Optimization of Public Transport Demand: A Case Study of Bhopal

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Abstract- Rapid growth in vehicles population has put enormous strains in all urban roads in all million plus cities in India, due to high vehicle ownership and poor supporting public transport facilities specially in the cities where the population is between 1 to 2 million. The major factor is very low ridership in public transport due to poor service quality and more traveling time. This study is concerned of assessment of public transport demand for Bhopal and identifies the major factors for poor ridership with estimation of the probable shift of personal vehicle users to bus due to the increase in its level of service also identifies ways to account for qualitative factors in the public transport project evaluation by adjusting travel time values to reflect comfort and convenience. This can help to find innovative solutions to the current problems such as increasing traffic congestion, energy-consumption etc. and can increase the efficiencies as well as support for alternative modes of public transport, making them more acceptable by the people & achieving their equity objectives and increased economic efficiency both also a new approach is required to estimate the actual public transport demand so that most feasible and suitable system can be selected to optimise the public transport demand.

Index Terms- Public transport, Optimisation Demand, Bhopal, transit demand factors

I. Introduction

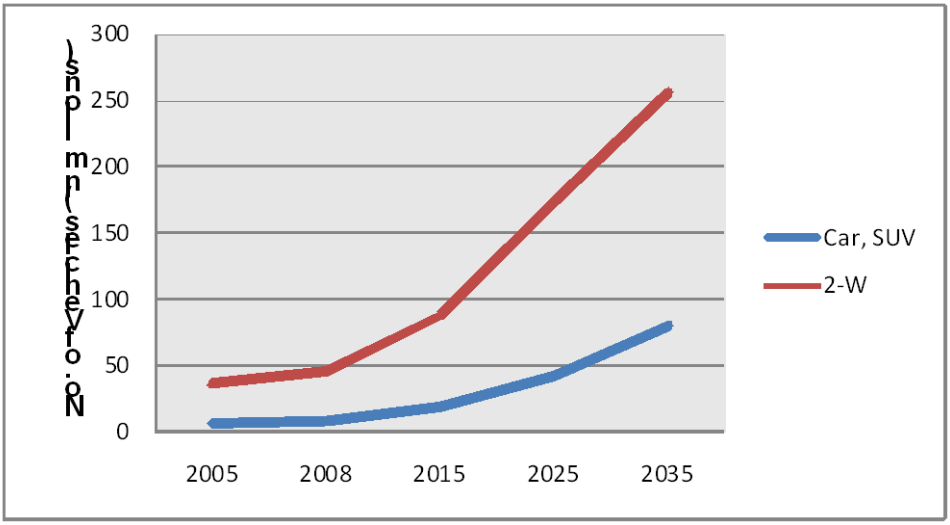
All the million plus cities in India facing a serious urban transport problems, due to the increases in population in urban areas as a result of both - the natural increase and migration from rural areas and smaller towns. The increase in the number of motorized vehicles and in the commercial and industrial activities has further added to transport demand in urban areas, as evident from ***Table 1*** & the corresponding ***Figure 1***. In many cases, this demand has outstripped the existing road capacity. This is becoming more & more evident in the form of greater congestion and delays, which are widespread in Indian cities and indicate the seriousness of transport problems. A high level of pollution is another undesirable feature of these overloaded streets. The transport crisis also takes a human toll. Statistics indicate that traffic accidents are a primary cause of accidental deaths in Indian cities.

Table 1: Forecast of Vehicle Populations in India (in million vehicles)

Population	**2005**	**2008**	**2015**	**2025**	**2035**
2-W	35.8	46.1	87.7	174.1	236.4
3-W	2.3	3.0	5.3	8.8	13.1
HCV	2.4	2.9	4.6	9.1	16.2
LCV	2.4	3.2	5.7	12.5	26.9
Car, SUV	6.2	8.8	18.0	41.6	80.1
Grand Total	49.1	63.9	121.3	246.1	372.7

Source: Ministry of Urban Development, Government of India, New Delhi (2006)

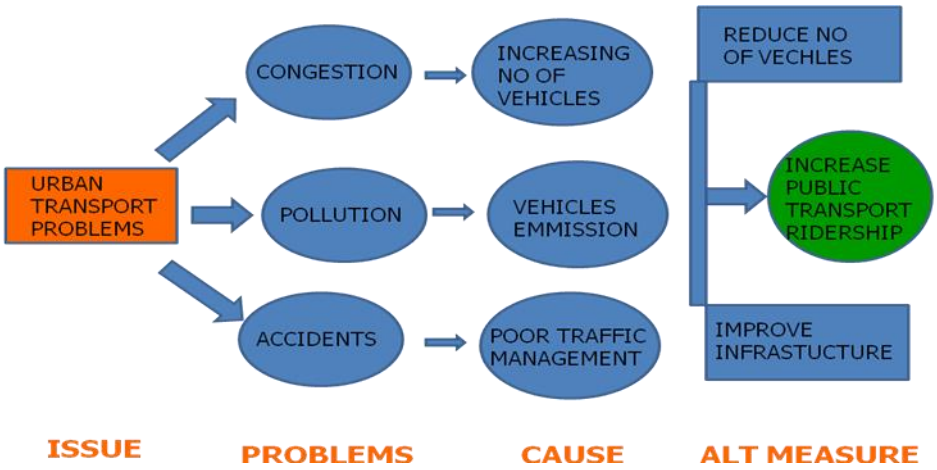
Fig. 1: Forecast of Vehicle Populations in India



Source: ministry of urban transport 2010

The main reasons behind these problems are (i) Prevailing imbalance in modal split, (ii) Inadequate transport infrastructure, and (iii) Sub-optimal use of existing transport infrastructure.
The existing public transport systems in the Indian cities have not been able to keep pace with the rapid and substantial increases in demand over the past few decades. Particularly the bus services have much deteriorated, and their relative output is further getting reduced as passengers are continuously switching to personalized modes and intermediate public transport (Pucher J 2004).

Fig.2: Improving Urban Transport Problems by Public Transport



The above figure mention the major issue, problems cause and best alternative measure related to urban transport and shows that how public transport can reduce urban transport problem in Indian cities. These cities cannot afford to cater only to private cars and two-wheelers. There must be a general recognition that without public transport cities would be even less viable. There is a need to encourage public transport instead of personal vehicles. This requires both an increase in quantity as well as quality of public transport and effective use of demand as well as supply-side management measures.

Hence, it is incumbent on the government to institute appropriate policy initiatives to increase the share of public transport by improving the service quality and comfort. Such interventions should identify & consider factors influencing the demand for public transport and should also quantify the impact of environmental and policy variables. Presently the public transport systems are either under crowed or overcrowded. That

means the demand measures which are used to project the actual demand are not appropriate.

In the Indian cities, the most serious traffic & transportation problems are encountered where the higher public transport facilities are found but the demand and the existing route cannot satisfy the requirements. In addition, many such available transport facilities are worn out and therefore do not satisfy the demand of passengers. There are many external and internal factors that affect the public transport demand. Whereas the external factors are associated with socio-economic development & are not subject to control (e.g. income, car ownership, population, employment, other household characteristics), the internal factors are characteristics of the public transport system and are subject to policy decisions (e.g. public transport fares, trip length, travel time and service levels).

