



## RESEARCH REPORT

Improving Public Transport System

Addressing the Missing Links



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HUDCO'S HSMI  
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## **PREFACE**

The research work is going to give an idea of **Last Mile Connectivity (LMC)** and it's need and importance for the metropolitan and mega cities of India and World, by providing facts of existing scenario and output of analysis of primary survey. The research is being done for least mile connectivity, considering study area as Delhi and five metro stations as study stations, out of 143 metro stations. Primary survey was conducted for public transport commuters and private commuters in peak and off-peak hours. The interview of service providers like cycle rickshaw, e-rickshaw, bus operators and auto rickshaw gave valuable suggestions in formulation of strategies for improvement.

## **FOREWORD**

Human Settlement Management Institute (HSMI) was established in 1985 as the research and training wing of Housing and Urban Development Corporation Limited (HUDCO) to provide training support for professionals engaged with the issues of day to –day practice of human settlement development. HUDCO is a public sector organization, fully owned by the Government of India, and it provides techno-financial assistance to all government agencies at centre, state and local level for housing and urban infrastructure.

HSMI plays a significant role in strengthening the capacities of borrowing agencies, through training. It helps in generating viable projects to improve HUDCO's lending operations directly as well as indirectly. This gives the institute a rare twin character of an R&T wing for internal capacity building, while also operating as a sector specialist institute. Through its capacity building, research and documentation activities, HSMI strives to fulfill the role of a facilitator for healthy debate on key issues in the habitat sector, act as a catalyst to stimulate innovative policy options & implementation strategies, and facilitate the participation of all in the dream of achieving sustainable habitat development.

Over the recent years the institution has been able to make a niche for itself by being one of the leading players in technical hand-holding and capacity building for successful completion of some of the major initiatives undertaken by the government of India. Study inputs, in the form of core conceptual cum feasibility studies, assessment reports, projects evaluation/ monitoring expertise and imparting a variety of skill sets to the functionaries who are entrusted in the working spheres of the prestigious Government of India's programs, is noteworthy contribution. The institute has always been on a self-renewal mode; by bring out various structural adjustments keeping in view the ever-growing challenges in the field of habitat development. The institute has be reoriented around four Centre of Excellence (CoE) with specialist teams and governing council with national level experts to guide its day-to-day activities.

## **ABSTRACT**

The prospect of providing economical and convenient “Last Mile Connectivity” (LMC), that is, from the trip ends to the point of accessing a public transport system, is an area of much neglect in Indian cities, including Delhi. And in the same time the private vehicle growth is increasing tremendously in Delhi city since 1991 to 2011. In this alarming situation, the Last mile connectivity is imperative that a rapid paradigm shift is taken on in order to move people away from private vehicles towards the role of public transit. The research discuss about overview of Delhi and present conditions at selected five metro stations by doing surveys regarding last mile connectivity. The important questions that the project tries to address are: an assessment of comfort, time, space, cost, incurred in the LMC as a ratio of the total journey for rapid transportation system users; user preferences and alternatives available, for LMC; and in the end, whether lack of efficient LMC options is a decisive element in the commuter’s choice of secret modes and how it involves the overall efficiency of a public transit organization.

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**Rajiv Sharma**  
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## List of Abbreviations

BRT	Bus Rapid Transit
CBD	Central Business District
HUDCO	Housing and Urban Development Corporation Ltd.
HSMI	Human Settlement management Institute (Research and Training Wing of HUDCO)
IPT	Intermediate Public Transport
LMC	Last-Mile Connectivity
MoUD	Ministry of Urban Development
MRTS	Metro Rail Transit System
NMT	Non-Motorized Transport
NUTP	National Urban Transport Policy
PT	Public Transport

## **1. INTRODUCTION**

The rapid growth of India's urban population has put enormous strains on urban transport systems. It is triggering to grow travel demand in urban cities especially in mega and metropolitan cities. Efficient public transportation system results in commuters taking multiple trips and longer trips in a day, thus increasing the load of this system. To bring efficiency in a network, an integrated and multi-model approach needs to be prepared and followed. Otherwise, full potential of a network is often not utilized. Like in the present day metro system, which is overcrowded in certain sections and unable, to get estimated ridership in many other sections (Tiwari and Advani, 2005).

Moreover, the public ownership and performance of most public transport services has greatly reduced productivity and inflated prices. Unfortunately, meager financial support and the utter deficiency of any supportive policies, such as traffic priority for buses, place public transport in an almost impossible situation. India's cities desperately need an improved and expanded public transport service by mixing different modes and effective transfers. This way optimization of the public transport system can be reached.

By 2051, the population of India is expected to be 1.7 billion. The number of cities with a population of more than 50 million people is expected to double. There will be 15 cities with populations in excess of 10 million each and 85 cities with populations between 1 and 10 million. That is the challenge India is confronted with. A recent study by Ministry of Urban Development (MOUD), Government of India, indicates that daily trips in the top 87 urban centres are anticipated to become more than double from 228 to 482 million in 24 years (2007–2031).

Hence, improving public transport is a critical component to bring efficiency in the performance of the city's transport system, improve quality of life for the city's growing population and building city's economic competitiveness.

### **1.1 Public Transportation in Indian Scenario**

The vehicular growth in Indian cities is increasing at a tremendous speed. It is rather alarming to note that during the period 1961 to 2011, while the number of cities in India increased three fold (from 2,363 in to 7,935) and the population increased 5 times (from 79 million to 377 million), the vehicular population marked a whopping increase of approximately 200 times (from 0.7 million to 142 million) (CSE, 2013). Of this, larger cities including metro and mega cities constitute the maximum share, with Delhi taking a clear lead.

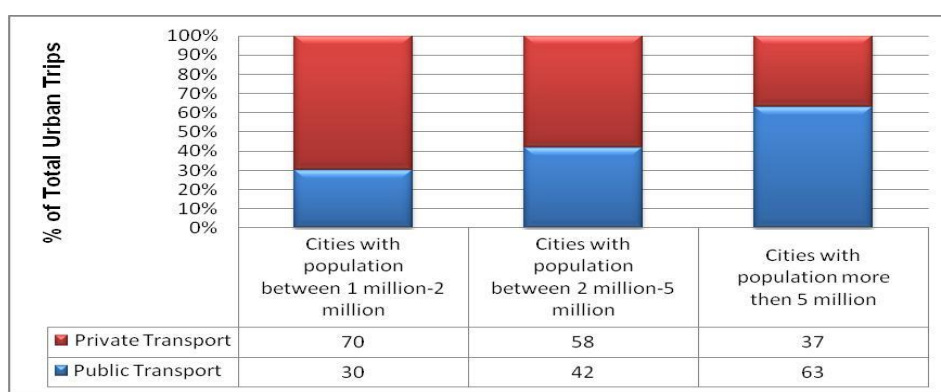
Auto rickshaws supply figures in Indian cities indicates that major metro cities exhibit a higher portion of auto rickshaws ranging between 7 – 13 auto rickshaws per 1000 population, compared to smaller cities supply ranging between 0.3 to 2 auto rickshaws per 1000 population (Wilbur Smith, 2007).

A report drafted in 2008 by Mirabilis Advisory says, "In larger cities, the proportion of people using conventional public transport was high, and consequently commuters walked the last mile". "For example, in cities with more than 8 million population: 22 percent

walked all the way, 8 percent used cycles and 44 percent used public transport. This totals up to 74 percent of people who rely on non-motorized transport for at least part of the commute,” the report states.

In the Indian context, the size of the city and the percentage of urban trips served by public transport are directly linked. Hence, larger the city higher is the average share of public conveyance. So according to this, 30 percent of urban trips are attended by the public transport in cities with population between 1 and 2 million, whereas it’s 42 percent in urban centers with populations between 2 and 5 million, and 63 percent in urban centers with populations over 5 million (Source: Census 2011). Hence, it can be concluded that the rapid growth of large cities results in a further increase in the future demand for public transport in India.

*Figure 1 Urban Trips in Indian Cities based on City Size*



Source: Source: Census 2011)

In India, main focus on the transportation sector was primarily directed towards metropolitan cities as these cities were in priority for political and administrative structure, which resulted in very few studies for small and medium towns due to their low priority. As a result, the transport planning for small and medium towns got neglected and adhoc.

Table 1: 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, MOUD, GOI, (2008).

The Indian cities are classified in six categories for transport studies, by Ministry of Urban Development, based on their population and travel behavior patterns.

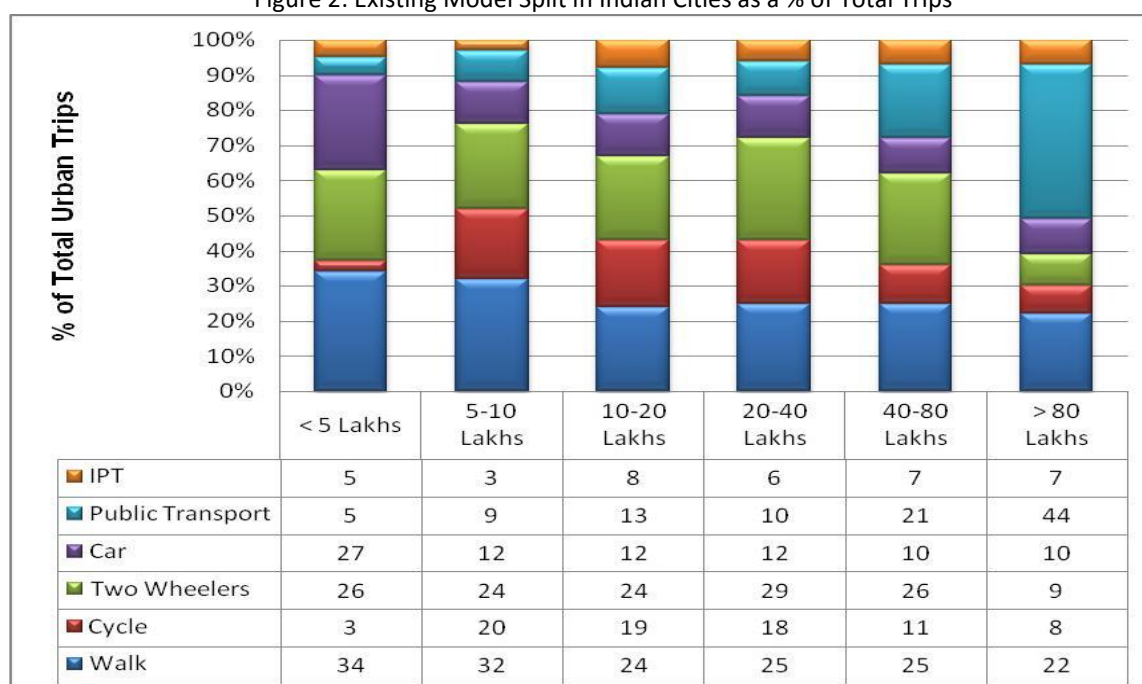
Table 2: Classification the cities in following six categories

City Category	Population	Avg. Trip Length (km)	Per Capita Trip Rate	No. Of Cities
Category 1	< 5 lakhs	2.5	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, MOUD, GOI, (2008).

In 2007, the average modal share of public transport in 21 Indian cities with populations of 0.05 million to 8 million was found out to be just 27 per cent. Public transport share in Indian urban centres with populations above 8 million was 44 percent, and in cities with populations of 4 million to 8 million was just 21 per cent in the same year (Wilbur Smith Associates and Ministry of Urban Development, 2008). Most cities do not have the financial and technical capabilities to fund and develop mass rapid transit projects on their own. With low per capita income and 27 percent of its urban population being in poverty, India has been thrust to hold its public transportation fares extremely low. This has sharply limited the operating revenues of all public transport systems, making it difficult to afford even routine maintenance and vehicle replacement, let alone system modernization and expansion (Pucher, Korattyswaroopam, & Ittyerah, 2004).

Figure 2: 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 1 & Table 3 indicate that there was a vast disruption of public transport share, particularly in low and medium cities. Hence there is an urgent need to balance the desired modal split. It occurred only after the introduction of JNNURM and National Urban Transport Policy (NUTP) that the stress was also applied to small and

medium towns, also especially 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 urban centers as they experience rapid development due to urbanization and industrialization.

Table 3: 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)

## 1.2 First-Last Mile of the user

An individual's 'trip' is understood as the entire journey between origin to destination. Individuals may utilize a number of modes of transport to complete the journey; they may walk, drive, ride a bicycle, take a train, or in many cases combine a number of modes. Public transit agencies typically provide bus and rail type services that may form the nucleus of such trips, but users must fill in the first and last portion on their own; they must first walk, drive or roll themselves to the closest place. This is referred to the 'first-last mile' of the user's trip. Though the streets and infrastructure that make up the first- last mile fall outside the boundaries of Metro's jurisdiction and control, they remain vital components of an efficient public transit organization. Simply cast, all Metro riders must contend with the first-last mile challenge, and the more comfortable it is to access the system, the more likely people are to use it.

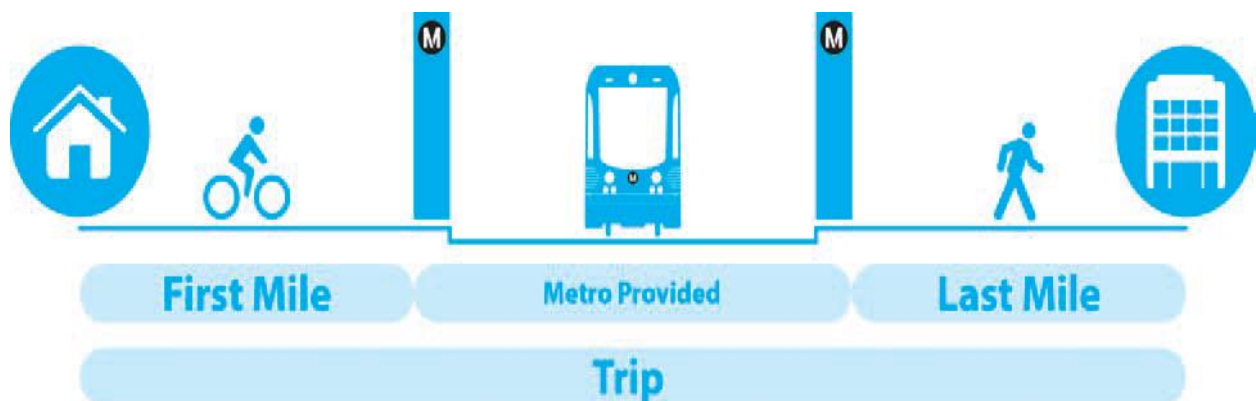


Figure 3 Understanding First Mile

Although the term reads a 'mile', the actual length of this branch may be considerably more than a mile, especially in rural regions. "Last mile" has likewise been applied to depict the difficulty in drawing people from a transport hub, especially railway stations, bus terminals, and ferry slip, to their last destination. When users have difficulty getting from their starting location to a transport network, the scenario may alternatively be known as the "first mile problem." Last mile connecting services enables commuters to easily plug in or transfer to mainline: rail / bus lines either at the start or the residual of their trips. They are significant because they complement rapid transit services by offering commuters the complete trip they need. Hence, poor last-mile connectivity promotes reliance on cars, which results in

more traffic congestion, pollution, and urban sprawl. The person's reverse trip is also an important aspect of last mile connectivity. A reverse trip can vary from the initial trip because of the time of day, traffic, time of year and several other elements.

Often last mile connectivity is synonymous with feeder services. Still, it implies much more than simply a feeder service; it comprises:

- Easy availability of mode and options.
- The time and cost incurred in the last mile.
- Ease of changing between modes.
- Ease of walking/cycling to/from stops/ stations.

### **1.3 Need for the Study**

The prospect of providing economical and convenient “Last Mile Connectivity” (LMC), that is, from the trip ends to the point of accessing a public transport system, is an area of much neglect in Indian cities, including Delhi. While feeder services do exist for metro, their services are limited to a few and selective places. The respite of the demand is mainly met through Intermediate Public Transport (IPT) such as auto rickshaws (that sometimes cost more than fifty percent of the entire price of the journey) or through cycle rickshaws, which are again expensive and confined to certain regions. There remains a lack of diligent efforts towards integrating these IPTs with rapid transit systems and optimizing their potential as an LMC option. The deficiency of adequate walkable and cyclable environment in the city further accentuates the problem of public transport users.

The important questions that the project report tries to address are: an assessment of comfort, time, space, cost, incurred in the LMC as a ratio of the total journey for rapid transportation system users; user preferences and alternatives available, for LMC; and in the end, whether lack of efficient LMC options is a decisive element in the commuter's choice of secret modes and how it involves the overall efficiency of a public transit organization.

### **1.4 Objective of the Study**

The main objectives of the project include the following:

- i.) To document the present practices of Last-Mile Connectivity as perceived in existing public transport systems.
- ii.) To evaluate the public transport system in order to identify the missing links for integrated transportation.
- iii.) To assess the role of Last-Mile Connectivity in efficient delivery of a Public Transportation System.
- iv.) To prepare a strategy to strengthen Last-Mile Connectivity with a view to improve Public Transportation Systems in a particular city.

### **1.5 Resources and Methodology**

Delhi has been selected as the case study region. The urban centre has currently two major types of transportation systems – metro rail transit system (henceforth, referred to as metro) and urban bus system. This project intends to discuss findings related to last mile connectivity in inter-city and intra-city public transport systems. Primary survey was conducted, covering commuter and non-commuter (including IPT Operators and Private

Vehicle Users) categories of commuters. Interviews for the commuter group were conducted at metro stations on identified metro routes of Delhi. Also offices within a range one kilometre from metro stations were also be included in the study. The studies will be conducted on working days during peak hours and non-peak hours. The focal point of the study was to cover regular trips like work and education trips. Stations chosen for the on ground survey were HUDA City Centre, Hauz Khas, Laxmi Nagar, Anand Vihar ISBT and Jahangirpuri Metro Stations.

