip of concrete some human aspect also need to go into it by adding the qualitative attributes like safety, walk environment and comfort.

To promote the walk trips as well as provide adequate pedestrian facilities the preferences and perceptions of the pedestrians have to be understood and included in the design methodology for pedestrian facilities. A study was formulated, to understand the sidewalk attributes that affect the walking experience of the pedestrians in Delhi. For qualitative evaluation of pedestrian facilities a proforma was designed using rating scale concept. Ten parameters were identified to be included in the questionnaire. Six parameters were pertaining to the physical evaluation of the sidewalk facility, which included sidewalk width, sidewalk surface, obstruction, encroachment, potential of vehicular conflict, and continuity. The four user factors were pedestrian volume, safety, comfort and walking environment. Pedestrians were asked to rate both the importance (how important good performance is to them) and performance (indicating 'bad' or 'good' condition) on a five-point scale. For quantitative evaluation of sidewalks videography was carried out for sidewalks and later Speed Density, Speed Flow and Flow Space models were developed. Using these models levels of service parameters have been evolved for sidewalks in Delhi. Quantitative as well as qualitative level of service models were used to estimate level of service for five identified location as given in Table 4. A comparison of level of service for all the five locations indicates that quantitative LOS is always higher than qualitative LOS. Quantitative LOS model tend to neglect the effect of subjective sidewalk attributes such as walk environment, safety, comfort, etc. This comparison indicates qualitative service models are more efficient in evaluating sidewalk facilities in terms of large number of attributes, being policy sensitive and taking cognizance of human factors. Developing design methodologies with user perception shall be useful in creation of pedestrian infrastructure that can receive appropriate patronage and enhance modal share for walk trips.

Table 4 Comparison of Quantitative and Qualitative LOS for Sidewalks

Location	Footpath Width	Peak Flow	Quantitative LOS	Qualitative LOS
Ashram	2.5	792	A	C
ITO	5	1992	A	A
CP	4.5	4298	C	B
ISBT	1.4	1651	C	D
AIIMS	2	1462	B	D

4.2 Non-Motorized Modes of Transport

There are 65 million cycles, 85 million draft animals, 15 million carts, 3.2 million pack animals and 5 million rickshaws in India. Nearly 10 million cycles are produced

annually as against over 2 million motorized vehicles. As cities grow in size, NMT remains relevant but its role shifts towards shorter lead and feeder services and providing access to public transport. Motorized transport is capital intensive, import oriented, environmentally hazardous and needs enormous investments in infrastructure. In contrast non-motorized transport which is labor intensive, indigenous, and benign to environment and can do with much lower cost in infrastructure besides its inherent qualities like non-fuel dependent and non-polluting makes it environment friendly and does not put any burden on the exchequer is a far more sustainable transport system.

In the US in early 1970s, bicycling underwent a renaissance and the country faced its first oil crisis, bicycling received a lot of attention not only as an attractive recreational activity, but as a viable commute alternative. USEPA calls them the Transportation Control Measures (TCM). Bicycle and pedestrian programs are one type of transportation control measure (TCM) which can be used to reduce air emissions associated with transportation Each trip shifted from a single occupancy vehicle to a bicycle or to walking results in a 100 percent reduction in vehicle emissions for that trip bicycling and walking realistically can substitute for relatively short trips which make up approximately 60 percent of all trips (i.e., generally less than five miles in length)Although the amount of saved vehicle miles traveled (VMT) may be small, the air emissions benefits can be quite large because cold start and hot soak emissions comprise a large proportion of emissions from a vehicle trip According to USEPA cold start and hot soak trip-end emissions comprise 75 percent of a 5-mile auto trip, 61 percent of a 10-mile trip, and 45 percent of a 20-mile trip of the vehicles total emissions.

Continuous improvement of pedestrian, bicycle and such other facilities assures the NMT users about government sincerity in its promotion. Delhi had a Master Plan 2001 covering 20 years period, accordingly to which a network of 5 major cycle paths should have been in position by 2001. But not a start has been made yet.

A flyover costs approximately Rs.30 crores and achieves precious little. This amount may suffice to provide a cycle track network for whole of Delhi urban area. The plans must include adequate network, parking and other ground facilities for non-motorized modes. In Delhi 57 percent of the journeys are estimated to be within 5 km, which can ideally be covered by NMT. Considering that average speeds of even motorized transport hardly exceed 15 km/h in Indian towns, time saving has little significance over distances up to 5 km.

4.3 Compact Land Use Arrangements

The development of neighborhood with compact land use arrangements with education, shopping and business located within acceptable distance for walking and bicycling should be a strategy. Also in this process the walking and bicycle facilities must be separated from motorized traffic to provide additional safety.

City size and its economic base are observed to have an appreciable impact upon the supply levels, spatial coverage, content and composition of intermediate public transport operation. Large metropolitan cities having organized public bus services exhibit localized use of the manually operated modes. In contrast to the above the manually operated IPT modes provide a wider coverage in small and medium sized cities. The level of intermixing of motorized and non-motorized modes in Indian cities is usually determined by human haulage, prevailing road network conditions and the level of public transport supply. However, it is common to observe considerably high volumes of cycles and cycle rickshaw operations even in metropolitan cities.

Most Indian cities, especially small and medium sized, have an extremely low area allocated for roads. Moreover, a large proportion of the road network is unsatisfactory in geometrics, riding quality and traffic regulations, thus leaving extremely limited routes and options for meeting the travel needs. The concentration of demand along a few selected corridors provides an ideal climate for IPT operations. NMT modes on account of their maneuverability in congested and poorly regulated traffic conditions offer a better level of personalized service to road users and are thus in certain cities / areas have become the main mode of travel.

Mass Rapid Transit System (MRTS) has become operational recently in Delhi. Land use in the proximity of metropolitan stations need to be restructured for enhanced ridership of MRTS. Compact land use development along metropolitan corridors shall be useful for the patronage of NMT modes, since they can act as affordable feeder service for the public transport system.

4.4 Restraints on Motorized Traffic

Restraining motorized traffic indirectly provides priority and preference to NMT modes in the traffic system operation. Through transportation system Management (TSM) techniques entry to congested areas and central business districts by motorized modes should be restricted permitting only public transport modes and non motorized modes. The motorized private modes should be taxed by way of road user charges and parking fee in the congested areas. Many case studies support this opinion that restriction on auto usage boosts patronage of walking, bicycling, rickshaw usage etc. In a project to promote better environmental quality around Taj Mahal (One of the Seven Wonders of the World situated in Agra, India) motorized traffic has been banned on all the approaches to this monument. At the same time battery operated buses, sufficient vehicle parking spaces, space for walking, bicycling has been developed around the monument to provide alternative modes of transportation. A careful mix of policies has been useful in promoting NMT around Taj Mahal. Implications of the above measures are quite conspicuous and resulted in pleasant walking experience around this heritage site.

In Indian Institute of Technology, Roorkee students are encouraged to use the NMT modes by not allowing them to keep motorized vehicles in the campus. It has gone a long way in keeping the accidents and environmental pollution at bay in the campus. Besides, it inculcates an affinity to use these modes. These examples can be replicated in other academic institutions Incentives to non-motorized users and disincentives for personalized motorized modes users can be worked out and implemented. These could be in the form of restricted access to motorized modes and closely located parking spaces for NMT modes.

4.5 Coherent Fare Policy

The NMT modes in India don't have a fare structure evolved by any designated authority as the other motorized IPT modes and public transport modes have. Therefore they tend to charge arbitrarily and indulging in haggling practices. This sometimes makes the users reluctant to use this mode. There is a need to evolve a fixed fare structure provided by local administration to avoid all these encumbrances and make the users feel that cycle rickshaw is also a conventional mode of transport.

5. CONCLUSIONS

Urban population in India is growing at a very rapid rate. Added to this the liberalization of economy has contributed to accelerated growth of socio-economic standards of urban residents. The result is increased demand for travel and this in turn requires transport infrastructure for smooth and efficient flow of traffic. Increasing number of metropolitan cities in the country has led to huge financial requirements for improving urban transport infrastructure. Delhi, the national capital, has witnessed unprecedented growth in automobiles. Last decade has witnessed a number of mega projects executed successfully. But still there is not much improvement in the overall transport scenario. There is a need to experiment with innovative ideas that can lead to sustainable transport development. Approaches that can minimize energy losses, enhance patronage of public transport and promote non motorized modes can pay great dividends in the longer run.

Institute of Town Planners, India Journal 6 - 4, 09 - 21, October - December 2009

Planning for Bus Rapid Transit System in Indian Metropolitan Cities: Challenges and options

H.S. Kumara

Abstract

India's transport system has not progressed alongside the extremely rapid growth of population and vehicular use. This has resulted in outdated transport infrastructure, uncontrolled suburban sprawl, sharply rising motor vehicle ownership and use, deteriorating bus services, a wide range of motorized and non-motorized transport modes sharing roadways, and inadequate as well as uncoordinated land use and transport planning. This article summarizes the present context of urban scenario, common transportation problems in Indian metropolitan cities, characteristics and historical development of BRTS, need for transportation alternatives in Indian metropolitan cities, followed by challenges, options and way forward.

1. INTRODUCTION

Growth of urban population has created serious challenges and imposed greater demand on the resources of municipal governments in India. Urban population in India has increased significantly from 62 million in 1951 to 285 million in 2001 and is estimated to be around 540 million by the year 2021. Another interesting phenomenon is constantly increasing number of metropolitan cities and their population. The number of metropolitan cities that is those with million plus population was only 5 in 1951 and by 1971, their number has jumped to 9; by 1981, the number of million plus cities increased to 12; by 1991, their number increased to 23; as increase of almost 100 percent from 1981 to 1991; and 2001 census, number of million plus cities has increased to 35. This number is expected to increase to 51 by the year 2021. The number of people living in Indian metropolitan as much as 107.88 million or 37.80 percent of the total urban population and this numbers are likely to grow in the coming years.

Rapid growth of India's metropolitan cities has generated a correspondingly rapid growth in travel demand, overwhelming the limited transport infrastructure. The sharply increasing levels of motor vehicle ownership and use, in particular, have resulted in alarming levels of congestion, air pollution, noise, and traffic danger. For most segments of the population, mobility and accessibility have declined. India's poor have been especially disadvantaged. They have such low incomes that they cannot even afford public transport fares and thus must walk or cycle long distances. In India's per capita income is almost Rs 40,000 per year, according to

***H.S. Kumara** has done Master's Degree in Development Planning and Master Degree in Urban and Regional Planning of University of Mysore, Karnataka. He has worked on Bangalore Revised Master Plan - 2015, City Development Strategies – Hubli - Dharwad, and presently working as Assistant Professor in Urban and Regional Planning, Institute of Development Studies, University of Mysore, Email: kumarahs@gmail.com*

the latest figures released by the World Bank. Indian Economy was ranked as fourth in the World. It is based on Gross Domestic Product, Purchasing Power Parity[1]. About 27.5 percent of the population lived below poverty line in 2004-2005 based on Mixed Recall Period Consumption (Planning Commission, 2007) roughly a fourth of urban residents cannot afford the basic necessities of life, including virtually any form of public transport or even a bicycle. The urban poor live in congested slums in older, deteriorating inner-city areas or illegal squatter settlements. Those living near the center suffer not only from overcrowded housing but also from high levels of air pollution, noise, congestion, and traffic danger. The poor living on the suburban fringe must endure ramshackle housing conditions, largely non-existent public services, and long, time-consuming trips to menial jobs in other parts of the city.

Problems of public transport occur within the broader context of demoralizing urban transport problems in general. Air pollution, noise, congestion, and traffic fatality levels are often much more severe than those experienced in the developed countries. Transportation and basic infrastructure systems have not kept pace with urban growth, further disadvantaging the poor. Road systems are piecemeal, grossly overloaded and under maintained, while the number of motorized vehicles increased at extraordinary rate (World Bank, 2001; Figueroa, 1996). Public transportation, which tends to be fragmented between public authorities and a myriad of private carriers, cannot extend too many of improvised settlements because the quality of roads is bad.

National Urban Transport Policy has emphasized on more equitable allocation of road space to people, rather than vehicles, greater use of public transport and non-motorized modes and reserving lanes and corridors exclusively for public transport and non-motorized modes of travel.

Transportation problems of Indian metropolitan cities are listed below:

- Unplanned, haphazard development at the suburban fringes without adequate infrastructure, transport, and other public services. The spatial growth differentials of Mega cities in India shows that, in case of Bangalore - growing core and declining periphery whereas in Delhi - declining core; growing periphery and rest of the four cities such as Greater Mumbai, Kolkata, Chennai and Hyderabad shows that declining core and periphery[2];
- Limited network of roads, often narrow, poorly maintained, and unpaved;
- Extremely congested roads with an incompatible mix of both motorized and non-motorized vehicles traveling at widely different speeds;

[1] World Development Indicators database, World Bank, 1 July 2008

[2] Census of India, Paper -2, Rural- Urban Distribution, Census of India, 2001 and Handbook of Urbanization in India (Spatial growth During 1991-2001).

- Rapidly increasing ownership and use of private cars and motorcycles;
- Inadequate roadway accommodations for buses and non-motorized transport;
- Primitive or non-existent traffic control and management, often without even the most basic street signage;
- Extremely high and rapidly rising traffic fatalities, especially among pedestrians and motorcyclists Non-motorized transport road user accounting for 60 to 80 percent and Motorized two;
- Wheelers comprises approximately 70 percent of all vehicles and constitute 20 to 30 percent of fatalities[3];
- Overcrowded, uncomfortable, undependable, slow, uncoordinated, inefficient, and dangerous public transport; and
- Extremely high levels of transport-related pollution, noise and other environmental impacts, especially in the metropolitan cities.

2. DEFINITION OF BUS RAPID TRANSIT SYSTEM (BRTS)

There is no precise definition of Bus Rapid Transit System. Wright (2005) defines it as a "bus-based mass transit system that delivers fast, comfortable, and cost effective urban mobility". In Levinson et al. (2003), it is defined as "a flexible, rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique image".

The 'Rapid Transit', which describes a high-capacity transport system with its own right-of-way, implemented using buses through infrastructural and scheduling improvements, to provide a high level of service. It incorporates most of the high-quality aspects of metropolitan systems without the high investments, it uses available space on arterial roads of cities with dedicated bus ways and it utilizes modern technologies for optimizing flow, passenger movement, ticketing, bus scheduling, and traffic signal priority. Bus Rapid Transit System as an approach to providing superior transit service with buses that integrate technology, an operating plan (or service design), and a customer interface.

2.1 Characteristics of the BRTS

- Physically segregated bus ways, it means separate lane is exclusively dedicated to Bus Rapid Transit System. The median and the inner most lane or the left most lane can be dedicated to the bus. In case of median lanes bus stops or stations can be built in the median to further improve the flow;
- Bus Rapid Transits system is on 'at grade level' so build easier access and comfortable and efficient high station platforms and shelters. Only BRTS buses have access rapid boarding and alighting, disability and user friendly;

[3] Dinesh Mohan, The Road Ahead Traffic Injuries and Fatalities in India, Indian Institute of Technology Delhi, April 2004

- Bus Rapid Transit is a relatively inexpensive mode and can be implemented more widely. In case of cost consideration for construction of BRTS approximately about 5-20 crores per km whereas in metropolitan rails about 125 to 220 crores per km;
- Gestation time for Bus Rapid Transit System is relatively short. Planning and construction of 18 km span of BRTS will take 1 to 3 years and in case of metropolitan areas it is about 3 to 5 years;
- Efficient fleet management and high passenger volumes - in case of Bogotá (Trans Milenio Phase 1+2a) about 1,020,000 passengers per day and maximum peak hour volume per direction is about 35,000 passengers per hour (including 2+2 lanes). Whereas in Curitiba about 530,000 passengers per day and maximum peak hour volume per direction is about 14,000 passengers per hour (1+1 lanes) and Quito(Trole) about 240,000 passengers per day and maximum peak hour volume per direction is about 8,000 passengers per hour (1+1 lanes)[4];
- High commercial speeds of bus operations notwithstanding at-grade intersections. The main reason for high speed is segregated bus ways, fare prepayment, high station platforms and express services. For example (commercial speeds including stops) in Bogotá express lines 32 km per hour, Bogotá all-stop buses 21 km per hour, Quito Central-Norte 20 km per hour and Curitiba19 km per hour respectively;
- Advanced Traveler Information System (ATIS) and Automatic tracking of buses;
- BRTS is look like a appearance with distinct identity and good image, choice of name new metropolitan type of buses and attractive stations along with optimized schedules and routes; and
- In BRTS commuters can only cross at the zebra crossings. Fatality rates will come down drastically. Experts observe that road based transport provides the most effective connectivity for residents.

3. HISTORICAL DEVELOPMENT OF BUS RAPID TRANSIT SYSTEM

3.1 BRTS in World

The first wide scale development of the Bus Rapid Transits started in Curitiba, Brazil in 1974, although there were several smaller scale projects prior to its development. Since then, Curitiba's experience has inspired other cities to develop similar systems. In the 1970s, development of BRTS was limited to the North and South American continent. In the late 1990s, the replication of the BRTS concept gained momentum and BRTS were opened in Quito, Equador (1996), Los Angeles,

[4] Gerhard Menckhoff, Urban Transport Consultant, Latin American Experience with Bus Rapid Transit, World Bank Annual Meeting–Institute of Transportation Engineers Melbourne, August 10, 2005.

USA (1999) and Bogotá, Columbia (2000). Especially, the TransMilenio project in Bogotá started operations in 2000 and its success drew attention from the world community as an example of the state of the art in BRTS. As of 2005, there may be up to 70 systems around the world, depending on one's definition of BRTS (Levinson et al. 2003; Ernst 2005; Wright 2005).

3.2 Bus Rapid Transit System in Asia

In Asia, prior to 2000, the experience of BRTS was very limited in number and scope. The systems in Nagoya, Japan and Taipei were regarded as relatively complete systems in the Asian region (Wright, 2005). The spread of BRTS in Asia has become more conspicuous since 2004. In 2004, the TransJakarta bus way was started along through the city centre (Hook and Ernst, 2005). On 1 July 2004, three BRTS corridors totaling about 37 km were installed as a part of Seoul's reform of its public transport system (Pucher et al. 2005). On 25 December 2004, the first stage commercial operation of BRTS was started in Beijing as a pilot line for 5 km (Chang, 2005). In Bangkok, the plan for BRTS was declared in 2004 by the newly elected governor of Bangkok Metropolitan Administration indicating that the first BRTS lines would be opened in October 2005. Although there was some confusion in Indonesia and Seoul when those lines were first introduced, the BRTS in Jakarta, Seoul, and Beijing has shown some success and those systems are under the process of expansion and upgrading. In contrast, the plan for BRTS in Bangkok has been delayed and has not been introduced yet, although rail and light rail expansion is underway. The number of cities looking at BRTS is rapidly increasing. In China, BRTS is longer than that in Beijing was officially opened in Hangzou in April 2006 (CAI-Asia, 2006b). According to a Website by CAI-Asia (2006a), BRTS are now planned or under construction in 18 cities and under consideration in 5 cities in Asia.

3.3 Bus Rapid Transit System in India

In India eight cities have started for getting approval and issuing of tenders for implementation. They are Delhi, Ahmedabad, Bhopal, Indore, Jaipur, Pune, Vishakhapatnam, Hyderabad and Nagpur. Ahmedabad, Indore and Jaipur have issued tenders in the last two weeks for Phase-I of BRTS. Pune has got the approval for BRTS and Bhopal is expected get a go ahead for the system soon. Proposals in other cities are at various stages of appraisal and implementation. The detail of Bus Rapid Transit System in each city has given in the Box1.

4. NEED FOR NEW TRANSPORTATION ALTERNATIVES IN INDIAN METROPOLITAN CITIES

4.1 Growth of Seven Metropolitan Cities

These metropolitan seven cities will experience dramatic increase in population and vehicular growth in 1991 to 2005. Population growth increased on an average

Box 1 Bus Rapid Transit System in Eight Metropolitian Cities

1. DELHI: Delhi with a population of 14 million (2001) is expanding and comprises an urban continuum including of a number of growing townships in Haryana and Uttar Pradesh. Phase one comprising seven corridors has been taken up for BRTS operations; this is a part of the transport plan that covers a total of 37 corridors comprising 500 km for road-based mass transit like BRTS, monorail and Light Rail Transit (LRT).

First contract for detailing 5 corridors in Delhi was awarded to TRIPP and RITES in 2003 and tenders were called in 2005. A Special Purpose Vehicle, The Delhi Integrated Multi-Modal Transport System (DIMTS), was formed in 2006 to manage the BRTS and other mass transit systems in Delhi. Contract was awarded to BSC and C&C joint venture for constructing the first corridor in 2006.

2. AHMEDABAD: Ahmedabad with a population of 45 million (2001), about 6,000 buses ply on these roads and close to 60% share is of public transport in the region. A pilot corridor of 12 km for Rs. 880 million is now under construction and detailed designs of phase one for 46km is now under active preparation as approved by the Ministry of Urban Development under JNNURM.

3. VISAKHAPATNAM: Visakhapatnam (Vizag) is a port city in Andhra Pradesh. It has a total population of 1.3 million (2001). It is spread over an area of 11,161sq km. It was recently expanded into Greater Visakha, incorporating the Steel Plant, previous outskirts like Gajuwaka and Madhurawada into the city limits. The total number of motorized registered vehicles was 209,000 in 2001, growing annually at a rate of 4%. Recently, planning for Bus Rapid Transit System has been initiated. A pilot corridor of 2 km stretch between NAD-Kotha road and Gopalapatnam now under construction.

4. PUNE: Pune is a city with a growing population of about 2.4 million spread over an area of about 244 sqkm. About 2.5 million trips are generated every day and 1,000 buses ply on the roads of Pune with a modal share of public transport at 13-20% only traveling an average distance of about 7 km. Bus Rapid Transit System planning started in 2003-04 and potential corridors were identified for the phase wise implementation. It is the first city in India to introduced BRTS system. About 130 km has been identified for a total block cost estimate of about Rs. 10,164 million. The entire process is planned in concert with an integrated cycle master plan. A BRTS project Pune Phase I about 13.2 km at a cost of Rs. 476.16 Crore was sanctioned in March 2007. The phase one of the BRTS route has been extended from 13.2 km to 52 km.

5. INDORE: Indore has an estimated population of about 1.8 million and is spread over an area of 134 sqkm. It has about 0.4 million registered motor vehicles with a per capita trip rate of 1.1 and it generated an estimated 1.8 million total trips. About 40% of the trips are made by public transport and

around 0.3 million trips are bus based traveling an average distance of about 6.0 km. There are some 150 buses and about 13,000 mini buses.

The Indore City Transport Services Ltd. (ICTSL) was set up to operate and manage the public transport system in Indore with private sector participation to overcome financial constraints. This has been so successful that now buses with Passenger Information Systems (PIS) and fully automated ticketing machines now operate in the city. A network of about 120 km is planned for BRTS by 2010 at a cost of Rs. 8,682 million. Suitably barriered, central bus lanes (at grade) are planned on these corridors to increase the carrying capacity by 50%. A pilot project of 11.45km was approved for about 985 million and is expected to be implemented towards the end of 2006.

6. JAIPUR: Jaipur is a medium sized city with a population of about 2.3 million (2006) spread over an area of 411 kms (2001). It has about 0.82 million registered motor vehicles (2004), of which 70% are 2 wheelers. A total of 2.7 million vehicular trips are generated every day (2006). Meager 13-19% trips are by city buses covering an average distance of about 9 km. The city has about 185 buses and some 3500 minibuses. Most of the people are dependent on private personal vehicles for their daily commute. The network of about 42 km for implementation of BRT has been identified in 8 interconnected corridors with about 4 km as an elevated section in phase 1. The other corridors will be identified in the new master plan. The entire project is estimated to cost about Rs. 7833 million and expected to be start in early 2007 and will be finished by the end of 2008. The BRTS will be suitably barriered (at grade) with an estimated carrying capacity of 25,000 people per hour per direction (pphpd). It is estimated to increase the modal share from ~20% to 40-50% with 500 new buses.

7. BHOPAL: The population of Bhopal Municipal Corporation was 1.5 million in 2001. Bhopal planning area consists of 601 sq km, out of which 285 sqkm is municipal area and the rest consists of BHEL Township, Bairagarh and 135 urban-rural villages. The total trips here were estimated to be 2.8 million including walk trips (2001). A per capita trip rate of 0.72 is observed excluding walk trips, with an average trip length of 5 km. Bus Rapid Transit System is planned for a total length of 230 km which is expected to increase to 330 km by 2021 for a total phased out cost of Rs.10710 million.

8. Hyderabad: The Population of Greater Hyderabad Municipal Corporation was 3.4 million in 2001. It has about 1.4 million registered motor vehicles (2005). The BRTS has designed a capacity of one hundred and ten buses with six round trips a day will have the capacity to carry 12,000 commuters per hour, with stops at every 450 meters and an average speed of 26 kmph. The 19.5km corridor extends from downtown Hyderabad to a suburban growth area known for its Intelligent Technology (IT) business hub – the biggest IT hub in India.

Source: JNNURM

Table 1: Growth of Population, Vehicles and Employment in Seven Metro Cities

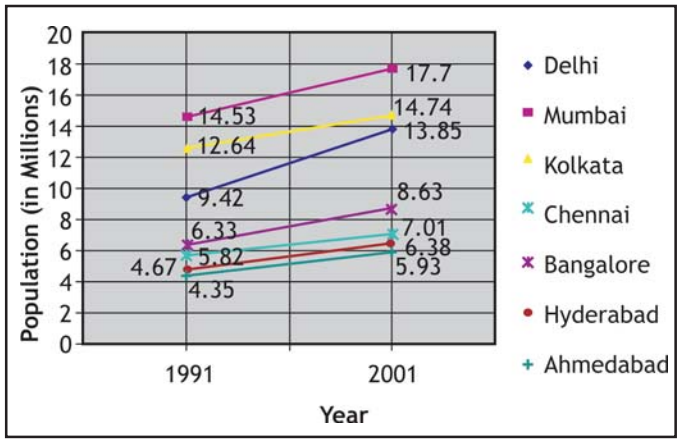
Metro cities	Population (in Millions)		Number of Vehicles (in Millions)		Employment (Male 1000 persons)		
	1991*	2001*	1995	2005	1993 -94	2004 -05	% of variation
Delhi	9.42	13.85	2.432	4.830	796	714	-11.48
Mumbai	14.53	17.70	0.667	1.400	773	786	1.65
Kolkata	12.64	14.74	0.561	1.144	803	751	-6.92
Chennai	5.82	7.01	0.768	1.644	773	749	-3.20
Bangalore	6.33	8.63	0.796	2.517	763	841	9.27
Hyderabad	4.67	6.38	0.557	1.466	750	770	2.60
Ahmedabad	4.35	5.93	0.510	1.173	764	795	3.90
Total	57.76	74.24	6.291	14.174	5422	5406	-0.30
Average growth rate (%)		22.20		55.61			

Note: *Population includes municipal area and surrounding planning area

Source: 1. Ministry of Road Transport and Highways & RTOs.

2. Employment and Unemployment Situation in Cities and Towns of India 2004-2005 - Report No520 of National Sample Survey Organization, Ministry of Statistics and PI, GOI.

Fig. 1 Growth of Population in Seven Metros



by 22.20 percent from 1991 to 2001 whereas vehicular growth has increased by 55.61 percent from 1995 to 2005. It shows that vehicular growth trend is two times more than the population growth rate (Table 1). The worker population ratio in seven metropolitan cities (Fig. 1, 2 and 3) is presented region wise for the last one decade. It can be seen that impressive growth in male Workforce Population Ratio of Bangalore has increased 9.27 percentage from 1993-1994 to 2004-2005, similarly, other cities like Ahmedabad; Hyderabad and Mumbai cities recorded 3.89, 2.60 and 1.65 percent respectively. In case of Delhi, Chennai and Kolkata cities male Workforce Population Ratio is decreasing.

In total, the metropolitan city expects to add more vehicles, population and employment opportunities. In the next decade transportation investment and system management choices will play a major role in shaping the pattern of the metropolitan cities and its growth. Traffic congestion, urban sprawl, central city decline, and air pollution are all problems associated with excessive dependence on automobiles in Indian metropolitan cities. There is a need for new transportation alternatives to serve high quality transit service to alleviate these conditions.

Fig. 2 Number of Vehicules, 1995-2005

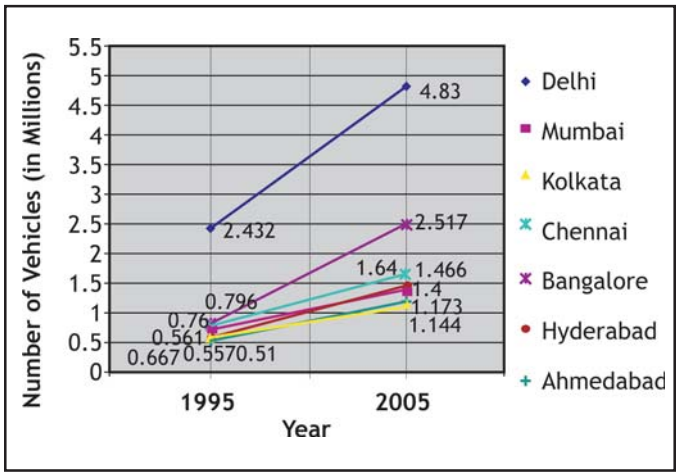
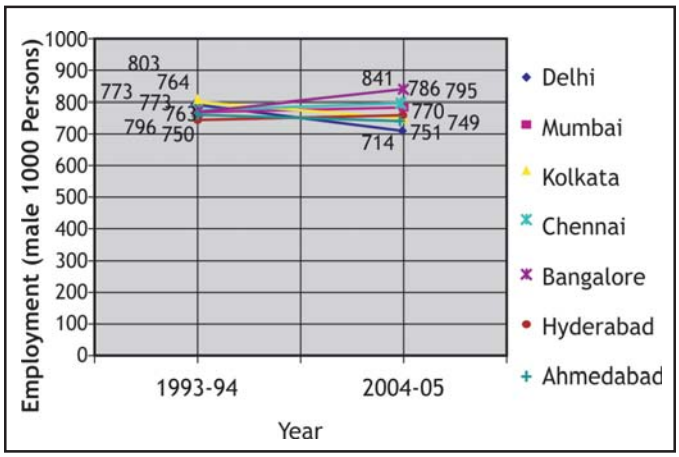


Fig. 3 Employment, 1993-94 to 2004-05



4.2 Trends in Travel Behavior - Types of Mode and Trip Purpose in Mumbai

There is considerable variation in travel behavior- types of mode and trip purpose within city size categories. For example, in case of Mumbai large shares of people go by walk for shopping and health care purposes. About 15.4 percent depends on rail and about 14.6 percent depends on public transport and remaining depends on various modes (Table 2 and Fig. 4).