The overall purpose of this study is to contribute to the understanding of how local public transport demand is affected by different factors. It will also identify the effect of parameters like land use, travel-time, travel-cost, accessibility, comfortability, density of study area, per capita trip-rate, affordability and flexibility onto the public transport demand. The key issues in the research will be the identification of factors influencing public transport demand and assessment of their impact on trip generation and modal split. Also, the role of these factors, i.e., how they can increase and stimulate the public transport demand so that most efficient and feasible public transport system can be introduced for the particular city, will also be looked upon so as to come up with innovative solutions for increasing the efficiencies as well as support for alternative modes of public transport.

II. PUBLIC TRANSPORT SCENARIO IN INDIAN CONTEXT

In the Indian context, the larger is the city size, the higher is the percentage of urban trips served by public transport. Thus according to this, 30 percent of urban trips are served by the public transport in cities with population between 1 and 2 million, whereas it's 42 percent for cities with populations between 2 and 5 million, and 63 percent for cities with populations over 5 million (Source: Census 2011). Thus, the especially rapid growth of large cities suggests a further rise in future demands for public transport in India.

Apart from the dependence of the urban trips on public transport based on the city size as shown in ***Figure 3***, there is also a substantial variation in the public transport led urban trips among cities of the same size category. Almost 80 percent of all trips in Kolkata are by some form of public transport, compared to about 60 percent in Mumbai, and 42 percent in both Chennai and Delhi, as shown in ***Figure 4***. Differences in land use and roadway supply explain some of the variation. Delhi and Chennai are lower density, more polycentric, and more spread out than Mumbai and Kolkata. Kolkata also have more restricted geographies, since both are situated on peninsulas that channel travel and land-use development in only a few directions. Such focused travel corridors especially encourage suburban rail use, as in Mumbai. Delhi has no such geographic restrictions and sprawls out in all directions. Thus, Delhi currently relies primarily on auto rickshaws, motorcycles, taxis, and private cars to serve the multi-destinational, less focused travel patterns of its residents (Pucher, J & Korattywaroopam, N 2005). Thus, apart from the city size, the demand for the public transport also depends substantially upon various geographical, transport supply & land use patterns of the city.

Fig. 3: Details of Urban Trips in Indian Cities (Based on City Size)

Source: Census 2011

In India most of transportation studies have been conducted only for metro cities in last few decades as these cities in priority in political and administrative point of view. Very few studies were conducted for small and medium towns due to their least priority in transport sectors & the extensive transport planning was generally neglected while planning such cities.

Table 2: category wise existing Modal Split in Indian Cities (as a % of Total Trips)

City Population	**Walk**	**Cycle**	**Two Wheelers**	**Car**	**Public Transport**	**IPT**	**Total**
< 5 lakhs	34	3	26	27	5	5	100
5 – 10 lakhs	32	20	24	12	9	3	100
10 – 20 lakhs	24	19	24	12	13	8	100
20 – 40 lakhs	25	18	29	12	10	6	100
40 – 80 lakhs	25	11	26	10	21	7	100
> 80 lakhs	22	8	9	10	44	7	100

Source: W. Smith Association, Ministry of Urban Development, GOI, New Delhi (2008)

The Indian cities were classified in six categories for transport studies by ministry of urban development. Our study is more concern with category 3 cities of population of 10 – 20 lakhs. Since in category 3 town rail transport is not feasible so more emphasis is given to bus transport as a public transport system.

Table 3: Classification the cities in following six categories

City Category	**Population**	**Avg Trip Length (km)**	**Per Capita Trip Rate (PCTR)**	**No of cities**
Category 1	< 5 lakhs	2.4	0.8	-
Category 2	5-10 lakhs	3.5	1	47
Category 3	10-20 lakhs	4.7	1.2	30
Category 4	20-40 lakhs	5.7	1.3	7
Category 5	40-80 lakhs	7.2	1.5	4
Category 6	>80 lakhs	10.4	1.6	2

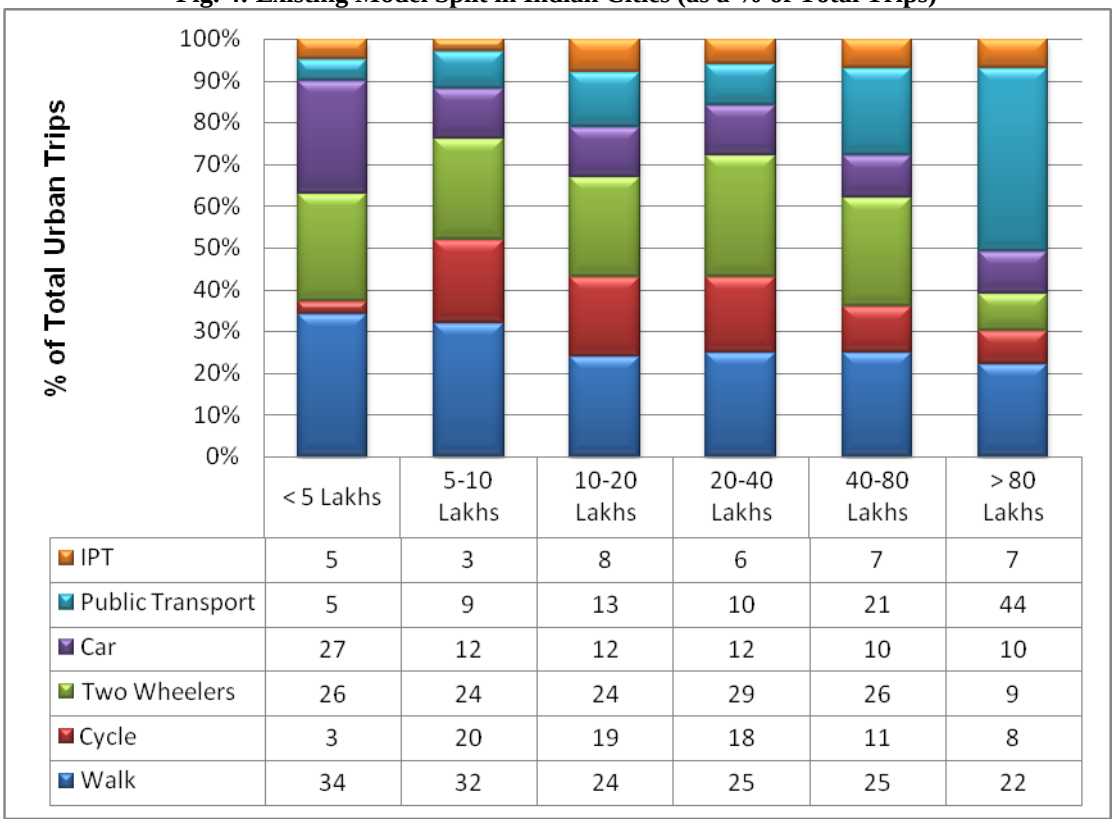
Source: W Smith Association, Ministry of Urban Development, GOI, New Delhi.2008, census 2011

Table: 4 category wise daily trips of cities

City Category	Population	Passenger trips/day (in lakhs)			
		2007	2011	2021	2031
Category 1	< 5 lakhs	8.5	10	13.4	17.2
Category 2	5-10 lakhs	263.1	308.3	423	558.3
Category 3	10-20 lakhs	427.7	498.2	675.6	871.9
Category 4	20-40 lakhs	183.6	210.4	309.6	433.5
Category 5	40-80 lakhs	403.6	469.8	675.2	868
Category 6	>80 lakhs	992.1	1124.9	1552.4	2054.7
Total		2286	2630.4	3661.2	4819.2

Due to the urbanization and modernisation there are several cities of category 2 those will become in category 3 in near future. In those cities the best mode of public transport will be the bus transport only as they cannot meet the passenger demand of the rail transport. So by doing the study of category 3 cities we can do the projection of demand assessment for category 2 cities in near future (Wilbur Smith Associates, 2008).