## **1.6 Expected Outcomes**

The study has been designed with the following outcomes in mind:

- To be able to analyze the gaps of Last-Mile Connectivity in public transport service delivery and its impact on overall ridership of a transit system on varied indicators such as accessibility, affordability, last mile connectivity, etc.
- To address the issue of last-mile connectivity in depth with a case study based approach including primary data collection and analysis to make public transport comfortable and seamless for its users with integration of private and public modes of transport.



## **2 LITERATURE STUDY**

### **2.1 Access And Egress**

According to Hoogendoorn-Lanser et al. (2006) the access trip is “the trip part from the origin to the boarding railway station” whereas the egress trip is “the trip part from the alighting railway station to the destination”. It is evident that these definitions consider the train as the main mode in the transport chain and are as such not useful for our purpose.

Notwithstanding the above, the complexity of analysing and modeling multi-modal travel necessitates a more universal and more flexible definition regardless of the main mode used. The definitions used in this study for access and egress trip are as follows:

The access trip of the multi-modal transport chain is the trip part from the trip origin to the first entry point of the public transport system. and

The egress trip is then defined as the trip part from the point of alighting the last public transport leg to the final destination. It is therefore also implied that within the PT system, different modes may occur, such as bus and Bus Rapid Transit (BRT). This distinction is necessary, in order to model the transport chains correctly at a later stage.

### **2.2 Multi-Modal Trips**

When one refers the integration of two or more modes (PT and NMT), the concept of multimodal trips emerges. Therefore, before discussing last mile connectivity further, first the concept of multimodality is discussed.

According to Van Nes (2002) a multimodal trip is “when two or more different modes are used for a single trip between which the traveller has to make a transfer”.

According to Hoogendoorn-Lanser et al. (2006) a multimodal trip is “a trip when it involves at least one transfer between – not necessarily different – mechanized modes”.

It is interesting to have a look at the position of walking in these definitions. Van Nes (2002) assumes that walking is a universal component at the start and at the end of any trip and therefore a trip in which walking is the mode for access and egress is not considered a multimodal trip. HoogendoornLanser et al. (2006) only consider mechanised modes in their study neglecting not only walking but also cycling as access and egress modes.

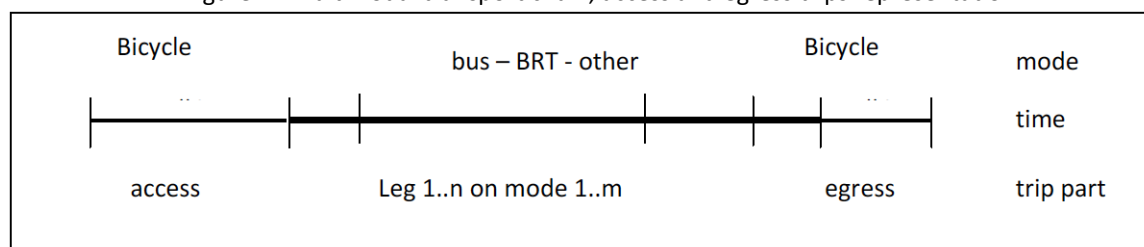
Walking, however, is not only a mode of transport in itself, but it is also an important complementary mode of all motorised modes. In many developing countries people walk long distances and walking has a high share in modal split (Vasconcellos, 2001). Even private modes require people to walk to their vehicles and PT trips often require considerable walking at the access and/or egress end. Considering walking as a transport mode could potentially make all trips multimodal, as always some walking is involved. This would render a definition that is pretty useless as a universal definition. In the current study, we are looking at Last mile connectivity in particular. Here, the importance of walking in combination with cycling and PT in integrated transport chains compels us to include it as a

separate mode. For the purpose of this study, walking is therefore considered a transport mode in itself. A trip that involves walking can therefore be considered a multi-modal trip.

The notion of main mode is not necessarily made explicit, as this presents no further benefits in the modelling stage. This brings us to the concept of trip chain.

A useful definition for trip chain is provided by Rietveld et al. (2001) who defines a trip chain as “an ordered sequence of trips where the endpoint of each trip is equal to the starting point of the subsequent trip in the chain. The starting point of the first trip is the starting point of the chain, and the endpoint of the last trip equals the endpoint of the chain”. The illustrated Figure 3 has been used to understand the concept of the multi-modal transport or trip chain.

Figure 4: Multimodal transport chain, access and egress trips representation



Source: Integrating Non-motorized Transport to Public Transport, 2009

## 2.3 Different Modes of Connecting Last Mile

The type of mode opted for going the last mile, varies at the initial (origin to metro O-M) and the final (metro to destination M-D) legs of the overall journey, with an exception of those commuters who opt for walking in the O-M section. Approximately 60% of the commuters, who walk while reaching the boarding metro station, also opt for the same while reaching the destination from the metro station.

In general, there are four distinct types of feeder modes in Indian cities: Non-motorized modes (i.e. walking, cycling), intermediate public transport (i.e. auto-rickshaws, taxis), shared-ride services (i.e. shared taxis, shared auto-rickshaws) and buses.

### 2.3.1 Walking

Walking distances vary based on route and trip qualities (such as type of transit service, transfers and wait time), as well as personal, household, and neighborhood characteristics. A service area around a transit station or stop is broadly defined as the area from which potential riders are drawn. Delineating the service area around public transit stations is a complex and important issue, and is used to determine optimal stop spacing, identify redundancy and gaps at the route and system levels, and understand and predict demand for transit.

In Calgary, Canada, Lam and Morrall (1982) observed a median walking distance to bus stops of 292 m, while the average was 327 m and the 75<sup>th</sup> percentile, 450 m. Studying walking distances to rail transit stations in Portland, WA, and San Francisco, CA, Schlossberg and his collaborators found a median distance of 0.47 miles (756 m) (Schlossberg et al. 2007). While Daniels and Mulley (2013) found the mean walking distance to bus service 461 m with 75th percentile at 566 m.

The 85th percentile walking distance to bus transit service is around 524 m from home-based trip origins, 1,259 m for commuter rail. This finding raises the importance of careful

revision of the 400- and 800-m service area rules used in the transit industry. El-Geneidy Grimsrud (2013) found that Riders walk about 13 m farther for work trips than other types of trip purposes, again possibly reflecting overall time budgets. Conversely, they walk about 9 m less during the AM peak, when work trips are most frequent, than at other times of day, probably due to additional services available at such hours such as frequent buses on otherwise infrequent routes. Males walk about 12 m longer than females and walking distances decrease by about ½ meter for each year increase in age.

### **2.3.2 Bicycle as a Feeder**

Bicycle is an accessible, low-cost, non-polluting and healthy mode of travel. One of the ways to promote bicycling is to encourage its use for making access and egress trip of public transit services. Bike-and-ride refers to the combined use of the bicycle and public transport for one trip. The combination can take different forms: trip-makers can use the bicycle as a feeding mode for access trips (at the home-end of a trip), for egress trips (at the activity-end of a trip), or for both. Average walking speed is approximately 1.2 m/sec and average bicycling speed is approximately 3 times higher than the walking speed i.e. 3.6 m/sec. Therefore, use of bicycle as an access trip makes significant addition in catchment area of public transit service, and time savings to individual users.

Bike-and-ride has recently gained attention as part of the wider search for multimodal alternatives for the private car (Hine and Scott, 2000; Gorter et al., 2000). The attractiveness of bike-and-ride lies in its potential to solve one of the key problems of public transport: the accessibility of stations and stops. As a feeding mode, the bicycle is substantially faster than walking and more flexible than public transport. The combined use of bicycle and public transport could thus be a relatively competitive alternative to the private car (e.g. Keijer and Rietveld, 2000; Brunsing, 1997).

Research work was conducted by **Advani and Tiwari (2006)** on BICYCLE AS A FEEDER. In this on board commuter survey was done in Delhi, dividing it into 5 zones on 130 different routes out of total 650 routes of local Public transport service of Delhi. Around 4000 commuters were interviewed for their full trip profile including access and egress time, cost and mode. A pre-designed survey form was prepared and whole survey was carried out by trained surveyors and administered. This study shows that the people owning bicycle are not using it for their access trip. The reason behind this can be

- (1) absence of parking facility at bus stops,
- (2) short distance from their origin to bus stop,
- (3) lack of safe cycling facility along the road.

The study showed that 43% among bicycle owners walk less than or equal to 500m, 48% walk more than 500 m but less than 1km and 9% walk more 1 km distance. Accepted walking distance to access the public transit is 500 m, in the present case 58% commuters have to walk more than acceptable walking distance of 500 m to reach at their bus stop. If a bicycle friendly infrastructure is created, these 58% commuters can shift to bicycles. This would reduce travel time by approximately 33% without any additional cost investment out of the total selected sample of 3632, 711 persons (20%) own bicycle. 652 (18% of total) have 1 bicycle and 58 (2% of total) have 2 bicycles at home. However, only 6 (0.15%) persons out of total 3632 are using bicycle for access trip to bus.

### **2.3.3 Cycle Rickshaw**

The cycle rickshaw is a local means of transport and also known as pedicab, cyclo, or trishaw in different part of the world. Cycle rickshaws in the present day scenario are acting as service providers and access and dispersal modes to MRTS in various stations in Delhi. Despite their potential role as an access and dispersal mode they are faced to biases in planning and policy decisions largely owing to lack of an understanding of their characteristics, contributions and constraint.

Metro user and Cycle rickshaw user surveys were carried out by **Gupta and Agarwal (2008)** to assess the role of cycle rickshaws as a feeder mode. . Amongst the cycle rickshaws users travelling it were observed that females dominate the usage of cycle rickshaws for reasons of convenience, availability, comfort etc. Cycle rickshaw users are maximum in the age group of 15-25 yrs (28%) followed by 25-35 yrs (20%).The users are normally educated and belong to middle to higher income levels with monthly incomes varying between Rs.15000- 25000 per month. It can be observed that walk and cycle rickshaws are the major access and dispersal modes at metro stations. While walk constitute 59% of the total access and dispersal trips, cycle rickshaw serves 24% of the total metro feeder travel demand to and from metro stations. The operational area of cycle rickshaws varies between 1.4 km to 2.2 km. with the overall weighted average trip length of 1.72 km. which indicates that it serves short distance commuting needs of its users

### **2.3.4 Feeder Bus**

Feeder bus is a desirable option for passengers that live further than walking distance to transit stations, especially for those who do not have private vehicles or cannot afford cost of parking at transit stations. Comparing to park-and-ride, feeder bus generate less traffic congestion and emissions. However, providing feeder bus service is costly when it has to time-competitive with cars, especially in low-density areas where number of passengers is low (TCRP, 2009).

XIE ,GONG AND WANG (2010) offers an all new choice to improve the final leg connectivity of the transportation system. The shuttle buses operate in short circular routes, linking the rapid transit stations/stops and the office buildings, residential houses, apartment buildings and many other sites in local areas together. Buses of smaller sizes are used for these lines not only to avoid the congestion, but also to serve in a short interval of less than 5 minutes Based on the detailed statistics of the population of local areas and the street-level traffic data, an innovative layout of the local shuttle bus system is discussed, based on the multiple-route, maximal-covering/shortest-path (MSMCSP) model. The models are applied to the local shuttle bus routes in Hepingli area of Dongcheng District, Beijing. Results show that it is possible to improve the efficiency, convenience and comfort of the public transit system by the application of the local shuttle bus system theory

## **2.4 Sustainable Urban Transport in India (Role of the Auto-Rickshaw Sector)**

Since the introduction of auto-rickshaws in India in the late 1950s, these vehicles have become an essential facet of urban mobility for millions of people. Auto rickshaws play a critical and vibrant role in India's urban transport schemes. Yet they also represent a very improvisational and increasingly inefficient sector – and they are getting lost in the

switching dynamics of urban mobility in India. Today, with increasing urban populations, there is growth in demand for urban transport, growth in private motorization and a decline in public transport share. How do auto rickshaws fit in and sustain a role that is efficient – for both the operators and their passengers? And how can these three-wheeled wonders contribute to urban transport sustainability – through both reductions in emissions and safety for everyone on the roads? These are the questions that are needed to be addressed in recent transportation system management in a developed nation like India.

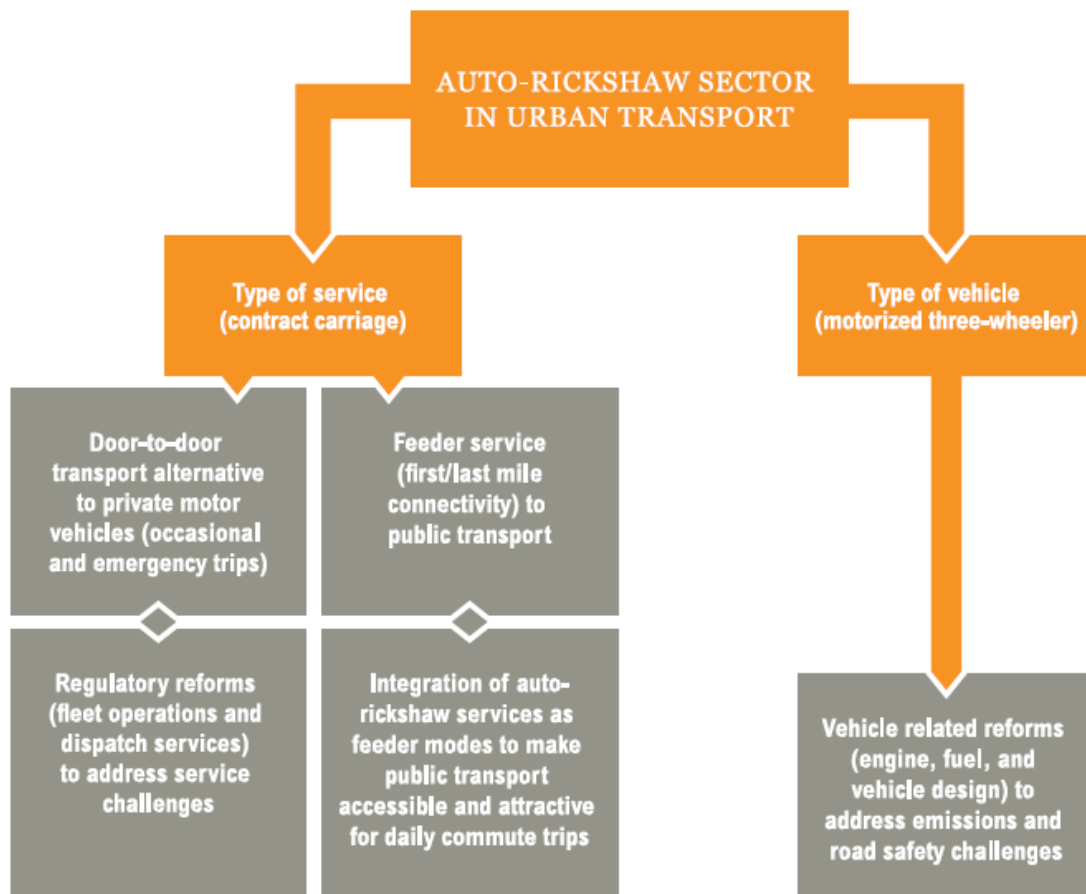
As the need for urban transport increases in India, so likewise does the popularity of the auto-rickshaw. Production of this type of motorized three-wheeler has doubled between 2003 and 2010. In major Indian metropolises, it is responsible for a substantial share of motorized trips. Schemes to better urban transport must include a policy vision for this increasingly significant sector. To that goal, this report examines the role the auto-rickshaw sector can act in encouraging sustainable urban transport in India. It prepares a policy vision for this sector and presents recommendations on reforms to address sustainability challenges.

It can be found from this subject field that auto-rickshaw services in urban centres can help fulfil the objectives of the Shift strategy of encouraging public transport and reducing private motorization based on the following aspects:

- **Last mile connectivity to public transport:** Auto-rickshaw services, mixed as a feeder mode, providing such connectivity, can complement public transport systems by assuring that all sections of the city have easy access to public transport stations.
- **A door-to-door transport alternative to private motor vehicles:** The door-to-door on-demand service provided by auto-rickshaws will ensure that transportation needs requiring door-to-door connectivity, such as occasional trips to the airport or emergency trips for health care can be gathered in cities without having to rely on private motor vehicles.

The Avoid-Shift-Improve (ASI) framework, one of the key approaches to improving the sustainability of urban transport systems, underpins this study. ASI sees “sustainability” in conditions of cutting greenhouse gas emissions, improving energy efficiency, cutting traffic congestion, and protecting public health and safety by encouraging alternatives to the private automobile, among other strategies (Bridging the Gap 2011). The ASI framework is based on three key strategies: avoid unnecessary trips, shift to more sustainable transport modes, and improve performance in all modes (Dalkmann and Brannigan 2007). While the Avoid strategy must be pursued on the demand side, through better urban planning and land use policies, both the Shift and Improve strategies of the ASI framework are relevant to evaluating the use of the auto-rickshaw sector in encouraging sustainable urban transport. The policy vision for the auto-rickshaw sector should recognize its role in promoting sustainable urban transport.

Figure 5: Policy Vision for Auto-Rickshaw Sector in Cities



Hence, the auto rickshaw sector can also turn out to be a vital factor for increasing the effectiveness of public transportation systems in a metropolis and can also take on a major role in the Avoid Shift Improve strategies promoting sustainable transport, which is the most significant necessity of Indian cities due to an alarming rise in road fatalities, degrading air quality, and so on.

## 2.5 Influence Zones of Transit Stations and Feeder Modes

Access to mass transportation system is determined as “both the trip to the place, and from the station to the final goal” (BART 2003). The quality of access, while a fraction of the price of the system, directly influences its ridership (Jaiswal, Sharma and Bisaria 2012). A good station area can not only maximize transit ridership, but also create streets for all users, provide affordable commuting options, make vibrant public spaces, manage parking effectively, help realize the economic growth benefits of transportation investments and serve its communities’ needs (HCRRRA 2013); (BART 2003).