4.3 Bus Fleet in Selected Indian Metropolitan Cities

In many metropolitan cities, the State Transport Undertakings (STUs) take the responsibility of operating the city buses. The city bus fleet size growth for selected STUs is presented in Table 3. It is observed that for all listed cities, except Bangalore, the fleet size has decreased over the past seven years and annual average growth rate of seven years show negative trend. And also observed that except Bangalore Metropolitan Transport Corporation, all State Transport Undertakings (STUs) in

Table 2 Percentage Distributions of Trips by Mode for Each Trip Purpose in Mumbai

	Work	Shopping	School	Social Visit	Enterta-inment	Health Care	Personal Business	HH Average
On foot	45.10	82.20	55.50	52.40	51.60	66.90	47.90	52.50
Bicycle	3.50	0.40	0.40	0.40	0.00	0.80	1.20	2.20
Rail	20.90	1.50	15.30	13.80	3.50	1.20	13.20	15.40
Public Bus	15.10	6.10	22.40	13.10	16.00	12.80	18.30	14.60
Auto-Rickshaw	2.10	5.40	3.30	7.50	7.00	13.20	6.60	4.30
Taxi	0.30	1.40	0.10	6.30	3.40	3.10	0.80	1.10
Two-Wheeler	8.60	2.40	2.30	3.10	8.00	1.20	8.30	6.40
Own Car	3.20	0.40	0.30	1.60	4.30	0.40	3.30	2.40
Others Car	0.40	0.20	0.10	1.50	6.20	0.40	0.40	0.60
Other	0.80	0.00	0.30	0.30	0.00	0.00	0.00	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Baker et al. (2005)

Fig. 4 Percentage Distributions of Trips by Mode for Each Trip Purpose in Mumbai

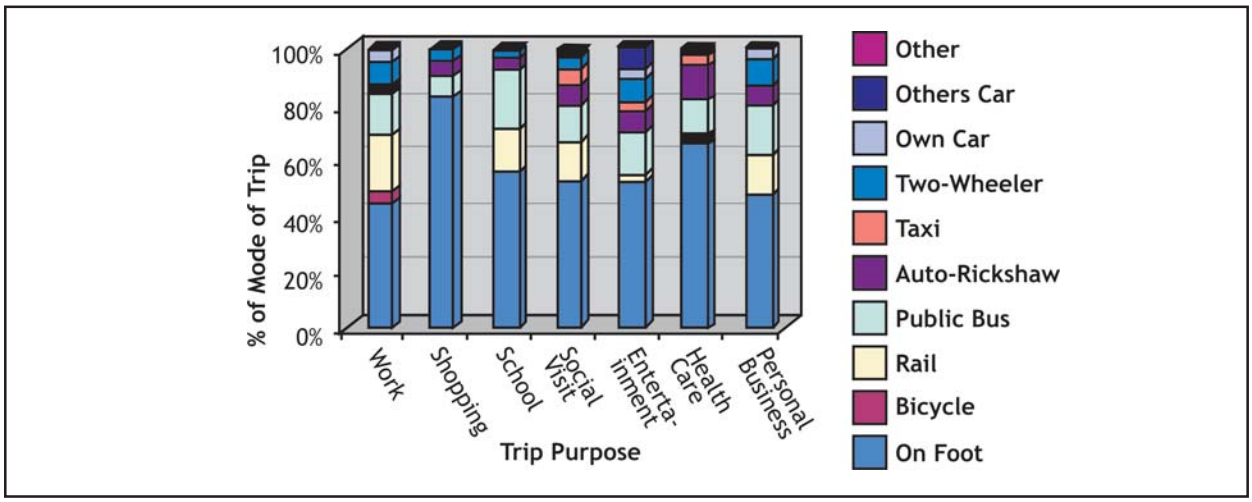


Table 3 Growth of State Transport Undertakings (STUs) Bus Fleet in Selected Metro cities

City	STU									
		2000	2001	2002	2003	2004	2005	2006	2007	Annual Avg. GR (%), 2000-07
Delhi	DTC	4916	4330	4466	2496	2905	3010	3143	2814	-7.7%
Mumbai	BEST	3269	3155	3075	3075	3074	3069	3075	3081	-0.8%
Kolkata	CSTC	814	821	856	800	769	707	659	635	-3.5%
Chennai	CHI-I	2353	2314	2211	2270	2251	2187	2176	2087	-1.7%
Bangalore	BMTC	2110	2250	2446	2656	3062	3533	3802	3967	9.4%
Ahmedabad	AMTC	752	729	630	410	382	371	545	727	-0.5%

Source: Various STUs

selected metropolitan cities are running loss meaning they are unable to recover operating expenses.

5. MAJOR CHALLENGES

- Indian metropolitan cities have a major problem because of rapid growth rate in the number of motor vehicles, which has even outpaced by the growth rate of the population in metropolitan cities. While consolidated figure of the annual growth rate of population in the seven metropolitan cities is 2.2 percent, the number of registered motor vehicles has grown at a much higher rate 3.97 percent between 1991 to 2005 (Table 1);
- Problems associated with mixed traffic conditions on urban streets of Indian metropolitan cities are unique. Automobiles, trucks, buses, scooters, cycles, animal driven vehicles and pedestrians sharing the same street space creating inefficient mobility conditions that are robbing the economic potential of the

cities in India. However, no significant effort is made to improve the conditions, especially in terms of safety, comfort and efficiency of these modes of travel;

- As Indian metropolitan cities have grown in population, they have also spread outward. Indeed, the lack of effective planning and land-use controls has resulted in rampant sprawled development extending rapidly in all directions, far beyond old city boundaries into the distant countryside. That has greatly increased the number and length of trips for most Indians, forcing increasing reliance on motorized transport;
- Trends in travel behavior in Indian cities has been changing, as city size increases and trip distances become longer, the relative importance of walking and cycling falls to about half of all trips in medium-sized cities and about a third in the metropolitan cities. In case of Mumbai about 53 percent households go for walk especially shopping, health care and school, etc. (Table 2);
- In general, the larger the city size, the higher the percentage of urban trips served by public transport in India averaging 30 percent in cities with population between 1 and 2 million, 42 percent for cities with populations between 2 and 5 million, and 63 percent for cities with populations over 5 million (Sreedharan, 2003). Thus, especially rapid growth of large cities suggests a further rise in future demands for public transport in India;
- Bus systems are operated in all cities which have transit services: they are practically ubiquitous. While partially used bus lines do not justify investments and efforts for improved operations and priorities for transit, there are numerous cases of heavily traveled bus lines where improved bus operations are needed. Potential for major improvements of bus services mostly exists in medium-sized and large cities. Even in cities which have extensive rail services, bus feeders and complementary networks are of great importance.

6. OPTIONS

- **Supportive land use policy**: Many cities have zoning ordinances and sub-division regulations that do not permit such facilities to be constructed, not even in areas that already are transit-oriented. Modifying land use policies to permit growth that is concentrated around transit nodes and corridors will help to maintain and increase transit's base of riders in the future. Including zoning regulations and master planning can promote high density development along transit corridors and in central cities and other commercial or neighborhood centers. Compact development will not only encourage use of Bus Rapid Transit, but promote the vitality of communities and local business districts and reduce automobile use, urban sprawl, pollution and energy consumption;
- At the metropolitan scale, policies which eliminate barriers to infill development and concentrated growth in central areas well served by transit can increase transit use. When major investments such as rail lines or bus ways are planned,

careful attention to station area land uses can have long term pay back. At a finer scale, transit-oriented development consists of land uses which are pedestrian friendly;

- **Better Quality, Better Service and providing value for the investment***:* A properly designed BRTS can serve more neighborhoods and provide better services than a comparably priced rail system. Customers can choose between express and local routes and many transfers can be avoided or eliminated. Better service means more transit riders and a more sustainable city;
- **Fighting Global Warming**: BRTS is the best transit strategy for most United States cities to reduce transportation related CO2 emissions, according to a recent analysis published in the Journal of Public Transportation. BRTS can be deployed more quickly and in greater quantities than rail systems. This increases opportunities to attract people out of their cars;
- An electric transit system powered by coal and other fossil fuels has greater CO2 emissions than a modern BRT system, and BRT has much greater potential to reduce CO2 emissions over the long term. That is why BRTS was the first, and so far the only, mass transit technology certified under the Kyoto Protocol;
- **New Technology in BRTS**: New Intelligent Transportation Systems or Advanced Public Transportation Systems applications could contribute to improved bus service and increased bus operating speeds, which include:
  - Smart card for fare collection, automatic vehicle location system, automated enforcement systems for exclusive bus lanes;
  - Computer-aided dispatching and advanced communications and passenger information systems; and
  - Precision docking at bus stops, tight terminal guidance and warning systems.

7. CONCLUSIONS

- Implementation of Bus Rapid Transit System poses a number of challenges, ranging from the need for adequate cross sections on city streets to provide separate rights-of-way for buses, to maintaining the quality of general-purpose traffic flow and minimizing local noise and air quality impacts. These challenges require detailed analysis in the context of specific local applications to identify appropriate solutions and to determine where Bus Rapid Transit Systems can have the greatest benefit;
- Bus Rapid Transit is a concept that merits widespread evaluation and consideration as an adaptable, effective public transportation alternative to automobiles that has the potential to meet a broad range of mobility needs and support an improved quality of life in Indian metropolitan cities;
- High quality bus operations have the potential to create new, improved land use options that provide for compact, pedestrian friendly and environmentally sensitive development patterns that preserve neighborhoods and open spaces.

Bus Rapid Transit System thus has maximum benefits when developed in close coordination with land use policies and community development plans;

- Bus Rapid Transit System is integrating the other transportation services, land use development and insures that pedestrian access to BRTS station is convenience and safe;
- Upgrading the performance of bus services to meet the objectives of Bus Rapid Transit System will require policies that give priority to bus operations and provide for investments in crucial system components: infrastructure that separates bus operations from general purpose traffic; facilities that provide for increased comfort and system visibility; and technology that provides for faster and more reliable operations. New guidance, information, and fare technologies offer an expanded range of possibilities for operating bus systems that have the potential to produce marked improvements in performance, surpassing previous standards and changing public perceptions of bus service.

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A Critical Appreciation of Road Transport Problems in Mauritius and Possible Approaches to Solutions

P.K. Sarkar, Kirtee B. Moonshiram and Dr. Manta Devi Nowbuth

Abstract

In this paper, the Authors have made an attempt to critically appraise the prevailing road based transport system based on the past traffic and transport studies undertaken and to explore ways and means to suggest suitable strategies and policies for development of safe and efficient transport system for the island.

1. INTRODUCTION

Mauritius is a paradisiacal and beautiful island set in western Indian Ocean with a coastline of 177 km and is increasingly becoming a centre of attraction for international tourists. It has flourished with many districts namely Port Louis, Grand Port, Savannae, Pamplemouses and Black River. Port Louis, an oldest city, is the capital of Mauritius. There are a number of urban centers like Curepipe, Quatre Borne, Rose Hill, Beau Bassin, Mahenbourg, Vacoas developed within the beautiful island. Since independence after the occupation of Dutch, French and British, the country has been recognized as one of the most progressive and stable countries in Africa. This independent island republic located east of Madagascar has an area of 1,865 sq km. In addition, this small country includes the island of Rodrigues with 109 sq km located at a distance of 560 km north east and island of Agalega to the north and Saint Brandon Group to the north east with a total area of 2,045 sq km.

This island has a volcanic origin offering a significant variation of geographic contours. The north of the country experiences low lying plain and rises to a plateau that covers the central part of the island. The southern part is most mountainous. It is worth mentioning that several lakes are located in the plateau region while numerous streams are found in the highland radiating to the coast of the country.

The population of the country is presently 1.274 million with a density of 541 persons per sq km and is expected to go up to 1.35 million in 2025 as per the estimate. Port Louis which is built in 1,735 in north west of the country by noted French Governor, Mahe de Labourdonnaise has a population of 146,319 in 2008. Being the CBD of Mauritius, it has become the location of major concentration in terms of density of population and employment. Population density in Port Louis is of the order of 3,250 per sq km which is four times than the national average.

P.K. Sarkar, *is Professor in Traffic and Transport Planning Department of School of Planning and Architecture, New Delhi.*
Kirtee Baguant Moonshiram, *is Senior Lecturer in Department of Civil Engineering, University of Mauritius.*
Dr. Manta Devi Nowbuth, *is Assoicated Professor in Department of Civil Engineering, University of Mauritius.*

The economy of the country has traditionally been characterized by sugarcane industries along with tourism. The clothing and textile industries got impetus during 1980s. The flow of international tourism is on the rise, presently recording more than one million per annum. The GDP of the country is of the order of $7.99 billion in 2008 with growth rate of 5.2 percent. It is presently estimated to decline to 2.5 percent in 2009. The present scale of economic development has helped the workforce to grow of the order of 0.554 million which is around 43 percent of the total population. Major concentration of employment is in Port Louis with 27 percent of the total employment. Employment in Mauritius accounts for 21.7 percent in tourism followed by 17.9 percent in manufacturing, 16.2 percent in government and 11.2 in construction.

With the growth of the economy, the vehicle ownership is also on the rise. The number of cars per 1,000 has increased by 34 percent since 1994 and 50 percent in last ten years. The economy has also boosted the growth of port traffic and air traffic with10 percent and 6.5 percent respectively. Continued intensification of land use activities as a part of urban development programme in general and in Port Louis and Plaines Wilhems in particular and tourist development along the coast has accentuated the need for different types of transport system for passengers and commuters in the island. Port Louis and Plaines Wilhems conurbation comprise of Beau Bassin, Rose Hill, Quatre Borne, Vacoas, Phoenix and Curipipe. With the growth of economic and tourist activities, traffic congestion during morning and evening peak hours has become a common feature on many travel corridors in the island. There is a clear indication that the existing transport supply system is increasingly being over utilized leading to traffic congestion and road accidents.

In this backdrop, it is imperative to ascertain the degree of nature and magnitude of traffic problems to be addressed in order to make it sustainable environment friendly transport system through various short term, medium term as well long term measures. In this paper, an attempt has been made to critically appraise the prevailing road based transport system based on the past traffic and transport studies undertaken and to explore ways and means to suggest suitable strategies and policies for development of safe and efficient transport system for the island.

2. TRANSPORT SYSTEM

The classification of transportation modes into different operational systems is important in appreciating the complexity of the total transportation system. By virtue of being small country, the transportation system is not so complicated as compared to other developing countries. Transportation system comprises of land, air and sea. Sea port and airport play an important role for international passenger and cargo traffic. Besides international air movement, there is domestic air travel between Mauritius and Rodrigues Seaport located at Port Louis while airport is situated at Mohebourg in the southern west of Mauritius.

2.1 Road Network

Internal movement within this island is primarily catered to by road based transport system. In the absence of any rail transport, the road based transport is characterized by car, public hauler, motor cycle, commercial vehicles and bicycles. The total road length of this island is 2,028 km comprising of motorway, A type of road, B type of road and C type and other type of roads with a share of 4 percent, 47 percent, 29 percent and 20 percent respectively. The growth of road length is very low with less than 1 percent since 1981. Motorway is characterized by either 4 lane and 6 lane dual carriageway running from Pamplemouses to S.S. Ramgoolam Airport located Mohebourg as shown in the Fig 1. The details of road network comprising of the above category is also shown in the Table 1.The Road types A and B are also defined as primary and secondary roads. As regards primary road, this is either 4 lanes with a share of small percentage of the total road or 2 lane road with major share while secondary road or other types of road is designed with 2 lanes only. Motorway and A type road northwest to southeast while B type road intersects A type road as can be seen in the Fig 1. It may be mentioned that there are more than 600 km of urbanized road developed without sidewalks. Among all the junctions, there are only 76 signalized junctions along with 24 signalized pedestrian crossings while the remaining junctions are mostly uncontrolled or designed with roundabouts. The land developed under road and traffic circulation is only 10.99 percent in context of total built up area while it works out to only 2 percent and 4 percent of the total area and without agricultural land respectively as per 1995 statistics which are quite inadequate as compared to international standards.

2.2 Registered Motor Vehicles

There is a significant rise in the number of registered vehicles over last seven years (Table 2). This has increased from 260,467 in 1998 to 358,347 in 2008 registering a growth of 5.36 percent per annum. Between 2001-2008, private car ownership has increased to more than 50,000 registering a significant rise of 12.64 percent per annum while lorries and vans has risen up by 2.4 percent. With this growth of motor vehicles on the roads, the density of traffic on roads works out to 177 vehicles per km. It is estimated that there will be an increase of 80 percent of vehicles on roads by 2020 in which the increase in the share of car is expected to be around 50 percent. In Mauritius, the transport sector consumes largest amounts of energy, accounting for 48 percent of total energy imports.

Table 1 Trend in Length of Road Network of Mauritius, 1981 - 2008

Particulars	1981	1985	1991	1995	2001	2005	2001	2005	2008
Length of roads (km)	1,781	1,783	1,831	1,899	2,000	2,000	2,000	2,020	2,028
Motorways	27	27	29	31	60	75	60	75	75
Main roads	838	840	886	902	950	955	950	955	962
Secondary roads	577	577	577	582	592	592	592	592	593
Other roads	339	339	339	384	398	398	398	398	398

Fig. 1 Road Network System of Mauritius

Table 2 Trend in Number of Registered Vehicles During 1981 - 2008

	1981	1985	1991	1995	2001	2008
Car	25,215	26,455	35,673	43,288	58,082	109,507
(of Which taxi Car)	(3,151)	(2,717)	(3,965)	(4,439)	(5,318)	(6,941)
Dual Purpose Vehicle	6,494	7,527	14,343	22,086	36,984	46,021
Heavy Motor Car	355	400	766	989	923	1,290
Motor Cycle	8,279	9,014	14,740	21,492	25,104	40,804
Autocycle	17,828	19,514	53,834	76,317	94,849	107,184
Lorry and Truck	4,592	4,717	7,226	8,815	10,888	12,726
Van	2,804	3,440	7,602	10,851	20,694	25,334
Bus	1,469	1,369	2,021	2,362	2,408	2,762
Tractor and dumper	1,623	1,788	2,274	2,546	2,683	3,045
Prime mover	101	120	197	256	335	505
Trailer	850	983	1,231	1,534	1,776	1,809
Road Roller	99	97	96	107	100	96
Other	138	171	251	315	323	323
	72,998	78,312	144,219	195,306	260,467	358,347
Growth Rate pa	in$^{c/o}$	1.82	14.02	8.85	5.56	5.36

2.3 Public Transport Operations

Buses play primary role in providing public transport system. There are primarily two well known bus companies namely National Transport Corporation (NTC) and United Bus Service (UBS) taking the major share of public transport system. The NTC being one of major public transport operators provides one third of total bus service in the country. National Transport Authority (NTA) acts on behalf of the government and is also responsible for giving licenses, checking and performance of vehicles. Modern types of buses with increased capacity and comforts have been introduced. Besides these two companies, the following companies and operators are also responsible for bus operations:

- RHT (Rose Hill Transport)
- TBS (Triolet Bus Service)
- IO (Individual Operator)
- MTB (Mauritius Bus Transport)

There are number of Bus Owners Associations in Mauritius that include Bus Owner Cooperative Society for North, Port Louis, Flacq, South, Quatre Borne, Moka-Flacq, and East. Bus operators are supposed to achieve at least 75 percent schedule adherence.

Bus services extensively cover all area of Mauritius. Presently there are about 4,644 buses out of which stage carriages and contract carriages are 1,824 and 2,824

respectively with total bus routes of 256 excluding Rodrigues. Out of total bus routes, there are as many any 30 bus routes operating from Port Louis area. There are five bus terminals located at five regions namely, Curepipe, Quatre Bones, Vacoas, Chemin Grenier and Port Louis. The rising cost of operation has put the bus industries in bad financial shape. Poor frequency, coupled with low productivity and technological and management inadequacy have been the primary causes for inefficient public transport system in the country. Commuters using public transport system are mostly captive riders. Most of the routes are primarily destination oriented. There is a lack of integration of bus operation in terms of routing, scheduling, ticketing coupled with lack of application of information technology. The poor performance is also attributable to the little information to public about routes and timings of the buses. Except during the peak hours, bus passengers are not found to be standing in the bus. The number of buses is adequate with respect to the demand of bus passengers. As most of the bus routes operate on two lane roads, the level of service of the operation of buses becomes extremely poor during peak hours resulting in long delay. As a result, passengers do not find the existing operations of buses attractive by any means.

2.4 Taxi Services

As a part of intermediate public transport service, taxi is only means of transport. This does not fulfill its intended responsibilities as it does not run with its meter service the fare for long distance travel is abnormally high primarily detected by tourist market. As there are few people making use of taxis due to this high price, taxis are found at taxi stands. One may get an impression that taxis are available in plenty. On the other hand, rental car services which have around 1,359 cars attached to tourist market at prices similar to those related to other high value tourist resort is operating satisfactorily. These cars are operated by 135 companies.

2.5 Goods Traffic

A substantial number of goods traffic is generated at the port located in Port Louis. Their operation to port related activities observed on Waterfront Road has an impact on the surrounding in terms of traffic congestion and environment problems. Presently, a total number of goods traffic comprising of trucks and lorries, which have grown nearly 5 percent per annum over the years, is around 12,000.

3. ROAD TRAFFIC SAFETY

There is a Road Traffic Safety Unit working under the Ministry of Land Transport responsible for ensuring safety to the users. Performance of road safety can be gauged with respect to minimization of road accidents. Present trend of road accidents according the recent statistics from 2005 to 2006 is a mixture decrease and increase with respect to causalities, fatal injuries and serious injuries. The total number of vehicles involved in the road accidents in 2006 was of the order of 40,205 which are comparatively less than 3,941 in 2005. A total number of accidents

in 2006 were 20,242 of which casualties and non-injury were 1947 (10 percent) and 18,295 (90 percent). Fatality with 122 accounting for 6 percent of the total accidents has increased to 5.2 percent as compared to 2005. Fatality is on the rise recording to 168 deaths in 2008 as compared to 141 in 2007. As far as the number of accidents per 100,000 is concerned, it has shown a decreasing trend from 1,809 in 2005 to 1,605 in 2006. As compared to accident statistics in other developed countries, the accident record shows a dismal picture.

4. TRAFFIC AND TRAVEL CHARACTERISTICS

Traffic flow on the road network provides an insight about the traffic pattern input for assessing the performance of the road network. Latest traffic and transportation study conducted by Halcrow Fox in association with MDS Transmodal throws some light on the performance of the road network based on the traffic and travel characteristics. An attempt has been made to highlight the salient traffic and transportation characteristics, problems and issues of Mauritius.

4.1 Port Louis and Plaine Wilhems Conurbation Area

Traffic flows for 12 hours on motorway routes south of Port Louis between Phoenix and Quatre Borne, and at Pailles are observed to be 43,300 PCUs and 39,600 PCUs for which equivalent traffic flows during the peak hours are around 2,870 and 2,740 PCUs respectively. This is clear indication of high degree of capacity utilization of the motorway. Traffic flows at the two east-west screen lines located at the southern side (between Vacoas – Phoenix and Quatre Borne) and northern side (between Beau Bassin and Port Kouis) are 55,000 pcus and 61,000 PCUs on three lanes in each direction respectively. Peak and Non-Peak hour traffic ratio works to 1.6 across various points in the road network.

With regard to traffic composition, average traffic flow is characterized by 73 percent of light vehicles followed by 12 percent of motor vehicles, 8 percent of trucks and 6 percent of buses with a predominant mode of car. It is worth mentioning that 60 percent of private vehicles perform their trips for work of which 70 percent of trips are made in the peak direction of travel.

As far modal split is concerned on some important transport routes, a maximum 61 percent of trips are catered to by personalized vehicles while the remaining 39 percent trips are made by public transport. It is estimated that more than 300,000 daily trips are catered by private vehicles as well as public transport vehicles in which the share of trips by public transport is around 35 percent. Accordingly per capita trip in the island works out to around 0.3. The results of the travel time study reveal that travel speeds especially on many routes in rural area are very similar during peak and non-peak hours.

All the above statistics clearly reflect the high magnitude of traffic flow during the peak hour as against the limited supply road capacity and will continue to face

more severe problems of traffic operation due to high growth of vehicles of the order of more than 500, 000 vehicles projected in 2020 dominated primarily by car.

4.2 Port Louis Area

On account of intense activities in Port Louis area, there is a significant number of traffic generated in the core of the area approaching from northern and southern sides of the area. The variation of traffic from the northern approaches reaches to a maximum of 3,200 vehicles per hour from a minimum of 1,200 vehicles per hour in different times of the day. Traffic approaching from the southern and western side to Port Louis is comparatively high ranging from 3,450 vehicles to 1,500 vehicles per hour. Car and taxi constitute around 50 percent of the total traffic on an average during the 12 hour period. With respect to travel time spent on entering Port Louis, it is as much as 20-30 minutes both from north, south and west approaches. One way operation enforced a number of streets has enabled traffic to move in a satisfactory manner. Major problem in the central area of Port Louis is the inadequate parking space. As per the study findings, there is a parking demand of 6,000 vehicles entering from the outside during the morning peak hours for which an equivalent parking space of 12,000-15,000 sq m is required. Presently, the off-street parking places available provide only up to 3,000 equivalent car spaces with the remaining to be adjusted from the on-street parking space. Even at 9 A.M., 85 percent of the on-street parking is fully utilized. With the present growth of traffic, Port Louis is expected to experience almost double of the present road traffic. This would result in serious consequence of traffic in terms severe traffic congestion on roads and huge parking demand to the already inadequate parking supply system.

5. ISSUES AND CONSTRAINTS IN THE ROAD TRANSPORT SECTOR

In view of the above, the major issues in the road traffic sector that have emerged can be listed as under:

- Severe traffic congestion due to entering and leaving Port Louis during morning and evening peak hour respectively. In the last five years the problem of traffic congestion is growing primarily due to high growth of car ownership;
- Travel corridor between Port Louis and Curepipe is heavily congested due to over utilization of road capacity during peak hours;
- High demand of parking poses severe problems to inadequate off-street parking supply in Port Louis area resulting in chaotic situation due to limited street parking places;
- Absence of any parking policies in Port Louis;
- Unattractive public transportation system due to poor reliability of bus operations, tentative routing and scheduling, absence of integration in the fare system, lack of public information system with respect to routes , time-schedule of bus operation, poor coordination with multiple bus operators, etc;

- Ineffective Intermediate public transport system comprising of taxies;
- 600 km of urban streets are without sidewalk;
- Lack of application of TSM or ITS for reduction of traffic congestion;
- Little or no consideration for display of names of the roads in the road network;
- Lack of road informative signs;
- Inadequate north-south and east west corridors in the conurbation;
- A large scale movement of trucks on the Waterfront Road causing traffic congestion in the vicinity;
- Inadequate road width of many roads unable to handle present growth of traffic; and
- Rate of accidents is quite high as compared to developed countries

The above issues need to be addressed through well planned strategies and development programmes. Before arriving at the consensus for strategy building exercise which is economical and financially viable and environmentally sustainable, there is need to examine the inherent weakness of the present transport system. The following may be areas of concern before possible transport strategies are attempted. These include the generation of adequate finances, examining the options of road widening, the extent of improvement of institutional framework, availability of expertise in the field transportation planning and transport engineering and any physical/geographic or archeological constraint coming on the way of development.

Major constraint in the development of transport projects in most of the countries is lack of adequate funding to support the project. Now a days many road and transport projects are being carried out through public private partnerships or PPPs. In India, there are a large number of roads and transport projects being carried out by using the PPP as major tool for implementation. Similar modalities can be adopted suiting to the need of the projects. Due to the presence of physical constraints of permanent structures in the form of buildings along the adjoining roads, the option of road widening is extremely limited. Therefore it would pose a great challenge in overcoming this constraint in the development of sustainable transport system.

Without strong institutional framework, it is difficult to make transport system strong, reliable, safe and efficient. In Mauritius, there is a lack of coordination between many agencies related to traffic and transportation sector. For example, multiple bus operators make the bus transport operation most unattractive in terms of lack of integrated bus routing and scheduling, ticketing coupled with little or no public information system. There is a need for the development of Unified Transport Authority of Mauritius where all the actions related to traffic and transportation components will be carried out with multi-way coordination mechanisms among the sub-systems.

6. EARLIER TRANSPORT STUDIES

There has been a number of transport studies conducted in the past with a view to improving the transport system in the country. Available three studies were reviewed in order to appreciate the efforts made so far and explore ways and means to suggest possible appropriate transport solutions for the country.

6.1 National Physical Development Plan

The National Physical Development Plan **(**NPDP) is concerned with national physical development plan and Outline Planning Schemes which relate with four rural districts and five municipalities. The NPDP in its report in 1993 identified the following transport problems.

- Increasing traffic growth and increased use of private transport without the possibility of similar infrastructure leading to ever increasing traffic congestion; and
- Traffic congestion affecting the commuter traffic in the conurbation with the situation expected to deteriorate.

The following measures were suggested in order to address the above problems:

- An accelerated highway investment programmes with the initial emphasis being placed on traffic management measures in urban areas including parking controls and special measures to assist buses in congested areas;
- Construction of new roads;
- A comprehensive strategy for public transport based on unequivocal long term policy support for the industry; and
- Adoption and implementation of a land use strategy that aims to minimize the amount of travel particularly related to daily commuting.

6.2 Free Transport for All and Congestion Buster Solutions

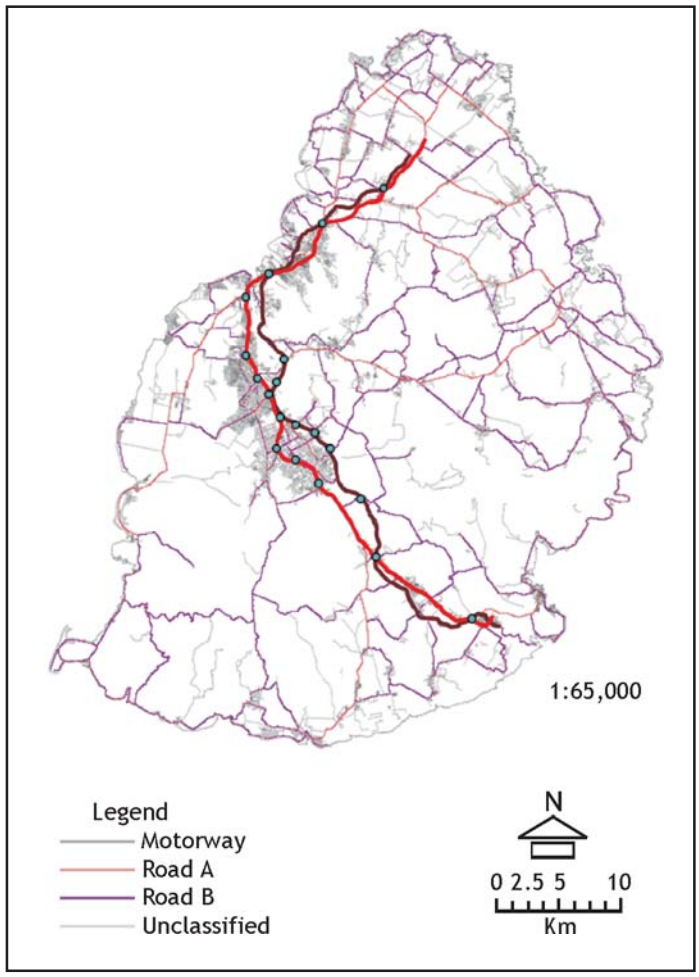
A team of researchers led by Prof. S. Rughooputh of the University of Mauritius conducted a study on transport problems of Mauritius and finally recommended two important solutions as given under:

- Free transport system for all; and
- Conversion of Motorway and A category road to one way

As these roads follow closely with each other with a maximum interval 3 km apart, traffic flow in the M1 motorway as well as A1 Road is proposed to be made one way towards north and south directions respectively in this broad concept as shown in Fig 2. In addition to this, the following measures are envisaged to be taken up as a part of the programme:

- It is expected that the A1 road will be upgraded to a motorway status in the shortest time possible with additional lanes;
- In order to ensure uninterrupted traffic flow, all roundabouts and traffic lights must be removed and major intersections must be replaced over time by flyovers of the Ebene type or simpler in design;
- Major interchanges must be located at selected sites such as Reduit, St Jean, Rose Belle, Rose Hill and Port Louis;
- All minor intersections must be removed with provision for local traffic circulation;
- Traffic in as many roads as possible be turned into one-way systems, especially in the heavily populated areas;
- A two-way bridge over the long GRNW Canyon can eventually be constructed at its narrowest constriction, sited at nearly at Coromandel, as an additional crosslink nearly halfway from the southern tip of Port Louis and Rose Hill; and

Fig. 2 Map Showing Motorway and A Type Road



- A common strip exists for both roads stretching from St Jean to Phoenix. It is proposed that at this site either additional lanes be provided or a sky road (similar to Oklahoma) be constructed on top of the existing motorway.

The study reveals that about one third population is within the catchments area of Port Louis-Curepipe travel corridor. Hence, it would facilitate people to use these one way roads for commenting on the corridor to meet the expected travel demand. The study further estimates the cost of congestion to be of the order of MRU 2 billion per year. The study emphasizes the role of free transport which would help reduce traffic congestion as well as help improve mobility for all section of people irrespective of rich and poor. Presently, Mauritius Government spends to the tune of MRU 2.25 billion for providing free transport to all students and elderly population. The Government may explore raising MRU 2 billion from private employers and MRU 1 billion from tourists along with its contribution of MRU 2.6 billion to make it free transport system for the country.

6.3 Integrated National Transport Strategy Study

In 2001, the Government of Mauritius published the final report on the Integrated National Transport Strategy Study (INTSS) in order to work out future transport requirements and investments. This study was conducted by Halcrow Fox in association with MDS Transmodal. The objectives of the study were to develop an integrated strategy which would provide the basis for formulating the action plans, policy statements and investment programme. The primary issues identified under this national development strategy are as under:

- Continued consolidation of urban development specially in the Port Louis and Plaines Wilhems conurbation;
- Tourism development in the coast; and
- Residents, commuters and tourists to and from the airport and the port.

In view of broad developmental issues, the INTSS identified the following strategic transport problems:

- Congestion in the conurbation including the town centre parking;
- Role and quality of public transport buses and taxis;
- Transport and environment; and
- Safety.

Severe congestion was identified with respect to localized and periodic in general and within the conurbation area relating to traffic entering and leaving Port Louis during the morning and evening peak periods due to growing number of vehicles in particular. Traffic problems in the countryside and on the coast are related with localized while periodic congestion occurs along the village shopping streets at peak market times including the weekends at tourist locations. The following measures were recommended in the light of broad transport strategies presented later.