Fig. 4: Existing Model Split in Indian Cities (as a % of Total Trips)



Source: Ministry of Urban transport, GOI, New Delhi 2010

These two tables, i.e., ***Table 2*** & ***Table 5*** shows that there was a huge gap of public transport share, especially in small and medium cities. So there is an urgent need to balance the desire model split. It occurred only after the introduction of JNNURM and National Urban Transport Policy (NUTP) that the emphasis was also given to small and medium towns also specially in public transport sector. The basic emphasis was to increase the public transport share and change in ridership so that the various problems like congestion, pollution and accidents can be minimized in such cities as they have rapid growth due to urbanization and industrialization.

Table 5: Desirable Modal Split in Indian Cities (as a % of Total Trips)

City Population (in millions)	**Mass Transport**	**Bicycle**	**Other Modes**
< 5 lakhs	30-40	30-40	25-35
5-10 lakhs	40-50	25-35	20-30
10-20 lakhs	50-60	20-30	15-25
20-50 lakhs	60-70	15-25	10-20
50 lakhs +	70-85	15-20	10-15

Source: Ministry of Urban Development, Government of India, New Delhi (1998)

III. PUBLIC TRANSPORT SCENERIO IN BHOPAL: AN OVERVIEW

Bhopal is the capital of the Indian state of Madhya Pradesh and the administrative headquarters of Bhopal District and Bhopal Division. Bhopal is also known as the Lake City for its various natural as well as artificial lakes and is one of the greenest cities in India.

Figure 6: Existing Road Network Pattern of Bhopal, Encircling Maximum Demand Nodes

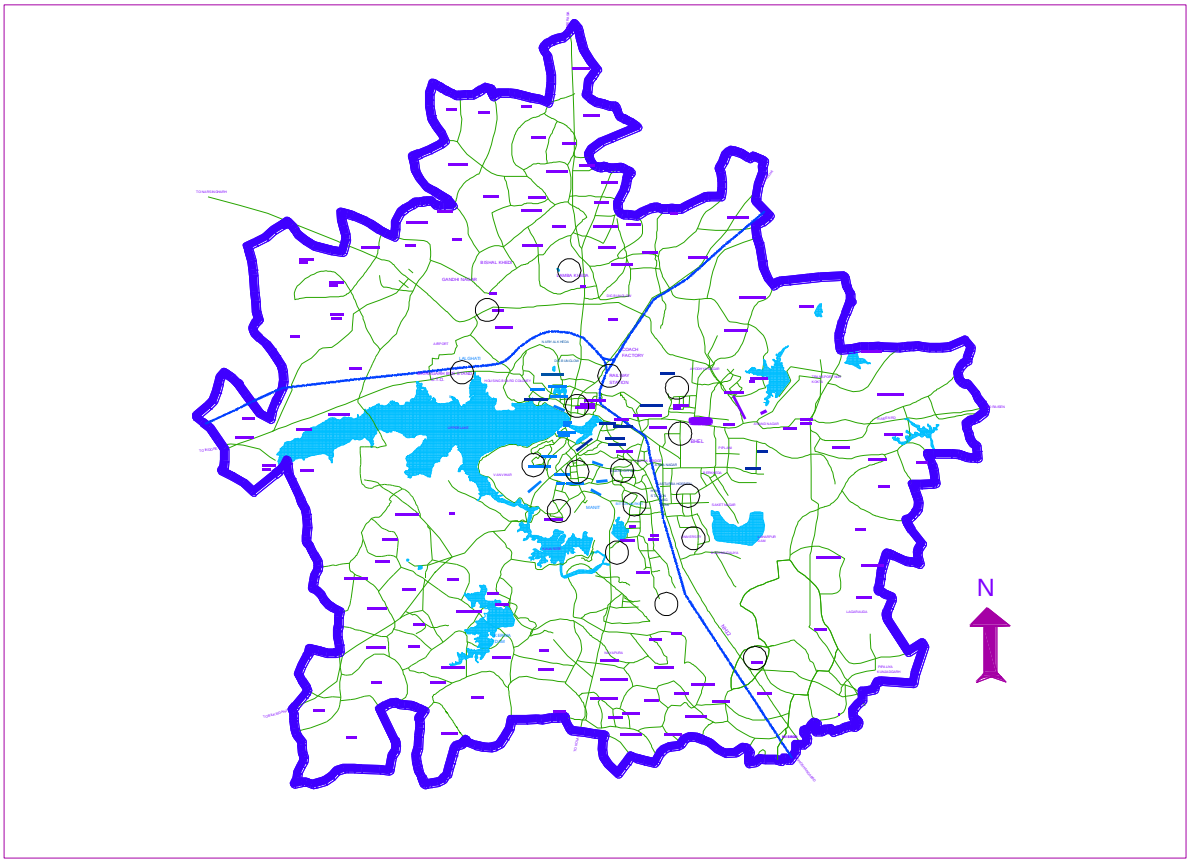


Table 6: Self contained Sub Cities of Bhopal

S. N.	**Name of sub city**	**Estimated population (lakhs)**
1	Bairagarh	2.00
2	Old city	4.00
3	Capital city (T T Nagar)	3.50
4	BHEL Township	2.50
5	Service Township (BHEL Extn)	2.50
6	Misrod	8.00
7	Neori	2.50
	TOTAL	**25.00**

Bhopal has a decent public transportation system comprising of buses, mini-buses, three wheeled autos and the odd looking tempos that are a major pollution concern for this growing city. Recently, under the scheme of JNNURM, a private firm has plied a number of full-sized buses called Star-bus and Red buses in the city streets for public usage which are quite safe and fun to travel in. These have started to gain popularity and are increasing in number.

Bhopal has its own city bus service: Bhopal City Link Limited, which operates larger buses, which are under GPS

navigation and smaller Metro Buses. In addition, around 600 mini buses are run by private operators. Metro or Radio Taxis and auto-rickshaws are another major means of transport. In some parts in the old as well as new city, the new Tata Magic Vans are running successfully and have replaced the older and bigger diesel rickshaws — known as "Bhat". Bhopal is also implementing a "Bus Rapid Transit System", projected to become functional from the year 2013.

Bhopal is planned on a ring radial pattern with a hierarchical road network, as shown in ***Figure 6***. The total road length in Bhopal is about 1500 km. The total road length increased from about 531 km in 1981 to about 800 km 1990-91 at the rate of 2.28 % per annum. There are 5 arterial roads of which three are national highway.

IV. ABOUT THE STUDY: ACCESSING THE PUBLIC TRANSPORT DEMAND

Today, the city of Bhopal is witnessing a major problem in the transportation front, mainly due to the following factors:

- Prevailing imbalance in modal split.
- Inadequate transport infrastructure and its suboptimal use.
- Disconnection between land use and transport planning.

As a multi functional city having & serving different roles simultaneously, an urgent need was felt to address the issue of urban transport in Bhopal, as it's a very important component for shaping urban development and providing quality transport service to the local community of the city.