So in India, improving access to mass transit stations can serve multiple aims in addition to leveraging investments of at least 15 billion USD2 (DIMTS 2014) in building new public transport schemes. There are about 19 BRT systems and 10 metro-rail systems in different stages of planning, construction, operation or expansion (MoUD 2013). In increase, two cities (Lucknow and Guwahati) are evaluating options between BRT and metro-rail systems (BRT Centre of Excellence 2014).

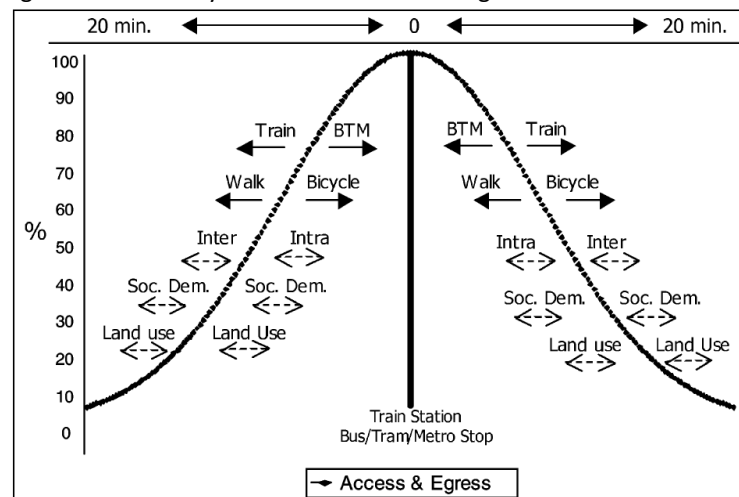
Still, station areas in India have yet to be perceived as places of connectivity, i.e. where large masses of people interact with multiple styles of transport, and as homes for living, exercising and recreation. In fact, these mass transit organizations are being introduced within the poor quality NMT infrastructure, characterized by a lack of safety, protection, comfort and convenience (Tiwari and Jain 2013). With 140,000 deaths in India per year due to road traffic.

Crashes (NCRB 2011), road safety pose a grave concern for non-motorized transport (NMT) commuters. For example, pedestrians, bicyclists, and motorized two-wheeler riders constituted 60–90 percent of all traffic fatalities in the urban centres of Mumbai, Delhi, Kota and Vadodara (Mohan and Tiwari 2000). In Bengaluru, pedestrians accounted for about 51 percent of the total road traffic deaths (NIMHNS 2009).

Information from the Netherlands suggests that, (a) ridership starts declining from a distance of approximately 150 m and beyond, and (b) 500 m should be considered a reasonable catchment radius for a walking trip to the station. For the bus, tram and subway system, mean access and egress times have been found to be 5.9 min of walking, which transforms to an average length of 393 m to the rail or coach station.

Hence it is correctly pointed out that the quality of public transport is influenced not just by the character of the primary transport mode, but likewise by the before (access) and after (egress) modes. Access and egress are the weakest links in a public transport chain. The interconnectivity of the different modes also becomes important in order to make a trip and set the availability and convenience of public transport (Krygsman, 2004). Initiatives aimed at improving access and egress hold potential to significantly cut down public transport trip time and are inexpensive options compared to the expensive infrastructure and vehicle enhancement alternatives frequently considered.

Figure 6: Probability Curves for access and egress time for Netherlands



Hence defining a station area influence zone helps in proper planning and implementation of access and egress modes for smoother transitions and better last mile connectivity. For example, direct and safe walking connections are most important in close proximity to the station, where there is often the highest levels of pedestrian activity. Farther away from the station, bicycle, bus and rickshaw/taxi connections become relatively more important to ensure convenient access. The station area boundary includes primary zone and secondary

zone as shown in Table 4. The catchment area includes the larger feeder area for the mass transit station.

Table 4: Defining station area influence zones with accessibility considerations

<b>Zone</b>	<b>Description</b>	<b>Accessibility Considerations</b>
<i>Primary Zone</i>	<i>Includes the transit station and immediate access routes</i>	<ul style="list-style-type: none"> <li>• <i>Generally within 5 minutes or 150m-250m of the station exits;</i></li> <li>• <i>The zone must prioritize pedestrian and cycling access and transfer to feeder bus, auto-rickshaws and taxis;</i></li> <li>• <i>Care must be taken to manage conflicts between different modes.</i></li> </ul>
<i>Secondary Zone</i>	<p><i>Includes the area and major destinations around the station, which can be accessed by walking and cycling.</i></p> <p><i>An intermediate tertiary zone maybe considered beyond the secondary zone when prioritizing cycling access.</i></p>	<ul style="list-style-type: none"> <li>• <i>Direct, safe walking and cycling connections are most critical and are to be prioritized.</i></li> <li>• <i>500m - 750m is generally adopted internationally. Since walking distances in India tend to be longer, this zone can be larger based on the station typology or average city-level walking distances, whichever is higher.</i></li> <li>• <i>When delineating tertiary zones, the cycling trip lengths of the station area should be considered.</i></li> </ul>
<i>Catchment Area</i>	<p><i>Catchment areas include the broader area of influence from the mass transit station. They provide significant number of passengers for regional and city-level stations.</i></p>	<ul style="list-style-type: none"> <li>• <i>Access by feeder buses, auto-rickshaws and cycle rickshaws are critical for the catchment areas.</i></li> <li>• <i>The catchment areas vary depending on the route lengths of feeder bus services and areas served by auto-rickshaws and taxis.</i></li> </ul>

Source: EMBARQ India, adapted from (Metrolinx 2011), (BART 2003), (CTOD 2008)

## 2.6 Public Transportation and Accessibility

Accessibility to opportunities such as usage, training, networking, etc., plays an important part in the welfare of urban populations, making transport a very important network infrastructure. This is more important for populations that are naturally and socially disadvantaged, such as low-income groups, women, the physically challenged, and the marginal and minority population groups. The disadvantaged populations require access to opportunities much more than the advantaged groups who, by their class, gender and through belonging to a majority group, earn admittance to all opportunities in animation.



Transport studies and transportation planning hardly reflected upon these bi-focal perspectives and thus have failed to realize that transport is as much a societal event as it is technological. Accessible transport opens up chances for disadvantaged and marginal populations as well as conducing to their capabilities, both of which are significant for the roles of equity as well as poverty alleviation.

Public transport stations must be near to the source and destination of commuters. Preferably within 500 m of both family and work. Only road based systems can perform this. Rail based systems, on an average; usually add another 200-300m of walking inside stations including staircases. This cuts down the acceptance of rail based systems compared to surface bus systems, especially for minors, the elderly, health impaired (heart disease, arthritis, and so on) and the physically handicapped. The latter group can account for 20-30% of the population on any given daytime.

## **2.7 Cost to Commuter**

Bikes, scooters and mopeds comprise 60-80 percent of motor vehicle fleet in Indian cities. In a metropolis like Delhi, approximately 60-70 percent of households own a motor vehicle (at least one car, motorcycle, scooter or moped). This means that motorized two-wheeler ownership has become possible for the main wage earner of lower middle class families and college students belonging to middle class families. A household earning around Rs.10,000-15,000 per month (US\$ 200-300) can own a motorised two-wheeler. This is a fresh development in urban living. When European and North American countries and Japan had similar levels of income vehicle ownerships were very low and people were impelled to utilize public transport. With such high levels of vehicle ownership it will be very hard to attract people to public transport unless the latter is made very convenient and cheap. The marginal cost of moving a motorcycle or scooter is about Rs.0.50-0.70 per km. It is unlikely that two-wheeler owners will utilize public transport unless the fare is about the same or less than the Rs.0.50-0.70 per km. Utilization of a two-wheeler, also gives freedom in mobility, it is easy to park at home and close to place of employment. Two-wheeler riders can also negotiate traffic snarls better than auto drivers and can come to the forepart of the line at traffic lights.

Public transport fares in Indian urban centres cannot be higher than about Rs. 0.50 per kilometre (2005 prices). Any organization which has operating costs above this amount will have to arrange for subsidies which are not regressive in nature. Research results indicate that public transport demand is comparatively sensitive to fare changes, then that policy measures aimed at fare reduction (subsidization) can take on a significant part in advancing

the usage of public transport, thus cutting the utilization of private cars. This rules out the function of most rail based high cost systems.

## **2.8 City Profile, Land-use and Public Transportation Relationship**

Transport systems and city character are interlinked. Land use characteristics of a city can regulate the type of transfer system it needs, and once a transport system is set instead, it influences land use characteristics of the city over time. Thus, the type of public transport system you want in a city will depend on the vision you hold for the future of your metropolis. If an economically vital large central business district (CBD) exists, it can turn the primary core for both employment and retail, and therefore lead to the achievement of an urban rail system (if the organization serves the CBD) because it can generate and attract trips onto the scheme. Even so, low-income neighbourhoods would still be unsuitable for urban rail operation.

Apart from the dependence of the urban trips on public transport based on the city size as shown in **Figure 1**, there is also a significant variation in the public transport led urban trips among cities of the same size class. Nearly 80 percent of all trips in Kolkata are in some sort of public transport, compared to nearly 60 percent in Mumbai, and 42 percent in both Chennai and Delhi, as depicted in **Figure 2**. Differences in land use and roadway supply explain some of the variance. Delhi and Chennai are lower density, more polycentric, and more spread out than Mumbai and Kolkata. Kolkata as well has more restricted geographies, since both are located on peninsulas that channel travel and land-use development in only a few ways. Such focused travel corridors, especially encourage suburban rail use, as in Mumbai. Delhi has no such geographic restrictions and sprawls out in all ways. Therefore, Delhi currently relies mainly on auto rickshaws, motorcycles, taxis, and private cars to do the multi-destinational, less focused travel patterns of its residents (Pucher, J & Korattiyaropam, N 2005). So, aside from the city size, the need for the public transport also depends substantially upon various geographical, transport supply & land use practices of the city.

Experience from existing rail-based transit systems indicates that they are successful in utilizing their maximum capacities only when implemented in cities that have the following characteristics:

- High density habitation with at least one major very high density, high rise CBD.
- Relatively high per capita income.

Cities with low per capita incomes, together with multiple dispersed business districts are unable to attract high ridership shares, and so rail based systems do not perform to capacity.

Therefore, the size of a city should not be used as a sole criterion for deciding the type of technology to be used for transit systems.

## **2.9 Transit-oriented development (TOD)**

Urbanization in India has been accompanied by an increase in the use of motorized vehicles. While transit-oriented development (TOD) have been adopted by some Indian cities to arrest motorized vehicular use, the direct impact of improved accessibility in increasing public transport ridership has received less attention.

The UTTIPEC India Defined “Transit oriented development (TOD) is essentially any development, macro or micro that is focused around a transit node, and facilitates complete ease of access to the transit facility, thereby inducing people to prefer to walk and use public transportation over personal modes of transport”.

“Transit-oriented development (TOD) is a type of community development that includes a mixture of housing, office, retail and other amenities in a walk able neighborhood located around high-quality public transportation”, as defined by Reconnecting America.

The definitions of TOD made by two countries are similar, while the in-depth meaning of TOD contains two Primary Goals are to:

- i. Reduce/ discourages private vehicle dependency and induce public transport use – through design, policy measures & enforcement.
- ii. Provide easy public transport access to the maximum number of people within walking distance –through densification and enhanced connectivity.

The above goals cannot be addressed by mere addition of transport infrastructure. To achieve this paradigm shift, TODs offer attractive alternatives to the use of personal modes – pleasurable walking experiences, very easily accessible and comfortable mass transportation with easy, convenient and comfortable intermodal transfers for last mile connectivity and other low cost, comfortable, non- motorized transportation options.

In addition, highest possible population densities (as per local context), enhanced street connectivity, multimodal networks around transit stations and compact mixed-use development providing housing, employment, entertainment and civic functions within walking distance of the transit system offers:

- An enhanced level of accessibility by non-motorized modes,
- A reduced trip length to the average commuter, and
- Economic viability of the public transportation system through substantial non-fare box revenues.

This, overall, results in lower levels of energy consumption per person for the city for the transport sector, besides numerous city/ local level benefits, as explained below. The private investment and development decisions play a large role in the TOD process. According some of the successful factors for TOD includes:

- Zoning that is altered to ensure that developers can pursue the visions planned
- Street design guidance that prioritizes station access for people who bike and walk
- Creating typologies and metrics that help find the best places to pursue TOD and support efforts to change how people access transit

- Transit-specific bicycle and pedestrian master plans, or integration of access to transit in bicycle and pedestrian master plans

### **2.9.1 Benefits of TOD to Delhi:**

- Mobility Options for all** - Change the paradigm of mobility by enabling a shift from use of private vehicles towards the use of public transport and alternative modes. Help in achieving Clean-Air Quality targets for Delhi and the targeted 70-30 (public-private transport) modal share in favor of public transportation by 2021, as envisaged in the Transport Demand Forecast Study for 2021.
- Better Quality of Life for All** - Provide a variety of high-density, mixed-use, mixed-income housing, employment and recreation options within walking/cycling distance of each other and of MRTS stations – in order to induce a lifestyle change towards healthier living and better quality of life. Integrate communities rather than segregating them and reduce social stigma and dissent.
- Give Everyone a Home** - Increase the supply of housing stock and commercial space in the city, which would bring down prices and make living and working in Delhi more affordable. (Current Need as per Table 18.1 is to provide approx. 3 lakh new dwelling units per year, with more than 50% of the new housing in the form of 1 and 2 room units with average plinth area of about 25 - 40 sq.m.)
- Market Participates in Better City** - Open up development opportunity to the private sector to bring in investment into the city's growth and revenue, and also help cross-subsidize social amenities, affordable housing and public transport, using a variety of possible development models. Low-income groups can be provided space and shared amenities in integrated mixed-income communities, thereby reducing further proliferation of gentrified slums and unauthorized colonies.
- Self-Sufficiency** - Creating high densities would make decentralized infrastructure provision and management techniques more feasible, thus making it more economical to recycle water/sewage locally to meet community needs.
- Cheaper Public Transport** - Provide a significant source of non-fare box revenue for a public transport fund, which may help reduce ticket prices and increase provision of public transport facilities.
- Reduce Environmental Degradation** - Set a clear vision for the growth and redevelopment of the city in a compact manner, by minimizing sprawl (low density spread out development). Help save environmentally sensitive lands and virgin lands through high-density compact development.
- Save Public Money** - Provide savings in public money through reduction of investments in physical infrastructure like additional road expansion, piping/cabling costs, time-cost of traffic congestion and other large costs associated with low-density sprawl.
- Multi-disciplinary Multi-Departmental Approach** - Provide a shift to a more holistic paradigm of planning where all sectors work together – mobility, planning policy, urban design, infrastructure and economics – to deliver integrated development.

### **Benefits to Transit Agencies:**

- Increased ridership due to larger population living/working within walking distance.

- xi. Value Capture of increased land values for long term cross-subsidy & maintenance of public transportation.

***Benefits to Land, Road & Service Owning Agencies:***

- xii. Potentially increased revenue from land due to increased development with lesser public money investment.
- xiii. City level reduced infrastructure costs (reduced length of roads, pipes, cables, tunnels, etc.) due to accommodating the overall planned population within lesser net land area, a more sustainable way.
- xiv. Increased feasibility for sustainable decentralized physical infrastructure.
- xv. Increased and more efficient use shared social infrastructure facilities.

***2.9.2 Components of TOD:***

***1. Pedestrian & Cycle/ Cycle-Rickshaw Friendly Environment***

***2. Connectivity:*** Create dense networks of streets and paths for all modes.

***3. Multi-modal Interchange:*** Mass transportation modes servicing the area should be well integrated to afford rapid and comfortable modal transfers.

***4. Modal Shift Measures:*** Shift to Sustainable Modes by Using Design, Technology, Road Use Regulation, Mixed-Use, Parking Policy and Fiscal Measures

***5. Place making and Safety:*** Urban places should be designed for enjoyment, relaxation and equity.

***6. High Density, Mixed-Income Development:*** Compact neighborhoods for shorter commutes and equity for all sections of society.

***2.9.3 Demarcation of the TOD influence zone***

1. A maximum up to 2000 m. wide belt on both sides of center line of the MRTS Corridor is designated as TOD Influence Zone, which has been identified in the combined Zonal Development Plans of Delhi.
2. The entire influence zone shall be considered as “white zone”. Final boundaries of Influence Zones shall be demarcated as per the Influence Zone Plans.
3. The overall Influence Zone further consists of three sub zones – Zone 1: Intense TOD Zone, Zone 2: Standard TOD Zone, and Zone 3: TOD Transition Zone. Application of zones is as per Table 5 below.
4. Development Control Norms of ‘High Density Mixed Income Development’ shall not be applicable to the TOD Transition Zone.
5. All properties public or private shall be able to avail the norms and benefits of TOD while complying to an approved Influence Zone Plan, with the following exceptions:
  - a. Special Areas - Lutyens' Bungalow Zone, Chanakyapuri, DIZ Area and Matasundari Area and Civil Lines Bungalow Area which may have height restrictions.
  - b. Monument Regulated Zones (as per ASI guidelines).
  - c. Flight funnel zones shall follow the height restrictions as per regulations of Airport Authority of India.
  - d. Environmental Protection Zones (as per Chapter 9).
  - e. Seismic Zones such as fault lines.

Table 5: Application of TOD Influence Zones

<b>Zone 1: Intense TOD Zone</b>	<b>Zone 2: Standard TOD Zone</b>	<b>Zone 3: TOD Transition Zone</b>
<ul style="list-style-type: none"> <li>• 300 M influence zone of all MRTS Stations.</li> <li>• 800m* (10-min walking) influence zone of Regional Interchange Station (i.e. Rail -MRTS, or two MRTS lines.)</li> </ul>	<ul style="list-style-type: none"> <li>• 800m* (10-min walking) influence zone of all MRTS Stations.</li> </ul>	<ul style="list-style-type: none"> <li>• 2000m** (10-minute cycling distance) influence zone of all MRTS Stations.</li> <li>• 300 M influence zone of BRT corridors.</li> <li>• Zones within Intense or Standard TOD Zones which are not permitted for redevelopment but need enhancements in public realm and network connectivity.</li> </ul>

Source: UTTIPEC, 2012.