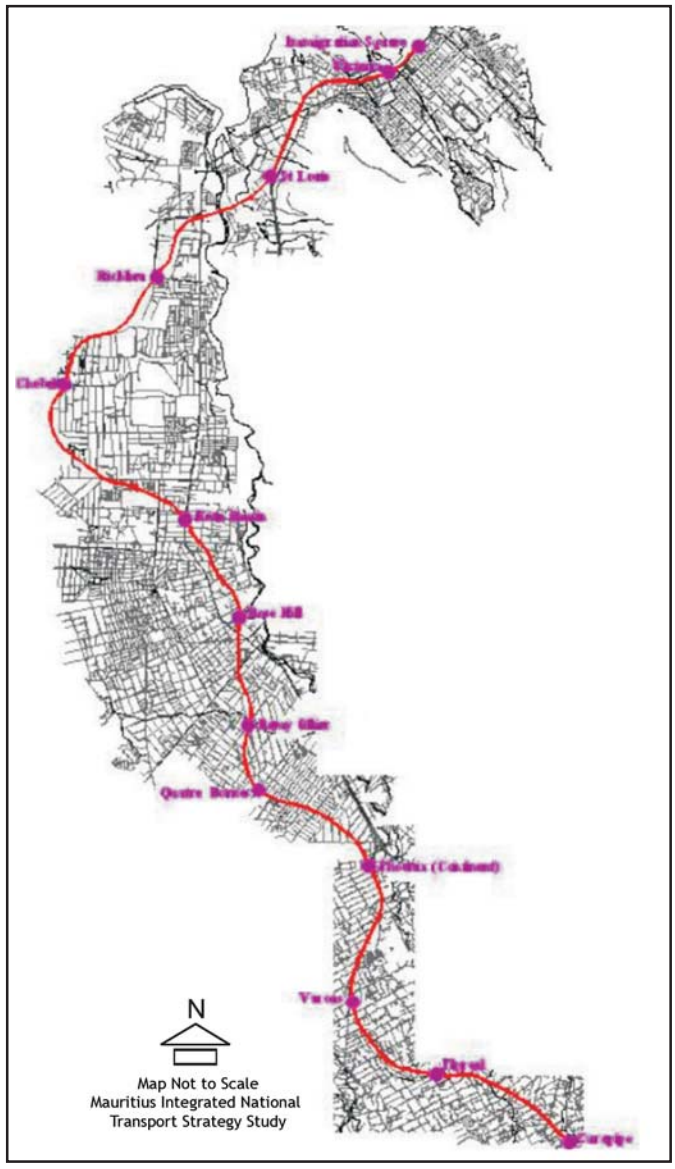
- Implement alternative modes of transport from Port Louis to Curepipe;
- Discourage car trips in the corridor Port Louis-Curepipe;
- Improve quality of bus services;
- Improve amenity and traffic circulation in town centers;
- Manage and maintain road networks instead of constructing new ones; and
- Building few roads in order to improve access to economically important areas.

While formulating the transport strategies, it was stated that transport strategy should complement land use strategy. The studies should be integrated with highway and land use planning. In view of the above, transport strategies formulated under the INTSS are as under:

- Minimize distance from home to work and encourage easy access to a range of activities whilst making best use of existing infrastructure and facilities;
- Encourage public transport and allow it to compete with private car provision of attractive and safe public transport;
- Encourage provision of special bus facilities in urban areas;
- Different authorities should devise parking strategies for the urban areas taking into consideration the need to restrict parking and not to discourage development in town centers;
- Traffic management schemes should be implemented within the growth zones specified by the government; and
- Traffic management in Port Louis should aim to provide better balance between pedestrians and vehicles.

One of the major proposals under INTSS is the alternative public transport system. The Government has decided initially to consider Light Rail Transit after a study carried out by World Bank on Multi-Criteria Analysis. For 25 km route between Curepipe and Port Louis, thirteen stations were identified mostly passing through the various town centers as shown in the Fig 3.

Fig. 3 Map Showing LRT Alignment and Stations



6.4 An Initiative by Government of Mauritius for Improvement of Transport System

Government of Mauritius is keen to solve the transport problems in the country. Presently there are a number of initiatives taken up by government. These include the development of Ring Road in Port Louis along with the construction of Harbour Bridge, Development of Bus Rapid Transit System from Port Louis to Curepipe and Bus Modernization Programme. The proposal for the construction of Ring Road in Port Louis along Harbour Bridge has already been approved. Tender has been floated recently in May 2008 for modernizing the bus system with a view to accomplishing the following measures.

- Design of bus way system;
- Priority lanes along side of the motorway;
- To incorporate smart technology to control and operation of traffic in order to prevent traffic congestion along with provision of ramp metering;
- Advance d Traffic Signaling;
- Introduction to variable speed system through variable message sign;
- Use of central control system; and
- 12 km unused railway track along with 12 km bus only lane to be placed along the existing motorway.

7. A CRITICAL APPRECIATION OF THE PAST TRANPORT STUDIES

In light of existing transport scenario emerging through traffic and travel characteristics and proposed transport strategies and proposals envisaged by the above three transport studies for Mauritius, an attempt has been made to review the above transport proposals to find out their suitability on ground keeping in view the benefits which could accrue not only to achieve short term goals but also to ensure long term environmentally sustainable transport system.

7.1 National Physical Plan

Problems identified were general in nature. This study recommends an accelerated highway investment programme along with the construction of additional links to solve traffic problems. Though the study recommended development of comprehensive strategy for public transport, there was a total absence of detailed action plan towards public transport plan. The adoption and implementation of land use strategy recommended does not spell out clearly the extent of reduction of traffic congestion. Though this study identifies the need for transport and land use measures, it requires more strategic analysis to detail out comprehensive programmes for transportation solutions.

7.2 INTSS Plan

Transport strategy plan envisaged in this document is quite bold and has identified various problems realistically. Six transport strategies are appropriate to cater to the present and future travel demand of the conurbation. The comments on the six transport strategies are as under:

- The need for implementation of Alternative Mode of Transport between Port Louis and Curepipe is well justified in order to relieve traffic congestion for a length of 25 km long section of travel corridor. The initial decision of the Government to pursue the Light Rail Transit bears a significant importance in the longer perspective;
- It is true that car trips need to be discouraged. The strategy is only focused on discouraging car trips through the control on the supply of parking spaces. In

addition to this measure, there is a need to enforce congestion pricing mechanism to effectively discourage the cars coming to the CBD of Port Louis. With this, the control of supply of parking spaces would not alone provide the relief in the reduction of car. Applications on congestion pricing measures in Singapore, London, and Trondheim, Norway have been very successful in the reduction of traffic in the central area;

- Restructuring the bus service would be step forward to improve the public transport services in Mauritius. The study has not addressed the deficiencies of the present bus operations with respect to lack of coordination, unscientific routing, poor scheduling, ticketing and lack of public information system;
- Traffic management system need to be restored. It would be put into a framework of Transport System Management which address not only the preparation of traffic management plan but also comprises of transit management system, demand management system and restraint management system. There is a need to increase the amenities and improve traffic circulation in town centers;
- Maintenance and management are two words from asset management without which the life of the road infrastructure reduces significantly. This would call for the application of HDM model with comprehensive data bases; and
- New roads to economically important areas and bye-passable roads are of urgent necessity. Apart from this, provision of new roads to supplement the exiting road system in the form of east-west links should not be ruled out.

7.3 Free Transport for All and Congestion Buster Solutions

A unique concept advanced by Prof. Rughooputh in the context of growing transport problems in Mauritius is good. The idea of free public transport will be of the first of its kind not only in Mauritius but also in the world. No doubt, it will help the Government to earn popularity in the country. It will provide a great impetus to people for increased mobility to all sections of society. The questions of how many people of choice riders would shift from their own transport to public transport remains to be answered. The study does not provide any quantitative analysis to determine the reduction of private vehicles on roads from choice riders. An analysis of logit model based on the concept of general cost and utility could throw some light in this regard. Even though this concept is good, but its overall implication in financial terms on the exchequer needs to be evaluated before the Government takes such decision.

As regards the concept on conversion of motorway and A type road into one way traffic operation, this proposal looks to be slightly unrealistic. Most of the road sections of A type road is characterized by two lanes. Additional two lanes along the road to make it compatible with motorway appears to be very difficult and challenging task as the RoW of the A type road does not have the land to fulfill the requirement of additional lanes. Acquisition of land along the abutting property

for both sides of 25 km stretch would be herculean task. The question of additional measures recommended as a part of this concept becomes redundant.

7.4 Initiative for Transport Proposals by the Government

The Government of Mauritius is fully aware of the growing transport problems in the country and is extremely keen to ensure the development of environment friendly transport system. Recent initiatives taken in regard for the development of Ring Road, the construction of Harbour Bridge along with modernization of bus transport system is highly commendable. Apart from this, three road schemes namely, Triolet Bypass, Nouvelle France Plain Magnien and South Eastern High appear to be committed projects to be implemented in order to relief traffic congestion on the travel corridors. Ministry of Public Infrastructure, Land Transport Authority and Shipping is now in the process of taking decision in favor of Bus Rapid Transit System as a part of Alternative Mode of Transport. The cost estimate analysis between BRTS and LRT options as presented by the Halcrow study, favors BRT as it will be less than around MRU 2,000 million. The success of BRTS depends on various factors. BRTS has been successful in Bogotá, Colombo and Curitiba, Brazil but it has failed comprehensively in context of Delhi, India. The Government should make in-depth analyses in case the BRTS is to be operational at grade competing with other modes of traffic keeping in view of long term perspective. It would be advisable to carry out a simulation exercise of traffic flow on BRTS corridor.

8. POSSIBLE APPROACES AND SOLUTIONS

In light of the present transport problems as reflected in various studies carried out as well as various transport issues emerging in the road transport sector, there are different approaches and strategies formulated to tackle the ever increasing transport problems for the country. Every transport proposal as recommended has strengths as well as weaknesses that have been discussed in the previous sections. In this section, an attempt has been made to look into these proposals carefully and explore further the possibilities of developing realistic transport solutions which are manageable, economically and financially feasible and environmentally sustainable. Keeping in view long term perspective approaches and possible solutions have been reviewed under four heads namely: immediate action plan, short term plan, medium term plan and long term plan. Government of Mauritius should integrate its approved programmes with the solutions being suggested.

8.1 Immediate Action Plan

The immediate action plan should focus on those measures where investment in transport sector will be minimal as far as possible. As per the nature and magnitude of the present problems, immediate attention has to be paid to minimize severe traffic congestion on Curepipe- Port Louis travel Corridor as well as to lessen the traffic problems entering or leaving Port Louis during the peak period to some extent.

Therefore the following actions should be taken as part of the immediate action plan:

- The major strategy would be to discourage traffic. The immediate action should be the introduction of congestion pricing for Port Louis area as made in Singapore as early as in 1975;
- As part of this strategy, staggering of working hours for group of employees and workers depending on their type of work for government and private organizations, this measure should be introduced. In line with action plan, the private companies as well as government organizations should make the transport arrangements for group or all of employees and workers in different hours in the morning as well as in the evening. This means the substitution of less number of public transport and company vehicles as against more number of private vehicles to be spread for considerably longer period than that of limited one or two hours in the peak period. Apart from this, flexible hours can also be introduced depending on the type of jobs offered in the companies and organizations This would result in significant reduction of traffic on various travel corridors in general and Curepipe–Port Luis travel corridor in particular. The option of telecommuting may also be tried where ever possible;
- There is an immediate need to provide facilities for displaying names of all the roads in order to enable road users to have better appreciation with the road system; and
- The effort for road safety auditing should be initiated as a part of immediate action plan.

8.2 Short Term Proposals

All the transport proposals being envisaged should be implemented by Government of Mauritius within the next 5 years and should be treated as short term proposals which are as under:

- Development of Ring Road;
- Construction of Harbour Bridge;
- Modernization of bus transport system;
- Coordination of Traffic Signals on the travel corridors;
- Development Variable Message Sign to enable road users to take appropriate decisions based on prevailing traffic situation;
- Monitoring the Road Maintenance programme through HDM model; and
- Capacity Building Programme.

Apart from these measures, continuous updating of traffic situation in all town centers needs to be conducted by Traffic Engineering Department, Ministry of Land Transport Authority. This would form the basis for preparation and implementation of low cost traffic management plans in those area.

8.3 Medium Term Proposals

Major transport proposals which are primarily related to road expansion program in terms of provision of new roads and links should be taken up. It is also proposed to widen Woton-Belle- Reve – Quartier Militaire Road and rehabilitate people, which is one of the major links between east-west corridors. A period of 5-10 years may be considered where moderate investment is required. In this period, an effort should be made to develop Intelligent Transport System to provide on line information to the road users whether they are travelling by private vehicles or public transport. The application of ITS would be in line with the bus modernization program to be initiated as a part of the short term measures.

8.4 Long Term Proposals

In view of growth and prosperity of Mauritius, long term proposals may have to cover a horizon period of 20 years or beyond. The ITSS report has viewed the integration between land use and transport a way forward, which ensures balanced and sustainable development of the conurbation. Besides this, the relocation of activities should also be considered as a centre stage of long term land use policies. All long term development should be implemented within 15 - 20 years. Major proposals envisaged as a part of long term scenario are as under:

- Identify and select new areas for future development, for example, highlands in the centre of the island should be earmarked where various government activities coupled with some part private sector activities should be shifted so that traffic congestion is reduced considerably; and
- Upgradation of BRTS corridor to LRT corridor depending on intensity of traffic on Port Louis and Curepipe Travel corridor.

9. CONCLUSIONS

In the present transport scenario coupled with severe traffic problems in the conurbation in general and CBD of Port Louis through various land use and transport strategies with the conduct of various studies and Government initiatives, this paper draws the following conclusions:

- Problems of transportation in Mauritius are unique in nature characterized by limited growth of road network coupled with high growth of vehicles dominated by the growth of cars and motor cycles;
- Bus transport is poorly organized lacking scientific approach with respect to routing, scheduling, ticketing, coordination coupled public information system;
- Heavy reliance on inadequate road based transport system with a population of more than one million is the primary root cause of severe congestion during the peak hours in the road network;
- Absence of sidewalks on 600 km of road along with poor road geometrics on the secondary road system in terms of sight distance at the intersections need to be addressed as a part of road safety audit;

- Planning of road transport system is primarily dominated by encouraging of vehicular traffic rather than encouraging peoples' mobility;
- Limited facilities of parking both in terms of on-street and off-street also result in severe congestion in Port Louis;
- Constraint in road building expansion due to shortage of space especially Port Louis is a major concern for road improvement;
- Most of the transport projects are delayed due to non-availability of funds. Mauritius is also facing the same situation. As a result, the delay in the execution of major projects would aggravate traffic problems to Curepipe-Port Louis travel corridor;
- Lack of integration amongst various agencies in general and within the bus operators in particular is a major cause of concern for safe and efficient transport system; and
- There is a scarcity of expertise in the field of transport planning, transport engineering and transport administrators.

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A Study on the Development Trends along the Proposed Chennai Metro Rail Corridor

Prof. Dr. S. P. Sekar and D. Karthigeyan

Abstract

The ongoing Chennai Metro Rail Corridor (CMRC) has been conceived as a project to provide relief from the traffic on the major arterials of Chennai Metropolitan Area (CMA). However, this project is anticipated to escalate the development all along the corridor. This article attempts to analyze the development trends which are about to take place along the proposed rail corridors. It also analyzes regulatory mechanisms to be followed to deliver better development.

1. INTRODUCTION

As the population of the city grows, the share of its public transport i.e. road or rail-based traffic should increase as a measure to provide better commutation for the general public. It is a thumb rule for a city with population of one to two million that the share of public transport should be between 50 percent and 60 percent and for cities with population of 2 to 5 million between 60 percent and 75 percent and for cities with a population of over 5 million between 75 percent to 80 percent. CMA has registered a population of 3.5 million in 1971. It is doubled by 2001 and by now it would have crossed 8 million. The share of CMA's public transport is only at 50 percent leaving a big gap to the standard of 80 percent. Worse is that over the past decade this share is reducing at a phenomenal rate. This phenomenon was well recognized in the past and a number of attempts were made to introduce better public transport system. These attempts include (i) Hybrid Monorail System in Chennai; (ii) MRTS Phase – III; and (iii) Increase in the frequency of local buses and suburban trains. Development of hybrid monorail system in Chennai for a length of 25 km comprising parts of Periyar EVR Salai and Anna Salai at a cost of Rs.947 crore was proposed to be implemented over a period of 27 months. Since the same corridors are being considered subsequently for development of metro rail, the project has not so far been implemented. The MRTS Phase – III, a short term study was conducted for establishing the feasibility of the alignment proposed for MRTS from Velacherry to Villivakkam for a distance of about 25 km. The first stage of the MRTS Phase III envisaging the elevated MRTS on single pillars along the median of the IRR, project is estimated at a cost of Rs.4,160 million. But this proposal is also kept on hold since the proposed Chennai metro rail is also along the same route in some parts. Increase in the frequency of local buses and suburban trains the third effort i.e. frequently, the number of bus services offered by the Tamil Nadu Local Bus Transport system is also increased both in frequency as well as in numbers.

***Prof. Dr. S. P. Sekar**, Professor and Head, Department of Planning, School of Architecture and Planning, Anna University, Chennai. E-Mail: sekar@annauniv.edu*
***D. Karthigeyan**, Junior Architect and Planner, M/s Cheralathan Associates, 13 Shanthi Enclave, NO. 25 Venkatakrishna Road, R.A. Puram, Chennai. E-mail: paradisepnd@gmail.com*

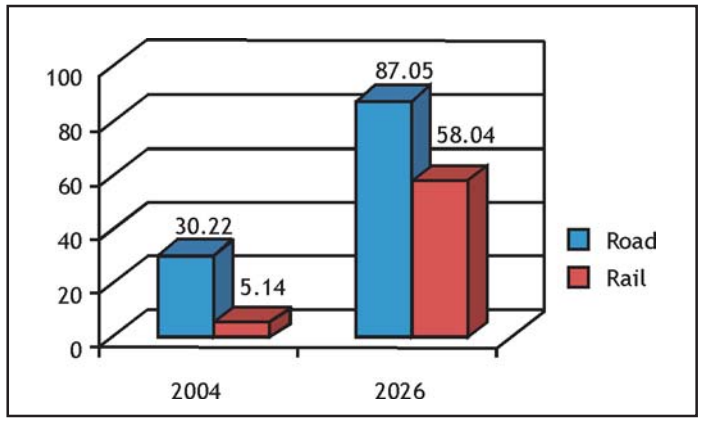
2. GROWTH OF TRAVEL DEMAND IN CHENNAI METROPOLITAN AREA (CMA)

Comprehensive Traffic and Transportation Study (CTTS) for Chennai provided the core inputs for predicting the future travel demand for the CMA. The travel demands in 2004, 2006, 2011, 2016, 2021 and 2026 have been projected on the basis of increase in per capita trips from 1.32 in 2004 to 1.6 by 2016 and 1.65 by 2026 (1992-95, CTTS).

In this study, different scenarios of modal split were discussed, and the scenario which is adopted in the second Master Plan (CMDA 2008) is taken here for further analysis.

- Modal split between public and private transport will change from 43:57 (1991) to 35:65 (2004), 55:45 (2011) and 60:40 (2016), 65:35 (2021) and 70:30 (2026) in line with the trend in share of public transport increasing with City size;
- Sub-modal split between bus and rail will have to change from 91:9 to 85:15 (2004), 75:25 (2011), 70.30 (2016), 65:35 (2021) and 60:40 (2026) if the road transport system is not to break down in the context of increased commuter trips; and
- It is seen from Fig. 1 that the number of trips carried by bus transport in 2004 could increase to nearly 2.8 times in 2026, and similarly the volume of passengers to be carried by rail transport will increase by nearly 11 times (CMDA, 2008).

Fig 1 Number of Trips to be Carried by Public Transport in 2004 and 2026

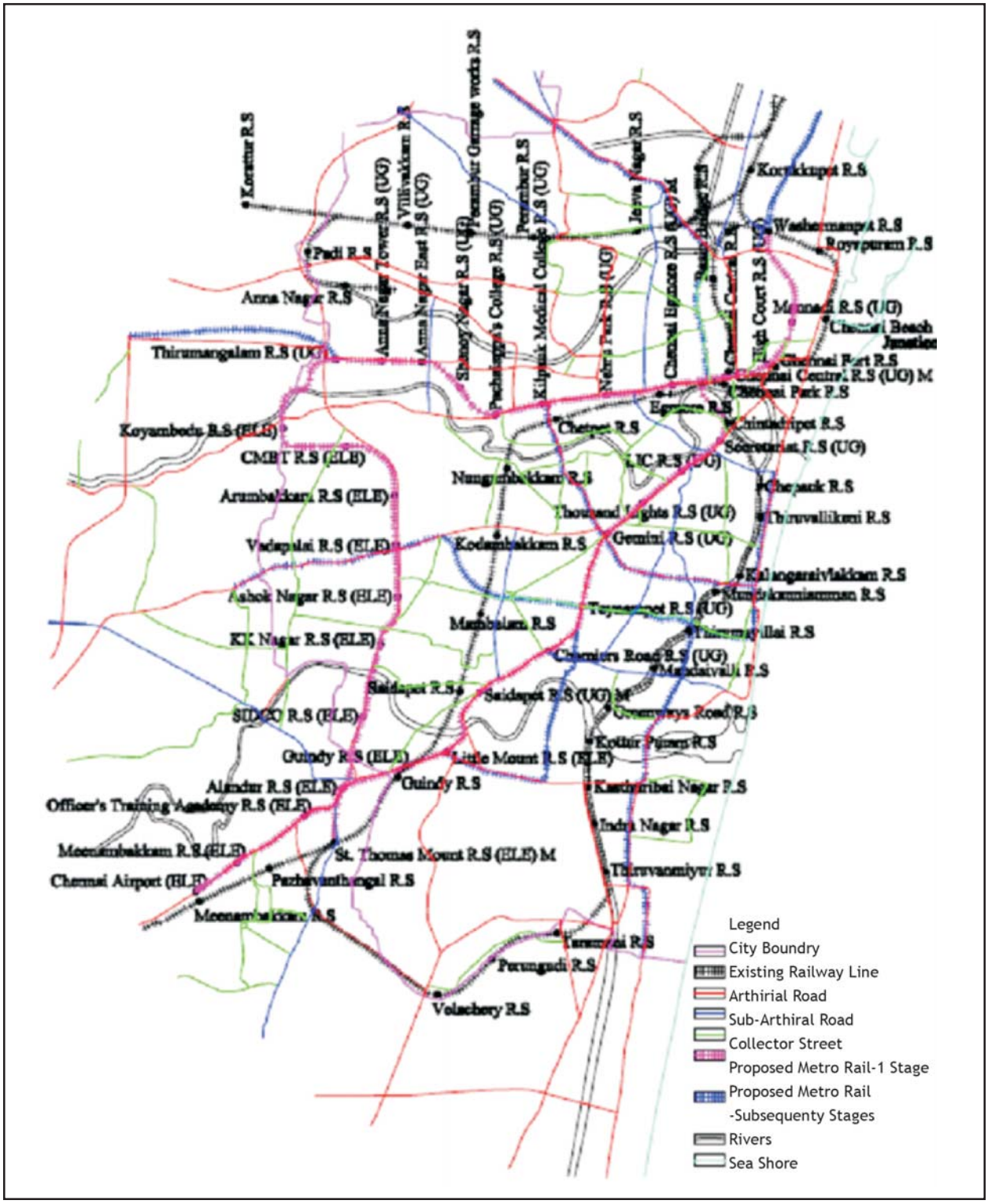


Source: CMDA (2008)

3. CHENNAI METRO RAIL CORRIDOR

A metro system is an electric passenger railway system in an urban area with high capacity and frequency, which is grade separated from other traffic. Underground tunnels represent a unique way to move transport systems away from the street level allowing more ground to be allocated to buildings or other purposes. In areas with high land values and high densities, land use tunnels may be the only way to feed sufficient people into the area (http:// www.masstrasportation/rapid-tansit.htm). Cities which have a population of more than three million are recommended to have a Metro Rail by the Delhi Metro Rail Corporation. Chennai have already exceeded that threshold limit. The DMRC studied seven high density transportation corridors in the city and decided on two routes in the first phase. The third phase is likely to link the shopping district of T. Nagar with any one of the proposed two routes of the first phase.

Fig. 2 Chennai Metro Rail Corridors (2008, DPR)



Source: CMDA (2008)

The corridors that are taken in the first phase are:

- **Corridor-1:** NH-45 (Airport) – Guindy – Saidapet – Teynampet - Gemini - Spencers -Tarapore Towers – Proposed Secretariat - Along Cooum River - Rippon building - Central Station-Broadway (Prakasam Road) - Old Jail Road – Thiruvottiyur High Road.
- **Corridor-2:** St. Thomas Mount – Kathipara Junction – Along 100' Road covering Ashok Nagar – K. K. Nagar – Vadapalani up to Koyambedu - Thirumangalam – Anna Nagar Tower - Anna Nagar Arch –Aminjikarai – Kilpauk Medical College – Egmore – Central – Fort – Beach.

4. ALIGNMENT OF THE PROPOSED CHENNAI METRO RAIL CORRIDOR

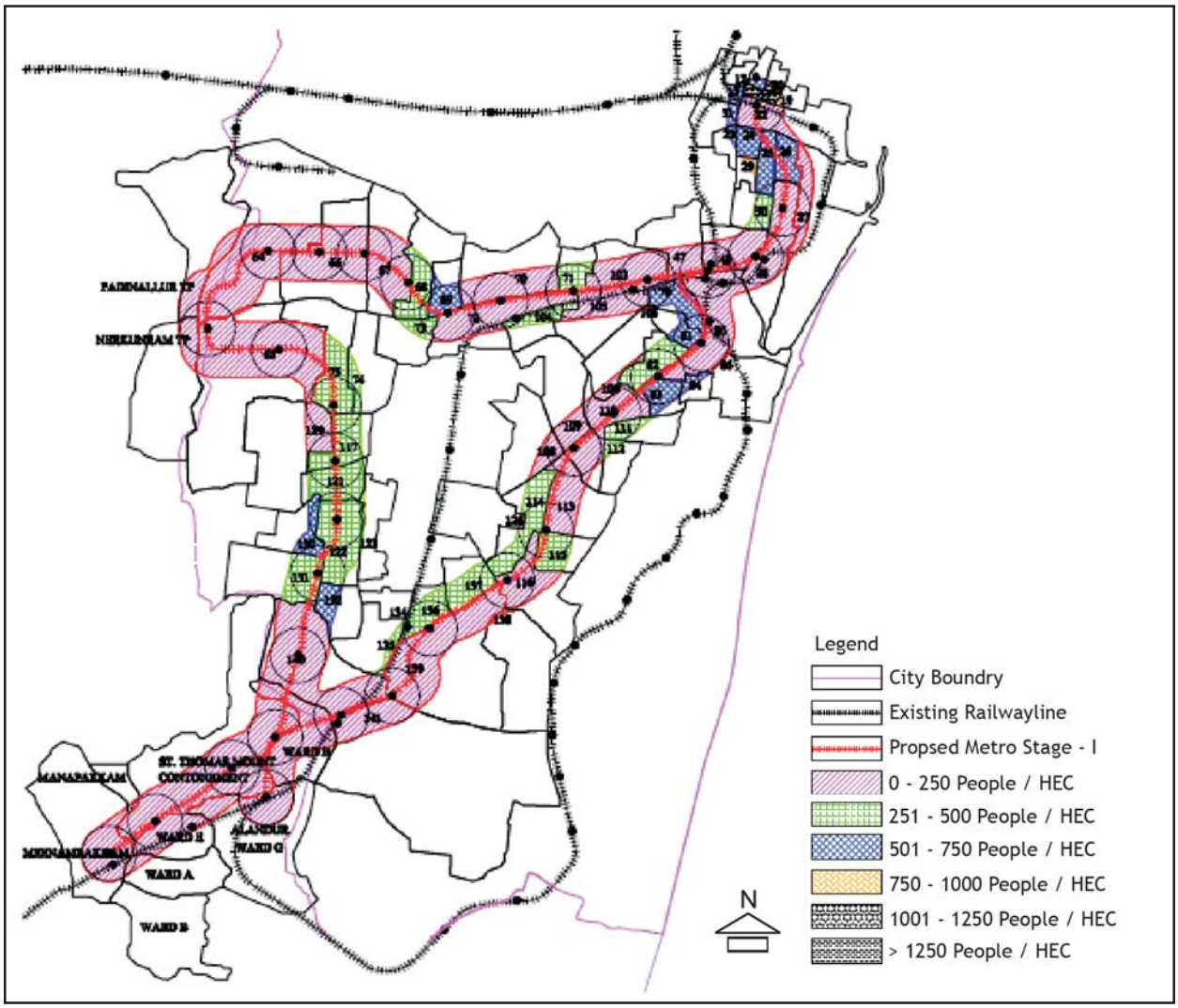
Loading on the proposed Metro Corridors is: corridor – 1 will have 32,900 peak hour peak direction trips or PHPDT and corridor – 2 will have 27,600 PHPDT based on the analysis done by the Delhi Metro Rail Corporation (DPR, 2008). Whether the public transport system on a corridor in the city should be road-based or rail-based will depend primarily on the traffic density during the peak hours on these corridors. Experience has shown that in mixed traffic conditions, comprising slow and fast moving traffic like Chennai roads have, buses can optimally carry 10,000 PHPDT. When traffic density on a corridor exceeds 10,000 PHPDT, the average speed of buses comes down, journey time increases, air pollution goes up, and commuters are put to increased levels of inconvenience. It has been the experience world over that a road-based system can cope with traffic demand levels of up to 12,000 PHPDT only. Thus, when on a corridor, traffic density during peak hours crosses this figure, provision of rail-based mass transport is considered. In any case, rail-based mass transport may become inescapable if traffic density on a corridor reaches 20,000 PHPDT.

5. POPULATION DENSITY

From the experience of impacts of the Delhi Metro Rail Corridor, it is found that the ideal walkable distance for a person to reach the railway station is about 500 meter. So the people living within the Ideal walkable distance i.e. 500 meter from the station have the highest opportunity and facility to use the Metro Rail. In this manner Chennai Metro Rail corridor was also analyzed and the details of the population living within 500 meter were taken from the Census Ward Level Population of 2001**.**

Population density analysis is done by calculating the population per hectare for every individual ward. This population per hectare is further multiplied by the total area of the ward which falls within 500 meter from the Metro Rail Line. It is found that around 971,873 people were living within the ideal walkable distance of the Metro Rail Corridor in CMA. However, in Chennai City around 899,310 people were within the walkable distance out of the total population of 4,343,645. Percentage of people living within the walkable distance of the Proposed Metro Rail in Chennai city is found to be around 20.70 percent.

Fig. 3 Population Densities Along the Metro Rail Corridor Considering Ideal Walkable Distance



5.1 Influential Land Area

The area falls within 500 meter of the proposed Chennai Metro Rail Corridor is about 40.29 sq km out of the total Chennai Metropolitan Area of 1,189.01 sq km. The area that comes under the direct influence in CMA is only 3.38 percent. Whereas in Chennai City the total area is about 173.19 sq km out of which 33.29 sq km comes under the direct influence of the proposed Metro Rail Corridor, which is about 19.22 percent of the total area.