The shift from private to public transportation can have numerous advantages as follows:

- **Ensures Safety**- Public transportation can be one of the safest modes of travel in the Bhopal. In fact, riding a transit bus is 91 times safer than car travel. Transit vehicle operators are highly trained to anticipate and avoid problems. Most transit vehicles are larger, newer and more substantial than autos or vans.
- **Saves Money**- Money is saved greatly in transportation costs to both highway and public transportation users. Studies have shown that public transport can save up to 2 to 3 times the money spent over private vehicles.
- **Eases Traffic Congestion**- Nearly half of all residents of the city believe traffic is a serious problem where they live, specially the people living in the space constrained Old City area. Most (about 57 percent) do not feel their commute will improve over the next three years, and nearly a quarter expect to spend more time commuting. Public transportation can help much to alleviate city's crowded network of roads by providing transportation choices.
- **Improves Air Quality**- Public transportation helps promote cleaner air by reducing automobile use, which can exacerbate smog and public health problems. For each kilometer travelled, fewer pollutants are emitted by transit vehicles than by a single-passenger automobile. (Buses emit 80 percent less carbon monoxide than a car.) Each year, public transportation use avoids the emission of more than 126 million pounds of hydrocarbons, a primary cause of smog, and 156 million pounds of nitrogen oxides, which can cause respiratory disease.
- **Reduces Energy Consumption**- Public transportation can significantly reduce dependency on petrol, reducing auto fuel consumption by 1.5 billion gallons annually.
- **Fosters More Livable Communities**- Public transportation facilities and corridors are natural focal points for economic and social activities. These activities can help to create strong neighborhood centers that are more economically stable, safe and productive. Studies have shown that the ability to travel in an area conveniently, without a car, is an important component of a community's livability. Public transportation provides opportunity, access, choice and freedom, all of which contribute to an improved quality of life.

All this & many more can be only achieved by the effective implementation and proper working of the public transportation services in Bhopal. Thus, this study was done to access the capacity of the existing public transportation system of Bhopal, and to find the various drawbacks in the existing system and to identify the factors on which the public transport demand for the city will depend, so as to make the system more efficient.

Thus, for properly accessing the efficiency of the public transportation system of Bhopal, two surveys, namely the traffic Volume Survey, and the Origin Destination Survey along with the Occupation Survey and the Public Opinion Survey was done on various major routes of the city, so as to:

- Properly access the exact demand of the public transport,
- Check whether the existing or proposed system is sufficient, and
- Know the various measures for improving the accessibility of the public transportation system.

A number of primary traffic surveys were carried out as a part of the study. The surveys were intended to update the available data and to demarcate existing traffic flow. Traffic pattern and characteristics of intercity passenger and entering/ leaving the study area were recorded during different hours of days.

The study was confined only to the municipal boundary with some exceptional outer cordon points & the scope of work of the study consisted of the following aspects:

- Study of existing traffic and travel pattern of Bhopal by carrying out primary surveys related to existing traffic pattern of the study area & finding out the existing model split.
- Analyzing the data collected through surveys & determining the future demand generation for the public transport in study area.

- Measuring the efficiency of existing public transport system for catering the present demands of public transport.
- Identifying & categorizing various factors & parameters which effect the public transport demands.

4.1 Operational Characteristics of Existing Public Transport System in Bhopal

The average route length of the public transport system in Bhopal is about 27km. The average number of stops on any route is around 23. Out of the total stops around one forth are request stops. The above phenomenon leads to one stop after every two minute & as such, it lacks a dedicated exclusive schematic system for itself. Most of the routes pass through the Old City Area, because of the high passenger demand directing towards this area of the city. The average number of passengers per trip comes out to be 46 per mode, whereas passengers on board at any time come out to be 14. Also, about 3 passengers either board or alight at a stop, whereas the average number of passengers waiting at a stop comes out to be 14. The most crucial data, i.e., the journey time ranges from 1 hr 5 min to 2 hr 15 min. & hence, the average journey time is calculated to be approximately 1 Hr 25 min.'s, where 50% of the time is spent either in boarding or alighting. Thus, the net travel time comes out to be 40 min.'s & the average travel speed is about 40 km's per hour.

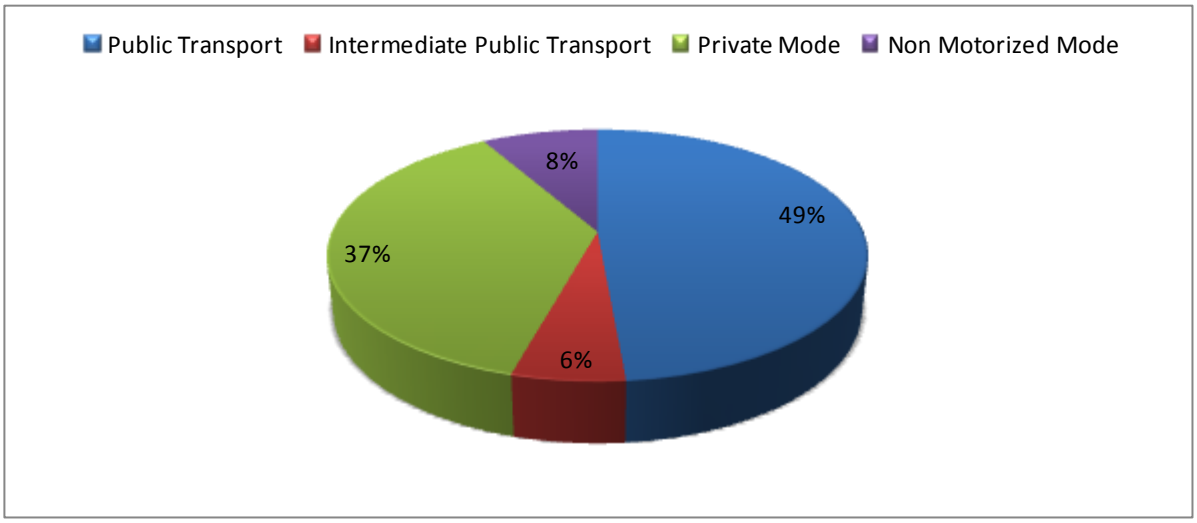
Table 7: Existing Public Transport in Bhopal

Type of Mode	**Share of Passenger Trips (%)**	**Remarks (Total No. of Vehicles)**	**%**
Public Transport	48.6	Standard Bus (39)	5.3
		Mini Bus (600)	31
		Tempos (450)	12.3
Intermediate Public Transport	5.7	Auto (3,000)	5.2
		Taxi	.5
		Two Wheeler (3,00,000)	34.5
Private Mode	37.4	Cars (50,000)	2.9
Non-Motorized Mode	8.3	Cycle	8.3
Total	100		100

(Source- B.M.C., 2009)

As of now, the public transit system of Bhopal is catering about 3 lakh passengers. It also amounts to around 8.6 lakh passenger's km/day. The maximum demands are observed at locations (nodes) along Hamidia Road, i.e. Bus Stand, Bhopal Talkies, Alpana Tiraha. Habibganj Naka, Bharat Talkies, Lal ghati are other important place, which basically act as interchange between two routes, also represent high demand, as shown by small black circles in ***Figure 7***.