## 2.10 Station Area planning (SAP)

Station areas need to be defined to understand the influence area of the new transport infrastructure, achieve its ridership potential and minimize its adverse impacts on surrounding neighborhoods.

A station area is more than just an area adjacent to a transit node. It is a place of connectivity where different modes of transportation – from walking to riding transit – come together seamlessly and where there is a concentration of working, living, shopping and playing (Metrolinx 2011). More than its adjacency to a mass transit station defines a well functioning station area. A station area is described by the ease and number of connections it offers its users and the multiple activities that occur here. Table 1 lists a few parameters to classify station areas (EMBARQ India 2014b).

The following 3 stages are identified as critical steps in understanding and defining a station area.

### a. Station Area Typology

Station area typology can be identified by the scale of the transit stations, the predominant land use in the area around it with any special historic or environmental features (Figure 13).

- **Scale:** Refers to the scale of the transit stop and the adjoining area. These can be classified as regional, city-level, sub-center level, neighborhood and suburban. The number of people boarding and alighting at the station, function of the station (terminal, transfer, origin or destination), intersection of transit lines, people density and attractors

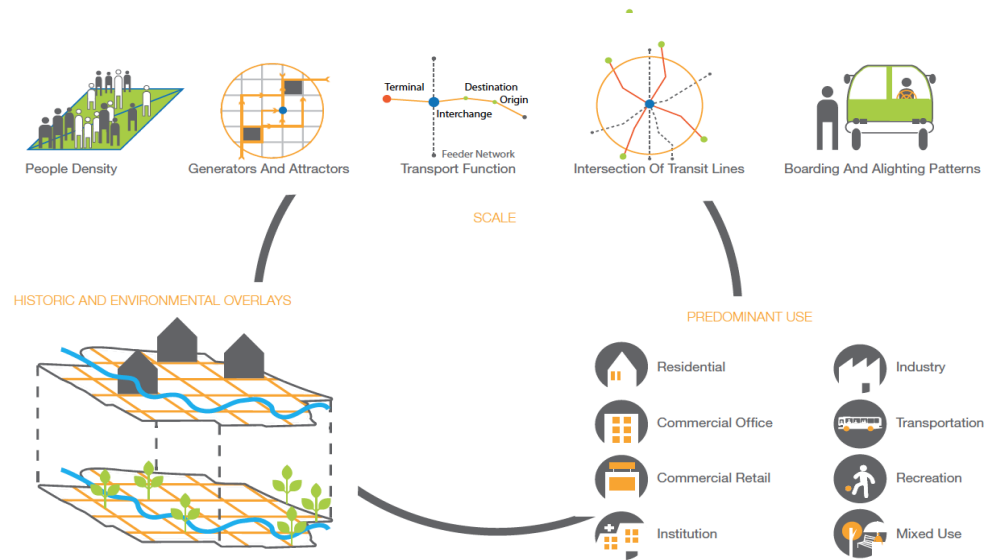


Figure 7: Station Area Typology

or generators around the station is indicators of these scales.

- **Predominant use:** Refers to the predominant land use surrounding the station. It can be classified as commercial-office, commercial-retail, institutional, industrial node, transport hub, mixed or purely residential neighborhood or a recreational node.
- **Historic precinct and environment overlays:** Refers to historic precincts or environmental features around the station, which can be preserved and enhanced in the plan.

## b. Station Area Influence Zones

The transportation and land use conditions typically vary with distance from the transit station. When planning in a station area, it is useful to divide it into zones to scope the planning exercise and understand the needs and opportunities in each area (Metrolinx 2011). For example, direct and safe walking connections are most important in close proximity to the station, where there are often the highest levels of pedestrian activity. Farther away from the station, bicycle, bus and rickshaw/taxi connections become relatively more important to ensure convenient access. The station area boundary includes primary zone, secondary zone and tertiary zones (Figure 4). The catchment area includes the larger feeder area for the mass transit station. Broad guidelines are suggested to assist in defining the influence zones.

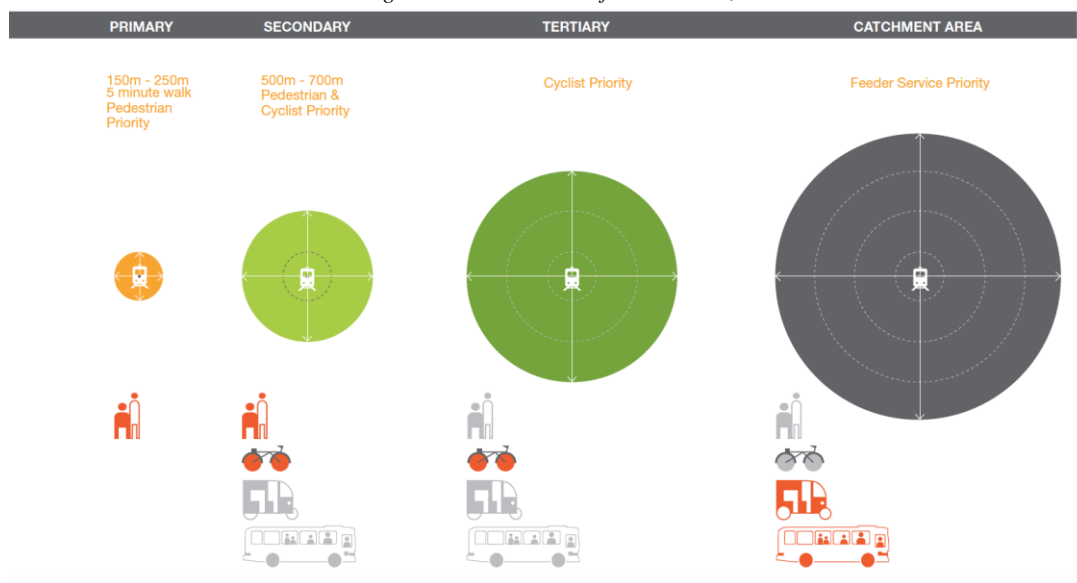
## NOTES:

\*Churchgate and Victoria Terminus are the terminal stations for the Western and Central and Harbour Suburban railway lines in Mumbai. These are within a 2km distance of each other, situated within the central business district of Mumbai. While a special feeder bus service operated by BEST, known as Fort Pheri connects major destinations to the terminals, it is not uncommon for people to walk 1-2km to these stations (EMBARQ India 2014a).

\*\*The average trip lengths for bicycles vary from 1.9 to 3.1km in small cities, 3.1km to 4.5km for medium and large cities. In Delhi, the average bicycle trip length is 5.1km (Tiwari and Jain 2008).

\*\*\*The feeder routes operated by BEST in Mumbai vary from 2-5km for residential neighborhoods, 3-8km in the central business district (Mulukutla and Vasudevan 2013).

Figure 8: Station area influence zones,



Source: EMBARQ India

### c. Delineating the Station Area

The station area primary, secondary and tertiary zones can be delineated based on the following guidelines (Figure 8):

**Plot boundary:** Each zone should follow plot boundaries.

**Major Attractors or Generators:** The mass transport stations of MRTC, BRTC generators or attractors of close proximity areas of it, have the potential to attract transit ridership.

**Environmental Features:** Natural reserve forests, environmentally sensitive areas like mangroves, rivers etc. can serve as boundaries of a zone.

**Infrastructure Barriers:** Infrastructure such as highways, rail corridors should not become a barrier in defining the station area. In fact, the plan should develop strategies to facilitate access across these barriers.

**Institutional and Planning Framework:** The station area should consider boundaries established by LAPs, Special Planning Authorities, administrative boundaries of transit authorities, and nodal implementation agencies (MRTS SPVs or municipal corporations).

Electoral ward boundaries must be considered to facilitate implementation.



Figure 9: Station area delineation



Source: EMBARQ India

## 2.11 Mode integration

Mode integration in urban trips deals with increasing the ease of ridership through the establishment of intermodal facilities and connections that ideally would allow people to reach their destination quicker, with more comfort and at less cost. Given the above, the potential for the integration of NMT systems to Public Transport (PT) systems. Policies to promote the use of bicycles as an access mode to PT may generally be targeted at a variety of groups, depending on the local context:

- (i) Current PT users, which would potentially benefit from an improved quality of their trip.
- (ii) Current cyclists that would potentially benefit from increased opportunities to reach more trip destinations at different distances/travel times, within their travel time budget.
- (iii) Current car users, aiming at providing an attractive trip chain that will induce them to switch to cycling and PT,
- (iv) Potential users of PT that are using other motorized modes such as motorcycles, scooters etc. And
- (v) Pedestrians, which may shift to bicycles in case favorable conditions, are created.

Integration can be studied at different levels of spatial and system hierarchy (both in terms of facilities at nodal points, the network structure and their interchanges, as well as positioning of the networks in the urban system).

According to Ibrahim (2003), four types of integration can be distinguished:

1. **Physical integration:** “seamless” trips with transfer facilities continuously improved and provided
2. **Network integration:** different hierarchical levels have to be integrated, and also the various modes must be connected as well.
3. **Fare integration:** provision of integrated ticketing system which enables passenger to use one ticket for any mode

4. **Information integration:** information on almost all aspects of travelling in every mode is available.
5. **Operational integration:** This means that the operation of different PT modes should enhance their integration. For instance, an urban bus service should be integrated with urban or regional rail services, in the sense that when a train arrives it must have bus services available within a short time and vice versa.

### 2.11.1 Measuring integration

In order to assess integration, it is necessary, firstly, to establish suitable measures for each of those levels, which are capable to reflect the degree of integration between bicycle/walking and bus systems. Several indicators could theoretically be applied to evaluate the performance of the integrated multi-modal transport system.

Table-6 shows a perspective of public transit system requirements that is suitable in understanding the different perspectives on their performance. The requirements indicated in table 1 operate at the system level, whereas in addition to this level we also have the facility level and the urban level.

Table 6: Transit System Requirements

<i>Passengers</i>	<i>Operator</i>	<i>Community</i>
<i>Availability</i>	<i>Area coverage</i>	<i>Service quality</i>
<i>Frequency</i>	<i>Reliability</i>	<i>Passenger attraction</i>
<i>Punctuality</i>	<i>Cycle speed</i>	<i>System cost</i>
<i>Speed / Travel time</i>	<i>Capacity</i>	<i>Reliability in emergencies</i>
<i>Comfort</i>	<i>Flexibility</i>	<i>Social objectives</i>
<i>Convenience</i>	<i>Safety and security</i>	<i>Environmental impact</i>
<i>Security and safety</i>	<i>Costs</i>	<i>Energy consumption</i>
<i>User cost</i>	<i>Passenger attraction</i>	<i>Long-range impacts</i>
	<i>Side effects</i>	

Source: Vuchic, 2005

## 2.12 Integrate cycling and public transport

Mobility that we observe on our streets, i.e. the bicycles, cars, rickshaws, trains, is not an end in itself. Its' users differ in their personal and motivational characteristics, as do their reasons to travel. Mobility is derived from a complex set of choices users make when deciding to travel from one location to another (or even decide not to go). These choices are influenced to a large extend by the structure, availability and affordability of different services provided through the traffic and transport system (i.e. the roads, routes, private and public modes, rules and regulations). Integration of these systems and services plays a big role in making the system efficient, a/o's allowing for smooth transitions from one mode to another, from one hierarchical system to another.

The traffic and transport system provides the supply side of this complex between system and its' users (the demand side). To get a better understanding of integration between different modes of transport, distinction can be made between integration at the (see also Figures 5 and 6):

- a. Facility level: the nodal interchanges
- b. Systems level: the integrated transport system
- c. Urban level: the land-use transport system

The mobility pattern of each city is different and so are their solutions. For small and medium towns, where most of the trips are still being made by walk or NMT, provisions of planning could include cycle tracks and pedestrian networks. For large cities, which have long trips, there needs to be a dedicated transport system that integrates various modes. To effectively coordinate the interaction of various modes and their integration, a city level transport authority is needed. The authority will have to work on measures like traffic calming, together with attempting to maximize the transition of commuters from motorized modes of transport to non-motorized modes and public transport.

### 2.13 Improving Safe Access To Mass Transit Stations

Access to mass transit is defined as “both the trip to the station, and from the station to the final destination” (BART 2003). The quality of access, while a fraction of the cost of the system, directly influences its ridership (Jaiswal, Sharma and Bisaria 2012). A good station area can not only maximize transit ridership, but also create streets for all users, provide affordable commuting options, make vibrant public spaces, manage parking effectively, help realize the economic development benefits of transit investments and serve its communities’ needs (HCRRA 2013); (BART 2003).

The station areas in India have yet to be perceived as places of connectivity, i.e. where large volumes of people interact with multiple modes of transport, and as places for living, working and recreation. In fact, these mass transit systems are being inserted within poor quality NMT infrastructure, characterized by a lack of safety, security, comfort and convenience (Tiwari and Jain 2013). With 140,000 deaths in India per year due to road traffic crashes (NCRB 2011), road safety poses a serious concern for non-motorized transport (NMT) commuters. For example, pedestrians, cyclists, and motorized two-wheeler riders constituted 60–90 percent of all traffic fatalities in the cities of Mumbai, Delhi, Kota and Vadodara (Mohan and Tiwari 2000).

Thus in India, improving access to mass transit stations can serve multiple objectives in addition to leveraging investments of at least 15 billion USD2 (DIMTS 2014) in building new public transport systems. There are about 19 BRT systems and 10 metro-rail systems in different stages of planning, construction, operation or expansion (MoUD 2013). In addition, two cities (Lucknow and Guwahati) are evaluating options between BRT and metro-rail systems (BRT Centre of Excellence 2014).

The station accessibility projects across the country vary in their approach and area of intervention see example in Box- 1.

#### *Box 2-1: Station accessibility projects in India*

**Mumbai:** *The Station Area Traffic Improvement Schemes (SATIS) were limited to the construction of 37 skywalks to suburban railway stations. Pedestrian access, buses, intermediate para-transport services or at-grade street infrastructure were not integrated with the skywalk projects at most station areas (EMBARQ India 2010). Additionally, the SATIS projects implemented around the metro-rail corridor limit their intervention to 330m around the station (BEST, Railways & MMRDA*

*plan seamless connectivity with dedicated stops at Metro Stations.” Rail News. 18 March 2014) and do not address the pedestrian catchment area.*

**Delhi:** interventions have been limited to the provision of feeder bus services (DMRC), and

**Bengaluru:** Adopted a more holistic approach, that it has initiated a request for proposals (RFP) for the preparation of station accessibility plans for 10 stations along the Namma Metro system.

There is a Huge need for to tie the different objectives of station areas, to provide improved connectivity, accessibility, safety, security, economic possibilities and enjoyment for its users. Thus, EMBARQ India has developed a Safe Access Manual, which focuses on improving accessibility to mass transit stations. In consonance with the National Urban Transport Policy (NUTP) (MoUD 2006b), the manual places people at the center and highlights strategies, guidelines and case studies to achieve pedestrian and cycling priority, seamless integration with feeder network and infrastructure, improved safety and security, parking management and an enhanced public realm in station areas. Figure 1 is a guide on what should be emphasized when preparing a station accessibility plan, how can the plan be implemented, how can the plan, its implementation and impact be evaluated and what are the learning's from different cities.

Figure 10: Safe access approach



Source: EMBARQ, India.

#### **Box 2-2: Indiranagar Metro Station Accessibility Plan, Bengaluru**

*The Bengaluru Metro Rail Corporation Limited (BMRL), created as a joint venture by the Government of Karnataka and Government of India, is building the Namma Metro or Bengaluru Metro Rail. The construction of Phase 1 began in 2007. Reach 1 (6.7km) from MG Road to Baiyappanahalli Station, is in operation since October 2011 (BMRL 2011).*

*The Indiranagar Metro Station Accessibility Plan was prepared by EMBARQ India in partnership with the Directorate of Urban Land Transport (DULT), and Bruhat Bangalore Mahanagara Palike (BBMP) in 2011 with the objective to demonstrate a methodology for station accessibility plan preparation, which could be scaled up to all 40 metro stations along Phase I.*

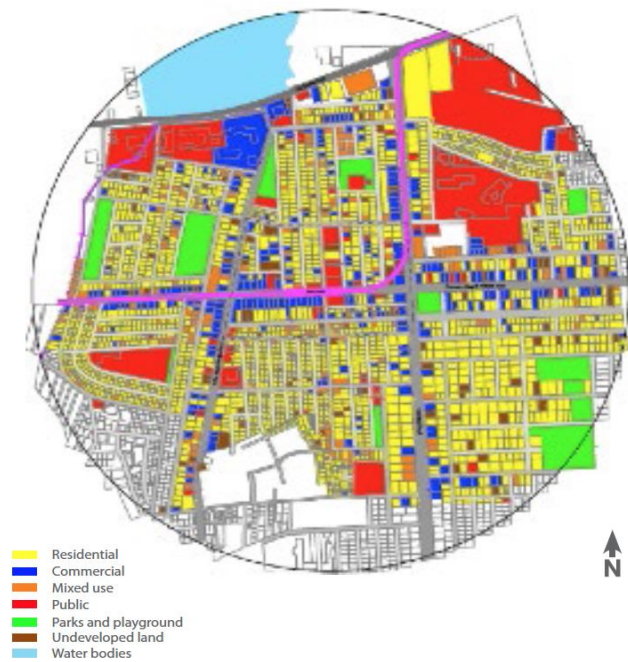
*The station area was delineated within 500m of the metro station. It is a predominantly residential neighbourhood with commercial activities along the main roads and large generators like medical and educational institutions (Figure 10). The residential population is around 34,0009 (Census India 2000) with an average density of 900 to 1200 persons per hectare.*

*The pedestrian origin-destination surveys revealed that at least 50 percent of the trips originated or terminated in Indiranagar. Further, at least 75 percent of the residents, visitors and passers-by felt*

that either there were no footpaths or they were obstructed or in poor condition. Additionally, street rating maps were created to analyze the condition of the streets

The plan proposals include restricting motorized vehicular access along feeder roads, provision of safe pedestrian and cycling infrastructure and integration with buses and auto-rickshaws. The detailed street design is limited to 150m around the station as per consideration of Urban Development Department (UDD) notification<sup>10</sup> (Government of Karnataka 2008). The proposals are prepared for three time frames – immediate, 5 years and 15 years.