5.2 Existing and Proposed Land Use – 2006 (Second Master Plan)

Land use is analyzed by taking half a kilometer radius around the proposed metro rail stations. So the total area which is analyzed is about 40.29 sq km and in this residential area is the highest i.e. 43.6 percent as the existing land use. In the proposed land use, there is a sharp increase in the percentage of mixed residential

Fig. 4 Existing Land Use, 2006

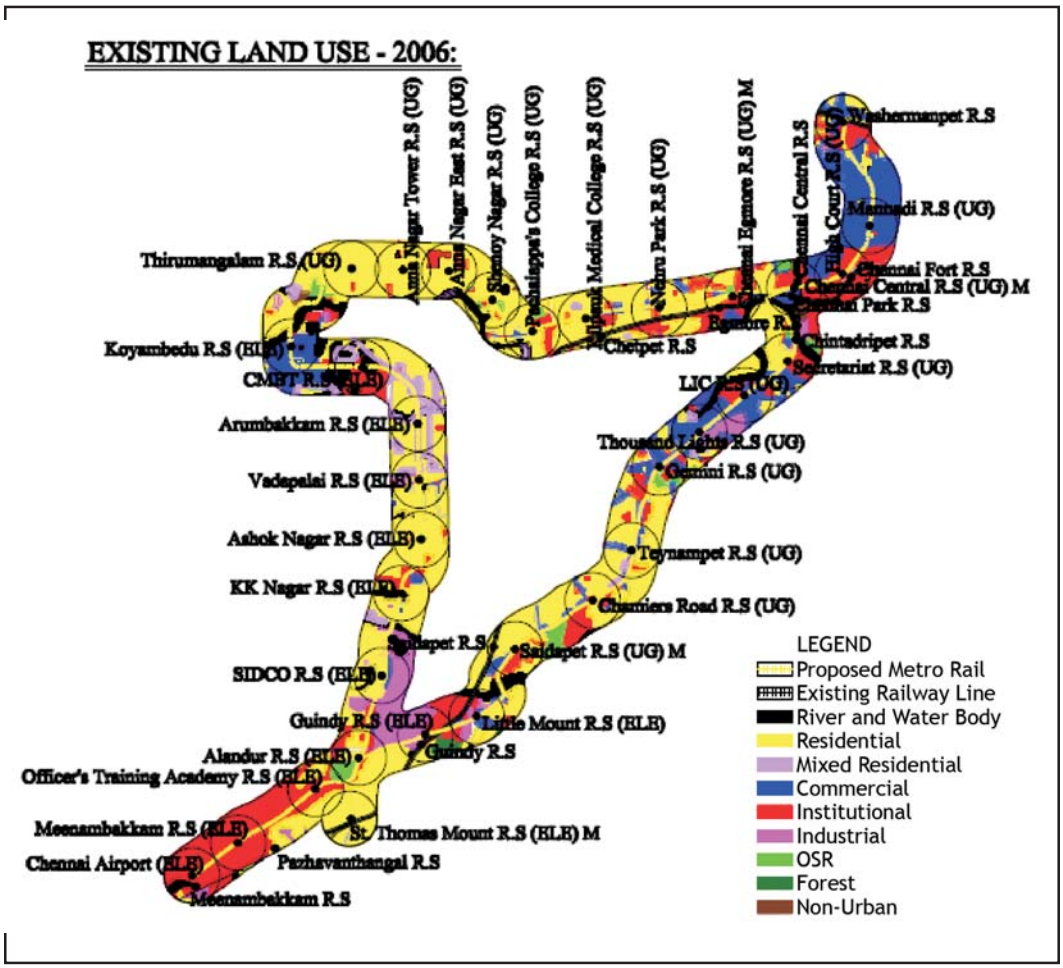


Fig. 5 Existing Land Use 2006 (Percentage)

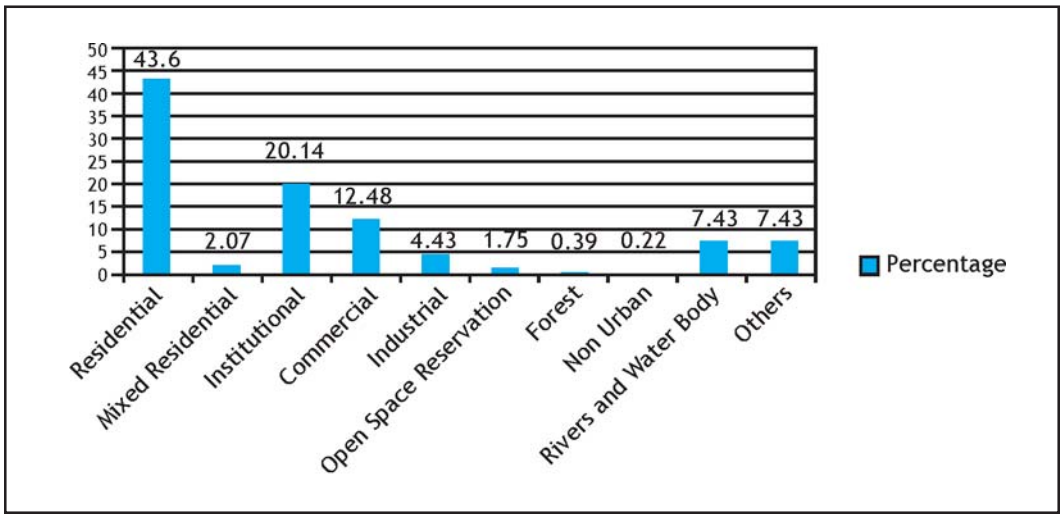


Fig. 6 Proposed Land Use, 2026

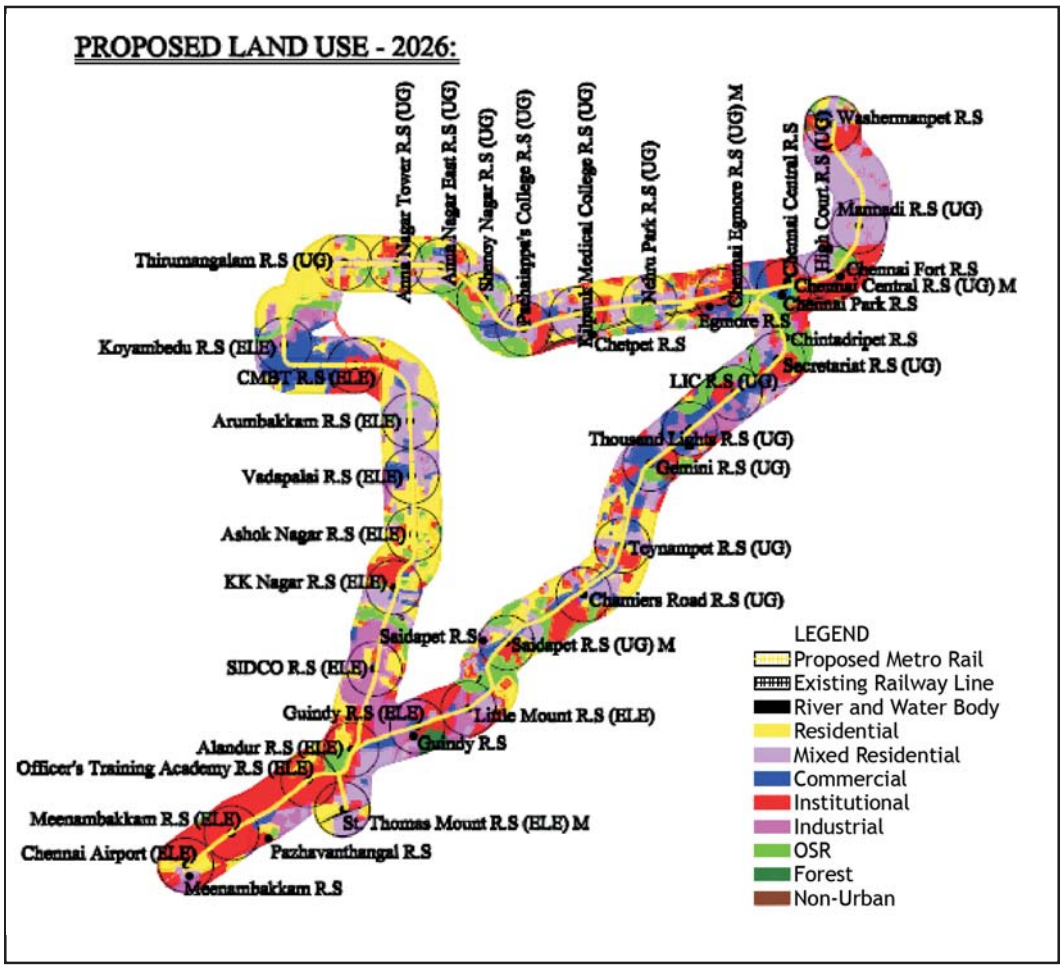


Fig. 7 Proposed Land Use - 2026 (Percentage)

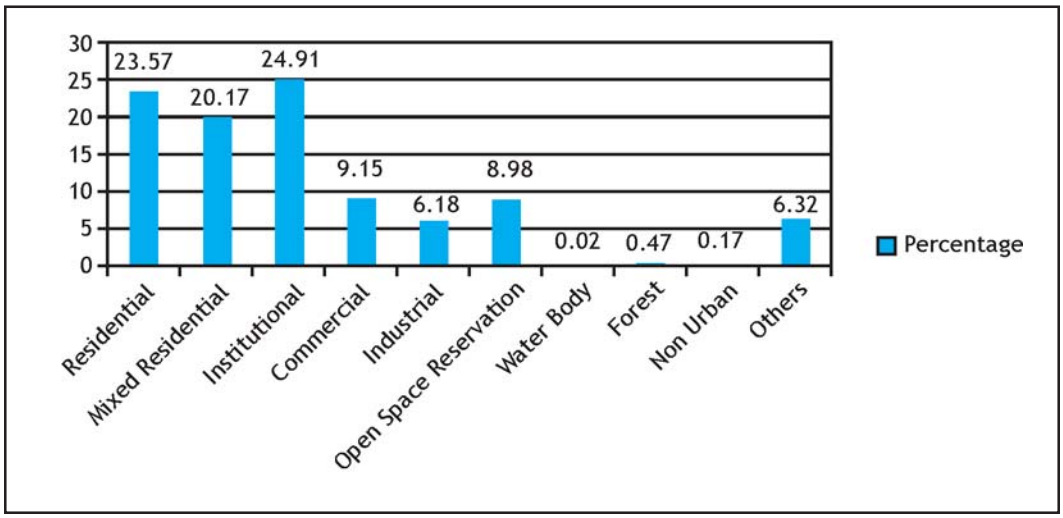
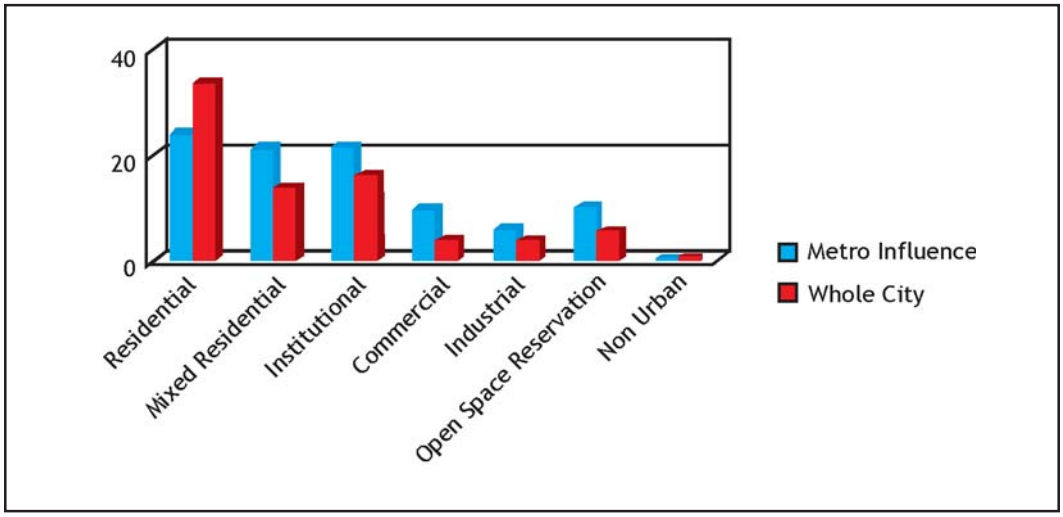


Fig. 8 Metro Rail Influence Area in Proposed Land use - 2026 (Percentage)



use from 0.83 percent to 20.17 percent. Out of the total commercial area proposed for the entire Chennai city of 7.14 sq km, metro influence area contains 3.27 sq. km, which comes nearly 50 percent. Metro's influence area also contains more percentage of institutional, industrial, mixed residential, open space and recreation uses than the rest of the city.

6. PARAMETERS FOR ANALYZING THE IMPACTS OF THE METRO RAIL CORRIDOR

Barrie Needham (1997) in his book 'How Cities Work: An Introduction', explains the reasons for change in land use and his reasoning forms part of the selected parameters. The communications take place along channels, which may be naturally provided e.g. rivers, but which more often are adapted e.g. roads, telephones. Again there is interaction between communications and channels. Road width and the condition of traffic flows play a major role in communication.

- Market Forces: If there is competition for space whereby two different activities want to be on the same site, the activity to which the site is more valuable obtains the site by paying more money for it.
- Commercial Use: Shopkeepers, in order to capture customers, want a location that is very accessible from residential areas. As there are few such locations within a town, the search for accessibility causes shops to cluster. Clustering of some shops may be further encouraged by business links between the shopkeepers. Shopkeepers believe that a continuous and unbroken

Fig. 9 Transport System and Land Use

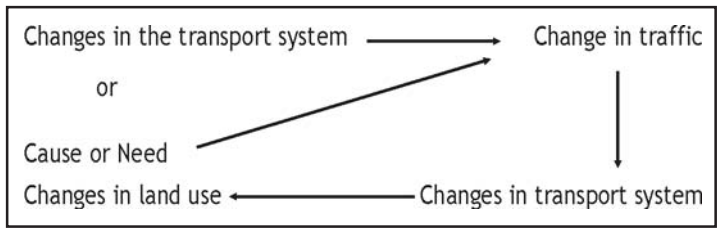


Fig. 10 Analysis of the Secretariat Station

Secretariat Station

Parameters:

Primary Parameters:	Weightage	Scored		Reasons
• Road Width	5	3		It varies between 18 - 28m.
• Communication channel - Roads • by 200m • by 300m • by 500m	 5 3 2	5		
• Inter modal transit • by Trains • by 200m • by 300m • by 500m	 5 3 2	3		
• by Bus • by 200m • by 300m • by 500m	 5 3 2	5		
• Population density	5	3		About 22,000 people-within walkable distance.
• Unbroken Shopping Frontage	5	3		There is unbroken shopping frontage, with no service lane and wide road on one side.
Secondary parameters				
• High visibility from Highway	3	1		This stretch has too many bends with wide road.
• Condition of Traffic Flow	3	3		As one side is undeveloped, the condition looks good.
• Nearby Facilities • School • Hospital • Recreational Spaces	 3 3 3	 3 1 3		Many cinema and drama theatres are within easy reach. Clinics are found in the residential areas. Schools are located in Chintadripet.
• Closer to workplace	3	2		Chintadripet and Triplicane are the residential locations within walkable distance.
• Social segregation of houses	3	0		It is not found here.
• Visual quality • Environmental Character	3 3	2 0		Secretariat will boast the visual quality. Coovum river, Spoils the surroundings.
• Local Labour Market	3	3		Slum people within chintadrepet.
• Future developments	40	40		Proposed Secretariat
Total	100	100		

Station location:
Left Side
The Mail, Hindu, P ORR & Sons.

Right Side
Government Estate.

Table 2 Consolidation and Classification of Stations Based on Scores

S. No	Name of the Station	Score	Envisaged major Planning Problems	Strategy for Development
Stations which will Undergo Drastic Changes				
1	SECRETARIAT	80	Proposed Secretariat - Crowd Generation.	A Subway - near Chintadripet Station.
Stations which will Undergo Intermediate Changes				
2	WASHERMANPET	55	Para Transit Facilities and Traffic Regulation	An Exclusive Parking lot and a subway to connect the bus stand.
3	CHENNAI CENTRAL	54	Inter modal Facilities - Traffic Regulation and Crowd Generation due to the Proposed General Hospital extension in Central Jail Land	Space for Auto/Taxi & a Flyover is required near Central Station.
4	CHENNAI EGMORE	54	The Apartment culture near is set to intensify.	MSB Residential Developments should be given with an increase in FSI.
Stations which will Undergo Minimal Changes				
5	SIDCO	52	More Office spaces are likely to come up here.	Need for a change in Land Use to Commercial.
6	THOUSAND LIGHTS	51	Industries may find it hard to survive.	It is likely to be converted to Office Spaces.
7	GUINDY	50	The space will likely to have more Office and Hotel facilities.	It should be encouraged.
8	LIC	49	The nearby residential areas that too an old settlement will be an hindrance for development.	Redevelopment of such spaces should be encouraged.
9	TEYNAMPET	48	The nearby residential areas are likely to become office spaces.	Residential areas are likely to have a high intensity of development that too of mixed residential character, which will find it hard to have the supporting infrastructure facilities.
10	LITTLE MOUNT	48	More Office spaces are likely to come up here, and the residential areas may find it hard to change as it is an old settlement with social grouping.	Office use buildings should be encouraged.
11	NEHRU PARK	47	Multi Storied Apartments trend in the surrounding areas is set to continue.	It should be encouraged.

S. No	Name of the Station	Score	Envisaged major Planning Problems	Strategy for Development
12	SHENOY NAGAR	46	Individual Houses are likely to become Apartments as it has all the needed other infrastructure facilities.	Development Regulations should be strictly followed and violations should be checked.
13	THIRUMANGALAM	45	Traffic Regulation and crowd management.	A flyover becomes essential to regulate traffic.
14	ANNA NAGAR TOWER	44	Informal sector will come up near Vishveshwara Park.	Separate space should be allocated for informal sector development.
15	ARUMBAKKAM	43	Office spaces are likely to come up here.	Nearby residential areas may find it hard to support such a high level of development.
16	GEMINI	40	Horticulture location near the station may not survive.	The space will become an office space or a Hotel, as horticulture plants may not survive in this high traffic zone.
17	ALANDUR	39	Para transit facilities become essential.	Creation of a bus terminus will cater to the need.
Stations which will have No Changes due to the Proposed Metro Rail.				
18	KK NAGAR	37	The slums next to the station will be removed.	Rehabilitation of slum dwellers.
19	HIGH COURT	36	Metro's effect will be minimal as only crowd dispersal will be there.	Already we have two elevated Foot over bridges.
20	KOYAMBEDU	36	This space will have more development, as the surrounding areas are undeveloped land.	Planning interventions is a must for better quality of living and environment.
21	VADAPALANI	34	Traffic problem and crowd generation.	A flyover and a pedestrian underpass become essential.
22	SAIDAPET	34	Para Transit Facilities and Traffic Regulation.	Pedestrian foot over bridge becomes essential.
23	KMC	32	Pond near the college may be eaten up, by development.	Conservation of water body becomes essential.
24	ST. THOMAS MOUNT	31	It is proposed here for para transit facility and not much scope for development nearby.	Underground connection between both stations becomes essential or a foot over bridge.
25	CHAMIERS ROAD	31	Individual Houses are likely to become Apartments.	Development Regulations should be strictly followed.
26	ASHOK NAGAR	31	Nearby Residential areas will have a high intensity of development.	Regulation adhering to development control becomes essential.
27	PACHAIAPPA'S COLLEGE	30	Crowd dispersal will be there.	Need for a Flyover becomes essential as it is a narrow road.

S. No	Name of the Station	Score	Envisaged major Planning Problems	Strategy for Development
28	OFFICERS TRAINING ACADEMY	28	Nearby Residential areas will have a high intensity of development.	Regulation adhering to Development Control becomes essential.
29	ANNA NAGAR EAST	28	Nearby Educational Institutions may find it hard to survive.	The land use may be changed to commercial.
30	CHENNAI AIRPORT	26	Security becomes a Problem, as more crowds are likely to be generated near Airport.	Security system needs to be enhanced.
31	MEENAMBAKKAM	26	Pazhavanthangal is set to have a high intensity in Residential Development.	Regulation adhering to Development Control becomes essential.
32	CMBT	25	The crowd in the Buses will be reduced.	The Bus services along the Proposed Metro Corridor should be Minimized.
33	MANNADI	22	This Metro station won't have much impact other than crowd generation.	A Flyover becomes must for Traffic Movement, as it is a narrow road.

Table 3 Major Planning Problems and Strategies for Development

Envisaged major planning problems	Strategy for development
Proposed Secretariat and its office facilities will generate lot of crowd, in the Chintadripet MRTS Station.	A subway near Chintadripet station will avoid more crowds on the road.
Para Transit Facilities and the road space which is set to be occupied by the Autos and Taxis.	Creation of Auto and Taxi stands in the vicinity.
More Parking demand, because of the crowd generation.	Providing Exclusive Multilevel Parking lots in the vicinity.
Informal sector will come up because of the more people's movement.	Separate space for informal sector development.
More Commercial and Office spaces will come up in the surrounding spaces due to the available transport facilities.	Converting the land use into commercial zone.
More slum areas will come up in Chintadripet.	Strategy to control the spread of slum areas.
Radio market will become a high tech electronic market.	Radio market should be converted to pedestrianized zone.Goods movement must be allowed only in the night time.
Nearby residential location - Chintadripet and Triplicane will see an high intensity in development that too in housing sector	Apartment coming up in the nearby residential areas should be given more FSI.
Selected Heritage Building conservation becomes essential.	The Mail building near Hindu should be protected as a Heritage building.

Fig. 11 Major Planning Problems and the Strategies Around Secretariat Station

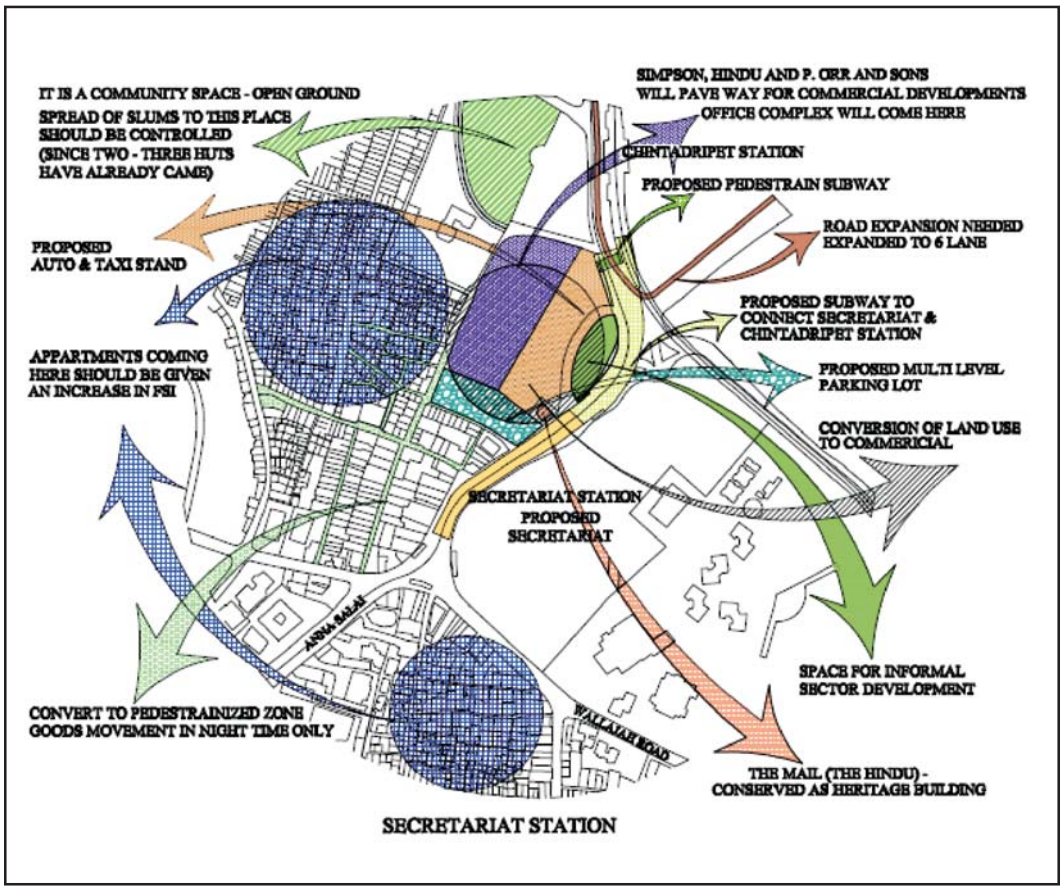


Fig. 12 Age of the Buildings Around Secretariat Station

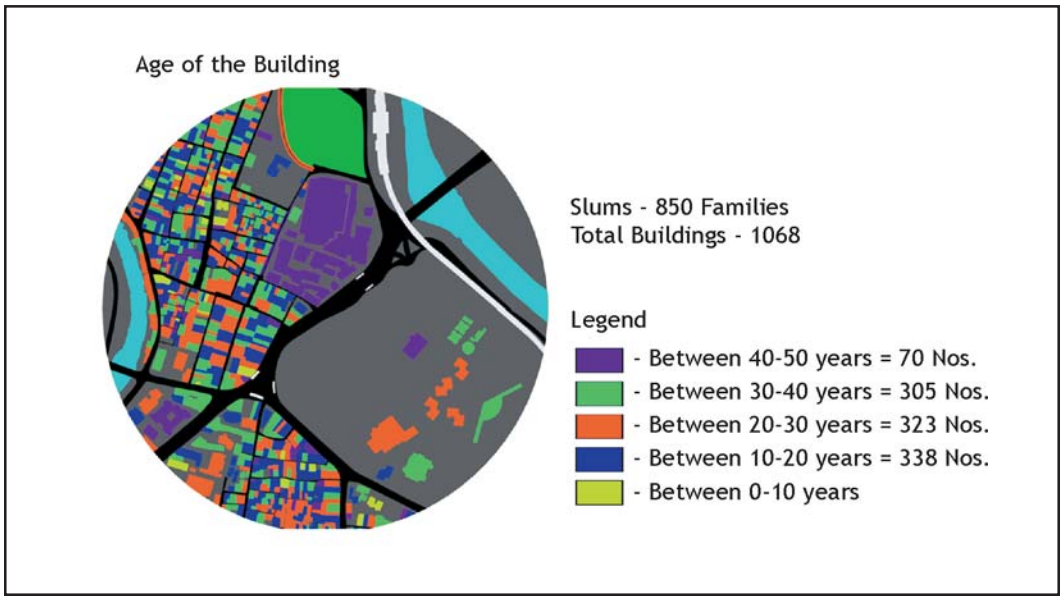


Fig. 13 Land Use, 2009 Around Secretariat Station

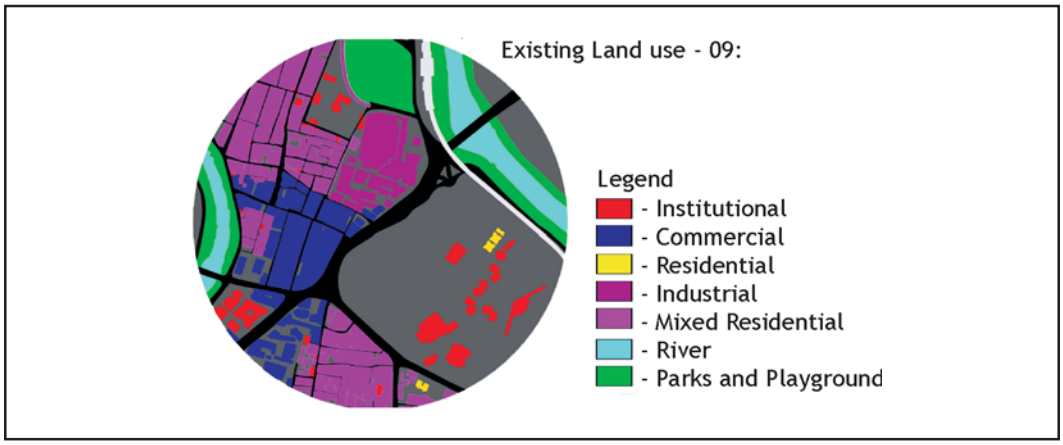


Fig. 14 Proposed Land Use – 2026 (Second Master Plan) Around Secretariat Station

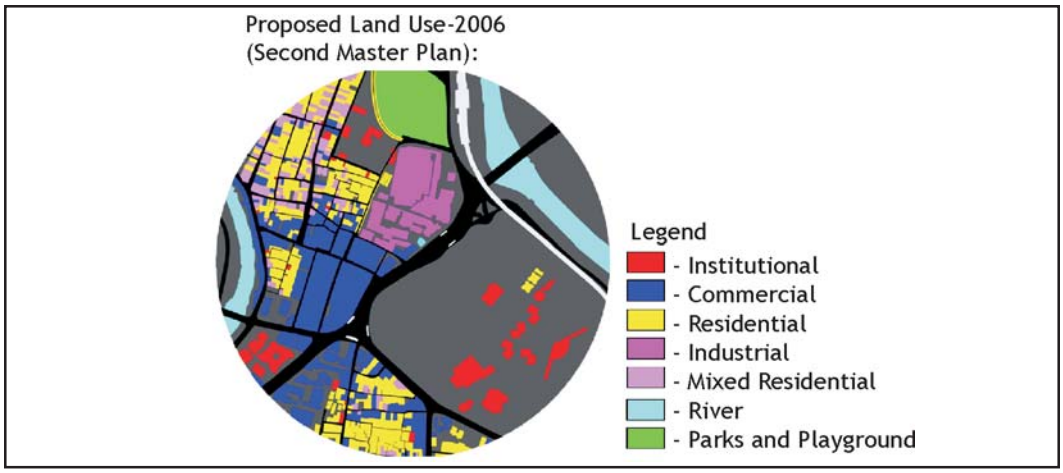
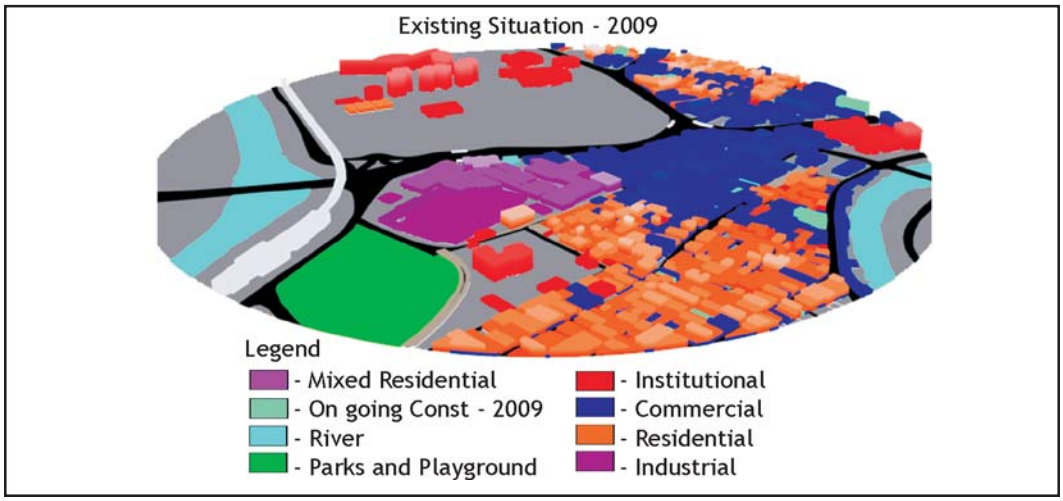


Fig. 15 Developments Around the Secretariat Station, 2009



shopping frontage is necessary for high sales in their shops, because a break in the shopping frontage reduces the attractiveness of the street to shoppers. The visibility from the highway is also an important factor for the attractiveness of the shops to the customers.

- Social Segregation: People want to live in same area as other households with similar social characteristics.
- Closer to Workplace: The usual assumption about housing demand is that all households want to live as near as possible to their workplaces and that the further away they are less prepared to pay for housing i.e. households substitute between transport costs and rent costs.
- Local Labor Market: Interactions between geographical labor markets are usually more important than between occupational labor markets, because it is easier for most workers to change their work journeys than their skills.
- Future Developments: Major infrastructure and commercial facilities, which are set to come up in a location marks the beginning of the development of that particular area.

By taking into consideration the above parameters and additional features like the road width, condition of traffic flow, inter modal transit facilities pertaining to a particular location, communication channels, population density of the locality and the nearby additional facilities were taken as the criteria for analysis.

All the proposed thirty three stations were analyzed on the above said primary and secondary parameters and their consolidated score points are shown in Table 2. Here the stations were classified into four categories based on the points.

From the above mentioned thirty three stations, only one station i.e. from the Secretariat Station is taken for detailed study because of the time constraint.

7. SECRETARIAT STATION

Major planning problems and the strategy needed to be adopted for a better planned development in and around the Secretariat Station is shown in Table 3.