Fig. 7: Existing Public Transport in Bhopal



(Source: B.M.C. 2009)

There are mainly ten prime corridor of traffic movement in Bhopal and some of them are as follows:

- Kamla Park - Polytechnic - Roshanpura - New Market – Board Office – Habibganj Naka – University.
- Board Office – Subhas Nagar – Khushipur on Eastern Side of Railway Station.
- VIP Road – Lalghati – Bairagarh.
- University – Misrod – Mandideep.
- Jahangirabad Police Control Room – Roshanpura – Jawahar Depot.
- Bharat Talkies – Pul Bogda – Raisen Road – Piplani – Anand Nagar.
- Mata Mandir Road – Main Road No. 3 – Kolar Road.

4.2 The Efficiency of Public Transportation System in Bhopal

Bhopal presents a classic example of a disorderly transportation environment amidst wide coverage and holding capacities of network. The problems have found their roots in the increasing urban sprawl, urbanization & the resulting haphazard growth of the city; and thus present many constraints on the way of proposing the ideal transportation system for catering the continuous increasing demands for the public transport system for the city. The transport supply demand situation is a matter of serious concern. The problems are numerous, some of them as follows:

- Lack of integration between land use and transport.
- Concentration of activities in core areas of the city.
- Lack of effective utilization of existing road system.
- Lack of public transportation system.
- High growth rate of vehicle.
- Lack of traffic control and regulation.
- No organized parking space.
- Severe congestion and mixed traffic.

4.3Factors Affecting the Public Transport Demand

The public transport demand largely depends on the fare structure, service quality, operation plan, system efficiency and route allocation. These can be broadly categorized as the ones which effect public transport demand directly and others, which can play a role of catalyst, known as latent variables. Following are some of the direct and latent variables (parameters) (Balcombe, R and Paulley, N 2004):

- **Direct variables**
  1. Travel Cost: cost form origin to Destination by any mode
  2. Travel Time: time taken
  3. Trip Length: distance from origin to destination
  4. Comfort levels: posses inside and outside
  5. Accessibility: approach to provide transport facilities
  6. Availability of feeder services: vicinity for model interchange
  7. Density: no of person per square kilometer
- **Latent variables**
  1. Landuse: type of landuse
  2. Income: for affordability of private and public mode
  3. Per Capita Trip Rate (PCTR): ratio of total trips to total city polulation
  4. Urban form and city structure:
  5. System performance: efficiency of available system
  6. Demographic: working population, age ratio, sex ratio
  7. Social factor: income, employment, city characteristics

Several other sources like as mentioned in ***Table 6***, have also identified the factors that directly or indirectly affect the Transit Ridership. More or less, these are more related to personal preferences & thus are largely subjective in nature & very diverse in nature.

Table 8: Factors Affecting Transit Ridership

Convenience	Increase transit service coverage and frequency.
Information	Provide information on where, when and how to use transit.
Price	Keep fares low and offer targeted discounts, such as commuter passes
Speed	Provide express commuter services and transit priority measures
Accessibility	Develop more accessible land use patterns and more diverse transport systems
Integration	Provide park & ride facilities, transit service to major transportation terminals.
Comfort	Provide adequate service so transit vehicles are not crowded
Security	Insure that transit vehicles, facilities and service areas are considered secure
Prestige	Treat transit riders with respect, and promote transit as a desirable travel option.

Source: (Kittleson & Associates)

Many studies have been conducted previously for identifying similar factors which directly or indirectly affect the demands of public transport & thus, can play a very crucial role in determining the success & efficiency of a public transport system. Some of the similar studies undertaken in past by various authors/researchers have been summarized in ***Table 9*** as follows:

Table 9: Comparative Analysis in Different Countries for selecting Parameters Effecting Public Transport Demand

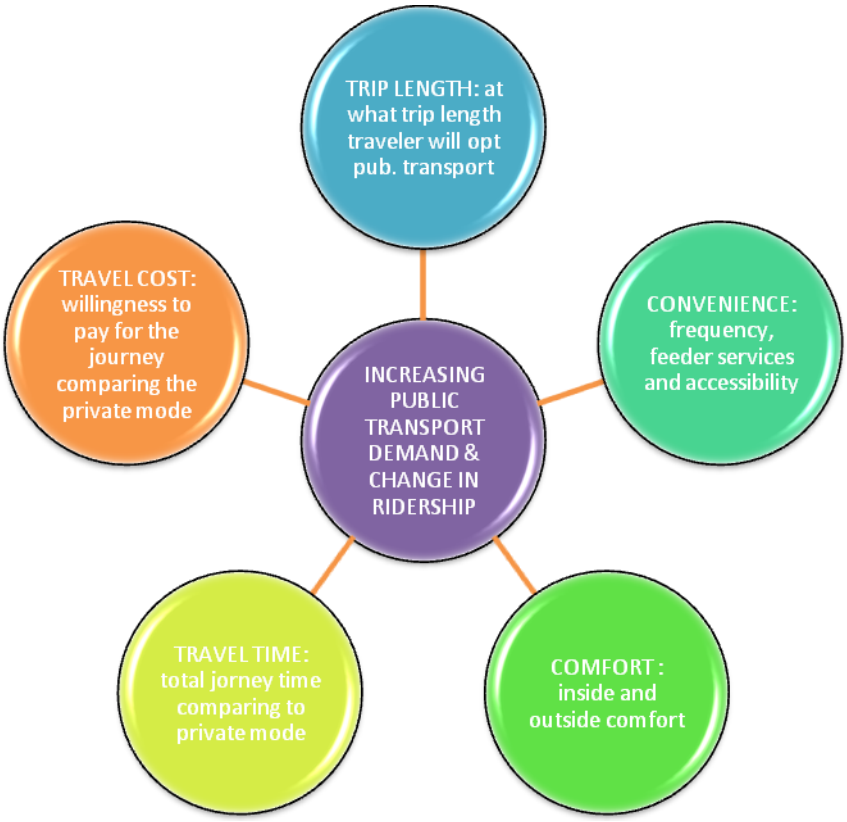
S. N	Country	Study	Parameters
1	Sweden (1999)	The Demand of Intercity Public Transport: The Case of Business Passenger *by Fredrik Carlsson*	Fare, Cost, Comfort and Reliability
2.	Bangalore India (2006)	Modeling Travel Demand in a Metropolitan City: Case Study of Bangalore, India *by Prem Pangotra & Somesh Sharma*	PCTR, Modal Split, Trip length, Population
3.	Bangkok (1999)	Analysis of Urban Travel Demand for Developing Countries by Integrating SP and RP data *by Dilum Dissanayake el at*	Travel Time, Travel Cost, Income
4.	India (2010)	Public Bus Transport Demand Elasticities in India *by Kaushik Deb, TERI University, New Delhi*	Transit Fare, Service Quality and Social Variables
5.	Shanghai, China (2006)	Study on the Demand Forecast Method for the Inter Urban Public Transport under the High-Speed Railways in Shanghai-Nanjing Corridor *by Prof. Rong Zhang*	Travel Time , Travel Cost
6	Ljubljana, Slovenia (2010)	Eva Mode Choice Model Parameters Estimation *by Irena Strnad, Marijan Žur*	Comfort, Time, Frequency
7.	Germany	Free Public Transport *by Herbert J Baum*	Fare, Travel Time, Vehicle Density, Length, Bus Kilometer
8	Great Britain (2004)	Demand of Public Transport: A Practical Guide *TRL Report 2004*	Fare Elasticity, Time and other Quality of Services, Urban Form, Income
9	Sweden (2008)	Study in Local Public Transport Demand for Sweden *by Johan Holmgren (2008)*	Time, Fare Service Qualities
10	Palestine	Ridership Demand Analysis for Palestine Intercity Public Transport	Fare, Population, Origin & Destination, Age Group
11	India, Chennai	Modeling for Optimization of Urban Transit system: A case study	Travel Time, Travel Cost and Accessibility
12	Hyderabad	Discrete Choice Model for Optimization of Urban Transit System	Travel Time, Travel Cost and Accessibility
13	England	Estimating The Demand for Urban Bus Travel by Paul Mullen	Travel time, Cost, Comfort and Convenience