Figure 11: Existing land use around Indiranagar Metro Station (2011)

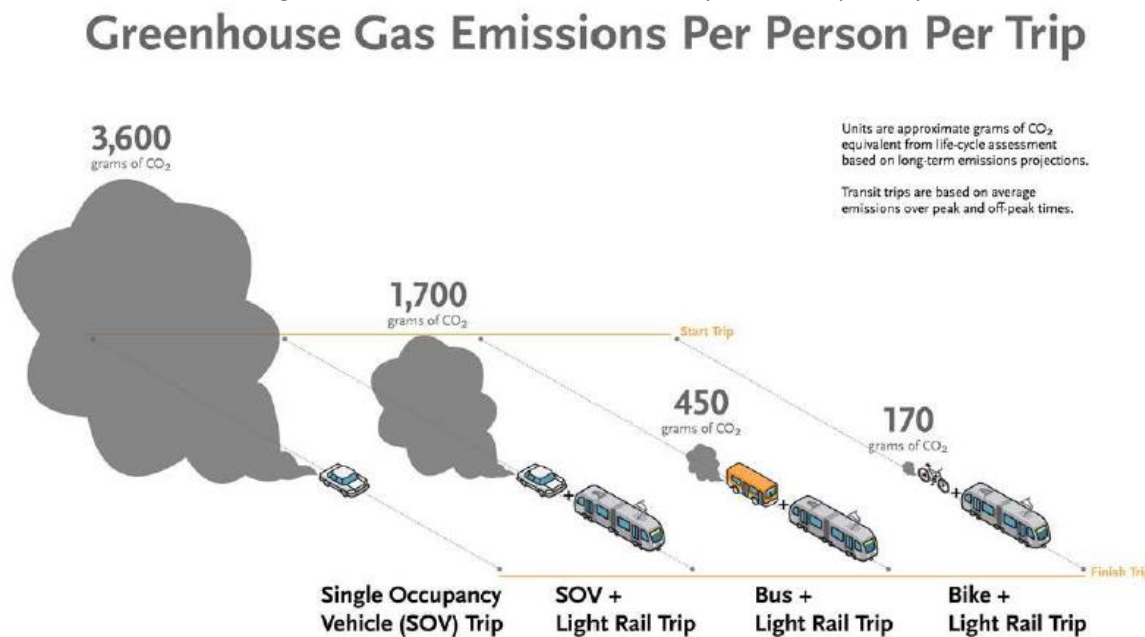


### 3 CASE STUDIES

#### 3.1 First last mile strategic plan of Los Angeles County

Los Angeles County Metropolitan Transportation Authority (Metro) is preparing a world-class rail system with stations that will be a short distance (three miles or less) from the homes of 7.8 million people, nearly 80% of Los Angeles County residents. Over time, this number will continue to grow as cities change their domain-use plans to provide more housing and businesses near stations, consistent with market demand and regional goals for more sustainable communities. These planning guidelines begin to draft a specific infrastructure improvement strategy designed to facilitate easy, secure, and effective access to the Metro system. They present a concept herein referred to as ‘the Path’, and provide instruction along the layout of Path networks and components within Metro Rail and fixed route Bus Rapid Transit (BRT) station areas. They function as a resource for Metro and the many public and private organizations throughout the region working to update plans, land-use plans, planning guidelines, business models, entitlement processes, and other tools that take advantage of LA County’s significant investment in the public transportation net.

Figure 12: Greenhouse Gas Emissions per Person per Trip



Source: Los Angeles County Path Planning Guidelines

There are a number of challenges associated with improving first-last mile connections throughout a city. In many places, especially along higher traveled corridors, right of way (ROW) is limited and already overburdened. Providing more robust access facilities could potentially put air on other complementary travel modes. For instance, providing protected bike lanes along a heavily used transit access route may affect vehicular throughput and bus operations in some spots.

Coordination is a challenge; there are many custodians of the public realm throughout a city. Metro is committed to the “continuous improvement of an efficient and effective transportation system for a city” but Metro does not possess or have jurisdictional control over transit access routes beyond the immediate confines of station facilities.

Financial support is set; on that point are numerous competing demands on public funds throughout a city. From a user perspective cost is a challenge; pay-for-service access solutions can be promising, but do not serve those already struggling to compensate for basic transit services. There are ranges of site-specific physical challenges faced by individual transit users. For some, the stations remain too far to access in a fair amount of time. Others don't move fast or nimbly enough to comfortably contend with broken sidewalks and hazardous street crossings. Some are afraid to hit the little walk from stations in the dark, which again raises safety issues of women passengers in a nation like ours. All of these challenges can be addressed through thoughtful consideration, strategic planning, engineering, design and most importantly - active coordination.

### **3.2 Integration in Public Transportation Systems by Vahid Poorjafari and Mohammad Poorjafari**

The number of urban trips has been increasing dramatically over the past decades. The main reason for this growth is the change of trip patterns, dispersal of urban activities and the sharp increase in car ownership and use in cities. The considerable growth of car-based trips in cities over the past decades has increased the importance of enhancing public transport as an alternative to compete with cars. Since the diverse public transport modes (e.g. MRT, LRT, bus, etc.) are being planned and constructed, especially in developing countries, the necessity of coordination and cooperation of these modes is becoming more and more critical. However, by considering the daily increment in environmental emission, specifically air pollution produced by vehicles, and the limitation of natural resources, it is obvious that increasing of car-based trips is a critical threat to the global environment. The term of ‘integration’ in public transport or ‘integrated public transport’ is similar to the concept of intermodal, which is generally used for the transport of goods. This concept is generally defined as a system that provides seamless (or ideally door-to-door) public transport services for passengers.

NEA defines integration by further and more comprehensive statement as “ The organization process through which elements of the passenger transport system (network and infrastructure, tariffs and ticketing, information and marketing, etc.) are, across modes and operators, brought into closer and more efficient interaction, resulting in an overall positive enhancement to the overall state and quality of the services linked to the individual travel components.”

Above definition emphasizes that:

- It is assumed to be less efficient and less close in the absence of an appropriate process.
- Integration refers to both intermodal and intra-modal issues.
- Includes wider integration with other transport modes (e.g. walking, cycling and private cars) and other non-transport services such as town planning and environmental and social policies

- Integration refers to the speedy, convenient and economical connection of services provided by public transport systems in order to make up complete journeys for passengers from their origins to the final destinations.

### ***3.2.1 The objectives of integration in public transport***

- Planned public transport system to capable to provide best services as possible
- Planned to facilitate the transfer between different public transport modes in order to provide seamless services for passengers.
- To provide a seamless service using two or more modes in order to achieve a high level of modal share by attracting more passengers, especially car users.
- Increase the ridership of public transport systems in competition with private cars.

### **Inferences**

- Integration is a key factor in enhancement and improvement of urban public transport systems.
- Integration measures and activities are involved with all aspects of public transport systems at the stages of planning, management and operation.
- Integration is not a definite status and should be improved continuously within different public transport modes and also between public transport and other transport modes.
- Integration can be implemented and achieved in different levels. These levels can be from a minimum form of integration at the operational levels, like integrated information and/or fare.
- The higher level of integration is achieved by extending its border beyond the public transport systems by involving other modes of transport and other policies, like land use planning, social and environmental policies.
- Successfully implementation of integration requires the commitment of all associated organization and authorities. A common policy framework can be an effective instrument to advance coordination and cooperation between these public/private bodies.

### **3.3 A Mechanism for Organizing Last-Mile Service Using Non-Dedicated Fleet(Cheng,Nguyen,Lau 2012)**

Unprecedented pace of urbanization and rising income levels have fueled the growth of car ownership in almost all newly formed megacities. Such growth has congested the limited road space and significantly affected the quality of life in these megacities. Convincing residents to give up their cars and use public transport is the most effective way in reducing congestion; however, even with sufficient public transport capacity, the lack of last-mile (from the transport hub to the destination) travel services is the major deterrent for the adoption of public transport. Due to the dynamic nature of such travel demands, fixed-size fleets will not be a



cost-effective approach in addressing last-mile demands. Instead, we propose a dynamic, incentive-based mechanism that enables taxi ridesharing for satisfying last-mile travel demands. On the demand side, travelers would register their last-mile travel demands in real-time, and they are expected to receive ride arrangements before they reach the hub; on the supply side, depending on the real-time demands, proper incentives will be computed and provided to taxi drivers willing to commit to the last mile service. Multiple travelers will be clustered into groups according to their destinations, and travelers belonging to the same group will be assigned to a taxi, while each of them paying fares considering their destinations and also their orders in reaching destinations. In this paper, mathematical formulations for demand clustering and fare distribution is provided. If the model returns a solution, it is guaranteed to be implementable. For cases where it is not possible to satisfy all demands despite having enough capacity, a two-phase approach that identifies the maximal subset of riders that can be feasibly served, is proposed.

### 3.3.1 Organizing The Last-Mile Service

The last-mile (LM) service can be organized under a wide variety of circumstances. In this paper, we assume that there is a single hub, and all demands are with identical departure time from the hub. The destinations of all demands are also assumed to be known and within certain radius from the hub.

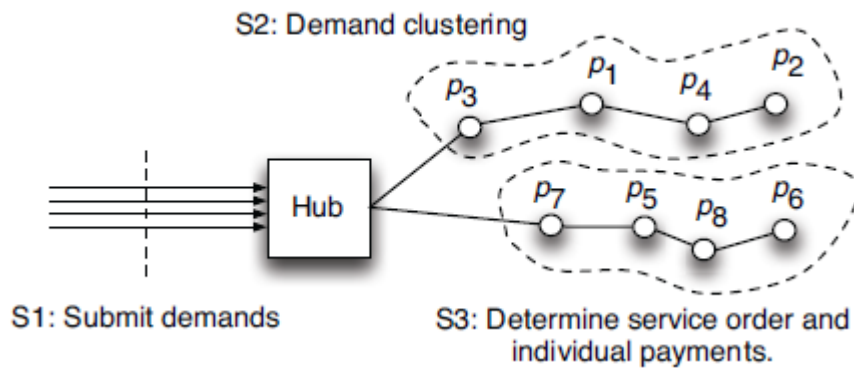


Figure 13 Organising Last Mile Service

A typical cycle of the LM service can be seen in Figure 13. There are three important steps in organizing the LM service:

- 1) LM service is organized at a particular major hub

where regular train or metro services will be bringing in potential riders at short intervals.

For riders who plan to arrive at the hub and utilize the LM service, they have to submit their intents some minutes before their arrivals. It's assumed that all riders will depart

immediately for the LM service when they reach the hub, and they will provide the exact coordinates of their destinations.

- 2) After receiving all destinations at the cut-off time, the central controller should optimally assign all riders to appropriate clusters, where each cluster is to be served by a participating driver.
- 3) The order of service and the payment to be made by each rider will be decided as we finalize the cluster assignment.

Based on above descriptions, there are two critical problems that need to be repeatedly solved:

- 1) Demand clustering: In which demands are clustered into groups to be served by different vehicles.
- 2) Service sequencing and pricing: In which the service order and the associated price for riders in every cluster is determined.

These two problems are closely connected since the planned route and the prices associated with a cluster are highly dependent on the assigned riders.

### **3.4 CHALLENGES AND INTEGRATION OF MUMBAI'S FEEDER ROUTES**

Among its peers, BEST is known to be proficient in operating feeder routes to connect to suburban railway stations (BEST 2014). The city however faces difficulty due to the lack of physical integration of its feeder and mass transit system. The suburban station areas are highly crowded due to many reasons including the number of commuters accessing the station and the vendors that operate in these areas. In addition, station access lanes are often narrow and have low capacity. In the case of feeder buses, these factors restrict the ability of a bus to turnaround or to stop for a long period of time. The physical integration of the mass transit station and feeder bus stops is needed to provide a more comprehensive public transport network.

Of the 7 million journeys made by rail every day, 1.5 to 2 million journeys access stations by a BEST bus (LEA Associates 2008). These numbers indicate the significance of this system in the colossal movement of people within the Mumbai Metropolitan Region (MMR). BEST capitalizes on the three railway lines' zones of influence by providing the following feeder services

BEST operates feeder routes to suburban railway stations. Given are details of Mumbai's feeder operations and financial statistics. The agency defines its feeder routes, as routes connecting to railway stations, within 10 km. More than 50 percent of all routes are feeder routes. While most feeder routes are within 10 kms, due to the lack of space, BEST is

required to operate long routes as feeders. This will be discussed in further detail in the next section.

Statistics also indicate that 38 percent of the fleet is used for providing the city with access to the suburban train stations. BEST's function as a feeder to Mumbai's key mode of transport establishes its significance in the urban transport network.

### **3.4.1 Planning of Feeder Routes**

BEST currently undergoes a small-scale planning restructure every four months - March to June, July to November and December to February each year. A dynamic growth pattern in Mumbai requires BEST to constantly amend routes and schedules in order to remain relevant. Drivers and ticket conductors

CHARACTERISTICS	TYPICAL EXAMPLES IN URBAN AREAS
Serves short distances	4 - 6 kms (typically)
High frequency service	5 - 10 minutes
Connects commercial, residential nodes to the trunk corridor or major destinations	feeders to the metro/suburban stations or CBDs
Requires a transfer at the end of the journey	Rail to bus transfers
Provides first / last mile connectivity	Shared 3-wheeler service at train stations
Extends the trunk corridor's area of influence	-
Vehicle type generally varies from the trunk mode	12-m standard buses
Operates amongst mixed traffic, without priority infrastructure or space	-
Bus stops are generally spaced within walking distance of each other	3 - 400m apart

*Figure 14 Typical Characteristics of a Feeder Bus System (EMBARQ India 2014)*

TYPE OF INTEGRATION	DEFINITION
Physical (locational)	The physical ease with which the mass transit and feeder systems can be accessed; integrates land use generators with transport planning efforts
Service (timetabling)	Reduces wait times through synchronizing timetables of complementary modes
Fare (ticketing)	Aligns fare policies across all mode operators to ensure requirement of only a single ticket throughout the journey
Identity	Enhancing the overall perception and understanding of the system by closely relating the identities of multiple services of the same system
Institutional	Enables coordination between legal / government structures to ensure consistency

Figure 15 Five types of Integration (EMBARQ India 2014)

There are three main types of feeder systems that are currently operational in Mumbai. The lessons learned from these examples provide the basis for designing a good feeder bus system for other Indian cities.

#### **3.4.1.1 NEIGHBOURHOOD COLLECTOR ROUTES**

Local neighborhood collector routes provide first and last-mile connectivity to suburban railway stations. Buses collect commuters from housing colonies and connect them to the local train station, where they connect to other parts of the city. For example, Routes 343, 344, and 346 are neighbourhood collector routes that operate between Goregaon Station and the residential areas of Aarey Colony. The operator faces three primary challenges in designing Neighborhood Collector routes:

- High level of Congestion
- Poor Integration between Transport and Land-Use
- Poor Physical Integration between Bus and Rail:

#### **3.4.1.2 LONG FEEDER ROUTES**

Long feeder routes are generally a combination of several routes that are merged together due to certain constraints. This results in trunk-like route lengths and operational inefficiencies. According to BEST, an ideal feeder route length ranges from 5 to 7 kms; however in the recent past, lengths have grown past 8 kms. The length results in three primary operational challenges – very high cycle times, high operating kilometers, and reduced service reliability. Buses can take up to 45 minutes to enter and exit a station area and drastically increase the cycle time. In this regard, the connection to multiple stations makes this route unreliable and highly vulnerable to congestion. Service reliability of a route is a key characteristic that influences ridership.

#### **3.4.1.3 CENTRAL BUSINESS DISTRICT (CBD) PEAK-HOUR FEEDER ROUTES**

The third category of feeder services caters to the heavy movement of commuters within the South Mumbai CBD area. The CBD is comprised of several smaller districts – Ballard Estate, Fort, Nariman Point, Colaba, and Churchgate. During peak hours, these services are operated in a waiting time. There is also a good level of physical integration at the 2 stations, with the provision of sufficient space for boarding / alighting and bus turnaround. The integration allows for safe dispersal of commuters from the two stations.

There are, however, several operational challenges that the BEST is attempting to address:

- 50% (or more) overlap in route structures adds to difficulty in managing and scheduling routes and adds to complexity from the user's perspective as well.
- Resources to maintain high-frequency are not always financially viable.
- A uni-directional flow of people during peak hours means that buses operate at full or overloaded capacity in one way and absolute zero load in the reverse direction.

### **3.5 Report On Rent-A-Bike Program Of Delhi Metro**

The Delhi Metro Rail Corporation (DMRC) launched the first software-based 'Public Bicycle Sharing scheme (PBS)' which would allow people to take cycles on rent from a residential area and travel to the nearest metro station. Under the scheme, commuters will be able to take cycles on rent from a residential area and travel to the nearest metro station and then again rent a cycle from a departing metro station to reach the nearby localities. To make this experience more convenient, automation software has also been put in place as per which, commuters will be able to use cycles at multiple destinations with the help of a rechargeable smart card. Updates about the travel along with details of the charges will be sent to the users via sms and e-mail.

DMRC has been operating a cycle rental service at the Vishwavidhyalaya Metro station successfully for the last six years in association with an organization called 'Greenolution'. Now, this new facility, oriented towards providing last mile connectivity as well as eco-friendly travel options, has been started in a fresh tie up with the same organization and has opened new bicycle rental shelters at Neb Sarai, Hauz Khas, Akshardham and Saket Metro station.