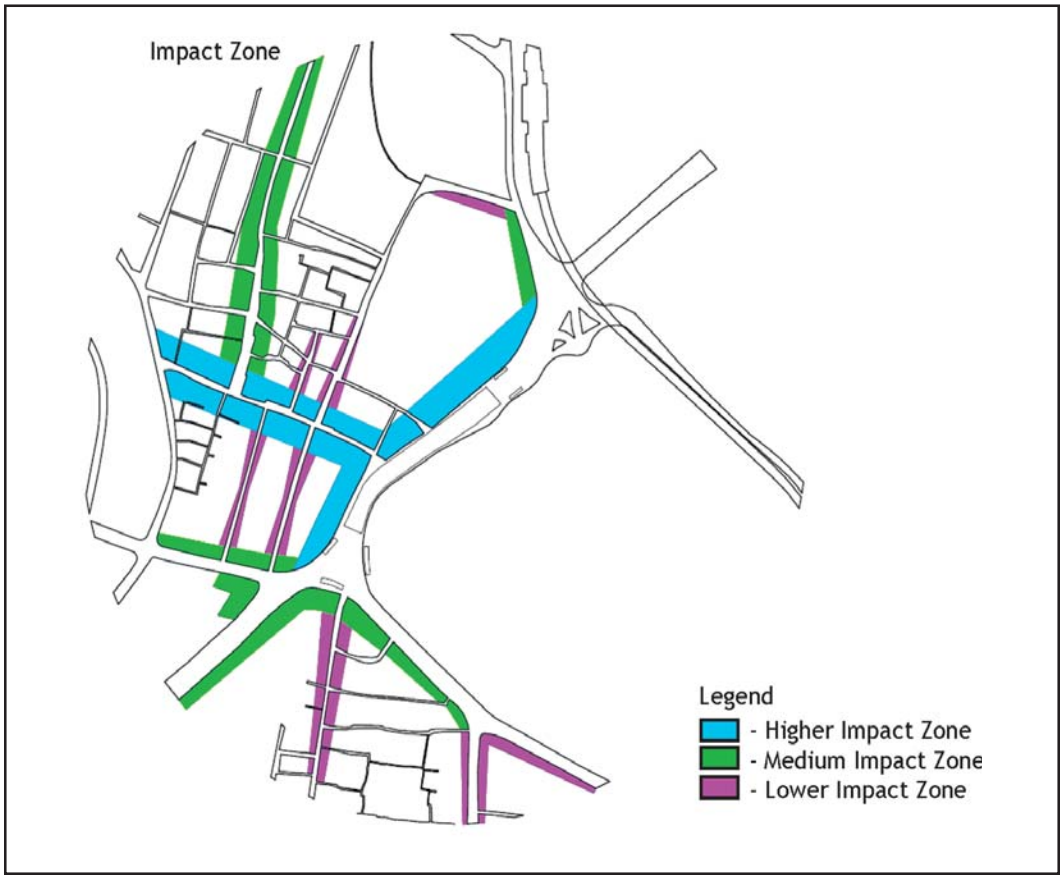
8. IMPACT ZONE

The space surrounding the proposed secretariat station is classified into three zones as shown below.

8.1 Higher Impact Zone

This zone contains the road or street which comes immediately next to the proposed station. This location receives the maximum impact. In this zone, all old and very old buildings (30 - 40 years of age as of today) will be the first one to go for redevelopment in the first five year time period after the arrival of the station.

Fig. 16 Impact Zones Surrounding the Proposed Secretariat Station



8.2 Medium Impact Zone

This zone can be accessible from the station only after crossing the higher impact zone. This zone will gradually be converted into a mixed residential area. This zone will go for redevelopment only when the old and very old buildings of higher impact zone are redeveloped. When this zone goes for redevelopment, its very old and old buildings will be the first one to go under hammer, and during this period all the medium aged buildings (20 - 30 years of age as of today) in the higher impact zone will also go for redevelopment.

8.3 Lower Impact Zone

This zone comes at the far end of the station. This zone will take at least ten years to go for redevelopment that too when all the old and very old buildings of secondary impact zone have completed the redevelopment process. When this zone is under redevelopment, all the new building (10 - 20 years of age as of today) in higher impact zone and medium aged buildings in medium impact zone will also see the redevelopment process. In lower impact zone too, the redevelopment will start only from the old and very old buildings. This zone is likely to remain as the residential use as it is today, but it will have a higher intensity in development.

9. ENVISAGED DEVELOPMENTS

The existing situation surrounding the proposed secretariat station is not very welcoming since the allowable Floor Space Index as per norms of the CMDA's Development Regulations is 1.5 but the currently existing FSI for residential development is between 2.5 – 3.5 and for commercial buildings it is between 3.5 to 4.5.

The reason for such mismatch is because of its strategic location and connectivity. While envisaging development trends for the next 5 years (2014), 10 years (2019) and 15 years (2024) that too after the arrival of the proposed Secretariat Station, the impact will be immense with more violation of building norms if the proposed Development Regulations of the Development Authority are not changed. So the envisaged development with respect to the built up area and the use of the building is shown in the Table 4.

Table 4 Envisaged Builtup Area and Usage

Year	Residential	Commercial	Institutional
5 Years (2014)	-	3 Lakh Sq Meters	2 Lakh Sq Meters
10 Years (2019)	1 Lakh Sq Meters	80,000 Sq Meters	-
15 Years (2024)	40,000 Sq Meters	60,000 Sq Meters	40,000 Sq Meters

For the above envisaged built up area the development regulations are worked out on two different scenarios, one is based on the plot coverage and the other with the setback requirements.

9.1 Option – 1: Plot Coverage

Here, the percentage of plot coverage is taken into account with no consideration for the minimum setback requirements given by the development regulations as this zone falls under continuous building area. The proposed development regulations are worked out considering the existing market situation, and inducing the developers to improve the existing situation to a more planned development, as this zone is part of the older settlements of the City (Tables 5).

FSI to Residential areas is allowed provided the minimum Flat Size is 60 sq meter with no car parking facility.

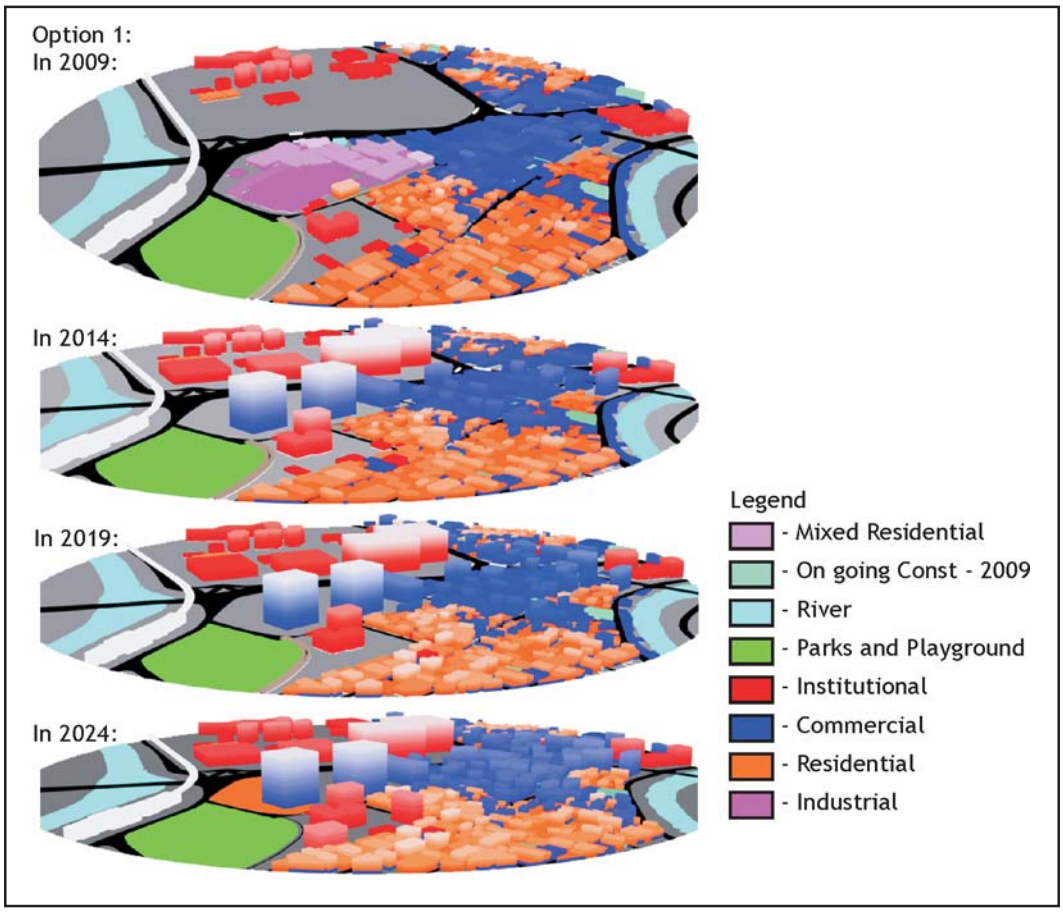
Table: 5. Proposed Development Regulations Based on Plot Coverage (Residential)

Plot Size	FSI	Plot Coverage	Floors	Height
1 Ground - Approximately (250 sq m) - (12.5m X 20m)	3.5 (875.00 sq m)	75 percent (187.50 sq m)	5 Floors	18.0 M
2 Grounds - approximately (500 sq m) - (20m X 25m)	4.0 (2000.00 sq m)	60 percent (300.00 sq m)	7 Floors	25.2 M
3 Grounds - approximately (750 sq m) - (25m X 30m)	4.5 (3375.00 sq m)	50 percent (375.00 sq m)	9 Floors	32.4 M
4 Grounds - approximately (1000 sq m) - (40m X 25m)	5.0 (5000.00 sq m)	40 percent (400.00 sq m)	13 Floors	46.8 M

Table: 6. Proposed Development Regulations Based on Plot Coverage (Commercial):

Plot Size	FSI	Plot Coverage	Floors	Height
1 Ground - Approximately (250 sq m) - (12.5m X 20m)	4.5 (1125.00 sq m)	75 % (187.50 sq m)	6 Floors	21.6 M
2 Grounds - approximately (500 sq m) - (20m X 25m)	5.0 (2500.00 sq m)	60 % (300.00 sq m)	9 Floors	32.4 M
3 Grounds - approximately (750 sq m) - (25m X 30m)	5.5 (4125.00 sq m)	50 % (375.00 sq m)	11 Floors	39.6 M
4 Grounds - approximately (1000 sq m) - (40m X 25m)	6.0 (6000.00 sq m)	40 % (400.00 sq m)	15 Floors	54.0 M

Fig. 17 Envisaged Developments - Option 1 (Plot Coverage)



An increase in FSI is given for the commercial establishment as more violations are found only in the commercial spaces. If the development is about to take on the above proposed development regulations, then we could very well envisage the surrounding areas around the Secretariat Station as shown in the Fig. 17.

9.2 Option – 2: Set back requirements

It is based on the set back requirements given for the multi storied buildings to the other parts of the City. The details of which are shown in Tables 7.

Table: 7. Proposed Development Regulations Based on Minimum Setback for Residential Use

Plot Size	FSI	Min setback (All around)	Built up area (sq m)	Floors	Height (Meter)
5 Grounds - approximately (1200 sq m) - (30 X 40)	2.5 (3000.00 sq m)	7 M (up to 30.5 M HT)	16 X 26 = 416	8	28.8
7 Grounds - approximately (1600 sq m) - (40 X 40)	3.0 (4800.00 sq m)	8 M (up to 36.5 M HT)	24 X 24 = 576	9	32.4
9 Grounds - approximately (2000 sq m) - (50 X 40)	3.5 (7000.00 sq m)	11 M (up to 54.5 M HT)	28 X 18 = 504	14	50.4
11 Grounds - approximately) (2400 sq m) - (50 X 48	4.0 (9600.00 sq m)	12 M (up to 60.5 M HT)	16 X 24 = 624	16	57.6

Fig 18 Envisaged Developments Option – 2 (Set Back)

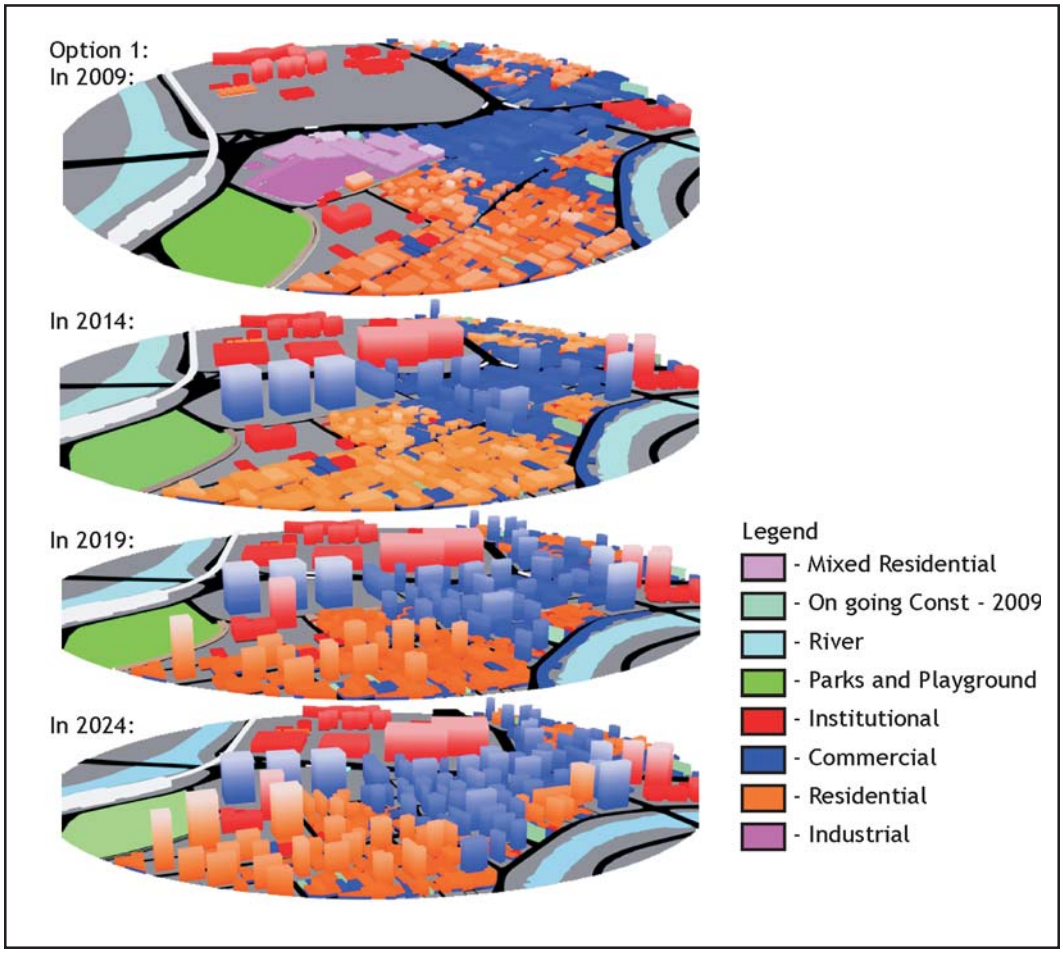


Table: 8. Proposed Development Regulations Based on Minimum Setback (Commercial)

Plot Size	FSI	Min setback (All around)	Built up area (sq m)	Floors	Height (Meter)
5 Grounds - approximately (1200 sq m) - (30 X 40)	2.75 (3300.00 sq m)	8 M (up to 36.5 M HT)	14 X 24 = 336	10	36.0 M
7 Grounds - approximately (1600 sq m) - (40 X 40)	3.25 (5200.00 sq m)	9 M (up to 42.5 M HT)	22 X 22 = 484	11	39.6 M
9 Grounds - approximately (2000 sq m) - (50 X 40)	3.75 (7500.00 sq m)	11 M (up to 54.5 M HT)	28 X 18 = 504	15	54.0 M
11 Grounds - approximately (2400 sq m) - (50 X 48)	4.00 (9600.00 sq m)	12 M (up to 60.5 M HT)	26 X 24 = 624	16	57.6 M

- FSI to Residential areas is allowed provided the minimum Flat Size is 60 SQ.M, with no car parking facility.

An increase in FSI is given for the commercial establishment as more violations are found only in the commercial spaces.

10. CONCLUSIONS

The development regulations as described above are followed based on the set back requirements, the resultant development will be as envisaged. This envisaged development also needs the supporting infrastructure facilities like the water supply, sanitation, electric supply, widening of existing roads, enhancing the security arrangement, need for more schools in the nearby locations, more open space, playgrounds, etc. With the provision of all the above said facilities, the Secretariat Station and its surrounding areas will become a better place to live. In the same manner, all the thirty three proposed stations all along the Chennai Metro Rail Corridor can be brought under planned and regulated development for the better quality of living of Chennai citizens.

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Institute of Town Planners, India Journal 6 - 4, 61 - 67, October - December 2009

Traffic Analysis for a Typical Four Armed Intersection at Madurai

R. Udayakumar and S. Ramamurthi

Abstract

The increase in the average income level of the people and the easy loans offered by the financial institutions coupled with the inefficiency of public transport has forced the common man to personalize a vehicle for his day to day movements. At the same time the increase in the infrastructure facilities especially the road space particularly at intersections has not seen the equivalent improvement or upgradation. This has resulted in congestion and enormous delays leading to wasting of man hours, money and natural resources. Treatment to an intersection from the traffic angle requires systematic analysis of the traffic flow in the intersection.This paper attempts to provide a systematic analysis of traffic flow in a four armed intersection.

1. INTRODUCTION

Urbanization in developing countries has resulted in tremendous increase in population in its cities during the 20th century. Census of India categorized urban areas into six classes as Class I cities to Class VI cities. Class I cities are those which have population of more than 1 million. It is observed from statistics that number of Class I cites is on the rise. All other classes also show an increase in its number over the period of time. The number of Class I cities was 9 in 1971 and rose to 12 in 1981 and then to 23 in 1991 and increased to 26 by the year 2001. The increase in the number of cities attracts numerous industries especially the automobile and its ancillary industries in and around the periphery of the city. This has resulted in mass production and sales of vehicles at competitive prices especially during the last decade. This is evident from Table 1 where vehicle population in Tamilnadu has reached nearly 3 times since 1997.

The reasons attributed to this trend of traffic growth are that along with the economy of the country, the average income level of the people has increased substantially. Moreover the financial institutions have opened up easy loan facilities for purchasing vehicles. At the same time the public transport facilities could not meet the transport demand owing to its inefficiency in services leading to long waiting time at bus stops. These factors have forced a common man to personalize a vehicle for his day-to-day commuting. But on the other side the existing infrastructure facilities especially the road network has not improved at par with the growth of vehicles. This has led to congestion, delay, queuing of vehicles at intersections, air pollution,

***R.Udayakumar**, is Senior Lecturer, Department of Civil Engineering, Sree Sastha Institute of Engineering and Technology, Chennai.*
***S.Ramamurthi**, is Deputy Planner, Chennai Metropolitan Development Authority, Chennai*

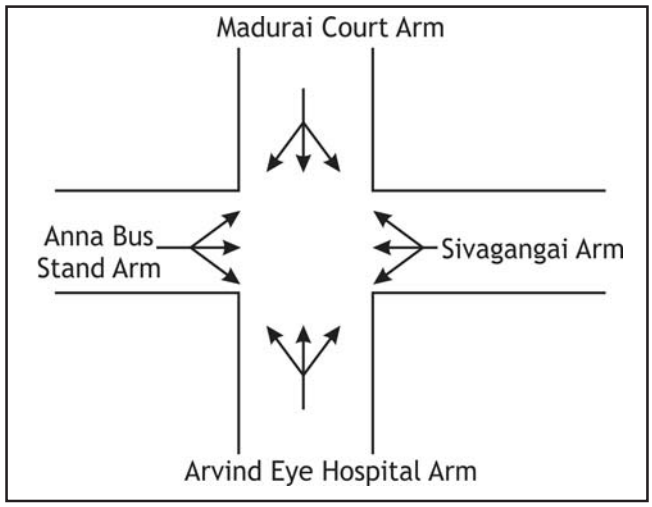
noise pollution, wastage of fuel, time, money, etc. This calls for improvements at the intersections apart from mere widening of the carriageway.

The type of treatment such as roundabouts, signals, grade separator, etc; required for an intersection is based on the existing traffic flow that is entering and leaving the intersection. Systematic analysis of traffic flow will provide clear guidelines in choosing the appropriate solutions. In this paper an attempt is made to provide a systematic analysis for a four armed intersection. An Intersection closer to Milk Depot (Milk Depot Intersection) at Madurai, a class I city, is taken up for the study. Fig 1 shows the sketch of the intersection.

Table 1 Growth of Vehicles in Tamilnadu

Year	Transport Vehicles	Non-Transport Vehicles	Total
1997	3,09,817	28,72,002	31,81,819
1998	3,44,244	32,70,004	36,14,248
1999	3,68,922	37,01,812	40,70,734
2000	3,99,300	42,07,928	46,07,228
2001	4,21,365	47,40,717	51,62,082
2002	4,32,106	52,25,991	56,58,097
2003	4,57,448	57,51,589	62,09,037
2004	4,72,172	62,80,301	67,52,473
2005	4,93,926	69,09,818	74,03,744
2006	5,81,106	76,40,674	82,22,730

Fig 1 Sketch of the Milk Depot Intersection



2. INTERSECTION VOLUME COUNT

24 hours classified traffic volume count survey was carried out for all the 7 days in a week. The left, straight and right movement for each mode and for each arm was noted exclusively on a data inventory sheet. The various modes such as two wheeler, auto, car, mini bus, standard bus, LCV-van, goods auto, 2 axle truck, 3 axle truck, multi axle truck, tractor, tractor trailer, cycle, cycle rickshaw, bullock cart, horse cart are considered for the survey. The vehicles were counted both manually and by using counters depending on the mode and entered in the inventory sheet using tally mark. Different types of vehicles were converted to a common Passenger Car Units (PCUs). The PCU values adopted for each mode is shown in Table 2.

A Master sheet is prepared consolidating the data for all the 7 days both in PCUs and vehicles. From this a particular day is chosen where the traffic flow is the maximum. Fig 2 shows percentage composition of traffic with respect to days of a week.

From the figure it is found that Tuesday carries maximum percentage of traffic. Thus the traffic data of Tuesday is considered for further analysis. Fig. 3 and 4

Table 2 PCU Factors for Various Modes

S.No	Description	Factors
1	2 Wheeler	0.50
2	3 Wheeler	1.00
3	Car/jeep/ Tax	1.00
4	Bus (Mini Bus)	1.50
5	Bus (Full Standard)	3.00
6	LCV(van)	1.50
7	Goods Auto	1.00
8	2 – Axle	3.00
9	Multi Axle	4.50
10	Articulated/semi articulated	4.00
11	Agriculture Tractor(with trailer)	4.50
12	Agriculture Tractor(without trailer)	1.00
13	Cycle	0.50
14	cycle Rickshaw	1.50
15	Animal drawn Bullock cart	8.00
16	horse drawn vehicle	4.00
17	other vehicles	8.00

show the trend of traffic flow over time. It is found that the peak hour of the peak day falls between 1800 and 1900 hours. This peak hour volume plays a major role in determining the appropriate treatment to the intersection. The term peak hour factor can be determined which is defined as the ratio between the number of vehicles counted during the peak hour and four times the number of vehicles counted during the highest 15 consecutive minutes. The peak hour factor can range from 0.25 to 1.00, the former value representing the extreme peaking condition and the latter representing a uniform flow during the peak hour.

3. COMPOSITION OF VEHICLES

The composition of vehicles during the peak hour is analyzed to find out the mode which is dominating the traffic. Table 3 and Fig. 5 show the composition of vehicles during peak hour. From the figure it is found that two wheelers constitute 42 percent of traffic volume followed by cars (21 percent) which is followed by autos (16 percent) and cycle (15 percent). Rest of the modes has negligible volume. Thus, while designing proposals due care must be given to predominant modes using the intersection.

Fig 2 Percentage Composition of Volume Vs Days of a Week

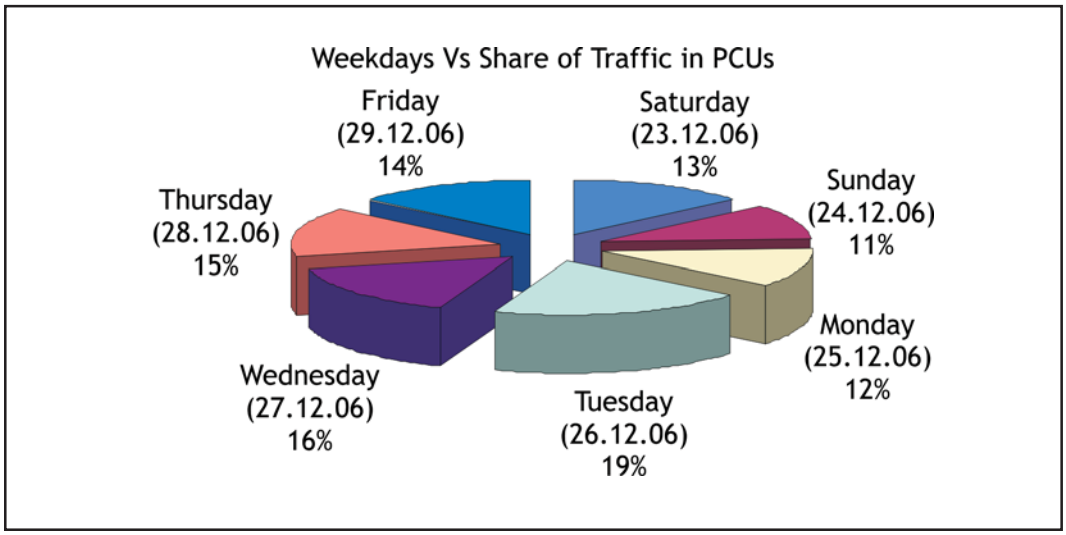


Fig 3 Trend of Traffic Flow in PCUs Over 24 Hours

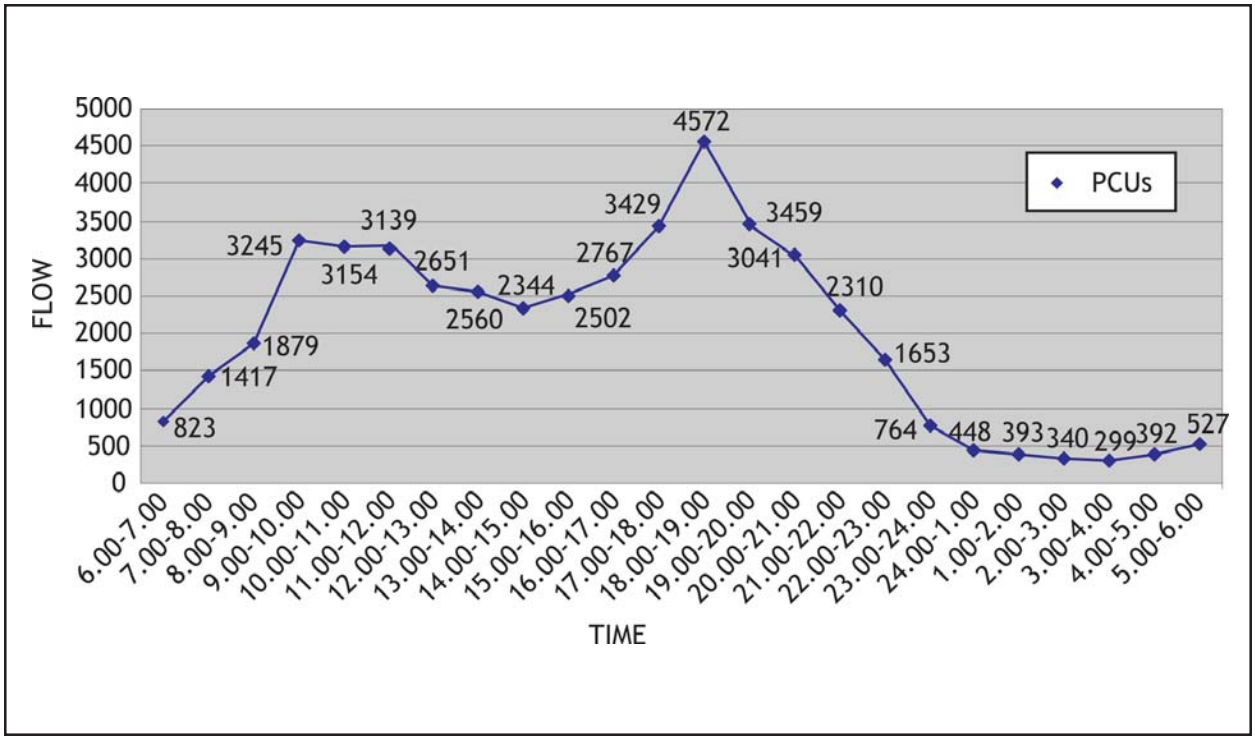


Fig. 4 Trend of Traffic Flow in Vehicles Over 24 Hours

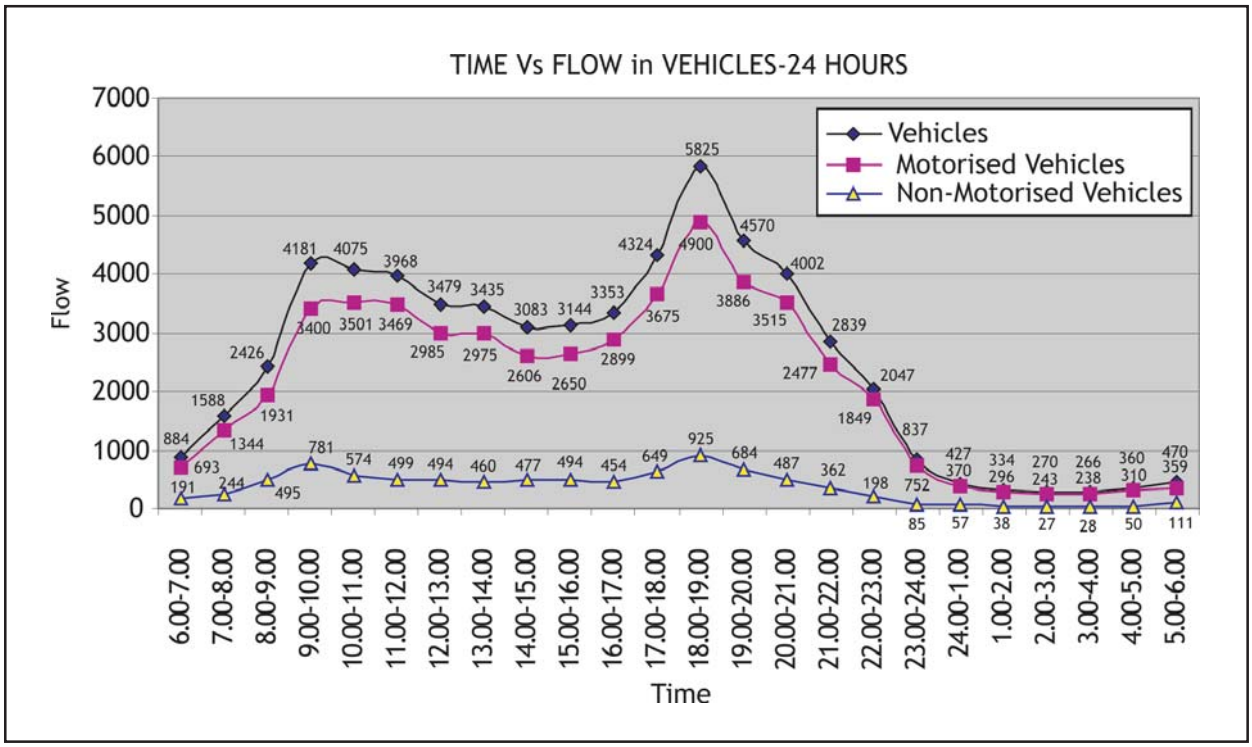
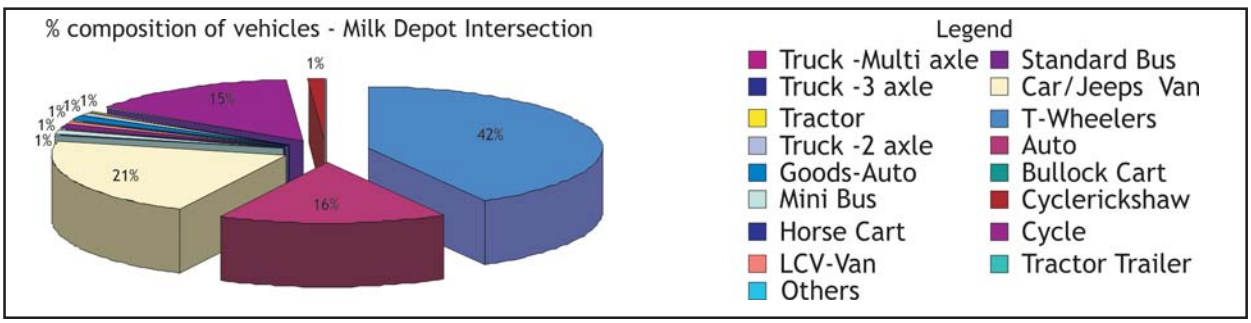