4.4 Selection of Parameters for Public Transport Demand Assessment

On the basis of previous studies undertaken in the past as mentioned in ***Table 7***, it can be summarized that the public transport demand may depend on various factors, ranging from travel behavior parameters (travel cost, travel time, trip length, accessibility ratio, comfort level, frequency, convenience etc), to landuse, density, PCTR, etc. Although for the purpose & context of our study which was on the city of Bhopal, we selected only the parameters of travel behavior as they directly affected the demand generation in our context. Thus, the selected parameters were travel cost, travel time, trip length, accessibility ratio, comfort level and convenience as mentioned in ***Figure 7***. These parameters were selected on the basis of a detailed stated preference survey conducted for understanding the travel behavior of Bhopal.

a. **Study of Travel Cost:** It basically represents the willingness of the potential user to pay for the journey as compared to what he'll pay for the private mode. As such, this is general perception that if the travel cost will increase in any of the mode, the demand for that mode of transport will decrease.

Fig. 8: Most Effective Parameters selected from the Stated Preference Survey



b. Study of Travel Time: Travel time is an important factor in the mode choice analysis. It includes egress and access time, waiting time, and journey time. Many of the factors that affect perceived travel time and unit travel time costs have significant implications for transit project evaluation. More accurate analysis tends to increase the relative value of transit improvements over a period of time.

It basically means total journey time spent in a mode of transport as compared to the time incurred in the private mode. A reduction in travel time not only adds to the value of the preferred mode, but can also be evaluated in monetary terms in the form of Time-Cost analysis; as very often, the saved time on a preferred mode of transport can result in more productive gain for the user of that transport, making the mode more preferred over others. Also, travel time can be of very important step while determining the traffic management schemes for synchronizing the existing infrastructure with the proposed one for making the public transportation system most efficient within the optimized use of energy & infrastructure.

c. Study of Comfort Level: It emphasizes on the extent of inside and outside comfort associated with the public transport system. Some examples of measures which can largely affect the comfort level are:

- The waiting areas at bus stops can be made more clean, attractive, well-lit and accessible.
- Well maintained transit shelters can be placed at busy and/or exposed stops.
- Modern accessible buses in good repair are used to provide service so that they can be operated safely.
- Bus interiors and exteriors are clean and well-maintained with air condition facilities.

Such service quality factors can be very important but are difficult to quantify. For example, the perception that the travel in the proposed public transport system is unsafe or stigmatized (i.e., transit riders feel that they are treated with disrespect by operators or their peers) can significantly increase travel time or unit costs and discourage that transit use. It is quite difficult to monetize these attributes and results may vary depending on how questions are phrased and who is surveyed.

Some more steps which can be used for increasing the comfort level related to the public transport system are as follows:

- Increasing adequate space, comfortable temperature, cleanliness, quiet, and ensuring smooth vehicle movement.
- Improving walking and waiting conditions.
- Reducing waiting time.
- Increasing travel speeds and reliability.
- Improving user information (schedule

information, transit vehicle arrival time, route guidance, easy to understand announcements etc.).
- Informing the passengers of problems, delays, and expected arrival times.
- Increasing perceived safety and security.
- Improving transit travel respect and prestige.

d. Study of Convenience: Whereas studying the comfort emphasized on the extent of inside and outside comfort associated with the public transport system, the convenience emphasized on the attributes like the frequency, feeder services and accessibility. Thus, the steps which determine the good convenience of a public transport system can be like:
- Provision of a network of well-maintained sidewalks for providing access to transit stops.
- Ensuring that the stop platforms and shelters are well designed and maintained in good repair.
- Easily accessible buses are used for providing service.
- Service schedules identify the trips operated by accessible buses.
- Allowing wheelchair access to regular transit.

e. Study of Trip Length: It basically means identifying the minimum trip length above which the traveler will opt public transport over the private mode. It's only up to a certain extent, that the private mode remains the preferred choice for the user, above which the user prefers or can afford the public transportation system even on the costs of other parameters. Thus, a properly considered trip length can hugely affect the observed demands for the public transport services for an area & if managed properly, can significantly increase the efficiency as well as trustworthiness of the public transportation.

f. Accessibility: It is concern of approach and availability of public transport facilities. The demand of public transport is highly depend on the distance for the availability of bus transit facilities, this is general perception that if the public transport is available up to 500 meters which is comfortable distance for walking the bus ridership will be high if the distance is more than 500 meters then the demand for public transport will decrease.

V. FINDINGS OF THE STUDY

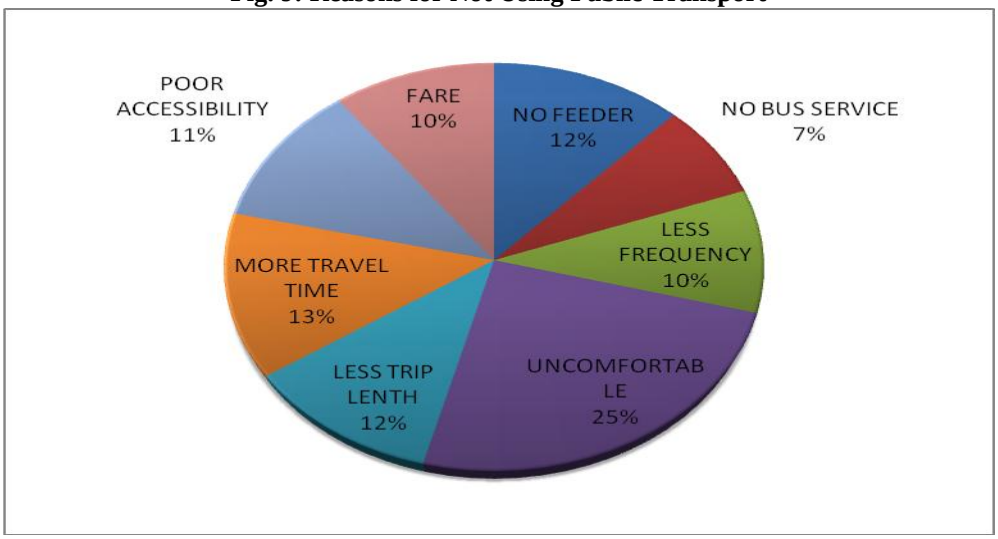
On the basis of above parameters a stated preference opinion survey was conducted at 16 locations spread all over the city of Bhopal on major nodes or hubs of transportation activities mainly to understand the reason for not using public transport system and also to identify the cost at which they will ready to shift their mode.

Figure 9 shows that the observed reasons for not using public transport. The population wasn't using the existing public transportation system mainly due to:

(i) Poor accessibility (11%),
(ii) Uncomfortable (25%),
(iii) Less frequency between trips (10%),
(iv) More waiting time (12%),
(v) More travel time (13%) compared to owned vehicle,
(vi) No feeder services (11%).