A study was conducted at Vishwavidhyalaya and saket metro station to review the cycle rental facility during morning peak hour. The cycle rental facility was not as successful as it was supposed to be. No cycle was rented during the peak morning hour. The whole cycle stand remained deserted. Reasons can be:

1. No proper infrastructure is in place like separate lanes , bicycle parking etc
2. Proper awareness is lacking.
3. Lack of proper planning like less number of stations for a large area. So cycle rented has to be returned at same station.
4. Climate of India is not suitable for bicycle riders.

5. Registration seems to be a problem at many stations as smart card facility is not available at all stations.



**Figure 16 CYCLE STAND AT VISHWAVIDHYALAYA METRO**



**Figure 17 AT VISHWAVIDHYALAYA METRO**

## **4 SELECTION OF STUDY AREA – DELHI & FIVE METRO STATIONS**

### **4.1 Ground reality of Delhi**

Delhi the capital city of India, has picked up huge investments to boost and augment its transport network and expand its rapid transit scheme. A reflection on whether the transport network and its rapid transit scheme is commensurate with surging vehicular growth reveals, an interesting dichotomy. On one hand, the road space as percentage of total land area in Delhi is 21% (Sahai and Bishop, 2010), much higher compared to cities like Tokyo (13%), Hong Kong (12%) and Bangkok (11%); as such, continued and aggressive expansion of road network is likely to be highly unsustainable. On the other hand, the road space availability has halved from 12 kms/1000vehicles in 1990-91 to about 6 kms/1000 vehicles in 2005-06, leading to heavy congestion on most city roads and increasing levels of vehicular pollution. This is a resultant of shifting trend towards private motorised modes of travel. On some major arterial roads, cars occupy as much as 70% of the road space carrying merely 20% of the total trips. The modal share of public transport (including bus and metro trips) in the city has gone down from 60% to 45.5% between the period 2000-01 and 2007-08 (RITES, 2008), despite introduction of BRT corridors and an expanding network of metro rail, because of the lack of first/ last mile connectivity to the public transport i.e. metro and bus stations. Yet, even as Delhi is investing in rail and bus lines, “last mile connectivity” – uniting people from their places to transport hubs are remains an area of neglect, off course, some small/trail initiatives are took place to provide least mile connectivity by providing feeder bus services, rental cycles and bikes etc. from some metro stations but those are not satisfactory and leads to unsuccessful stories. This lack of last-mile connectivity has created a state of matters to the poor (LIG and EWS), women, etc. who rely most on mass transport, are the very people that are causing the most difficult time reaching safe, sustainable, affordable transport options.

A certain percentage of the demand for least mile connectivity is met through para-transit modes such as auto rickshaws, Cycle rickshaws, Battery rickshaws, minivan etc. while auto rickshaws are convenient, quite often, they are expensive in the city, sometimes costing more than fifty percent of the entire price of the journey; carry individual passengers, thereby adding to the load on the road space; and operate in an unorganized way. Cycle rickshaws serve as important feeder systems, but are useable only in certain places.

In November 2013, the Rapid Metro, India’s first entirely privately funded mass transport venture, began operations in Gurgaon. It sought to address the issue of last-mile connectivity by connecting commuters from the nearby Delhi Metro to six key places within Gurgaon, including the commercial hub “Cyber City”. However, this being a private venture, it does not meet the needs of all residents.

In this alarming situation, it is imperative that a rapid paradigm shift is taken on in order to move people away from private vehicles towards the role of public transit. The aim of achieving this paradigm shift is to bid more attractive alternatives to the utilization of personal modes – low cost, comfortable, non- motorized transport, pleasurable walking experiences and very easily accessible and comfortable mass transportation with easy, convenient and comfortable intermodal transfers for last mile connectivity.



## 4.2 Selection of Delhi and Metro stations

The significant reliance on transport infrastructure and above mentioned facts has been considered Delhi as the subject area. The urban centre has developed a highly efficient public transport system with the unveiling of the Delhi Metro, which is undergoing a rapid modernization and enlargement. Alongside the MRTS Delhi has a full-fledged City Bus Transit System supported by a variety of Para transit modes varying from rickshaws, auto-rickshaws, minivan, and so onward. These modes mainly function as the major feeder services for the high speed Metro Rail System of the city. However, due to lack of focus on efficient last-mile connectivity these feeder services are generally unreliable, uncomfortable, unorganized and often times dangerous. Due to lack of good pedestrian and cycling infrastructure commuters are dependent on this motorised mode of feeder services for the last-mile connectivity.

Another rationale behind choosing Delhi as the study region fulfils the intent of getting analysis based on land usage practices as it boasts of a vast 153 km long (Metro) rail network integrating various types of city regions. Out of 143 metro stations, five Delhi metro Stations were selected for the sample survey based on average ridership / footfall (Table-5) and various land use patterns, namely residential, commercial, and educational where most of the daily trips are likely to happen involving the usage of public conveyance. Stations included in the on-ground survey were HUDA City Centre, Laxmi Nagar, Hauz Khas, Anand Vihar ISBT and Jahangirpuri Metro Stations respectively

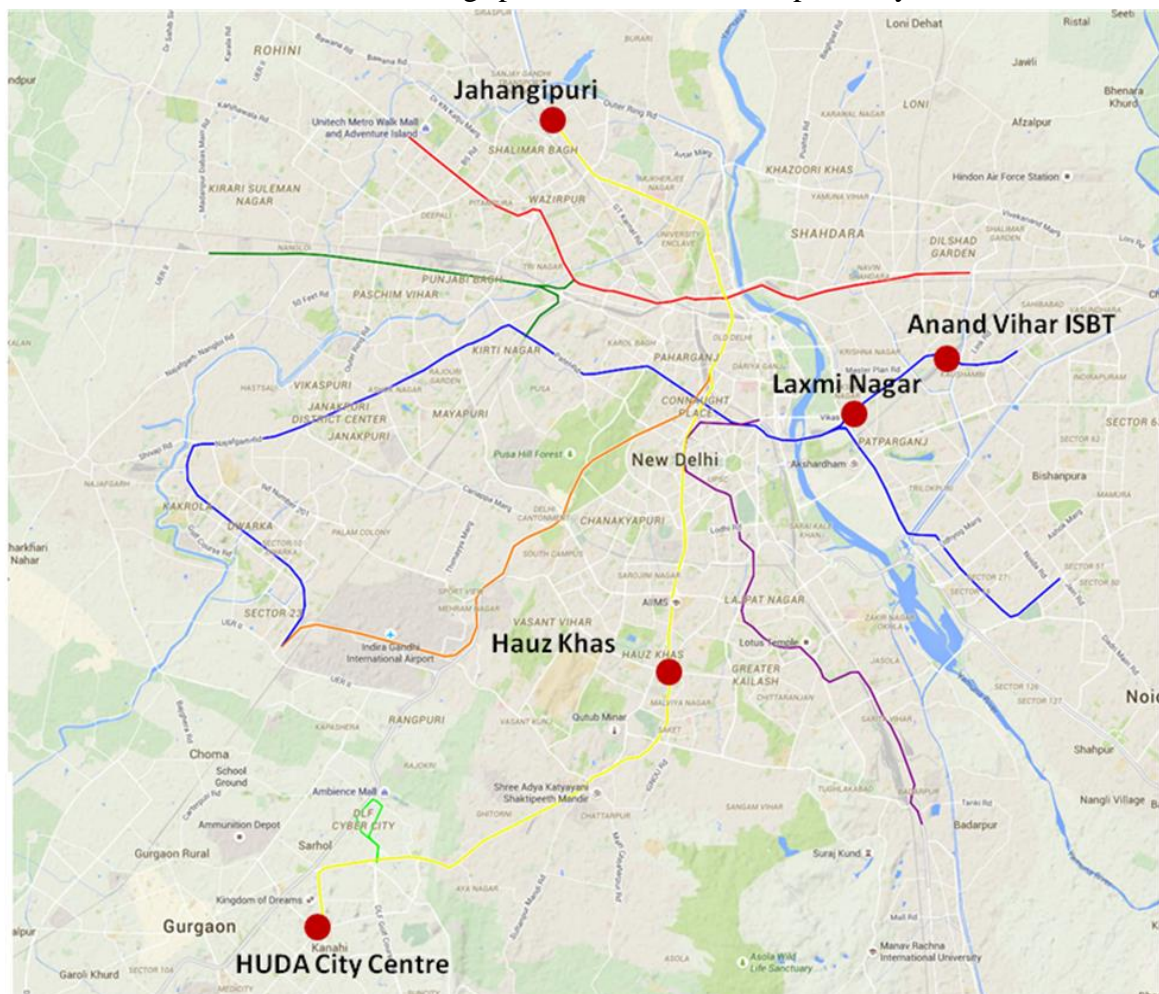




Table 7: Top 20 Metro stations in terms of ridership, 2014

<i>S.no</i>	<i>Station</i>	<i>Avg. Ridership</i>
1	Rajiv Chowk	5,69,003 (including interchange footfall)
2	Chandni Chowk	74,013
3	New Delhi	56,106
4	Karol Bagh	42,941
5	Laxmi Nagar	38,434
6	Uttam Nagar East	38,644
7	Saket	39,560
8	Vaishali	38,618
9	Huda City Center	41,198
10	Shahadra	36,013
11	M. G. Road	33,880
12	G.T.B Nagar	36,225
13	Hauz Khas	30,477
14	Dilshad Garden	32,252
15	Dwarka Mor	33,095
16	Noida City Center	29,821
17	Kashmere Gate	28,0227(including interchange footfall)
18	AIIMS	29,624
19	Central Secretariat	20,3284(including interchange footfall)
20	Anand Vihar	23,647
21	Badarpur	28,987
22	Inderlok	1,04,422(including interchange footfall)

Source: [www.delhimetrorail.com](http://www.delhimetrorail.com)

Table 8: Study Area Selection Details

S.No.	Station Name	Metro Line	Land Use Patterns
1	HUDA City Centre	Yellow	Residential, Commercial, Industrial
2	Laxmi Nagar	Blue	Residential, Commercial, Educational
3	Hauz Khas	Yellow	Residential, Educational, Recreational
4	Jahangirpuri	Yellow	Residential, Commercial
5	Anand Vihar ISBT	Blue	Multi modal intra-intercity transport junction including metro, bus and various Para transit.

## 5 Analysis and Findings

### 5.1 Survey Technique

For this study a sample size of 460 in total is chosen, which includes commuter and non-commuter (including IPT Operators and Private Vehicle Users) categories. Primary survey was conducted consisting of a pre- designed questionnaire survey consisting of objectives, multiple choice and open ended questions. The was conducted at 5 metro stations namely *Huda City Centre, Jahangirpuri, Anand Vihar ISBT, Hauz Khas, and Laxmi Nagar*. The Station wise sample size in peak and off-peak, with commuters and non-commuters are detailed in Table: 9.

Table 9: Sample Size

S. No.	Station Name	Commuter		Non-Commuter	
		Peak	Off-Peak	IPT	Private users (Control group)
1	<i>Huda City Centre</i>	35	35	5	12
2	<i>Jahangirpuri</i>	35	38	7	14
3	<i>Anand Vihar ISBT</i>	35	36	10	15
4	<i>Hauz Khas</i>	33	30	10	7
5	<i>Laxmi Nagar</i>	45	30	13	13
Total		185	169	45	61

Source: Primary Survey, 2015

At each of the chosen station, the survey was carried out between peak (800hr to 1100 & 500hr to 800hr) and non-peak (100hr to 500hr) hours. The sample size consists of commuter and non-commuter (Private Vehicle Users) categories to infer the issues of last-mile connectivity from both perspectives, additionally, 10 quaternaries were also convened at each station to capture the view of IPT operators. The survey aimed at targeting 500 samples out of which 460 were found to be productive for the study. Categorically for commuter and non-commuter categories sample size of 350 and 150 was targeted respectively. Three distinctive sets of questionnaires each for commuter and non-commuter (including IPT Operators and Private Vehicle Users) categories were utilized for collection of sample survey data. Questionnaires included objectives, multiple choice and open ended questions aimed at understanding the aspect of comfort, time, space, cost, incurred in the LMC as a ratio of the total journey for public transportation system users and operators; user preferences and alternatives available, for LMC; and in the end, whether lack of efficient LMC options is a decisive element in the commuter's choice of secret modes and how it effects the overall efficiency of a public transit organization. The survey targeted at two main components: 'Origin to Public Transport' (O-PT), and 'Public Transport to Destination' (PT-D). The analysis also lets in the types of modes opted for LMC, perceived problems and user features. Some questions included in the survey on problems faced and suggestions were deliberately left open-ended in order to make the real perception of the commuters.

## 5.2 Survey Findings

The study incorporates, for commuter category, the aspects of time, cost, and comfort for the overall journey with main focus on last mile connectivity options involving, “Origin to PT” and, “PT to Destination” trips. The analysis also included several types of LMC modes available, perceived problems, suggestions and user characteristic during peak and non-peak hours.

For private vehicle users, the analysis included various styles of travel and user characteristic. But the main objective here was to obtain an estimation of the perception of user for not using public conveyance and its connection with the LMC options available. An open ended question targeted at the willingness of user to opt for public transport if proper LMC options and parking mechanisms are in place near major PT systems was also admitted.

For IPT operators, analysis was focused on current scenario of LMC options available and their ownership. Looks like average expenditure on parking, permits, operation and maintenance of the vehicle were included to get insights of the functioning of the various LMC options available to the commuter.

## 5.3 Commuters study

### 5.3.1 *Modal Split for covering last mile*

Mode selection for a commuter for the final mile of the trip varies mainly at the initial (Origin to PT) and terminal (PT to Destination) leg of the journey. Figure 13 & 14 illustrates the distribution of modes at Origin to PT and PT to Destination sections respectively during both peak and Off-Peak hours. It is observed that walking along with Rickshaws and Buses are the most favored modes in covering the initial leg (Origin to PT) of the journey during peak hours. The intermediate distance, time and fare incurred by the commuter for the initial leg (Origin to PT) are 4.08 km, 16 min and 20 Rupees and for the final leg (PT to Destination) it totals out to be 3.46 km, 13 min and 20 Rupees respectively during peak time of days. More than 80 percent of the trips are work/education related on a daily basis. It is likewise interesting to observe that not a single commuter took an auto-rickshaw at both sections of the journey. This points to two things: that commuters are not willing to travel a larger distance to/from the transit stops at both terminals of the commute and that they desire to hold the price of the overall journey down as auto-rickshaw is one of the most expensive feeder services available to the user in the present scenario. None of the persons interviewed used bicycles and cars as LMC options in both the sections. This may also be attributed to the fact that the sample size was limited.

Figure 18: Modal Split during Peak Hours

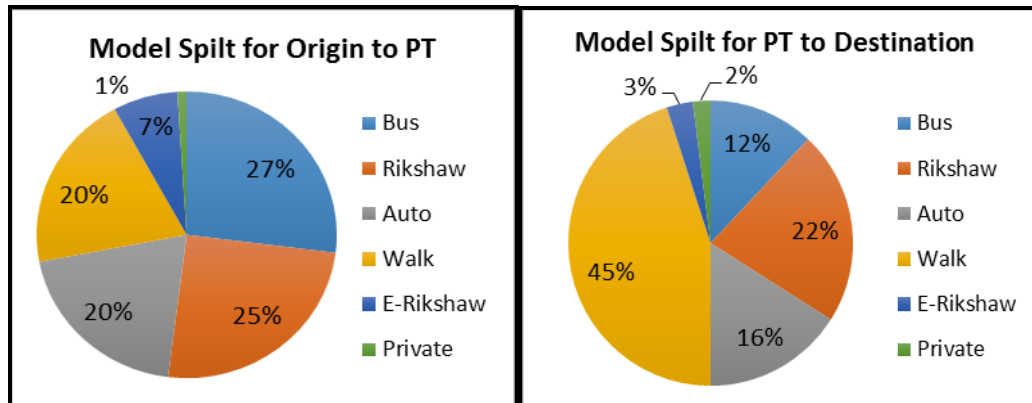
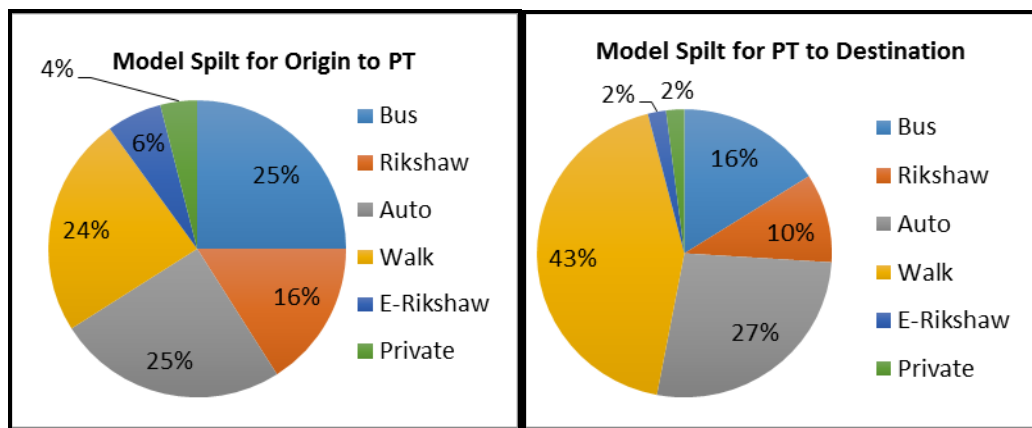


Figure 19: Modal Split during off-Peak Hours



### 5.3.2 Distance, Time and cost incurred in last mile

#### Access distance to Public transportation

An average distance from origin to public transportation and public transportation to destination is important aspect in last mile connectivity. The Distance factor affects the transportation system of city/town. The average distance from origin to public transportation of selected metro stations in time of peak and off – peak and mode wise average distance are detailed out in fig.15 and 16.