Table 3 Classified Volume During Peak Hour in Each Directional Movement

Movement	Time:	T=Wheelers	Auto	Car/Jeeps Van	Mini Bus	Standard	LCV-Van	Goods-Auto	Truck-2	Truck-3	Truck-Multi	Tractor	Tractor	Cycle	Cyclerickshaw	Bullock	Horse Cart	Other	Total
Sivagangai to Arvind Eye Hospital	18.00-19.00	152	16	40	1	0	1	6	0	0	0	0	1	88	2	0	0	0	
Sivagangai to Anna Bus Stand	18.00-19.00	296	189	207	5	17	6	14	29	0	0	2	0	89	16	0	0	0	
Sivagangai to Madurai Court	18.00-19.00	139	15	37	2	0	0	2	1	0	0	0	0	47	1	0	0	0	
Madurai Court to Sivagangai	18.00-19.00	107	20	37	2	0	4	4	1	0	0	0	0	35	1	0	0	0	
Madurai Court to Arvind Eye Hospital	18.00-19.00	629	315	470	26	3	15	18	0	0	0	0	0	265	13	0	0	0	
Madurai Court to Anna Bus Stand	18.00-19.00	183	64	70	4	11	1	6	1	0	0	0	0	98	0	0	0	0	
Anna Bus Stand to Madurai Court	18.00-19.00	102	39	25	2	2	0	2	1	0	0	0	0	36	3	0	0	1	
Anna Bus Stand to Sivagangai	18.00-19.00	207	59	69	4	7	7	11	17	2	0	0	0	7	3	0	0	0	
Anna Bus Stand to Arvind Eye Hospital	18.00-19.00	63	10	24	0	1	0	4	0	0	0	0	0	6	1	0	0	0	
Arvind Eye Hospital to Anna Bus Stand	18.00-19.00	263	62	131	8	17	3	3	2	0	0	1	0	88	21	0	0	0	
Arvind Eye Hospital to Madurai Court	18.00-19.00	195	99	86	1	13	6	5	1	0	0	0	2	55	2	1	0	1	
Arvind Eye Hospital to Sivagangai	18.00-19.00	98	34	32	3	1	0	3	4	0	0	0	0	42	1	1	0	1	
Total		2434	922	1228	58	72	43	78	57	2	0	3	3	856	64	2	0	3	5825
% Composition		41.8	16	21.1	1	1	1	1	1	0	0	0.05	0.05	15	1	0	0	0	100

Fig. 5 Percentage Composition of Vehicles During Peak Hour



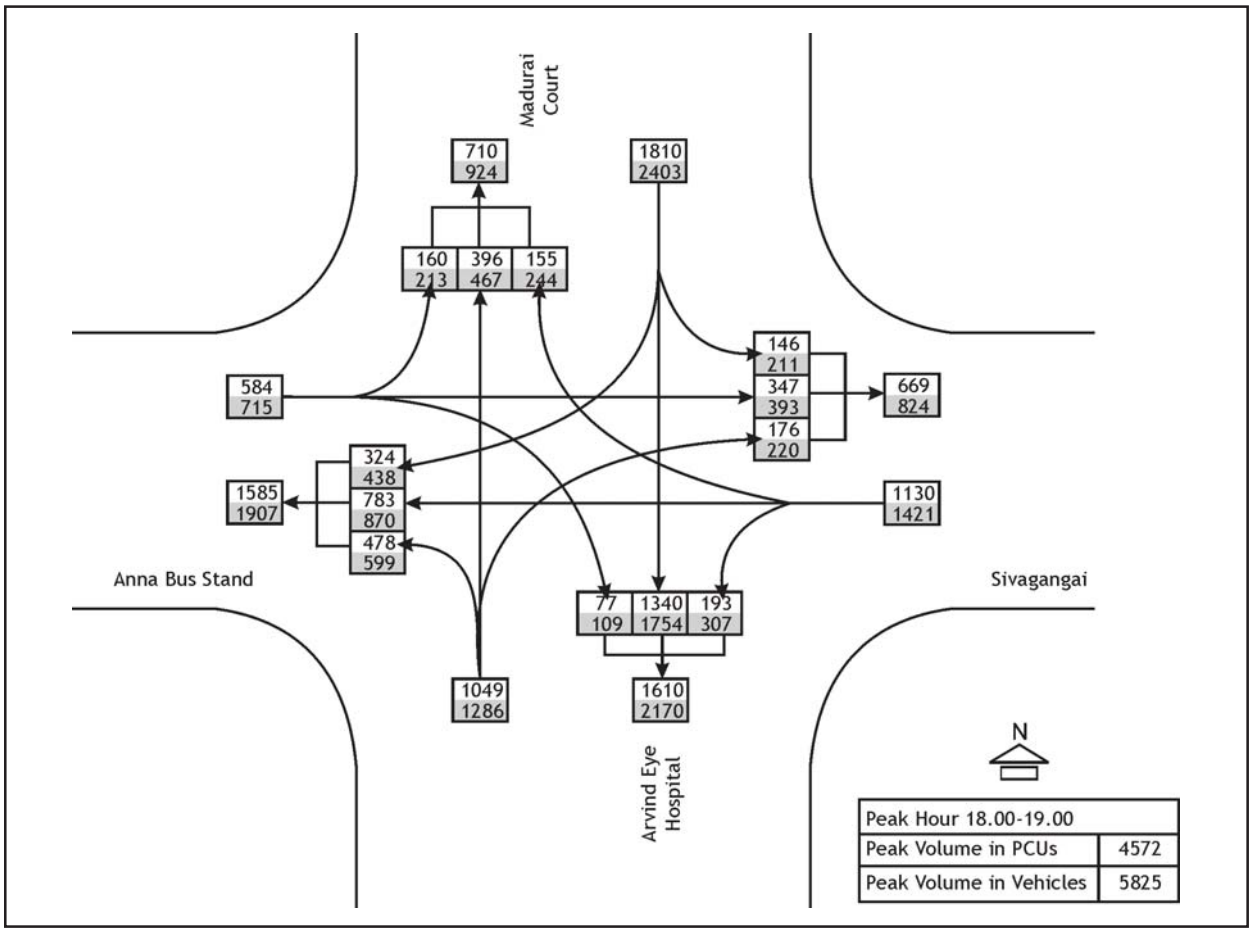
4. TURNING MOVEMENTS

Table 4 and Fig. 6 show the turning movements at the intersection. The turning movements diagram reveals that almost in all the arms the straight movement traffic

Table 4 Turning Movements at the Intersection

Turning Movements at Milk Depot Intersection during peak hour 18.00 to 19.00 in PCUs								
	Turning Movements						Volume	
	Left		Straight		Right			
Name of the arm	Value	%	Value	%	Value	%	in PCUs	Volume in %
Sivagangai	**193**	17.04	**783**	69.29	**155**	13.67	1130	24.72
Madurai Court	**146**	8.04	**1340**	74.05	**324**	17.91	1810	39.58
Anna Bus Stand	**160**	27.34	**347**	59.47	**77**	13.20	584	12.76
Arvind Eye Hospital	**478**	45.52	**396**	37.70	**176**	16.78	1049	22.94
							4572	100.00

Fig. 6 Turning Movements Diagram - Milk Depot Intersection



is predominant except the Arvind eye arm where left turning traffic is maximum (45.52 percent). The to and fro (straight) movements between Arvind eye arm and the Madurai Court arm is maximum (1,736 PCUs) when compared to all other movements. Thus, this information is very vital in fixing the orientation of proposals for the intersection.

5. CONCLUSIONS

This paper provides a clear understanding of analyzing traffic volume of a typical four armed intersection. The peak hour volume and time, the percentage composition of vehicles and the turning movements at the intersection during the peak hour were analyzed. The results of analysis are very vital in determining the type as well as the geometrics of the proposed treatment. This paper emphasizes that a systematic analysis is required to provide appropriate treatment to an intersection.

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Institute of Town Planners, India Journal 6 - 4, 68 - 72, October - December 2009

Technical Rationality, Equity and Transport Planning: Future Agenda for Research and Practice

Prof. Dr. Ashok Kumar

Abstract

In this paper, the author argues that transport planning has become highly sciencitized discipline. Sciencitization of transport planning practice, among others, have led to two main consequences for society and economy. One, sciencitization of transport planning has led it to achieving the ends of technical rationality that is transport planning practitioners firmly believe that technical robustness of their proposals and projects remain their primary task, and moral goals such as transport equity are mere social irritants. Second, excessive emphasis on technical rationality has created a condition whereby problem formulation and reformulation has become detached from societal needs, particularly those of the majority urban poor. The paper ends by suggesting that moral principles such as equity and by implication social justice must remain at the heart of transport planning practice and education, if this important specialization has to make any significant contribution to the most important exercise of nation building.

1. INTRODUCTION

Transport planning is an integral part of town and country planning. It is the only land use, which has the capacity to provide links between other land uses physically. Whatever may be the level of technological advances aimed at reducing the need to travel (globalization of work and work processes, working from home within a city, studying in a virtual university, internet based entertainment), place remains important. As long as *locale* remains vital for human civilization to function and flourish, transport planning will continue to occupy high place on the table of town and country planning. In this specific sense, transport planning is the only land use which could thus afford meaning to other land uses because without physical links through road networks, it is not possible to reasonably enjoy activity systems located in the form of other land uses.

Whether we meet people for specific purpose or get together on a social occasion, the significance of transport planning could not be overlooked because in order to make every trip affordable, comfortable, enjoyable and sustainable (less time and energy consuming), someone must do a good job at transport planning. Most of the efforts in transport planning are made to achieve efficiency by use of scientific or instrumental rationality. Instrumental reasoning implies complete reliance on scientific methods of analysis and examination and proposed action premised on such reasoning. Thinking, conceiving, planning and implementing planning projects through instrumental reason is acceptable provided it does not become an end in

***Ashok Kumar**, is Professor and Head of the Department of Physical Planning at the School of Planning and Architecture, New Delhi. He researched at the University of Liverpool, England, U.K. for his doctoral degree, which he received in 1992. Email: dak_13@indiatimes.com*

itself. Transport planners are known for their technical prowess as most of the practitioners of transport planning generally have engineering background.

In this paper, I make the argument that transport planning is highly sciencitized discipline. Sciencitization of transport planning practice, among others, have led to two main consequences for society and economy. One, sciencitization of transport planning has led it to achieving the ends of technical rationality that is transport planning practitioners firmly believe that technical robustness of their proposals and projects remain their primary task, and moral goals such as transport equity are mere social irritants. As I will try to demonstrate below in briefly, engineering content dominates the essence of both transport planning practice as well as education. Second, excessive emphasis on technical rationality has created a condition whereby problem formulation and reformulation has become detached from societal needs, particularly those of the majority urban poor. I intend to close my discussion in this paper by suggesting that moral principles such as equity and by implication social justice must become the nerve center of transport planning practice and education, if this important specialization has to make any significant contribution to the most important exercise of nation building. Improving one or two intersections or roundabouts could never achieve these moral ends.

2. TRANSPORT PLANNING IN MASTER PLANS

Master plans continue to remain one of crucial planning instruments for bringing about orderly and planned development in cities of India. By looking at the contents of the chapter on transport planning in a master plan one could quickly assess how far this issue has been sciencitized. There is very little analysis in the form of peoples' needs. There is no sustained discussion about the impacts of transport related activities on the lives of city dwellers. There is almost no discussion on sustainable funding of transport projects. In this whole technical exercise, people remain sidetracked like trucks parked in the service lanes waiting to be driven away after the drivers have taken rest. This is not only in India; in America things are no different. In a classic article Norman Krumholz, Cleveland's Planning Director from 1969-1979 noted: "Transportation problems are usually defined in terms of rush hour congestion, auto access, or the need for more off-street parking" (Krumholz, 1982: 166).

In India, the entire exercise of transport planning in master plans is mired by technical details on trip lengths, trip projections, modal splits, hierarchy of roads, right of ways and carriage ways, underground parking, over ground parking, road widening, new roads construction, flyovers, foot bridges, subways, location of freight complexes, goods movement, fuel stations, and the like. Undoubtedly, planning for all these aspects is important for transport planning or even city planning. Even use of technical knowledge is helpful in exploring these issues. But what master transport planners tend to sidestep is the exercise of identification of the transportation needs of the city dwellers. These needs are diverse over space and time as people have diversity of economic and social wellness. Just to mention one example, generally transport planners are busy in enhancing unhindered movement of private vehicles by construction of new roads and widening of existing

roads and construction of flyovers, when the real transport planning problem is low accessibility particularly to the urban poor.

To further elaborate on the above point, as an illustration, let us take Master Plan for Delhi, 2021, which was approved by Government of India in February 2007. Master Plan for Delhi, 2021 intends to restructure the city through mass public transport systems. What are the moral grounds for such city restructuring exercise are not known? Nonetheless, various interventions are identified including setting up of Unified Metro Transport Authority; synergy between land use and transport; private sector developed parking spaces, increase in norms of parking spaces, multi level parking and underground parking; integrated multimodal public transport system to reduce dependence on personal vehicles; road and rail based mass transport system, optimal use of existing road network and development of missing links; restructuring of existing network through expressways, elevated roads, arterial roads, distributor roads and relief roads; and provision for cycle tracks, pedestrian and disabled friendly features in arterial and sub-arterial roads (Government of India, 2007: 5).

The chapter on 'Transportation' in the Master Plan for Delhi, 2021 begins by performing the well known exercise of focusing on increasing demand due to rising number of vehicular and passenger trips and increasing supply for meeting this rising trip demand. Consider this:

The period between 1981 and 2001 has seen a phenomenal increase in the growth of vehicles and traffic in Delhi. There has been a rise in per capita trip rate (excluding walk trips) from 0.72 in 1981 to 0.87 in 2001. Keeping in view the population growth, this translates into an increase from 45 lakh trips to around 118 lakh trips. The population of motor vehicles has increased from 5.13 lakhs in 1981 to 32.38 lakh in 2001, and the number of buses has increased from 8,600 to 41,483 during this period (Government of India, 2007: 68).

It is also argued by the master transport planners that in addition to the above mentioned vehicles and traffic, additional vehicular and passenger trips are being made from outside of Delhi. It is concluded that due to increase in the number of vehicular and passenger trips, all hell has broken, including the problems of congestion, accidents, more pollution, increased commuting time, and wasteful use of energy.

Based on instrumental reasoning, this demand and supply centric approach frames the problem in such a manner that increasing number of vehicular and passenger trips are viewed as major transport planning concern. It is insisted that increasing demand should be met with increasing supply by whatever means. Out of 14 transport planning interventions mentioned in the Master Plan for Delhi, 2021 not a single intervention explicitly takes into account urban poor and more specifically women and children apart from the fact that a passing reference is made in the 14 intervention about the differently able and old city dwellers. Here also the emphasis is placed on design rather than their movement, accessibility and need for travel.

3. EQUITY AND TRANSPORT PLANNING

All 14 planning interventions mentioned in the Master Plan for Delhi, 2021 are aimed at meeting the demand by enhancing the supply by creating more road space, by integrating multi-modal transport systems, more parking spaces, etc. In the following discussion, I would argue that transport planning of Delhi could be addressed by doing relevant research and even before that, by asking moral questions in addition to technical questions. An illustrative list to explore travel needs of city dwellers is given below:

- Who is traveling? Analysis of the social and economic profiles of commuters would certainly help planners focus on framing policies for enhancing accessibility of those commuters who cannot afford to travel on their own. The question of transport equity is central to any city where a substantial majority of population is classified as income poor. As more and more commuters begin to travel by Delhi Metro, the issue of transport equity should become central. We certainly need to ask: should government continue to subsidize the movement of elite classes and high and middle income groups through the mass public transport systems at the cost of low income groups? Who travels by Delhi Metro? Who is going to benefit from Delhi Metro connectivity to recently developed settlements in Haryana and Uttar Pradesh? What would be the impact on the transportation condition (economy and society) of Delhi if such Metro links are continually increased?
- As mentioned above there is a passing reference to differently able and old people. However, there is no reference to women, which is certainly one of the most important groups of commuters in all cities of India including Delhi. In this regard, relevant questions could include how many women commuters travel daily through mass public transport systems? Do they feel safe while traveling through mass public transport systems? What kind of planning interventions could be considered for addressing issues faced by women while traveling through mass public transport systems? Apart from women, another special group of commuters includes children. Important transport planning issue would be to protect the interests of the children when they travel for education or entertainment or any other purpose.
- What is the average trip length and how this has been changing over the last few years? If it is increasing, what are the reasons for increase? Does it have anything to do with people commuting from cities located in the periphery of Delhi? What are the implications of increasing average trip length on environmental sustainability? Partly this cluster of questions could help in finding out answers about how the city should be restructured so that average trip length is minimized to a certain extent. Containment issues and compact city approach become central to examining the issue of average trip length in a city.
- As percent of the urbanized area in Delhi, 21 percent space is used by roads (Vasconcellos, 2005: 13). This is not a question of exceeding planning norms

but an issue of distributional justice because such lopsided land use distribution allows spaces being used and occupied by the rich classes who have private vehicles and could spend substantial amounts of money on travel. Similarly, under residential use major portion of land is used by higher and middle income groups. It is in this manner that income poor are increasingly pushed aside by planning. Examining across land uses, transport planning could contribute greatly in creating or redressing spatial inequalities.

- Does transport fare policy formulation and evaluation form the proper area of concern for transport planners and master planners? Largely in planning schools this area is not regarded as proper for transport planning although subjects such as Transport Economics are taught in many planning schools. Exclusion of such vital concern is also due to excessive emphasis on technical rationality. Anything involving politics, economy and society is sidetracked by transport planners and master planners as it is considered out of the scope of technical professionals. Physical planning is a means (not an end) for obtaining societal ends of equity and justice.

Many more clusters of questions could be developed to address the diverse transport planning needs of city dwellers with particular focus on the majority low income groups, women, children, differently able and old people.

4. CONCLUSIONS

I have developed these clusters of questions because I view transport planning, like other forms of town and country planning, as a professional activity aimed at the well being of people in general, and poor and excluded in particular. Transport planners have special responsibility therefore to provide accessibility to those who are unable to have access to private modes of transport. Transport planning, like other areas of physical planning, is distributional in nature. It distributes costs and benefits. Costs are imposed in the form of pollutions, congestion, delays, exclusion due to non-availability, and so on. Benefits are distributed in the form of accessibility and rising property prices due to provision of certain transport facility like Delhi Metro or a road network. There is no reason that transport costs and benefits are distributed inequitably. While planners should make all efforts to reduce transport costs to all groups of people, attempts should be made to distribute benefits equitably. There is also no reason that in a democratic egalitarian society like India, transport planners should not address transport planning inequities and inequalities.

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Multi-modal Public Transport System for Urban Areas: A Case of Metropolitan Cities in India

Kshama Puntambekar and Dr. Ashutosh Sharma

Abstract

Many people in metropolitan areas have to use different modes of transportation systems in daily intra-city journey. Because of complicated, compacted and dynamic networks of public transportation in metropolitan areas, travelers face many problems to find the best routes based on cost, time, and mode of transportation. This paper studies the elements, which are responsible for the use and choice of the mode of transport.

1. INTRODUCTION

Transport has brought a major change in the life of people making the distances barriers free for movement of goods and people. Transport sector has greatly influenced the economy and the society and catalyzed the urban growth. But it is also acting as a degrading element for the environment. Environmentalists are now concerned about the growth of the vehicular population and pollution they are going to add with every mile driven. It is time for planners to think about how balance could be maintained between degradation of environment and urban growth.

Single occupant driven private vehicles are maximal in number; they occupy a lot of space on the roads and parking lots and with lesser efficiency in number of passengers commuted. Many people in metropolitan areas have to use different modes of transportation systems in daily intra-city journey. Because of complicated, compacted and dynamic networks of public transportation in metropolitan areas, travelers face many problems to find the best routes based on cost, time, and mode of transportation. This paper studies the elements, which are responsible for the use and choice of the mode of transport.

Fig 1 Modes of Transport

- Pedestrian
- Bicycle
- Auto rickshaw
- Bus
- Rail
- Water Bus
- Aerial Ropeway,
- Underground Railway
- Overhead Railway (Aerial Monorail),

2. MODE OF TRANSPORT

A range of modes are available to commute on, above and below the ground to reach any destination. Which mode is chosen by a person depends on a range of parameters as shown below.

2.1 Multi-modal transport system

Combination of modes to link any origin or destination is defined as multi-modal transport system. A multi-modal transport system

***Kshama Puntambekar**, is Research Fellow Department of Architecture and Planning, Maulana Azad National Institute of Technology, (MANIT) Bhopal.*
***Dr. Ashutosh Sharma**, is Dean (Admin), HOD Department of Architecture and Planning, Maulana Azad National Institute of Technology, (MANIT) Bhopal.*

integrates different geographical scales from the global to the local. With the development of new modal and intermodal infrastructure, urban regions have a growing accessibility to the international market.

Inter-modal Passenger Transport involves more than one mode of transport for passengers. Some modes of transportation have always depended on other modes; they are to be connected with local streets. Urban bus systems generally serve train and subway stations and often extends to local airports. A major goal of modern inter-modal passenger transport in developed countries is to reduce dependence on the automobile as a major mode of ground transportation and increase use of public transport.

In the developing countries a variety of modes of transport are used. When these modes are run on the same track they retard the efficiency. The system can otherwise help improve the efficiency if managed properly where local bodies have defined tracks for them. This multi modal system can be helpful for the cities which have a fast rate of urbanization and population is nearing one million mark.

India is experiencing fast growth of urban population and 35 cities are million plus according to the 2001 Census. With this speed we

Table 1 Million Plus cities, Urban Agglomerations in India

Rank In 2001	Urban Agglomeration /City	Civic Status	Persons
1	Greater Mumbai	UA	16,36S,084
2	Kolkata	UA	13,216,546
3	Delhi	UA	12,791,45S
4	Chennai	UA	6,424,624
5	Bangalore	UA	5,686,844
6	Hyderabad	UA	5,533,640
7	Ahmadabad	UA	4,519,278
8	Pune	UA	3,755,525
9	Surat	UA	2,811,466
10	Kanpur	UA	2,690,486
11	Jaipur	Municipal Corporation	2,324,319
12	Lucknow	UA	2,266,933
13	Nagpur	UA	2,122,965
14	Patna	UA	1,707,429
15	In-dore	UA	1,639,044
16	Vadodara	UA	1,492,398
17	Btiopal	UA	1,454,830
1S	Ccimbatore	UA	1,446,034
19	Ludhiana	Municipal Corporation	1,395,053
20	Kochi	UA	1,355,406
21	Visaknapatnam	UA	1,329,472
22	Agra	UA	1,321,410
23	Varanasi	UA	1,211,749
24	Madurai	UA	1,194,665
25	Meerut	UA	1,167,399
26	Nashik	UA	1,152,048
27	Jabalpur	UA	1,117,200
2S	Jamshedpur	UA	1,101,804
29	Asansol	UA	1,090,171
30	Dhanbad	UA	1,064,357
31	Faridabad	Municipal Corporation	1,054,981
32	Allahabad	UA	1,049,579
33	Amritsar	UA	1,011,327
34	Viayawada	UA	1,011,152
35	Rajkot	UA	1,002,160
	Total		107,881,836

Fig. 2 Role of Multi-modal Transport System

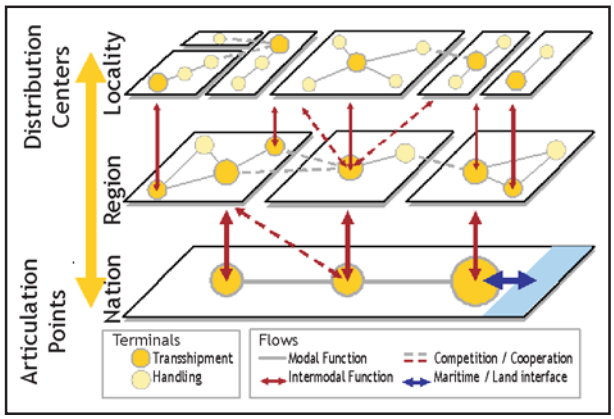


Fig 3 Major Trips generated in Intra-city Transport

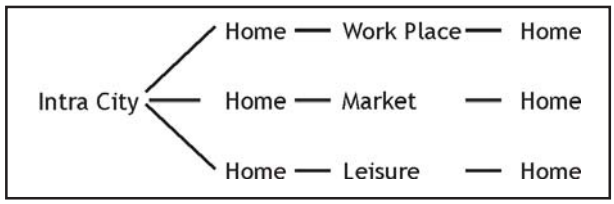
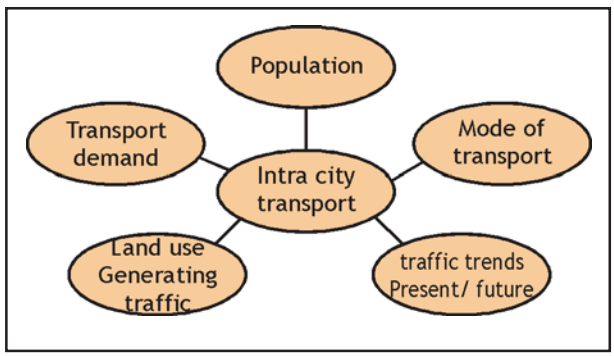


Fig. 4 Components of Intra-City Transport



have to take care of the transport system, which is the lifeline of a growing city. At this time, the cities have space to design traffic corridors, which will be difficult when the problem is aggravated due to unplanned growth. Present census indicates the growth of newly made million plus cities as the growth center with economic opportunities.

2.2 Role of Multi Modal Transport System

A multimodal transport system integrates different geographical scales from the global to the local. With the development of new modal and inter-modal infrastructure, urban regions have a growing accessibility to the international market. The change in mode is required at the junctions where you change from inter-city to intra-city travel or from national to local, etc.

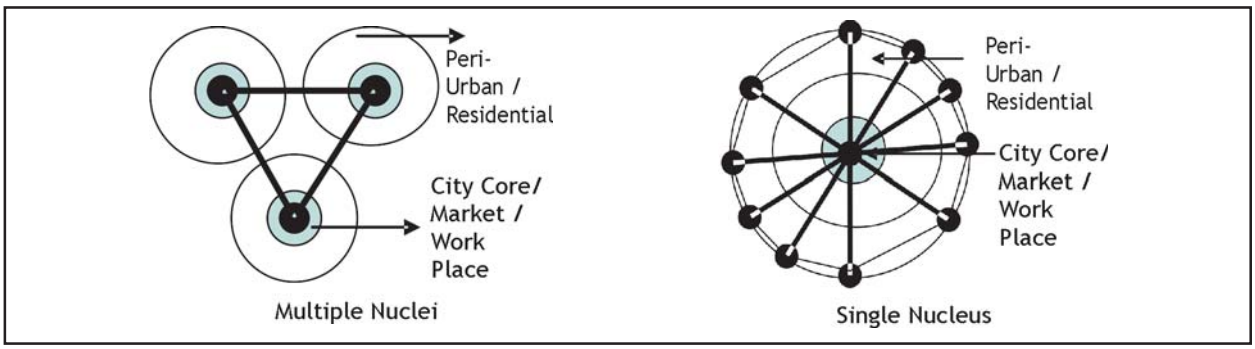
2.3 Urban Transport Demand

People in urban areas have to commute within cities and between cities. The movement between the cities is inter-city and have proper terminus for road rail and air traffic. Movement of public in a city revolves around three major origins and destinations namely work place, residence and market. The trips generated amongst them are 80 percent of the total trips.

2.4 Components of Intra-City Transport

Land use alone may not be enough to justify

Fig. 5 City Form Affects the Need of Transport



the need for a transportation facility i.e. road, bridge, recreational trails, bicycle-pedestrian trails, airport access, etc.

Before a facility can be developed, the transportation planning analysis process must show that a need exists based on impact on one or more of the following areas of concern.

- Social and economic development
- Health and safety
- Environmental concerns
- Scenic byways and tourism
- Development of natural resources

2.5 Linkages

Linkages change according to scale and growth pattern of the city. Single nuclei city needs to be connected from the central core area to the peri-urban. Multi nuclei city needs all the nuclei to be connected with each other and further form the web.

2.6 Environmental Degradation: Role of Transport

The transport sector is the second largest consumer of energy next only to industry. The relationship between transport and emissions in India is established via the use of fossil fuels. The linkage between transport and the environment is particularly visible in the urban transport sector due to the dominance of road transport. In addition, the transport sector accounts for a large and growing proportion of Greenhouse Gas (GHG) emissions. The pollution caused by vehicles due to combustion in the engines is in the form of suspended particulate matter, sulphur dioxide, oxides of nitrogen, carbon monoxide, volatile organic compounds, and lead.

It is important to reduce the use of automobiles. One of the steps could be to increase the use of public transport and reduce the need for private vehicles.

2.7 Strategies to reduce the pollution

People all over the world are finding strategies to reduce vehicular pollution in the environment. Some of the measures to be taken by the transport industry are seen in the figure below. The figure shows three strategies to reduce emissions. The strategy two states that if the share of public transport increases there will be a considerable reduction in the emissions. To achieve this objective sharing the modes is the best solution. The use of modes varies from place to place depending on the infrastructure.

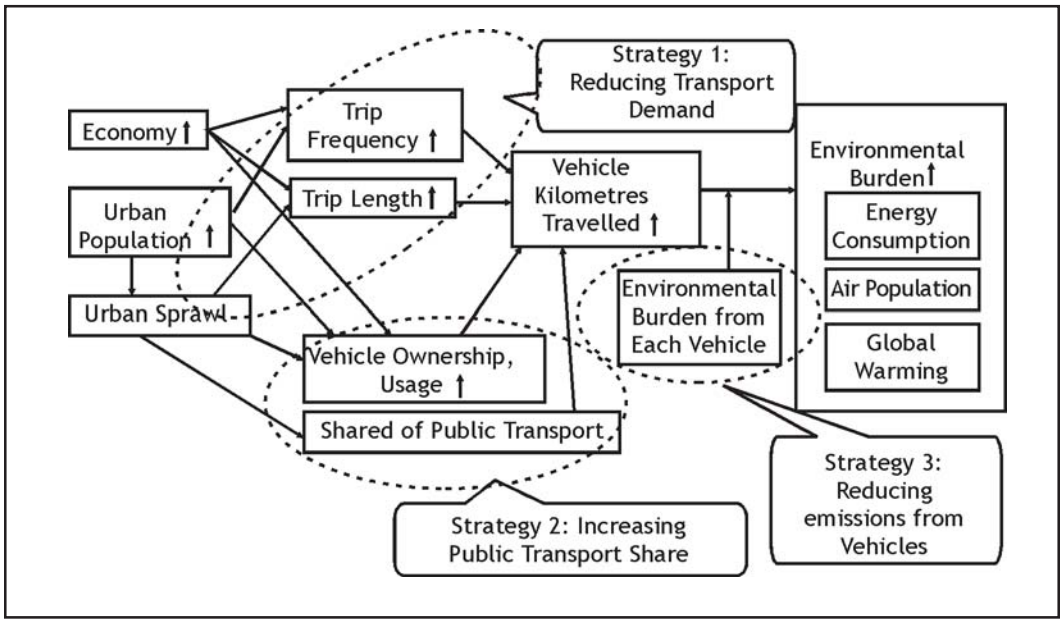
Box 1 Vehicle Production Crosses 10 Million in 11 Months

An analysis of production data by the Society of Indian Automobile Manufacturers (SIAM) revealed that the vehicle production by Automobile Industry in India crossed 10 million in a calendar year for the first time in the history of the automobile industry in India. For the period, January to November 2006, the total production of vehicles in India, as per SIAM data, was 10,031,886. Given that the 10 million mark was exceeded by just over 31,000 vehicles it is certain that the 10 millionth vehicle was produced on 30th November 2006.

The 10 million mark was achieved as the industry grew at 16.82% as compared to last year. Last year for the same period, 8,587,131, vehicles were produced. The fact that the industry served the needs of mobility of the masses was underscored by the fact that over 77% of the vehicles were two wheelers. According to SIAM, 7,741,261 two wheelers were produced this year as compared to 6,686,963 during the same period last year, reflecting a growth of 15.77 %. Motorcycles and Step-Through led the growth in the two wheeler segment with an increase in production of 19.96%.

Source: SIAM

Fig. 6 Strategies to Reduce the Pollution

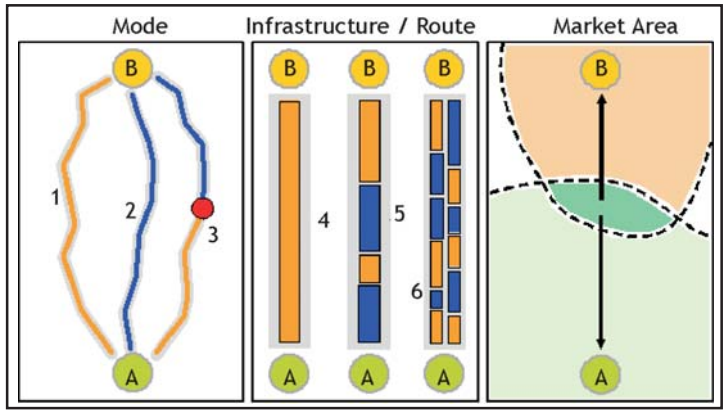


Let us now study the factors responsible for affecting the selection of modes of transport available.