Hence the major reasons for not using public transport came out to be low accessibility, less comfort & more travel and waiting time as compared to the private transport modes.

Fig. 9: Reasons for Not Using Public Transport



Source: primary survey conducted on 2011

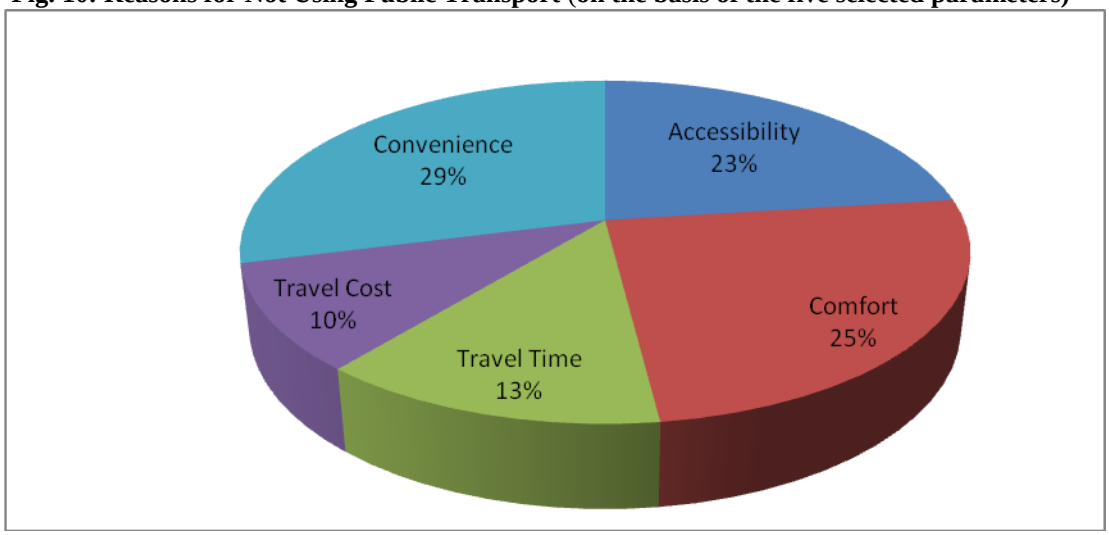
The analysis of opinion survey also showed that nearly 50% of people who were not using public transport were doing so because of less convenient travel, more incurred travel time, less frequency between the successive trips and lack of accessibility in the modes of public transport.

The findings of the study revealed that the problems with the existing public transport system being operated in the city is basically location dependent, i.e., on moving from one area to another, the attributes or reasons which determined the parameters for not using the public transport system varied significantly, thus showing the lack of synchronization between the existing operated transport systems. Upon further categorizing these attributes, it was revealed that the basic lacunas which significantly affected the overall efficiency of the public transport system & directly determined the demand generation in an area were broadly under the same five aforementioned parameters, namely the travel time, travel cost, comfort, convenience and accessibility.

However, due to the fact that the city of Bhopal is spread over a large uneven terrain having many areas of varying topography, during surveying it was felt that the trip length parameter taken alone could not suffice its individuality as all other parameters because the uneven terrain often posed numerous problems for the users & largely affected/determined his travel behaviors both in long & short distance trips. For example, due to a steep slope present in the Roshanpura Square, a majority of buses often avoided that steep climb & preferred to go on the alongside route, forcing the user to choose private vehicle to traverse on that route. However, if the user had to take his private vehicle for getting to the nearest bus stop, he then preferred going to his destination via his private mode itself due to unavailability of 'Park & Ride' styled bus stops. Furthermore, due to these steep slopes present in various parts of the city, users were forced to depend significantly over the feeder services so as to make use of the available public transport system. Thus, this parameter of trip length was submerged into the accessibility parameter also taking along the 'no feeder services' parameter, as the accessibility to the existing public transportation system largely affected both the demand as well as the trip length of the user. Also, 'less frequency between trips', 'no bus service' & 'more waiting time' was considered to be included in the 'convenience' parameter as these three largely determined the convenience factor of the existing public transport system.

Thus, upon categorizing the reasons for not using the public transport under the five selected parameters, they came out as represented in ***Figure 10***. As such, this study revealed that the major reason for not selecting the public transport system was the convenience, closely followed by the comfort & accessibility. It also revealed that the issues related to travel cost & travel time were not that significant in the case as they remained significantly low, being just 10% & 13% respectively. This clearly highlights that the most demand affecting parameters are related to the lacunas due to the inefficiency of the existing public transport system to properly cater & manage the existing demand as well as the transport system properly. It also showed the major hurdles to be overcome related to the synchronization of various different modes of public transport & highlighted the need to emphasize demand management strategies. Contrary to many assumptions which predicted travel cost & travel time to be the most responsible parameters affecting the demand, this study revealed that although they do have a major role to play, but given the other parameters like the comfort, accessibility & convenience are good, people are willing to prefer public transport over the private modes, thus solving most of the traffic related issued of Bhopal.

Fig. 10: Reasons for Not Using Public Transport (on the basis of the five selected parameters)



VI. CONCLUSIONS

We infer that in the context of Indian cities, the dependence of the urban trips on the public transport is based on numerous parameters like the city size, geographical considerations, land use & functional segregation of activities

over the city. Also, due to the previous negligence in the transport planning exercise in case of Small & Medium Cities, there is an absolute need of complete overhauling of the existing transport facilities in these cities, especially in the public transport facilities, so as to make the system efficient for fulfilling the arising transportation demands in the cities & to make them competent for addressing the future demand projections. Also, it'll not only make the existing system efficient, but can also lead towards making the future public transport systems more acceptable & can help in switching the people towards alternative modes of transport.

Bhopal is developing majorly along the highway. New settlements are taking shape in the outskirt of the city. Stated preference survey showed that there is a huge demand of public transport but services are very limited. So, there is a need to develop a comfortable and efficient public transport system along the corridor especially newly developed areas so that people are used to travel by public transport only.

The proposed public transportation system for the city of Bhopal, due to the space constraints which it poses in the Old City area which generated a high demand, should be selected with an aim to cater the total maximum total travel demand to ensure the optimum use of the existing road infrastructure in a cost effective manner. For this purpose, the possibilities of a combination of alternative high capacity public transport system should be evaluated with an aim of providing an integrated multi-modal mass rapid transport system, which can work well in the existing space & infrastructure constrained Old City area, synchronizing itself with the proposed Mass Transit System in the New Bhopal area.

In enabling the economic efficiency, social cohesion & the physical integration of an urban area, transport has a very important and a key role. In developing the comprehensive transport system plan for the urban area of Bhopal, the following objectives have been identified till now, which should be appropriately fulfilled so as to achieve the desired results:

- To improve the mobility of the people and of the goods.
- To improve accessibility to opportunities in an economic and equitable basis.
- To enable function and spatial integration amongst the activities (land use) distributed over the city.

Study of stated preference shows that the public transport demand responses most sensitive on travel time, accessibility and convenience. Consequently it can be elaborated the effort on reducing travel time and more convenience with proper accessibility to attract more public transport ridership. Other factors like comfort level, frequency, headway, feeder service and fare will also consider for optimisation of public transport demand for Bhopal and similar million plus cities (Muthukannanet al. 2008).