Figure 20: Average Distance to Public transportation in peak and off- peak

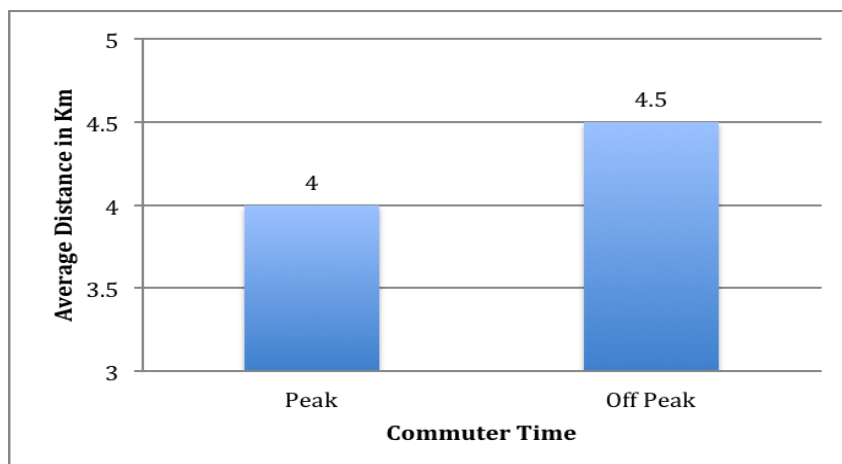
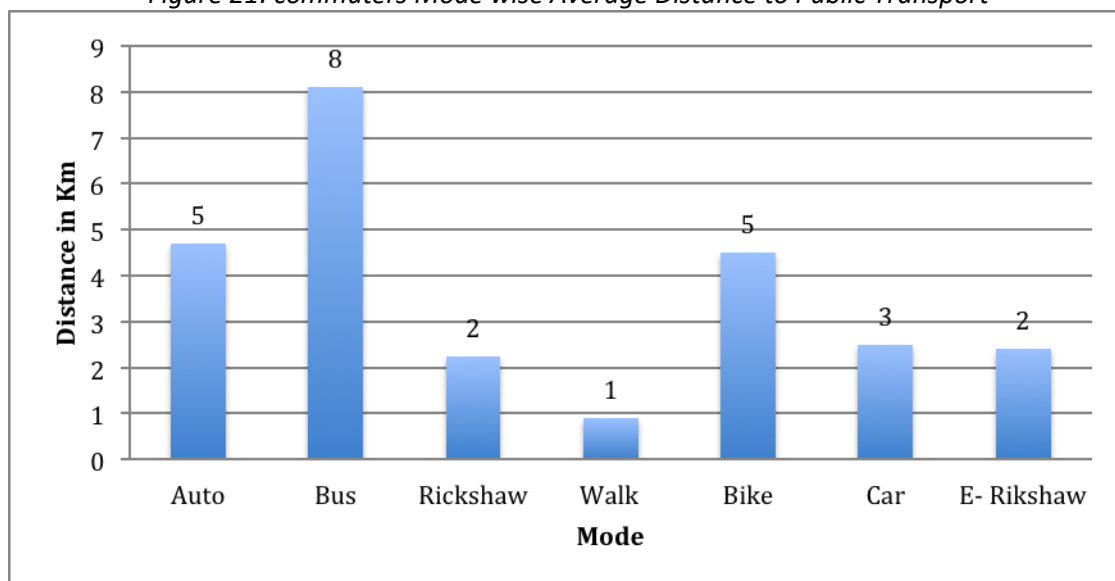


Figure 21: commuters Mode wise Average Distance to Public Transport



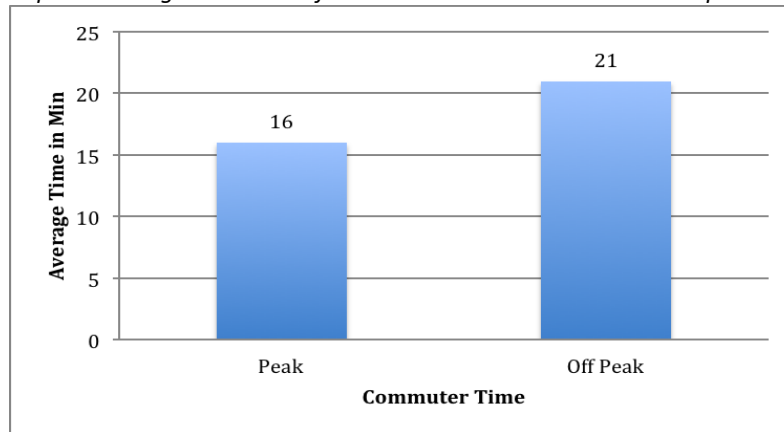
#### Inference:

- The average distance from origin to public transportation in peak hours is 4 Km which is 0.5 km less than the less compared to off-peak hours which is 4.5 Km. Because many of public transportation (PT) commuters (refer figure:) are using for public transportation in the peak hour means these are traveling for the purpose of Work, Education, Shopping, etc. these are giving more preference to nearest public transportation facilities compared to off- peak commuters.
- Come to commuter's mode wise average distance to public transportation, the average distance of bus mode is higher than the others, which is about 8 Km, due to some of the commuters are coming from outside the city and taking metros specially at Anand Vihar, Huda City Centre, and Jahangirpuri. Followed by Auto & Bike 5 Km, Car 3Km, due to the maximum distance from origin (Home/ Working place) to existence metro station is about around 5Km radius across Delhi as per the surveys. Rickshaw & E-Rickshaw are functioning as feeder to metro stations for 2 Km catchment areas. The commuters who prefer to walk 1 km to use metro (Public transportation).

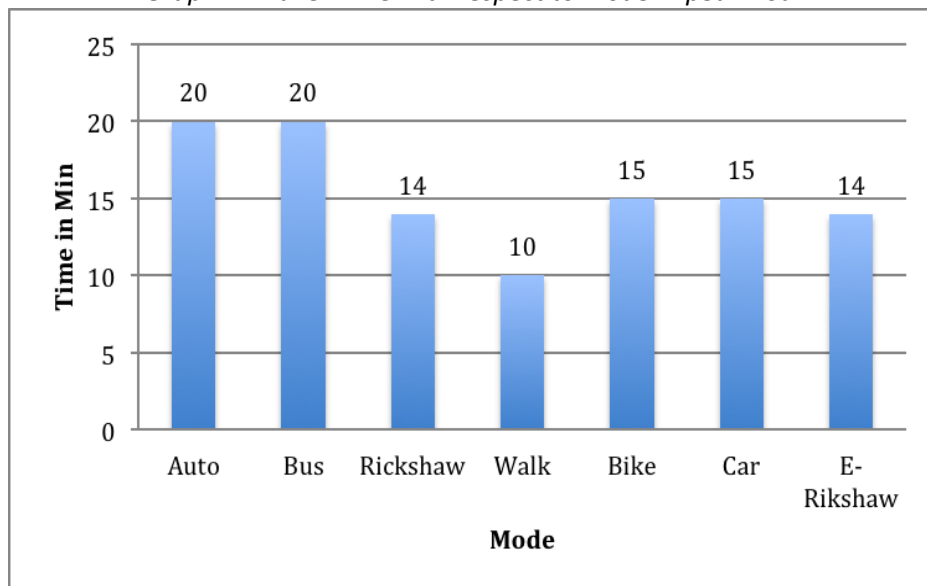
#### Travel time to reach public transportation

The average time spent and cost incurred in extending the last mile reflect a lot close to the quality and availability of last mile connectivity services. The details of average travel time taking for commuters to reach Public Transportation in peak and off peak hours and mode wise average travel taking to reach metro station (Public transportation) are detailed out in **Graph.1, 2 and 3.**

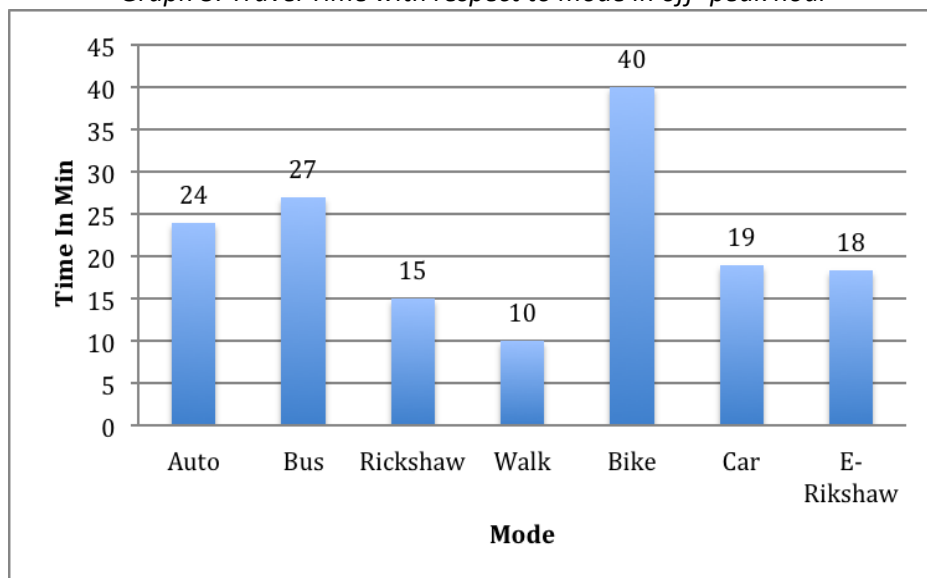
Graph 1: Average travel time for commuters to reach Public Transportation



Graph 2: Travel Time with respect to mode in peak hour



Graph 3: Travel Time with respect to mode in off-peak hour



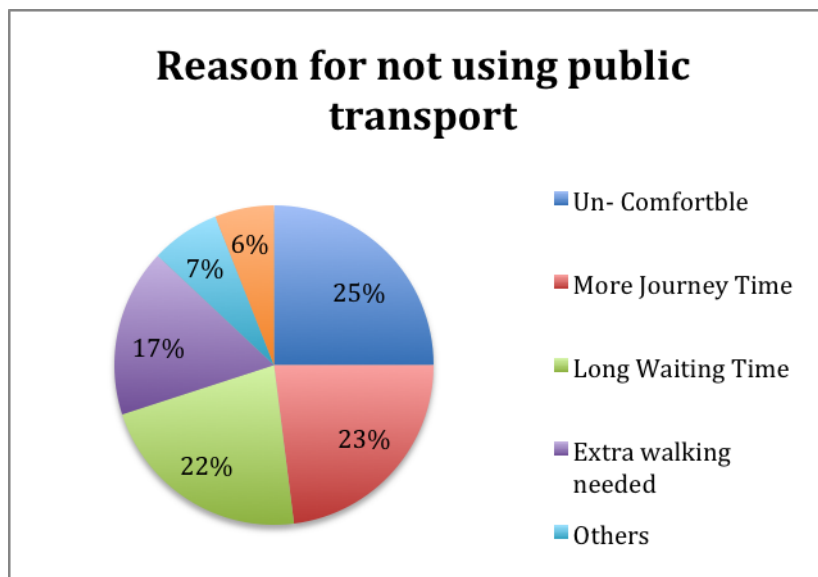
### **Inference**

An Average travel time taking from origin to reach Metro station (public transportation) in off-Peak hour is 21 minutes which is about 5 min higher than the peak hour- 16 minutes, due to the lack of availability and frequency of feeder services to the metro station it enhances the waiting time of commuters for feeder service (refer graph.)

The mode wise are indicates that the average time spent by the commuter to reach public transportation (Metro) is vary during peak and off peak hours. Despite walking being the dominant style in the final leg (PT to Destination) of the journey the mean time is less than the initial leg (Origin to PT) indicating that commuters prefer to spend less time in the final leg of their journey. But it is seen that the average cost incurred in the last mile does not vary significantly and comes out to be Rs.20 approximately.

### **5.3.3 Perceived Problems**

Most of the commuters cited problems relating to over-crowding during peak hours, low frequency of metro services and too long walking distances for addressing the last mile connectivity options of their journey. High prices of last mile connectivity often times more than half of the total journey expenditure and poor pedestrian infrastructure further adds up to the complications for the commuters. Approximately 49% commuters wait 10 min for LMC options during peak hour and 30% during off-peak hours. Women and elderly regarded current last mile connectivity options as inconvenient, unsafe and overcrowded.



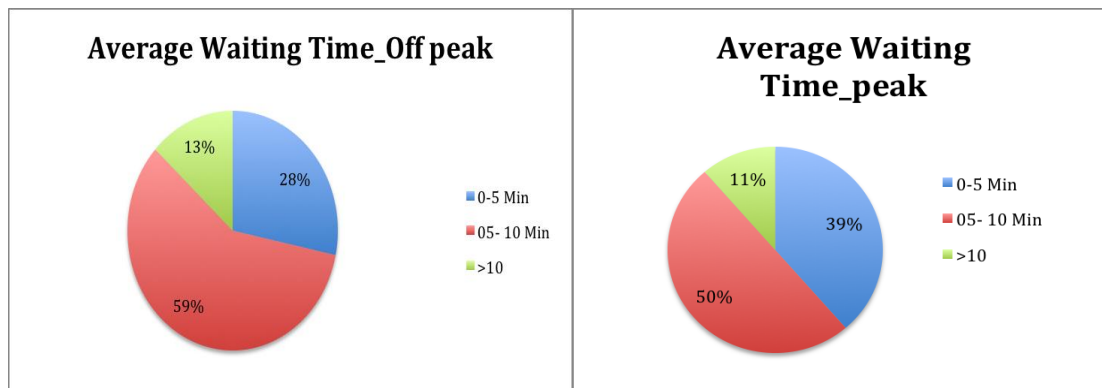
### **Inference**

People avoid the public transport citing many reasons mainly comfort , journey time and waiting time. PT tend to get overcrowded during peak hours which makes it uncomfortable and difficult for the commuters to reach their destinations on time, leading to their switching over to privately owned vehicle. Moreover journey time and waiting time are also main reasons for the neglect as PT tend to

make many stops during their journey which increase their journey time. So people prefer to travel with their own vehicle as they can travel without stops and thus reach their destination on time. For the metro users, the extra walking needed at the stations is also a factor. As user has to walk a long way to board the train after parking their vehicle.

### Average waiting time

Average waiting time is one of the main concern for the people using public transport. If the waiting time is more, people will try shifting to some other modes.



### Inference

People avoid the public transport citing many reasons mainly comfort, journey time and waiting time. Public transportation tends to get overcrowded during peak hours which makes it uncomfortable and difficult for the commuters to reach their destinations on time, leading to their switching over to privately owned vehicle. Moreover, journey time and waiting time are also main reasons for the neglect as PT tends to make many stops during their journey which increase their journey time. There is more than 50 percent of people are waiting for 5 minutes to more than 5 minutes for public transportation during peak hour itself, whereas in the off-peak hours it is increasing to about 70 percent (refer graph). So people prefer to travel with their own vehicle as they can travel without stops and thus reach their destination on time. For the metro users, the extra walking needed at the stations is also a factor. As user has to walk a long way to board the train after parking their vehicle. Women and elderly regarded current last mile connectivity options as inconvenient, unsafe and overcrowded.

## 5.4 Non-Commuters

### 5.4.1 Private Vehicle Users

For private vehicle users survey was conducted near parking stations and within a kilometer radius of various offices; 50 percent were car users along with 50 percent 2-wheeler commuters.



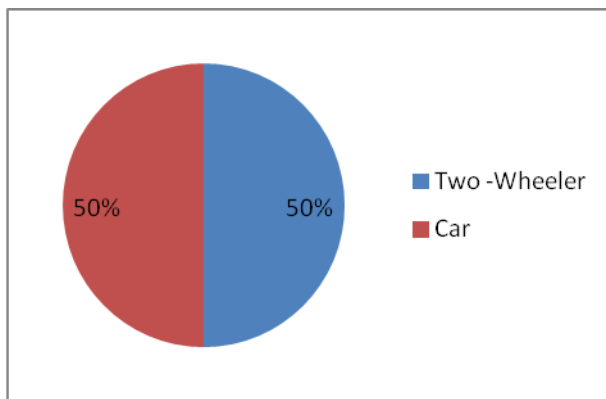


Figure 22 TYPE OF VEHICLE

## Distance, Time and cost incurred in last mile

### Travel Distance

An average distance from origin to Destination is about 18 km. The distance of private travels are most similar from classified three categories are less than 10 Km, between 10 to 20 and more than 20 km which are 25 percent, 37 percent, and 38 percent respectively, which is reflecting that the private vehicle users are mostly depending and desiring to use their own vehicle due to the several reasons, mainly more journey time, uncomfortable, long and extra walking time, safety and security etc. refer graph?

### Travel time

An average time taking to reach destination from the origin for the private travelers is about 42 minutes. The least time for travelers is 7 to 10 min and maximum travel time is 60 minutes. Nearly 40 percent of the private travelers are traveling daily for maximum travel time in this survey which is 60 minutes (1hr) to reach their destination. See graph

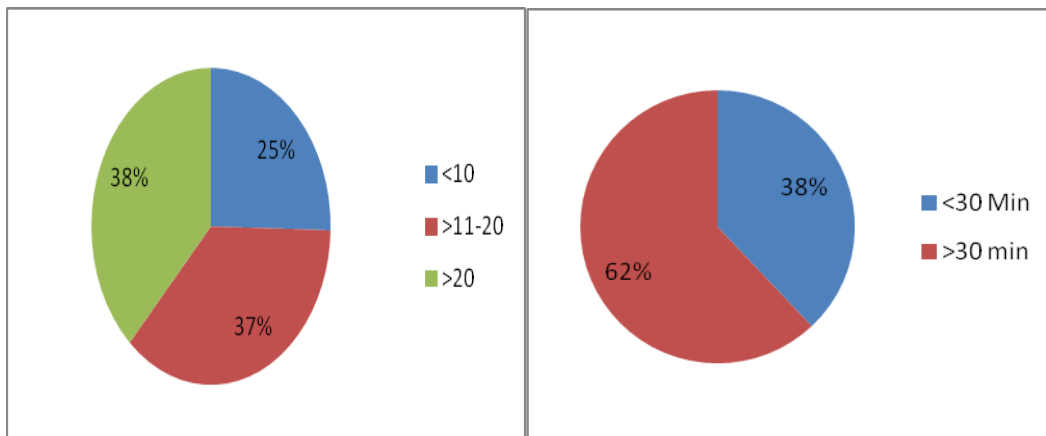


Figure 23 TRAVEL DISTANCE

Figure 24 TRAVEL TIME

### Travel cost and monthly income of Private

Just an average travel cost only Rs.3000 per month for the private travelers. The highest travel cost is Rs.10,000 per month and minimum is about Rs. 500 per month. About 70 percent private travelers are spending more than Rs.1500 per month. These values are giving idea and representing those expensive travel fares of Delhi scenario.