2.8 Modal choice

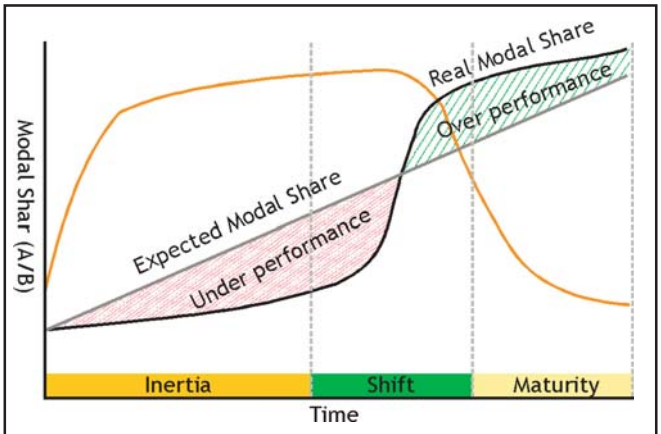
Three major dimensions are of concern to depict the concept of modal competition. The above figure depicts those three dimensions for two locations (A and B):

Fig. 7 Choices of Modes



- Modal choice competition is the most basic consideration in the modal competition process. In the above example, this solution is derived by comparing the two available modes and choosing the one that answers best the requirements of shipping freight or passengers between locations A and B. Case three represents a possible solution where the two modes are used in a combination of two segments with a point of transfer (red circle). This alternative is the classic multimodal transport solution which is increasingly been applied over transport systems. It enables us to use modes over the segments they are most efficient.
- Infrastructure or route competition represents another dimension where modal competition occurs over the usage of a specific infrastructure or route. Three scenarios are generally possible. In the first case, there is simply no competition as one mode has a **monopoly** over a route, either because of technical (a subway line for instance) or regulatory (car-only expressways) reasons. The second case represents an exclusive sharing arrangement where two modes are using the same infrastructure, but at different moments. The issue of rail passenger and freight is a relevant example as both are using the same infrastructure but not at the same time. A decision has thus to be made about which mode gets priority. In North America, priority is given to rail freight while in Europe priority is given to rail passengers. The third case illustrates a situation where two modes have a mutual sharing arrangement. Access to infrastructure is generally unconstrained but the total capacity is obviously the result of respective levels of usage. Cars and trucks are commonly sharing the same road infrastructure.
- Market area competition is the third dimension of modal competition, which is highly tied to geographical considerations. It mainly concerns transport terminals that are drawing users and their associated flows, people and freight from their surroundings. In the above example, locations A and B have their own exclusive market areas (light green and orange) over which they have a clear advantage. Competition occurs over a portion of the territory where the respective advantages of locations A and B are not clear (green); the **competition margin**. Technical improvements have increased competition margins as terminals such as ports are competing over overlapping market areas that may span whole regions.

Fig. 8 Performance of Mode



Thus a modal shift takes place in a context where from a macro perspective there are changes in the transport supply and from a micro perspective the decisions (behavior) of individuals (passengers) and firms (mostly for freight) is changing.

For example, if you have reached any city by air, you will require a different mode to reach your work place destination in the city. You will take a taxi to do so, as it takes the minimum time and provides maximum comfort. But if one is provided better options for fast movement and comfort for the money being spent, the choice may be different.

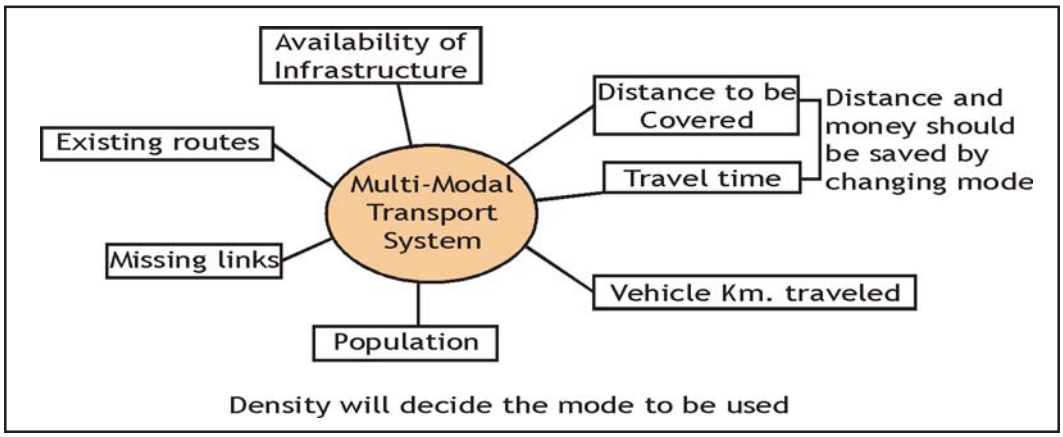
2.9 Modal Shift

A modal shift occurs when one mode (A) has a comparative advantage in a similar market over another (B). Comparative advantages can take various forms, such as costs, capacity, time, flexibility or reliability. Depending on what is being transported, importance of each of these factors would vary. Modal shift will occur only if the new mode offers time improvements, while for others it is mostly a matter of costs. This process often takes place over three phases:

- Inertia: Public tendency to remain unchanged and not to accept the new mode. It takes time to improve on this process.
- Shift: People slowly make the shift after getting accustomed to the mode.
- Maturity: The use of the mode is at its fullest and reached the best performance level.

We can conclude that given factors are affecting the choice of the mode of transport being used. Some of the examples were studied to understand the use of the multimodal transport system.

Fig. 9 Factors Affecting the Choice of Mode



3. USE OF MULTIMODAL TRANSPORT SYSTEM

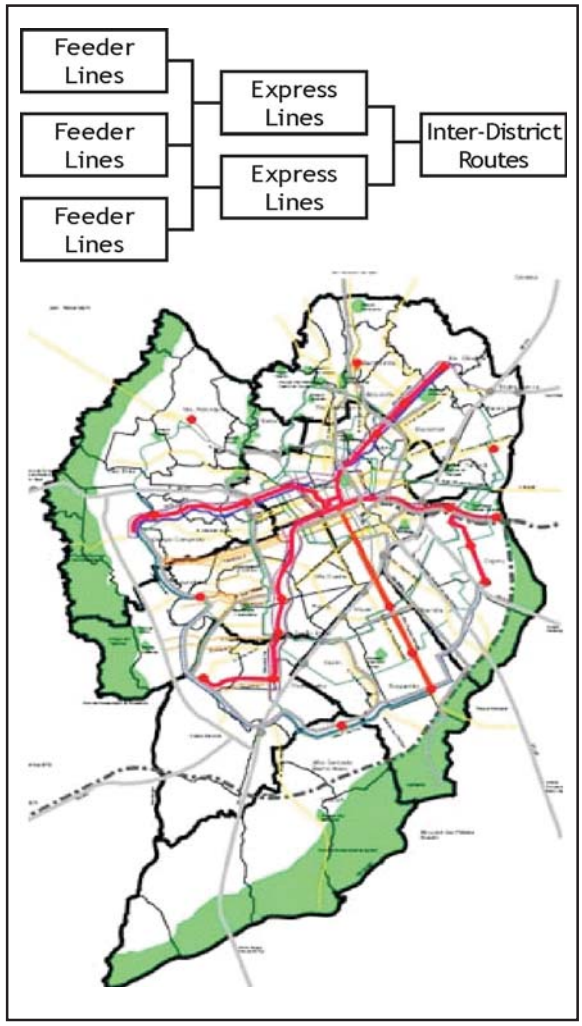
3.1 Curitiba, Brazil

Efficient transportation through successful urban planning in Curitiba (Brazil) is an example from a developing country. Private vehicle population is 500,000 in a city of 1.5 million. The transportation system is made up of three complementary levels of service that include the feeder lines, express lines and inter-district routes. The feeder lines pass through outlying neighborhoods and make the system easily accessible to lower density areas. Sharing the roads with other vehicles, these feeder lines connect with the express system along the structural corridors. The express system then utilizes these dedicated bus lanes and transports large numbers of passengers to various locations.

3.2 Delhi, India

Delhi has experienced a lot of pollution in the yesteryears whereby for the first time anywhere the country, public transport system was converted to CNG driven vehicles in such a short time span. This reduced the air pollution levels to some extent even with the increase in the vehicular population. The increased traffic has reduced the speed of the movement of the passengers wasting a considerable amount of time and money commuting the daily work place.

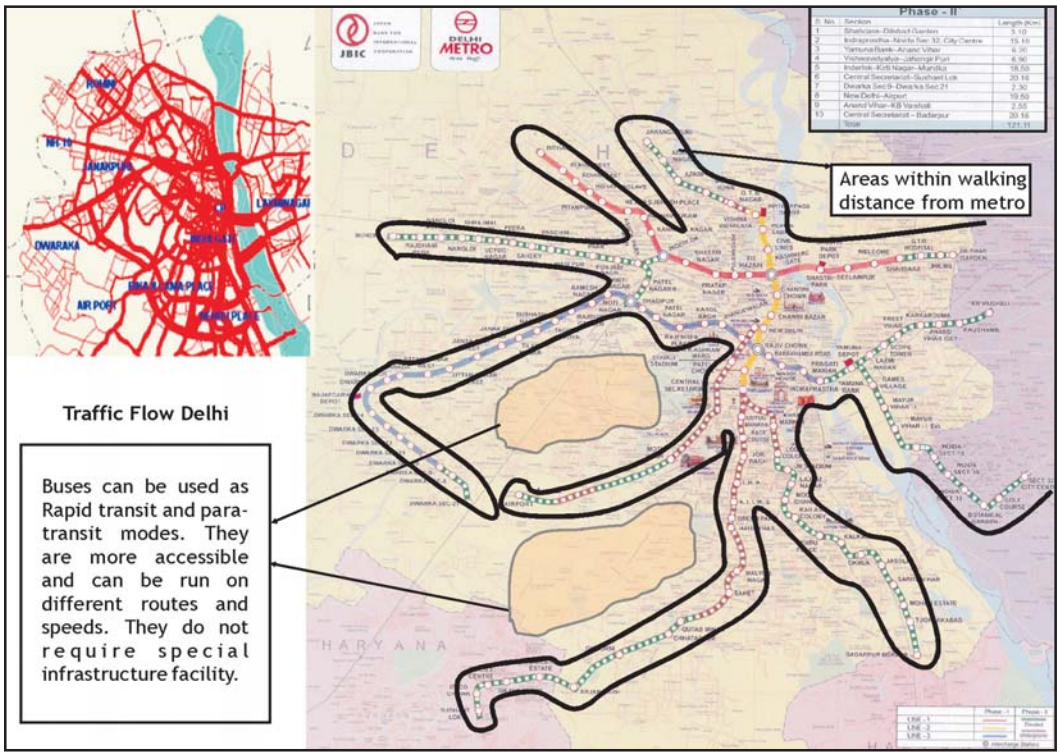
Fig. 10 Mode Changes with the Change in the Speed and Distance to be Covered



Delhi Master Plan, 2021 speaks of the major projects which should ease the traffic situation in Delhi. These projects include the Integrated Multi-Modal Transport System - the metropolitan, Ring Rail, High-Capacity Bus System and IRBT. These have also been identified in the NCR Board's Regional Plan. Delhi Master Plan, 2021 also stresses that district and community centers should be developed along major transport corridors and networks.

Despite measures by way of increasing the length of road networks and road surface space through widening, construction of a number of flyovers, grade separators and by launching Delhi Metro (which is estimated to carry 1.25 lakhs passengers per day), the traffic congestion has continued to increase unabated. This has its inevitable consequences in terms of accidents, pollution, increased commuting time, and wasteful energy and fuel consumption.

Fig. 11 Delhi Metro Layout



4. CONCLUSIONS

Multi modal public transport is a correct option for a place like Delhi. It is widely spread in all directions and further growing. Million plus cities should have plan in which every part of the city is connected to fast modes of transportation. If there are frequent stoppages then the vehicle cannot pick up speed. Hence there is a need of para-transit modes which collect traffic and are easily approachable from all the corners in the city. These also facilitate easy movement of the public. This also helps to maintain the speed of fast moving modes and reduce the travel time and congestion on the roads. This will add to the effective working hours of the population and people can lead a healthy life. Mode selection will depend on how effectively parameters of selection of mode are fulfilled.

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Institute of Town Planners, India Journal 6 - 4, 82 - 93, October - December 2009

Impact of Mehrauli-Gurgaon MRT Corridor and Strategies of Development

Rashmi Ashtt

Abstract

There is also a planned effort to ease pressure on Delhi by transferring the growth impetus of Delhi to the adjoining regional towns as envisaged in the NCR plan. The corridor is planned to pass through green zone of Delhi linking the upcoming Cyber City Gurgaon. Introduction of MRTS with increased accessibility and mobility will definitely bring dynamic changes in the distribution of people, activity patterns and land use, etc. The impact could be felt in the form of transformations in land use, built form, rise in land values, increased accessibility and mobility and increase in population and employment density. If it is not properly planned, this phenomenon can lead to haphazard growth and unplanned development.

1. INTRODUCTION

Population of Delhi has been growing steadily over many decades. It has increased from 9.4 million in 1991 to 13.8 million in 2001 and MPD 2021 further projected it to 23 million by 2021 with about 3 million people commuting daily. Accessibility and mobility will play a significant role in furthering urbanization during the development phase. Allocation of more funds to urban transport and particularly investment in mass transport are important for fast, dependable and efficient intra city movement and integration of activities and land uses. Qutub – Gurgaon metropolitan corridor while serving intra city movement will add another dimension integrating two important cities in the NCR for fast comfortable intercity movement and an attempt to give credence to the NCR concept of regional development and decongestion of Delhi.

Growing at an unprecedented pace, the city needs to be able to integrate its glorious past as well as modern development into an organic whole, which demands a purposeful transformation of socio economic, natural and built environment over a period of time. Mass transport will play a significant role to achieve that end.

2. MRTS IN CONTEXT OF THE NCR

Due to the limitations of holding capacity of NCTD, the concept of planning Delhi in the context of its region (NCR) has evolved during the formulation of the Master Plan for Delhi, 1981. Master Plan, 2001 and 2021 also have reiterated this concept of decongestion of Delhi for regulating immigration from the neighboring states to Delhi and build up of infrastructure and the need for regional development around

***Rashmi Ashtt**, Director 'Sat Priya School of Architecture and Design, Rohtak, Haryana. An Architect and Urban Planner from S.P.A .New Delhi. She did Master's level research on 'Impact of MRTS on Structure and Urban Form, Case Study: Qutub - Gurgaon Corridor '. Email: rushme_arch@yahoo.co.in*

Delhi. This could be achieved by implementing transport plan of the NCR, which establishes the need for efficient and reliable cost effective inter and intra city transport system like RRTS, metropolitan, network of rail with an efficient road networks and road based public transport system to integrate the whole NCR, opening up intercity as well as intra city movements.

The Plan proposes to create expressways, upgradation of existing national highways, development of outer and inner grids and sub-regional road networks along with cost effective, efficient and commuter friendly rail based transport system by improving existing rail corridors, connecting regional towns by developing new urban dedicated RRTS, etc. There is also an effort to link upcoming urban centers like Gurgaon, Noida, Faridabad, and Bahadurgarh with MRTS. The NCR plan advocates decentralization of urbanization to satellite towns. The introduction of expressway corridors and rail linkages may open new vistas for urbanization especially along these corridors. Therefore, the induction of high speed and high capacity MRTS corridors in the Qutub Gurgaon road in near future is a welcome step.

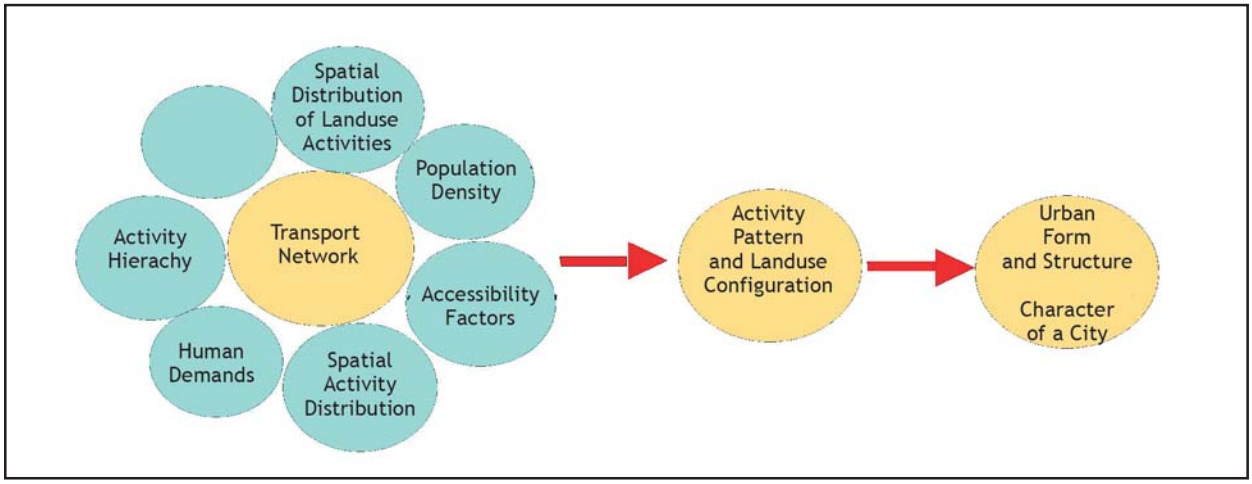
2.1 Transportation and City Structure

Within a city there is an inherent relationship between accessibility, population density and spatial distribution of land use, economic activities, transport network and activity hierarchy, interplay amongst them result in activity patterns and land use configurations unique to an urban area. Therefore, it is important to understand this complex relationship. This relationship is manifested over space, in various urban forms and structure, over a period of time. Transport network is the skeleton of the city through which energy flows in the form of mobility and improved accessibility. However, with the ever growing vehicular population and inefficient and inadequate public transport, there is a lot of congestion and chaos on roads leading to increasing air, noise and visual pollution. All these have adverse or negative impact on urban structure and a deterrent for congenial urban form. These are further conditioned by location, rentals, land values, availability of type of infrastructure, politico – socio-economic environment, etc; as these exercise influence the spatial distribution of urban population and activities over times.

Theorists, social scientists, planners and transport engineers have tried to establish relationships between these factors i.e. spatial distribution of people and activities; activities and land use pattern, land use pattern and transportation and so on. There are theories and definitions on urban form and structure to comprehend the relationship between transport system and urban form and structure, reflected through cause and effect relationship between transport system, on one hand and spatial distribution of activities and land use pattern. On the other theorists like Kevin Lynch, L.J. Dull, M.M. Webber, Chapin, Worsted, etc;have also established this relationship through their research works.

A host of factors, for example, size, shape, land use, land ownership, travel characteristics, accessibility and mobility, population and employment density,

Fig.1 Concept Urban Form and Structure



energy and pollution and environment, land values, social factors like gender equity, safety cultural and heritage values also play their significant roles to dictate form and structure (Fig. 1).

2.2 MRTS in world context

As happened worldwide like in Singapore, Paris, etc. to achieve a balanced modal mix and high class development and facilitate travel with comfort and speed, mass rapid transport is augmented by massive capital investments along with buses and NMTs and interchanges at vantage locations. Although urban MRT projects are meant to provide a safe, speedy and affordable mode of travel to the commuters, they have not been found to be financially viable in most cities of the world, as noted in the research study by TRRL[1]. The TRRL has taken the issue of building metropolitan areas in the third world cities to counteract the unabated urban growth and traffic congestion. The report highlights the findings of worldwide study involving observations and data collected from 21 developing countries. It establishes that only few can be financially viable but can give good economic returns in right conditions. Fare Box collection may not be able to match even the operation and maintenance cost. Even the votaries of critics will not challenge the idea that this gives a tremendous push for development and provide a very effective, safe fast and comfortable public transport facility for commuters of high capacity.

A rail based metropolitan system is inescapable world over the practice is that when the population of a city reaches 1 million mark, the studies and investigations needed for a metropolitan system are taken up. Singapore MRTS is a good example of a successful MRT Project started in 1983. In the first phase it passed through highly dense central areas. The Concept Plan that followed later incorporated orbital and radial lines in further covering about 500 km route length to serve the

[1] TRRL-Transport and Road Research Laboratory (Research report 278)

city's public transport needs along the routes and their influence area. To avoid haphazard development and potential use, Singapore MRTS developed a noble concept which gives variable bonus (incentives) to the different sizes of plot falling within 200 m of metropolitan station for built up purpose, thus signifying the increase in scope of physical transformation around the station area.

3. DELHI METRO

With the objective of achieving a balanced modal mix and to discourage personalized transport, it is proposed to augment mass transport by massive investments accompanied by institutional improvements in metropolitan and commuter rail. Para transit modes like autos and taxis are envisaged to provide feeder services along with buses in designated areas catering to work and leisure trips even non-motorized transport like bicycles and cycle rickshaws are to be integrated with the metropolitan system.

Delhi Metro was introduced to the capital initially for intra city commuter travel. Six sections comprising 67.5 km length were implemented in Phase I completed in 2001. It is envisaged to run full system by 2021 which will cover a length of 245 km in four phases (Fig. 2). Transport demand forecast done by RITES for 2021 is estimated as 28.9 million of which 26.1 m are intra city trips and 2.8 m are intercity trips (Table 2).

This project is being implemented by DMRC, a joint sector company of central, state and Japanese Bank. Project is financed by way of equity contributions from the GOI, GNCTD, soft loan from the OECF of Japan, property development revenues and certain dedicated levies and taxes on the city dwellers. The loan will be paid partly from surpluses from the fare box revenues, partly through dedicated levies and taxes in the NCT.

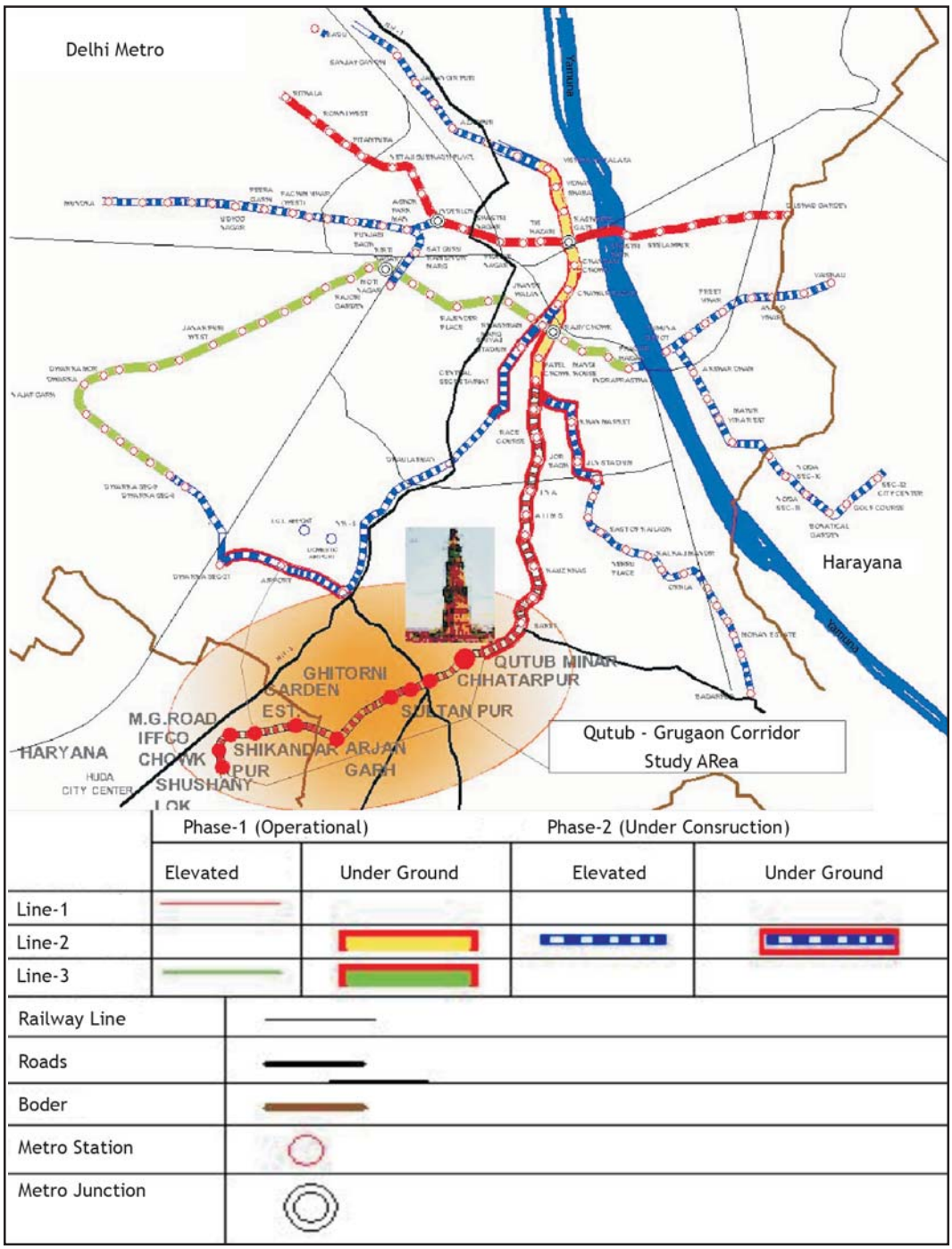
The Mehrauli Gurgaon MRTS elevated line from Qutub Minar to Shushant Lok (16 km) is a project worth Rs.1,320 crores and Central Secretariat to Qutub Minar will cost Rs.2,358 crores including the underground sections (Times of India, 2009).

4. QUTUB-GURGAON CORRIDOR

Gurgaon has emerged as an important town of NCR due to its close proximity to Delhi and access to high level infrastructure such as airports, railways, highways, embassies, and reputed national and international institutions. It shows typical characteristics of tertiary sector based economy attracted by multinationals, nationals, etc. companies. It has established the credibility of an emerging work centre. It has a population of 16 lakh and is projected to accommodate 37 lakh by 2021 as per Gurgaon Master Plan.

Delhi being the mother city and Gurgaon an emerging employment hub, there is a large flow of worker population between Gurgaon and Delhi. This necessitates

Fig. 2 Delhi Metro



movement of commuters through only two link roads NH-8, and Mehrauli Gurgaon Road and lack of reliable public transport have led to proliferation of personalized vehicles. This in turn has put the commuters to immeasurable inconvenience of getting locked in traffic jams for hours together apart from hazards of accidents,

Table 1 Financial Plan- DMRC

Source of Fund	Percentage of Total Cost
Equity contribution from GOI& GNCTD	15% each
OECF (Japan) Loan	56%
Revenue from Property Development	6%
Subordinate Debt towards Cost and Land	8%
The above financial plan is based on : • Debt Equity ratio 2:1 • Fare: Base rate Rs. 5.00 (at April, 1995 prices) per passenger trip of 7.12 km.	

Table 2 Transport Demand Forecast

Figures are in Million	2004	2011	2021
Population	15.2	20.1	24.8
Employment	5.5	8.1	10.3
Per Capita Trip Rate-vehicular (including home-based and non-home based)	0.88	1	1.05
Total Daily Vehicular Trips	15.2	22.4	28.9
Intra- study Area Trips/Day	13.3	20.1	26.1
Inter-city Trips/Day	1.9	2.3	2.8
Mass/Public Transport Trips/ Day (intra+inter-city trips)	65	70	75
Modal share for intra-city trips (in percent)	10.3	15.7	21.7

Source(RITES)

Table 3 Estimated Daily Traffic on Metro Network (Ph1+Ph2+Gurgaon Corridor)

	2011	2021
originating passengers/day (in lakhs)	27.76	44.9
Passenger km/day (in lakhs)	401.25	688.49
Passenger km/km (in lakhs)	3.24	5.23
Average Trip length (in km)	14.45	15.33
Incremental Daily Traffic Due to Qutab-Gurgaon Metro Corridor		
originating passengers/day (in lakhs)	1.6	3.4
Passenger km/day (in lakhs)	46.8	86.5
Passenger km/ km (in lakhs)	2.8	5.38
Average Trip length (in km)	29.2	25.4

Source(RITES)

fuel wastage and environmental pollution.

It is being envisaged to extend the phase II Metro corridor from Central Secretariat to Qutub Minar corridor, up to Gurgaon. It runs south-west from Ambedkar Colony to Shushant Lok via Andheria Mor, Arjangarh, Sikander Pur, and IFFCO Chowk covering a distance of 16 km between two terminal stations. A total of 10 stations have been planned. The total daily passenger trips for this elevated corridor are estimated at 28.9 million out of which 26.1 million are intra-city trips and 2.8 million are inter-city trips. All stations are proposed to be elevated. Average inter station distance is 1.6 km, though it varies from 0.91 km to 2.56 km due to traffic and topographic reasons. While providing relief to transport system of entire city, MRTS also offers high level of accessibility along influence area of corridor with potential for higher holding capacities. In order to achieve optimum benefits of capital intensive facility and achieving more efficient urban form, it is desirable to integrate land use to Metro corridor to achieve transit supported urban development.

The corridor is the result of joint efforts of Haryana Urban Development Authority or HUDA and DMRC and the ensuing Commonwealth Games has hastened the construction. This is expected to ease the traffic flow on Mehrauli Gurgaon Road and NH-8 because it will carry a large number of passengers with improved comfort, safety and time of movement. It will also act as a catalyst for new urban development, redevelopment and rejuvenation. It will bring a dynamic transformation spatially in land use and trigger economic activities. This Qutub-Gurgaon Corridor will facilitate inter as well as intra city movement of people and may help attracting activities away from Delhi as envisaged in NCR Regional Town Development Strategy.

This is in line with development as seen along the Metro alignments abroad like in Singapore, Hong Kong, and nearer home Kolkata, Mumbai and Delhi. Field study shows that commercialization in Rohini as the most recent development, has increased 4-5 percent[2] and a variety of activities developed including informal activities and haphazard built form in post Metro period. If not dealt with meticulously it may lead to unplanned development, encroachments by informal activities and unauthorized parking, chaos and congestion.

For study purposes, this Corridor has been sub-divided into three sub-areas based on parameters like accessibility, mobility, population, employment, density, land use, land values and social and gender equity and scope of development in the context of MPD 2021 and Gurgaon Master Plan (Fig. 3).

5. PRE METROPOLITAN SCENARIO

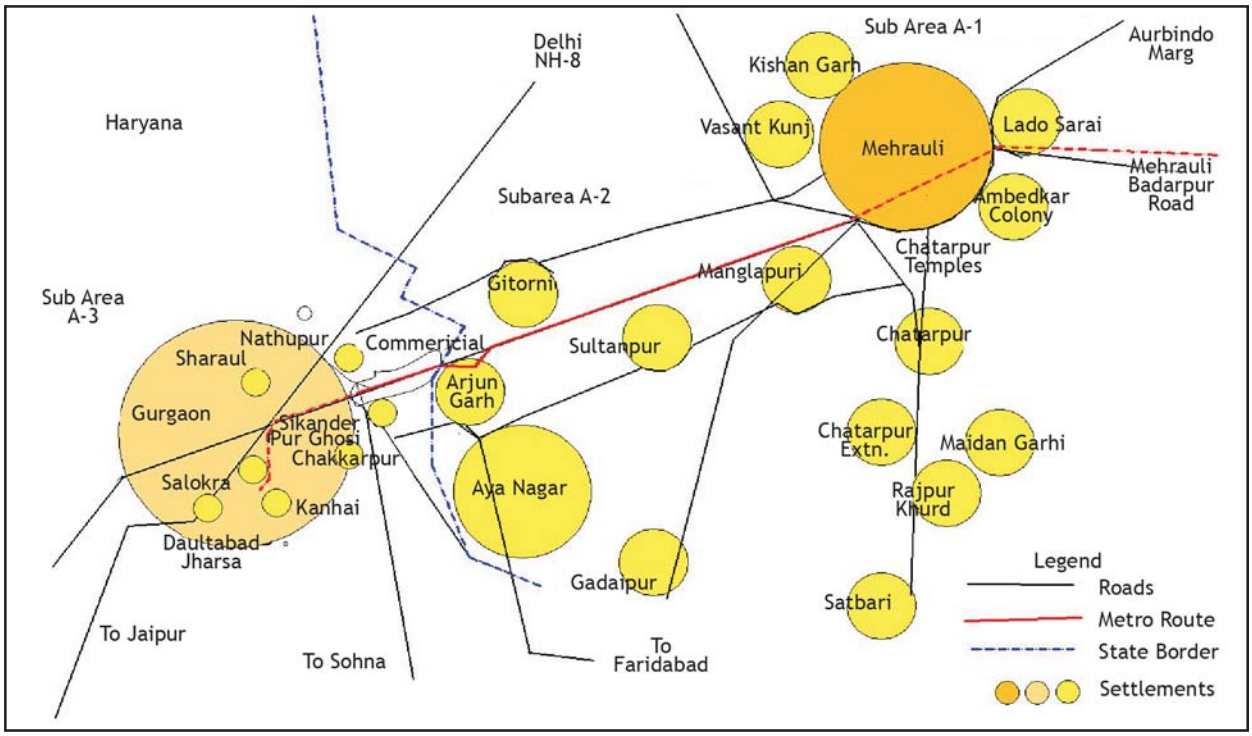
The Metro Corridor is linking parts of two states of Delhi and Haryana. Gurgaon is linked to Delhi through two link roads NH-8 and Mehrauli Gurgaon Road. The elevated Metro corridor will follow alignment of the Mehrauli Gurgaon (M.G. Road).