6.1 Strategies to Achieve the Desired Public Transportation Share

Following are some of the proposed strategies for achieving the desired public transport share among the total generated urban trips:

a) **Subsidized Public Transport**: The fare levels in the public transport modes should be targeted to be affordable to a larger percentage of population specially, the lower income group.
b) **Strengthening and Optimization of Bus Services**: In order to provide quick, convenient and economic service, measures like reserved bus lanes, priorities at intersection and good terminal facilities to improve turn round time should be undertaken.
c) **Organized Public Transportation System**: A planned public transport system in terms of routing, scheduling and ticketing system would help in attracting more passengers.
d) **Accessibility to the System**: The system can be made more accessible by expanding its influence area, reducing the walking time and proper information system.
e) **Disincentives for Private Mode Users**: Taxation on motorist, high parking charges and other such ways should be introduced to discourage the use of private mode of transport.
f) **Specific Bus Services**: Bus services targeting people from particular origin or destination can also help in increasing the share of public transport.
g) **Special Consideration:** Consideration of various sections of society such as women, aged people, handicapped etc. while designing the public transportation infrastructure can also immensely help to increase its share.
h) **Interchange facilities:** Provide major interchanges for bus services as in metro trains in Delhi, with proper parking space and informative services

Apart from these, there are many other possible ways to improve the transit service quality, including reduced crowding, increased service frequency, nicer waiting areas and better user information. Some more measures to improve the comfort ability & the convenience factor are as follows:

- Improving vehicle comfort and cleanliness.
- Increasing service frequency to reduce wait times and vehicle crowding.
- Improving wait areas and nearby walking conditions, including development of transit stations and shelters, and transit-oriented development.
- Improving boarding ease and speed, with pre-paid fare collection, wider doors and more convenient loading areas.
- Increasing fare options, discounts and passes purchased through work, school and communities, and for shoppers (similar to merchant-paid parking).
- Integrating fare systems, allowing free or discounted

transfers between routes and modes.

- Improving user information, customer service, and marketing programs.
- Parking pricing, parking cash-out, commute trip reduction programs, and similar programs that promote use of alternative modes.
- Modal integration, with transit service coordinated with walking and cycling facilities, taxi services, intercity bus, and delivery services (to facilitate shopping by transit).
- Improving accommodation of people with special needs, including people with physical disabilities, poor vision and difficulty reading signs.
- Improving security for transit users and pedestrians.

Because discretionary passengers (people who have the option of driving) tend to be particularly sensitive to service quality, these strategies often increase public transport ridership and can immensely reduce automobile traffic. Although few motorists want to give up driving altogether, many are willing to drive less and rely more on alternative modes, provided that those alternatives are comfortable, convenient and reliable. Improving transit service quality can therefore, as mentioned in **Transit Service Quality Improvement Benefits** (Litman 2005), provide many more benefits like:

a) Benefits existing transit passengers (who would use transit even without the improvements).
b) Benefits new transit passengers (who would only use transit if service is improved).
c) Benefits society by reducing traffic problems (congestion, roadway and parking costs, consumer costs, accidents, energy consumption and pollution emissions).
d) Benefits from economies of scale (increased ridership can create a positive feedback cycle of improved service, increased public support, more transit-oriented land use, and further ridership increases).
e) Benefits transit agencies by increasing fare revenue.

6.2 Alternative approach to estimating bus transport demand

To estimate the bus passengers demand have always been important to service providers and bus operators. Forecasting public transport demand by conventional methods requires massive data and long time. So there is a need of such kind of models in general or city specific based on most effective parameters on which transit demand depends. Present study is the part of a research study to development a model for optimisation of public transport demand for Indian million plus cities.

REFERENCES

[1] , A. K 2004, 'Urban Transport Issues and strategies', Proceeding IUT, India.

[2] Akshima, T and Sunder, S 2010, A Focus on the Passenger Transport Sector in Million-Plus Cities, India Infrastructure Report

[3] Balcombe, R and Paulley, N 2004, 'Demand of Public Transport: A Practical Guide' TRL Report 2004, TRL Limited, Great Britain

[4] Berechman, J (1993). Public Transit Economics and Deregulation Policy. Amsterdam, North Holland.

[5] Dissanayake, D and Morikawa T (1999) ' Analysis Of Urban Travel Demand For Development Country By Integrating RP And SP Data' Proceedings of Infrastructure Planning **Vol** 22, pp. 381-384

[6] Deb, K and Philippini, M 2010, Public bus transport demand elasticities in India" 2010

[7] Holmgren, J 2007, 'Meta-analysis of public transport demand' , Science Direct, Transport Research, part A 41, pp. 1021-41

[8] Holmgren, J 2008 'Study in local public transport demand for Sweden' Linköping Studies in Arts and Science No. 460,

[9] Irena,S and Zura,M, 'EVA Mode Choice Model Parameters estimation', Mathematical model for engineering Science, ISBN 978-960-474-252-3, pp. 232-237.

[10] Kittelson & Associates 2003, Transit Capacity and Quality of Service Manual, Report 100, Transit Cooperative Research Program, Transportation Research Board.

[11] Khalid, A and sadeq, H 2003, 'Ridership Demand Analysis for Palestinian Intercity Public transport, Journal • of • Public • Transportation, Vol. • 6, • No. 2, pp. 20-35

[12] Litman, T 2010, Evaluating Public Transit Benefits and Costs: best practices Guide book, Victoria Transport Policy Institute

[13] Muthukannan, M and Thirumurthy A (April 2008) 'modelling for Optimization of Urban Transit System Utility', ARPN Journal of Engineering and Applied Sciences, vol.3, no.2, pp. 71-74

[14] Nijkamp, P, Pepping, G., 1998. 'Meta-analysis for explaining the variance in public transport demand elasticities in Europe'. Journal of Transportation and Statistics, vol 1 no. 1, pp.1–14.

[15] Pucher, J & Ittyerah, N 2004, 'The crises of public transport in India: Overwhelming needs but limited resources', Journal of Public Transportation, vol. 7, no. 4, pp 1-20

[16] Pangotra, P and Sharma, S 2006, Modeling travel demand in Metropolitan cities case study of Bangalore, IIM Ahmadabad research publication.

[17] Pucher, J & Korattywaroopam, N 2005 'Urban transport crisis in India' Transport policy 12, Elsevier , pp.185-198

[18] Sing, S K 2005 'Review of Urban Transport in India", Journal of Public Transport, Vol 8, pp. 67-88

[19] Sharifi, M & Shamsudi, K B 2006 'Spatial criteria Decision Analysis in Integrated planning in Public transport Malaysia' , ISPRS, July 2006

[20] Sreedharan, E., 2003, Need for Urban Mass Transport System for Our Cities. Press Information Bureau, Government of India, New Delhi, India.

[21] Sobota, A & Zochowska, R May 2008 'Model of urban public transport network for the analysis of punctuality', Journal of achievements in materials and manufacturing Engineering, vol.28,issue 1, pp. 63-66

[22] Waterson, J & Hounsell, N 2003, 'Simulating the Impact of Strong Bus Priority Measures, Transport Engineering', ASCE, November 2003

[23] Wilbur Smith Associates 2008, Study on traffic and Transportation Policies and Strategies in Urban Areas in India final report, Ministry of Urban Development, India

[24] Zargaris, A and Morteza A 2008, '**An Integrated Urban Land Use and Transportation Demand Model Based on Lowry Linage',** Journal of Applied Sciences, Volume 8, Number 7, pp.1197-1205

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