In Delhi Region, the Metro line passes through Mehrauli towards south West and is covered under sub zone F-15 of Delhi Master Plan 2021. It is a part of green under south central ridge and also an area of urban heritage with archeological monuments and remnants of nine historical cities of Delhi.

Area around Qutub Minar has been declared heritage zone and proposed for integrated conservation of Mehrauli at zonal plan level. The area behind Qutub is proposed to be developed as Archeological Park having 70 monuments. It is further extended to Vasant Kunj which is virtually a planned integrated township falling in category C and other settlements in close vicinity like Kishan Ganj and Gaushala and on the other side of Mehrauli Gurgaon road linking Chattarpur, Maidangarhi villages by Main Chattarpur Road with Metro stations of Qutub and Chattarpur.

[2] Source - Edward j.Bostin School of planning and public policy, New Jersey (Study by Sweta Gulati, 2007)

Fig. 3 Conceptual Diagram of Study Area



The intervening corridor from Qutub to the Delhi Haryana Border along the old Mehrauli Gurgaon Road is a part of green belt. This area is occupied by villages like Ghitorni, Sultanpur, Aya Nagar, Gadaipur and one will see all along farmhouses and vanishing cultivated fields which have made room for ostensible and pompous commercial development and residential blocks .

Gurgaon, mainly known for automobile and ancillary industries, modern commercial malls, towers of cyber ware, BPOs and software companies is situated on NH-8 in close proximity to Indira Gandhi International Airport. It has become a hub for multinational companies like Pepsi, Coca Cola, Concor, Dupont, Sapret, Microsoft, DLF, Reliance, Advertising and Media offices etc. It is emerging as one of the biggest cyber cities in India spreading over an area of 90 acres. The HUDA and licensed colonies of builders collectively have developed 8,000 hectare for residential, commercial, institutional and industrial purposes to meet the demand for private housing and other needs of public. Besides, HUDA has developed many sectors as integrated townships. It is projected to have 1,600,000 population by 2011. It is characterized by high density development with high rise distinctive apartments.

Mehrauli on one end is an already developed and urbanized but due to its heritage character and notified heritage zone, further development is restricted. It is connected by Aurobindo Marg and Vasant Kunj road. Many G+3 and G+4 structures and high density and encroachments which are not in conformity with development

controls are visible. Commercialization and mixed land use are threatening the green and areas of historical and archeological importance. Land values have risen 3-5 times in the last 6 years.

On the either side of the corridor many farm houses are being used for residential and commercial purposes. The practice of subdivision of plots without proper plan and controls is leading to haphazard development. Commercialization is taking place at the ground level along the roads running parallel to the corridor and feeder roads up to one plot depth with G+2 and G+3 structures with 100 percent coverage and encroachments by parking and informal activities. All this is leading to chaos and congestion and haphazard development. Land values are already high because of speculation and restriction of development. It has recorded an increase of 10 times in the last six years.

Gurgaon has its Master Plan in place so there is a chance of rapid land use transformations, and structural change and high density. Metro will give a fillip to increased mobility and intercity movement as well as for intra city trips which is at present a setback because of inefficient and inadequate mass public transport. Land values have been constantly increasing in the last few years and Metro will help further property appreciation because of efficient linkage and rapid urbanization which will dictate the structure and urban form of Delhi area and NCR towns in future. A number of issues have surfaced in this background.

MRTS on one hand is expected to ease the traffic flow and improve comfort and safety of movement; on the other hand it will also act as a catalyst for new urban development, redevelopment and rejuvenation. It may trigger a dynamic transformation spatially in land use and give fillip to economic activities. These dedicated high speed, high capacity corridors will improve inter and intra city mobility, frequency, and accessibility and also make an impact on adjoining areas, land use structure, urban form including rural settlements in general and station nodes in particular.

This may lead to commercialization and development of a variety of activities including informal activities. If not dealt with before hand meticulously, it may lead to unplanned development, encroachments of space by informal activities and unauthorized parking, chaos and congestions which will have adverse impact on real value generation. To promote development and discourage haphazard growth some of the major issues which need to be addressed are:

- Lack of feeder roads and pedestrian and cyclist facilities;
- Unplanned commercialization and haphazard mixed land use development on immediate rural surroundings;
- New upcoming gaudy and ugly, G+3 and G+4 structures without any semblance of aesthetics and a total disregard of Delhi's archeological heritage conservation and natural environment especially the remnants of Aravali Ridge;

- Non implementation of development controls;
- Paucity of physical and social infrastructure;
- Land use transformation without any plan; and
- 3 -5 times rise in land values further tend to skew the development and promote speculative pressure.

6. POST METRO SCENARIO

Already the area through which the Metro corridor will run has registered a quality change, but this MRTS corridor will integrate Gurgaon not only with Delhi but also with other NCR regional towns which are also envisaged to be connected with RRTS. This high speed high capacity mass transit facility will trigger transformation in urban form and structure in Mehrauli area. Increased accessibility will lead to more pressure on roads especially connecting stations such as Chattarpur Road, Aurobindo Marg, etc; which need upgradation, widening, etc. New feeder routes and services are required to be provided.

Commercialization and other uses along roads will further increase. Parking demand and other encroachments will rise in spite of provision of new parking spaces at Metro stations.

Ground plus 3 or 4 structures in residential localities may replace non-descript single storey developments. Also high density cooperative and builder's group housing will replace individual plotted development and farm houses because of high land value and connectivity. Population density will further increase to 220 pph, which will create high demand for other infrastructure like education, health and institutional facilities. Increase in employment opportunities in the tourism and hospitality sector is anticipated as this area will be a showpiece of archeological conservation and protection and visual admiration. Increase in land value will continue manifold closer to road and nearer the stations.

The intervening corridor area includes 3 stations Ghitorni, Sultanpur, and Arjangarh. These are stations with max load of approximately 55,000 to 100,000 passengers in 2021 as per the RITES feasibility report. New feeder roads will be planned as per zonal plan J Zone of MPD 2021.

Commercialization along roads connecting the *abadies* will continue. Farmhouses and agricultural land will amalgamate for residential development on public private partnership basis. Commercial, institutional and recreational use up to a depth of 500 m on either side of the facility corridor will increase drastically as per provisions in zonal plan. The effect will be more pronounced at station nodes. DMRC has been working on concept plan for commercial air space utilization at the stations in addition to their logistics requirements.

The *abadi* areas may show G+1 to G+3 or G+4 structures with commercial use at ground floor. Farmhouses will develop as group housing or plotted houses by private builders and real estate developers. High rise commercial, institutional and recreational developments will come up. Density may increase up to 270 pph due to development as envisaged by Master Plan 2021. Area along the facility corridor will provide employment in commercial, institutional developments land value will register upward swing.

Gurgaon part of Metro corridor includes 4 stations passing through high density area. It opens intercity as well as intra city HSHC transit i.e. Delhi Gurgaon - two hubs. Feeder routes and services will require to be built as worked out in master plan. Gurgaon will develop according to land use plan with increased pace of development and quality of life will be improved in the adjoining sectors. 1.75 FSI is allowed for both residential as well as commercial use. Multi storied buildings for residential, commercial and institutional purposes will come up in near future as development will get a fillip because of effective linkage. Density is 150 pph as on today but is anticipated to reach 270 pph with the introduction of MRTS as envisaged by Gurgaon Master Plan, 2016.

CBD and commercial hub is growing indicating higher employment density because of improved accessibility and land values will register higher increase. Thus, it will be exerting tremendous influence on structure and urban form of Gurgaon in general and along MRT routes with station areas in particular.

7. STRATEGIES

In order to take full advantage of the Metro corridor for injecting or giving fillip to development, a number of strategies may be formulated for the three sub areas of the corridor.

7.1 Mehrauli Area – (Sub-Area A-1)

- Development of cycle and pedestrian tracks along with buses and Metro to maintain harmony and balance in area of archeological importance and natural topographical elements;
- Develop this as Hub of Cultural Tourism and Archeological importance integrating and enhancing beauty of ancient monuments through proper conservation measures and landscape plans with sunken gardens, amphitheatres, crafts bazaar, water bodies and fountains, tree lined pedestrian and cycle paths, etc. and activities of tourist interest and planned parking and terminal facilities;
- Integration of feeder roads with arterial, Mehrauli Gurgaon Road and Metro corridor; and
- Low rise and medium density development.

7.2 Intervening corridor area - (Sub-Area A-2)

- The corridor area should be developed with intensive activities related to well-designed work and business centers and public and semipublic uses on 500 m land on either side of Metro corridor and MG Road;
- Residential area should be planned well to take full advantage of existing natural landscape elements like remnants of southern ridge, wooded areas and interesting tree lined road network;
- Road and Metro rail transport system should be well integrated with NMT with planned and well defined on and off street parking facilities;
- Group housing through public private partnerships or cooperative societies as per Master Plan Guidelines should be encouraged to counter the ill effects of upswing in land values and unauthorized illegal construction and use; and
- Innovative use of TDR and AR should be encouraged for urban development in harmony with rural environment and in conformity with natural heritage.

7.3 Gurgaon Area - (Sub-Area A-3)

- Internal road based transport infrastructure should be integrated with Metro to ease inter or intra city movement;
- New roads should be planned along with segregated cycle tracks keeping safety consideration and encourage walking, cycling, etc. as a green mode;
- High rise developments with access to assured city infrastructure and higher mobility will continue to dominate the skyline; and
- New work centers, malls and multiplexes should be proposed to take advantage of available land and air space along the corridor and Metro stations.

8. CONCLUSIONS

Infrastructure investment affects an area spatially by opening up inter and intra city movements as well as leading to land use and built form changes, rise in population and density, employment opportunities, property appreciation, etc. This will set the process of dynamic changes in spatial and built form horizontally and vertically. Hence it would be desirable to undertake a study as to how this will affect spatial structure and form, density, land value, and other social aspects, etc. and this gives a fillip to overall urban development. The study will also justify that implementation of Metro Corridor will not only improve linkages and mobility but also trigger quality urban development which will be seen as reflection of change of urban structure and form. This line of thought further strengthens the justification of taking up Metro Project.

Institute of Town Planners, India Journal 6 - 4, 94 - 100, October - December 2009

Rethinking Street Use: A Need for Pedestrian Sensitive Planning

Meenakshi

Abstract

Streets today fail to address, in their planning and design approaches, safety needs and aesthetics aspirations of pedestrians. Health and social benefits of pedestrians on streets are well understood and recognized across the globe. Walking affects all sections of the society and for shorter distances it still remains the most feasible option. In this context, this paper attempts to revisit the streets as regards their essence and bring forth apathy of present day authorities towards pedestrians on the Indian streets. Attempts in the other countries are being considered to establish the need for promoting pedestrianisation at the street level.

1. INTRODUCTION

Streets are generic and pervasive elements of cities that form an integral part of our movement and communication networks. The Oxford English Dictionary contains numerous entries suggesting the particular, continuing, multiple nature of the street. It is at once a road and a place, inseparable from the buildings that flank it. Amos Rapoport asserts that streets are physical entities which are 'more or less narrow linear spaces lined by buildings found in settlements and used for circulation and sometimes, other activities' (Rapoport, 1987: 81-81).

This definition highlights the three-dimensional quality of streets. It does not simply mean the road or sidewalk surfaces but also the buildings located along it, the street furniture and other ceremonial structures that mark its length or define its beginning and end. The two important social functions also become implicit in the definition:

- Circulation is perhaps a street's most visible use. The unrestricted movement of people and goods within a city is essential to its commerce and vitality, and streets provide physical space for that; and
- Activities, signifying communication and interaction that serves to bind together the local urban community. Streets offer sites for social interaction including recreation, conversation, and entertainment, as also ritual observances, such as processions.

Interdependency of these elements and functions underlies most of the essential qualities of the street. The word 'street' is sometimes used colloquially as a synonym for road. However, a clear distinction can be drawn between the two in common

***Meenakshi**, Senior Lecturer, Department of Architecture, Guru Nanak Dev University, Amritsar, Punjab. Email: meenakshi_gndu@yahoo.com*

parlance and increasingly in the profession. A road is a highway with its main function being to accommodate the movement of traffic. Street on the other hand is typically lined with buildings or public spaces which generate other activities along its length. Movement is still the key function of street, but there are several others of similar importance. Thus while roads connect places, streets connect people.

As a component of the built environment, streets along with their antecedent roads are as ancient as human settlements they serve. Streets sustain a range of activities vital to civilization. Its roles are as numerous and diverse as it is ever changing cast of characters. Streets have persisted in the face of technological and social change. Despite the building booms and powerful technological innovations (rail, motor car, elevator, television), functions of the street have only been modified, not altered out of recognition in existing cities. They still have the potential for enriching individual activities and our collective conception of the urban surroundings we share.

2. PRESENT APATHY: STREETS FOR HUMANS OR VEHICLES?

Streets today remain neglected spaces of public realm and are viewed merely as conduits for traffic. The cherished environments are being eroded by cars and the clutter that goes with them. Traffic and the accompanying noise, fumes, visual clutter and dirt that streets are often beset with impacts badly upon the character of streets. This has impacts the peoples' sense of pride in the local environment. With the car ownership rising, places are losing their individuality and heritage in favor of the car-oriented tower block dominated place. Urban areas today are designed related to the scale and pace of the fast moving vehicles. As Francis Tibbalds puts it:

New environments are all too often characterized by spread-out mediocre buildings, lots of left over space and rather uncomfortable arrangements for pedestrians. Such environments appear to be designed for the benefit of the moving vehicle. By contrast, traditional environments emphasize the spaces between buildings and usually produce an attractive, organic whole with a variety of useful pedestrian areas on a comfortable human scale (Tibbalds, 2005: v).

A clear cut power hierarchy gets established in streets with the most powerful vehicles being automobiles, trucks and buses. Then there are those who travel on fragile, non-motorized vehicles such as cycles, rickshaws and the like. The pedestrians, especially the old and the infirm, the children and the disabled, are the weakest and because of this power hierarchy, they get virtually confined to the sidewalks in most cities. As per the nationwide assessment carried out by Wilbur Smith Associates for the Union Ministry of Urban Development on 'traffic and transportation policies and strategies in urban areas' in 2008, the share of walkers in Indian cities can vary between 16 to 57 percent depending on the nature and

size of the city (Centre for Science and Environment, Delhi, 2009: v). It is ironical that despite such high share of walk trips, cities are not walkable.

There is continuous erosion of space for walkers even though every journey begins and ends with a walking trip. The sidewalks are being steadily chipped away to provide more space for carriageways of motorized traffic. Wilbur Smith study has found that the percentage of the road with pedestrian footpaths runs hardly in 30 percent in most cities (Centre for Science and Environment, Delhi, 2009: v). Even the little that exists is clogged with hawkers, vendors, municipal garbage dumps and electric transformers in an unplanned manner. Pedestrians walk in extremely unsafe and hostile conditions, in constant conflict with motorized traffic and various encroachments and thus become easy victims to crashes and accidents.

Professionals dealing with built environment have often worked in isolation in this context. Walkers simply do not matter in planning approaches. Wrong policies are leading to urban sprawl increasing journey distances and making cities less walkable. The whole paradigm of traffic engineering has been directed at expanding the capacity of streets to accommodate ever increasing number of automobiles. Increasingly technological answers to solve imminent transport crisis are being sought, yet walking is often overlooked as a viable alternative for shorter trips. Architects too often are engaged with a single building or a group thereof. Thus identity and social significance of streets is always overlooked.

A rich texture of activities and significances is associated with streets. Simple virtues and joys of urban life that street uniquely offers through varied patterns of daily human contacts have been diminished for all social groups. This reduction in the level of satisfaction and safety leads to increased alienation of the inhabitants from the city, the cost of which is social stress, rising crime rates, the wasteful use of space, urban blights and consequent breakdown of the community.

3. NEED TO RETHINK: ADDRESSING PEDESTRIAN CONTEXT

In view of the street's primary social function, rethinking is required with a wholly new emphasis. Streets need to be judged according to the life they generate. The problem of the city is not much of the functional organization – the fitting together of places for work, residence, recreation and the circulation system that connects them – but instead is the issue of human association – finding the patterns that will enable people to live together.

Walking enhances urbanity and lifestyle. Unlike other travel modes, pedestrian behavior is millions of years old and has remained essentially unchanged. It has evolved in settings of a particular level of complexity. In fact, the pedestrian strolling about his neighborhood represents one of the essential ingredients of urbanity and of a meaningful social existence. The renewed interest in walking globally is fallout of the interest in building cities in new ways to reduce energy, pollution and climate

impacts of urbanization. New Urbanism attempts to promote 'greener' travel through physical design especially through the provision of compact, walkable neighborhoods served by transit.

Walkability is increasingly valued for a variety of reasons. Not only does pedestrian transportation reduces congestion and have low environmental impact, but it also has social and recreational value. Research suggests that walking also promotes mental and physical health. In the western world even health dynamics play an important role in reinforcing walking, as a measure to fight obesity. Urban environments that have high levels of walking benefit the local community in many ways including health, social capital and local economic stability.

Pedestrianisation for short distance commuting could be encouraged. While all journeys end and begin with a walk trip, a large number of people walk to access essential services like education, local shopping, leisure trips within neighborhoods and job centers. Many of these journeys are usually less than a kilometer or two. This is very significant part of non-motorized trips that has enormous potential for pollution mitigation. But increasingly the walking trips within this distance range are being replaced by motorized trips due to hostile walking conditions. The experience from other countries shows that a significant proportion of car trips in the distance range of 3 kilometers can be easily substituted by walking trips if adequate steps are taken.

Walking demands safe and quality environment. The quality of the pedestrian environment is the key to encouraging people to choose walking over driving. Streets need to be safe for adults and children, for those who cycle and walk. They must function as part of the symbolic environment epitomizing the community sense of place and expressing collective territoriality. As per Donald Appleyard, streets need to be seen as 'places rather than channels'. They should be 'destinations, not routes'. 'None of this is possible as long as the automobile retains its supremacy over all other forms of transportation' (Moudon, 1987: 41).

Pedestrians form the largest group of road users yet they find the least attention being paid to them in the provision of road infrastructure facilities. Our Constitution has certain provisions in the form of fundamental rights as well as Directive Principles of State policy that have far reaching effects on promoting road safety. Lack of facilities to walk safely and being subjected to miserable walking conditions is a glaring example where the basic human right to walk safely is being infringed daily. These rights are covered under Article 19 and 21 of the Indian Constitution. Everybody is a pedestrian at one time or the other. Article 38 of the Indian Constitution directs the state that the ownership and control of the material resources of the community should be distributed as best to serve the common good. Provision of road infrastructure facilities seems to be violating this principle with impunity.

4. PEDESTRIAN BEHAVIOUR: IMPACT OF CULTURE AND PHYSICAL ENVIRONMENT

In general, walking and other street activities are mainly a function of two major sets of factors - cultural and physical.

Pedestrianisation is culturally based in that it is the result of unwritten rules, customs, traditions, habits and the prevailing lifestyle and definition of activities appropriate to that setting. As per Rapoport, there are two major styles of street use with some cultures predisposed to using urban spaces for many more activities than others.

- Dynamic pedestrian behavior, mainly walking and strolling, are comparatively constant in nature across all the cultures. The culture influences how acceptable walking is, who walks, where, when, how fast, and with whom; and
- Static pedestrian activities viz. sitting and standing, squatting, lying down, eating, playing, working, sleeping and so on, tend to vary greatly with culture and may not be acceptable in all cultures.

The physical factors include those characteristics of settings that are supportive of the activity in question. The environment does not determine behavior, but can be supportive or inhibiting. In other words, given a set of cultural rules, certain physical or perceptual characteristics are needed that shall maximize and encourage walking. Among these may be

- The size of a town indicating the acceptable levels of physical exertion;
- Safety from traffic or crime;
- Environmental variables such as noise, fumes, congestion, quality of paving, etc;
- Climate, sunshine and shade, topography; and
- Presence of services such as food, shopping, toilets, or seating.

In India, street use reflects two distinct traditions viz. the indigenous and the colonial. On one hand, streets particularly in small homogenous residential areas are semi private so that effectively only residents have access. Streets provide a setting for a bewildering variety of activities and correspondingly diverse sounds, smells and sights. Activities are intermingled at an extraordinarily fine grain and in close juxtaposition. On the other side are the high status areas inhabited by high officials or professionals, whereby the streets are mostly found empty and quiet.

Many European city centers as also the residential neighborhoods have been returned to the pedestrians as examples in Switzerland, France, Germany, Netherlands, Denmark and England attest. As per Norman E.P. Pressman, these have proved

instrumental in protecting the pedestrian domain from automobiles; returning public open spaces and streets to people; and creating environments that can once again become agents of social contact, reflection and vitality (Moudon, 1987: 40). Containing automobile traffic has eliminated a major source of visual and atmospheric pollution. They have taken measures to calm traffic. Broadly, two forms of traffic calming measures are applied that would restrict the volume, speed, composition, and direction of traffic as also its access.

- Passive psychological controls normally involve signs and rely on obedience and enforcement if they are to prove effective; and
- Physical controls comprise obstacles such as diverters, cul-de-sacs, barriers and so forth, which are more effective and exert greater control over driver behavior. These systems create 'protected neighborhoods' limiting access and frequently segregating pedestrians from vehicular flows and thereby restricting motorcar movements to peripheral and arterial roads.

Some of the well known global experiments include the Woonerf experiment in the Netherlands that catalyzed and spread traffic calming measures. The Dutch *woonerf* is an interesting protective device applied in residential areas, whereby the street becomes a space shared both by pedestrians and cars but pedestrians rather than the motor vehicles have the dominant role. Following are the salient features:

- Drivers must maintain a speed limit of 10 to 15 km per hour. Thus, it accommodates cars yet makes them feel fundamentally uncomfortable;
- Each *woonerf* is marked clearly at its entrance and within its precincts, and cars that are not destined for the area are strongly induced to confine their movements to peripheral higher speed roads;
- Several residential neighborhoods in the Netherlands and Sweden are being protected through hydraulic gates that block access to private cars but allow buses as well as pedestrians and cyclists to enter. The weight of the buses activates a pressure system that in turn engages a horizontal wheel causing the gate to swing open;
- Other techniques used include elimination of both straight line streets and curb separations, the selective positioning of street furniture and children's play equipment and the creation of public open spaces and generous parking areas; and
- Special planting and visually interesting paving materials give them a pleasing appearance. For the children, they serve as play spaces and for the elderly the possibilities of sitting, daydreaming, chatting and exchanging glances with neighbors and passerby.

Thus these are safer than conventional public streets, which have a pleasant appearance, exhibit greater potential of becoming part of social realm and fostering

social interaction and recreation. The overall design philosophy is to give a clear message that street belongs to residents.

Wohnbereich in Germany and Wohnstrasse or rue residentielle in Switzerland are variations of the same concept. In Scandinavian countries like Norway, Denmark, Sweden and Finland 'traffic tranquilization' measures and 'neighborhood protection' devices are viewed as an integrated part of neighborhood planning.

5. CONCLUSIONS

The renaissance of urban streets is what is being called for. What is desired is an environment that ensures comfortable human scale related to pace and scale of a pedestrian not to that of a fast moving vehicle. Urban streets need to be humanized; the balance between the needs of the people and that of motor vehicles must be redressed. It is now being widely recognized that making attractive streets that engender a sense of place among local people is vital for the creation of sustainable communities. Delivering high quality walking environments requires an understanding of generic pedestrian issues such as accessibility for all users regardless of age or ability, designing out crime and connectivity as also specific local knowledge. It is important to ensure an effective collaboration among all the environmental professionals. A community's comprehensive plan, policies and other implementation devices must all reflect and endorse the need for pedestrian sensitive street spaces.

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Institute of Town Planners, India Journal 6 - 4, 101 - 104, October - December 2009

Methodology for Organizing Future Growth in Areas Abutting Proposed High Order Roads: A Case Study of Newly Formed State Capital Ranchi

Sangita and Dr. Satyaki Sarkar

Abstract

Government of Jharkhand has proposed to develop a Ring Road spanning 85 km running along the periphery of the city. In fact, there exist vast stretches of land beyond the city municipal boundary and the proposed Ring Road which has of late been characterized by unorganized development and land speculation in the eve of the proposal for a Ring Road. This paper deals with the problems arising out of this development and proposes a methodology that might suit in terms of planned allocation of land uses in areas abutting Ring Road outside the city limits so as to organize future development.

1. INTRODUCTION

Nowadays, cities are developing very fast as a result of which city high speed corridors are necessities to mobilize society's economy and life style. At the same time population is increasing by leaps and bounds due to migration and intrinsic growth which has resulted in increased transport demand and more land. These are felt more in cities that have undergone change in stature in the recent past, especially in newly constituted state capitals and the likes. Hence Ring Roads, in these cities, act as a temporal horizon. Ranchi, the newest state capital from Indian perspective is also impregnated by such problems to decongest the city. Government of Jharkhand has proposed to develop a Ring Road spanning 85 km running along the periphery of the city.

In fact, there exist vast stretches of land beyond the city municipal boundary and the proposed Ring Road which has of late been characterized by unorganized development and land speculation in the eve of the proposal for a Ring Road. This paper deals with the problems arising out of this development and proposes a methodology that might suit in terms of planned allocation of land uses in areas abutting Ring Road outside the city limits so as to organize future development.

2. THE CASE OF RANCHI

Jharkhand is the 28th state of Indian union and Ranchi is one of the newest state capitals in the Indian context. The city has developed along the major regional linkages in a radial pattern in the past. There has been a commendable effort in the recent years to improve conditions of major and minor roads under Ranchi Municipal Corporation. The primary concern in this sector is decongestion, improvement of the traffic speed, mass transit system, channelization of traffic, improvement of road appurtenances, traffic discipline to cater to the ever-

***Sangita**, is Final year student in Masters in Urban Planning, Department of Architecture, Birla Institute of Technology, Mesra, Ranchi. Email:*
***Dr. Satyaki Sarkar**, is Senior Lecturer, Department of Architecture, Birla Institute of Technology, Mesra, Ranchi. Email:*

increasing number of vehicles in the city, which is expected to be doubled by the end of next decade.

Government of Jharkhand therefore in recognition to the need to decongest Ranchi, the capital of Jharkhand State has proposed to develop a fully modern system for safe and efficient movement of traffic. As a first step, it has decided to take up the development of Ranchi Ring Road which will be an 85 km long six lane double carriageway facility running along the suburbs of Ranchi and providing bye pass facilities to national highways, state highways, other roads, presently running through Ranchi City.

But with the proposal to develop Ring Road, problems have started surfacing in various capacities. The issues encircling the proposed Ring Road are:

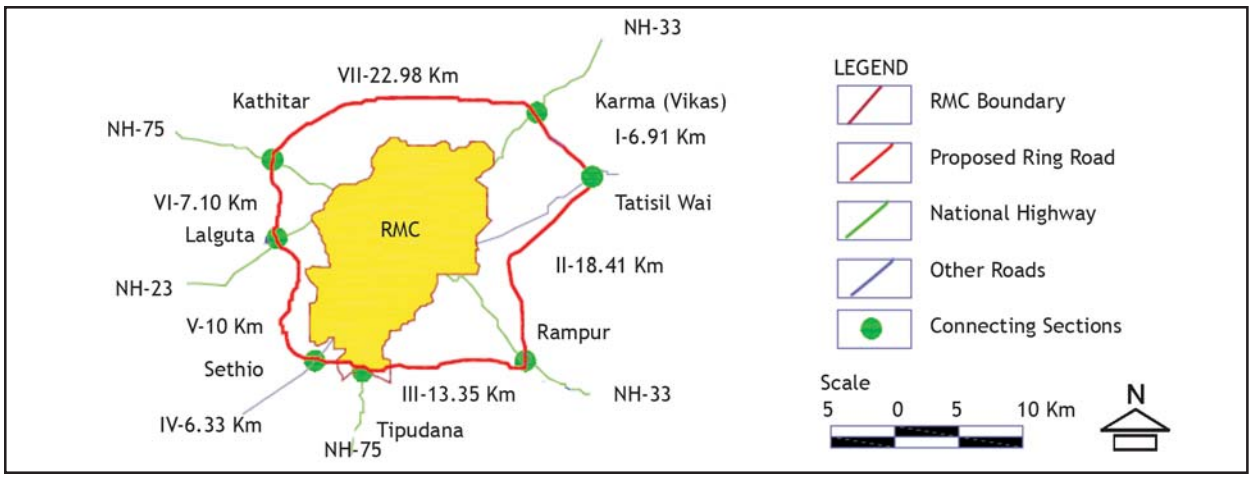
- Unplanned growth in phases has already been recorded along fringe areas through which a Ring Road passes;
- Tremendous economic pressure is generally adding up to increase land values resulting in organic growth;
- Demand for urban transport in Ranchi is projected to be almost double by the year 2011 and the proposed road might help in decongestion; and
- There is already evidence of land speculation through planning areas adjoining proposed Ring Road.

3. THE APPROACH

So, to cope up with these problems, we need to:

- Understand the development profile of the Ranchi Urban Area under consideration;
- Access the type of growth that may be proposed for these new areas that are increasingly being added to the state capital; and

Fig. 1 Section Map of Ranchi Ring Road



- Arrest the possible unplanned growth of new areas along the proposed Ring Road; and
- Guide the development process of areas abutting Ring Road keeping in mind the existing proposals as laid down in the Master Plan and newly proposed City Development Plan.

But in doing so the approach should focus on:

- Identifying the existing settlement pattern and propose the same for future in order to fill up the pockets surfacing between the Ranchi Municipal boundary and proposed Ring Road;
- Identifying the topography, nature of soil, depth of water table, presence of existing water areas, different landforms, and nature of land use, geomorphologic vulnerability, accessibility and land value so as to identify the land use suitability for various types;
- Identifying the future land use pattern in area based on above parameters which will provide the basis of organizing planned growth;
- Setting up development control guidelines for the area in response to a variety of developments that are likely to emanate in lieu of the proposed Ring Road; and
- Striking a balance between tangible and intangible aspects: between short term economic returns and long term socio-economic values so as to give due consideration to all possible aspects of development.

4. THE METHODOLOGY

With an initial understanding of concepts of transportation and urban land use interactions from the literature, efforts should be made for identification of the problems, issues and conflicts in the concerned region including a pilot study of the accelerated and uncontrollable growth pattern occurring along Ring Road. But parallel to the need for such evaluation, aims and objectives and finally scope and limitations must also be identified, as proposals will be bound within certain norms and charters.

The next rung will be in the form of data collection and development of tools and techniques as it is important to analyze potentials of lands that are contiguous to the catchment areas of proposed Ring Road. In order to achieve these objectives, an algorithm may be conceptualized and its value calculated for each of the station catchment areas. The criteria and sub criteria may be selected appropriately, keeping an eye on their nature of present influences and future impacts on the land use and other attributes of land development. Even though the criteria or sub criteria are qualitative in nature, they may be quantified in order to include them in the algorithm. Findings in the form of potentials of the existing land may be

validated by the primary survey findings and other allied secondary data sources. The validation process may be conceptualized to find out potential residential and commercial locations abutting the stretch of the Ring Road. The potential residential location model may be conceptualized on annual savings of a head of the family residing in the catchments area of a Ring Road. Whereas, secondary data sources and few primary survey findings may be used in the potential commercial location model. After the validation process, desirable land use of the entire stretch may be projected to achieve optimum quality of land development in various mixed pockets of used and available land. This technique may form the basis for analyzing the existing situation and foreseeing the future changes. Finally, proposals, policy guidelines, recommendations may be formulated as per analysis.

5. CONCLUSIONS

In lieu of the proposed Ring Road around Ranchi, the city is poised for greater future development. Considering the immigration happening and intrinsic growth that city is experiencing, it is expected that the city will grow to its limits within another few years and this proposed Ring Road is expected to be a delineating boundary of the city. Hence adopting this methodology will streamline the plan, necessity for which has surfaced since the vacant intermediated spaces between present city limits and proposed Ring Road if not planned will surely go for organic development which itself is a character of the city. Such planned initiatives will also have its implications on the regional scale and will help in the process of planned devolution of funds for orienting the growth process.

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