When the travel cost is compared to monthly income of private vehicle users nearly 50 percent of the people are having below Rs. 20,000 per month, which means these are

spending more than 15 percent of their spending their monthly income on travel only. Followed by 30 percent are by people who are earning more than Rs.40, 000 and between Rs. 20,000 to Rs. 40,000 per month

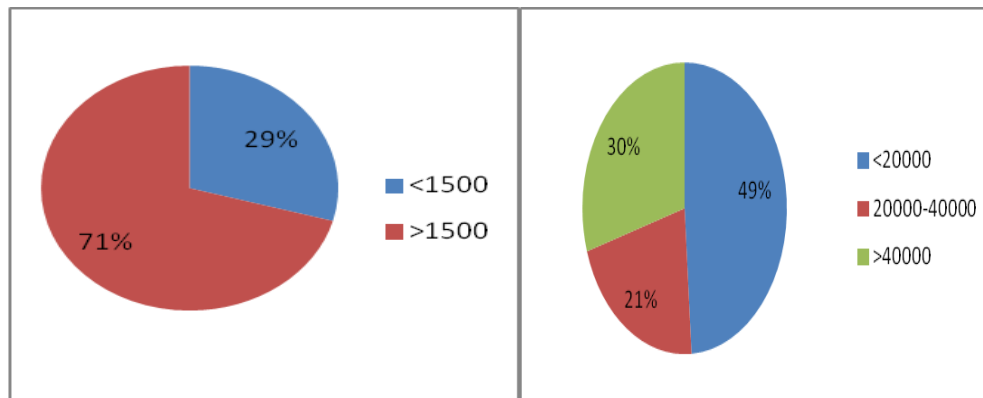


Figure 25 TRAVEL COST

Figure 26 MONTHLY INCOME

### Trip purpose and frequency

The trip purpose of the private vehicle users is 100 percent Work / Education / Shopping / other work related trips. Almost 83% trips are on a daily basis with users mostly comprising of high and middle-income groups with an average monthly income of Rs.32000. Almost 60% commuter willing to pay extra Rs.2-8 if services are improved and 58% commuters are willing to use PT if Park & Ride facilities are available. The survey the details are shown in Graph.4.

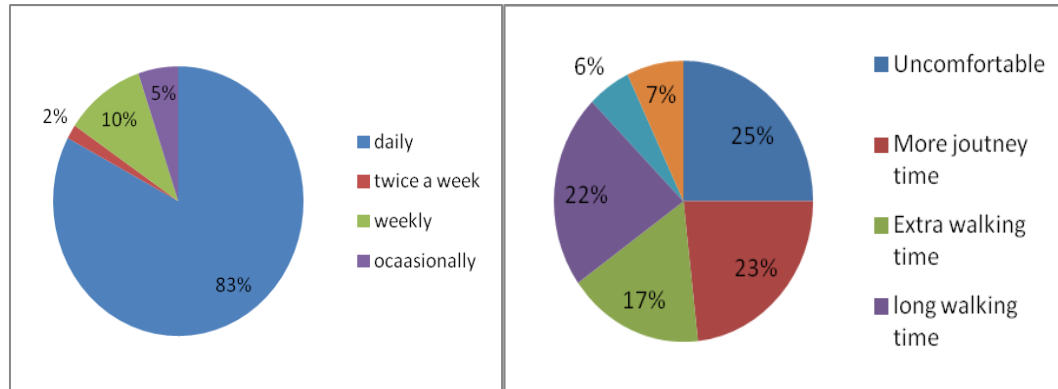


Figure 27 TRIP FREQUENCY

Figure 28 REASON FOR NOT TAKING PUBLIC TRANSPORT

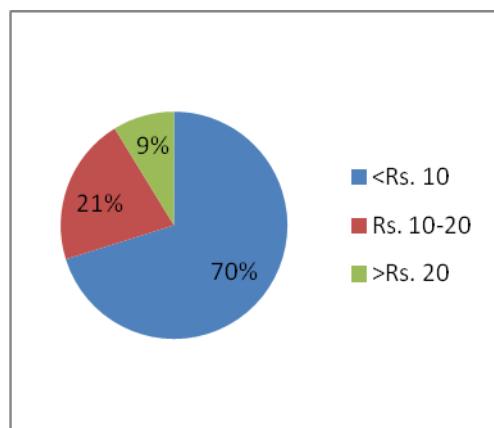


Figure 29 VALUE OF MONEY FOR 10 MIN

### 5.4.2 Intermediate Public Transport Operator

For IPT, survey operators within a kilometer radius were interviewed within chosen metro stations. It was found that about 46.66% of the vehicles were rented. Most of the vehicles excluding buses have 5 year permit which is renewable by paying a fees of Rs.10000. The average parking cost incurred by most vehicles is around Rs.1200. The average monthly running cost and Operation & Maintenance cost is shown in Table 9.

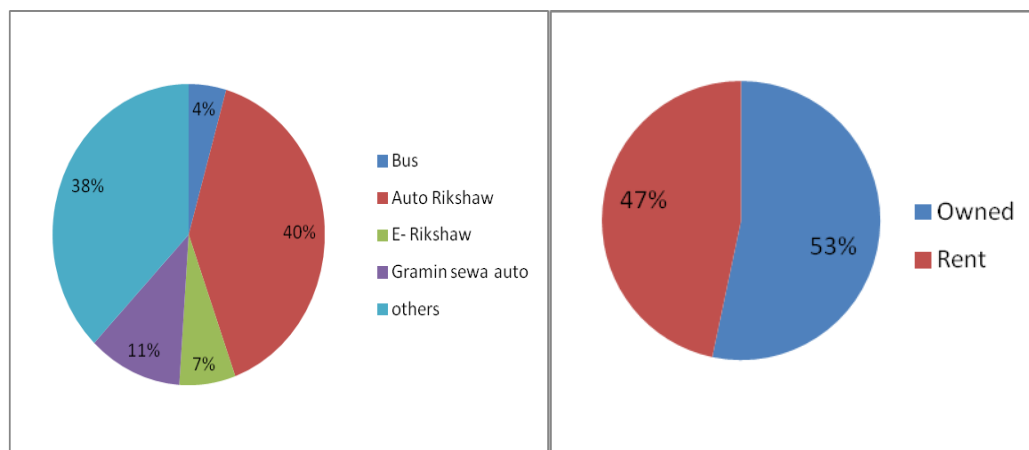


Figure 30 MODAL SPLIT

Figure 31 OWNERSHIP

From the survey conducted, some modes of IPT were identified which are feeder bus, auto-rickshaws, E-rickshaws, Gramin-Sewa Auto and others. Out of these proportion of auto-rickshaws was high, nearly 40%. Out of 45 total operators surveyed, 18 were auto-rickshaw operators, 2 bus operators, 3 e-rickshaws and 17 were other modes like taxicab, cycle rickshaws etc. Out of these 24 were owned and 21 were rented.

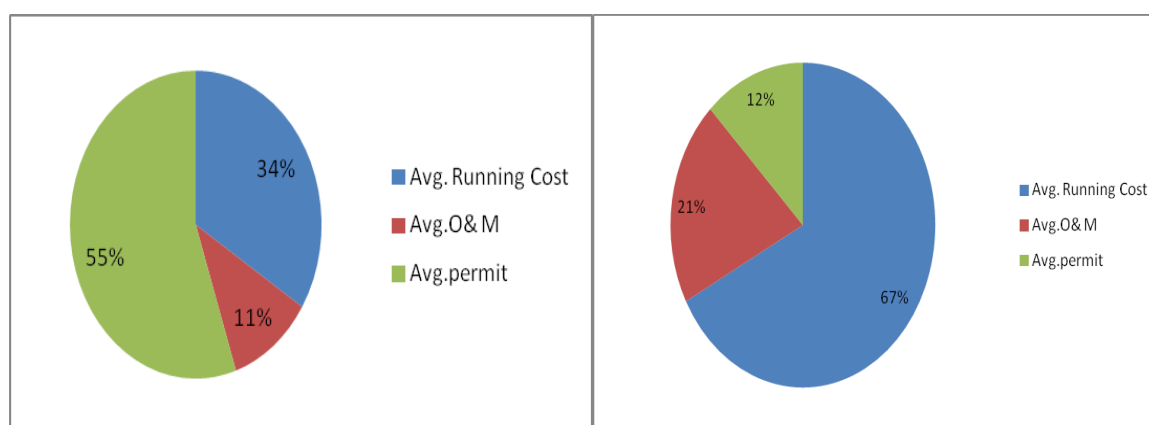


Figure 32 OWNED OPERATIONAL COST

Figure 33 RENTED OPERATIONAL COST

Table 10: Most Preferred Vehicle

S.no	Category	Avg. Running Cost (Monthly)	Avg. O&M Cost (Monthly)
1	Bus	62500	7000

2	<i>Auto</i>	6964	2309
3	<i>E- Rickshaw</i>	2583	533
4	<i>Minivan</i>	15190	1500
5	<i>Rickshaw</i>	1659	68

### 5.5 Detailed analysis of Hauz Khas metro station

Out of selected five metro stations, Hauz Khas Metro station is considered for detailed study on last mile connectivity. Because the metro station has significance characteristics are following:

- **Different land use:** Institutional, Residential, Commercial, and Heritage & culture
- **Type of Commuters:** Regular working class, corporate and central government employees, school college and university students, residential, visitors, etc.
- **Age group of Commuters:** Most of the commuter's age is between 16-50, followed greater 50 and below 16 years.
- **Last lime connectivity options:** The Hauz Khas Metro station is one of the Metro stations which are having both the last mile connectivity options from and to station to and from origin and destination such as rented bicycling and Feeder bus service.
- **Availability of Land:** the Metro station not have extra land to promote last mile connectivity around the metro station due to the metro station is completely surrounded by central government police residential colony, Laxman Public school, etc.



Figure 34 At Hauz khas

### 5.5.1 Commuters analysis in Peak Hour

Access distance plays an important part in planning last mile. People living far way tend to use PT only when it is well connected. People residing nearby take up walking, cycle, rickshaws etc and those far away tend to use motorized modes. During peak hour people tend to use motorized as compared to off-peak hour.

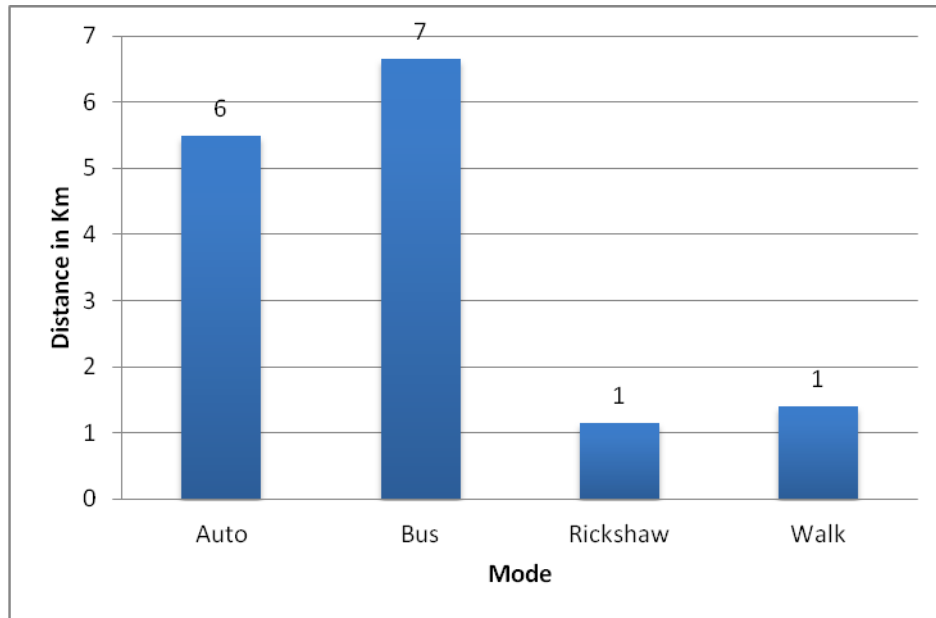


Figure 35 Average distance to public transport

#### Inference

Average access distance depend upon the type of land use and mode used for access travel. People have to cover more distance to reach hauzkhas metro station as it is surrounded by central government police residential colony and Laxman Public school which leads to the increase in use of feeder buses and auto rickshaw.

If the access distance is less then walking and cycle rickshaws are preferred. The graph shows that if the distance is around 1km then rickshaw and walking are preferred. If the distance is more then motorized modes are preferred like auto-rickshaw and feeder bus. The graph shows that the average distance for auto and bus is about 6km and 7km respectively. Buffer zones can be allotted to different modes on the basis of their travel distance during peak and off peak hour. Most people use motorized modes around hauz khas metro station due to surrounding land use and it location. More than 70% people use these motorised modes

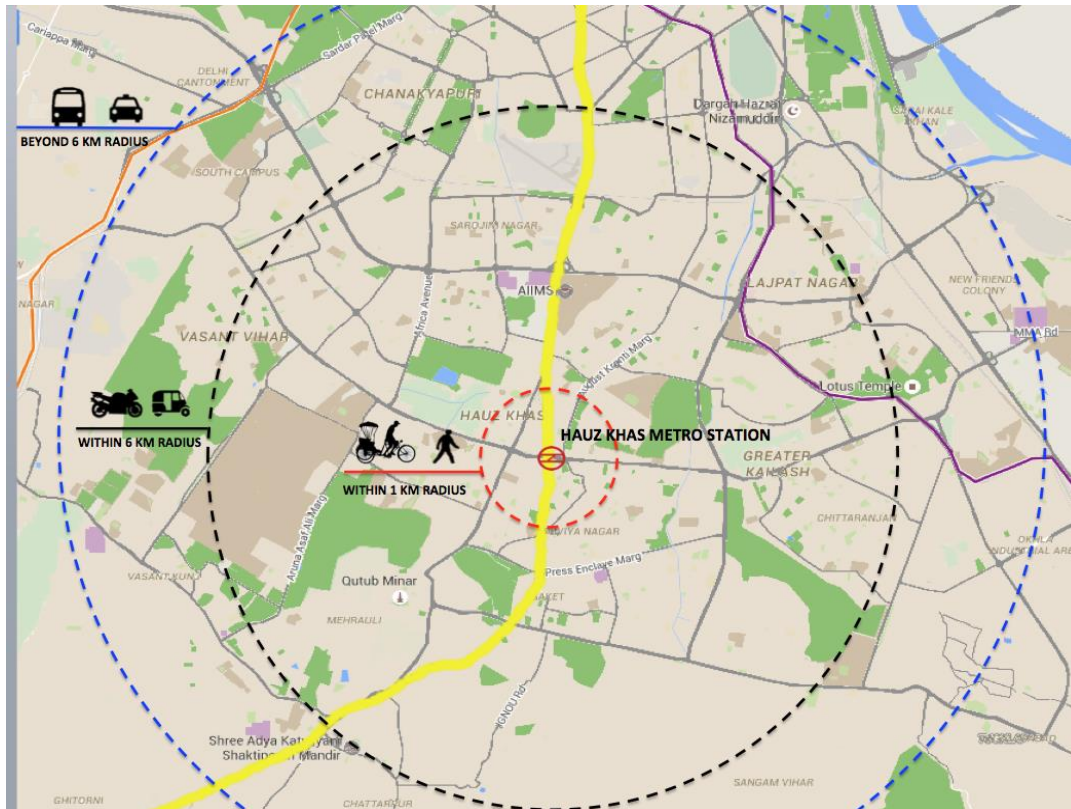


Figure 36 Influence zones during peak hour

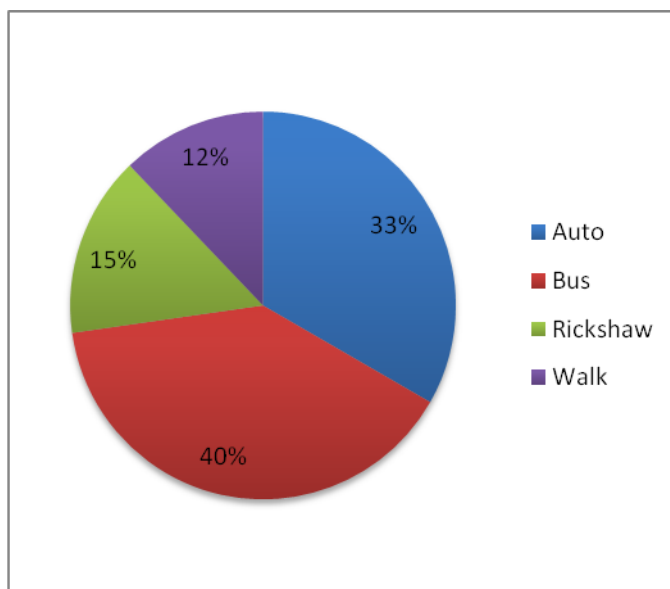


Figure 37 MODAL SPLIT

### Trip purpose and Frequency

As the area around hauzkhask metro station is mostly institutional and commercial, the trips mainly comprises of work, education and shopping trips. Out of 180 commuters surveyed, only 20 commuters made home trips and rest of them i.e. 160 were of work and educational purposes. Also



as these trips are of work and educational purposes, they are made daily rather than weekly. Out of total trips made, 88% of the trips were made daily and only 6% were made once or twice in a week.

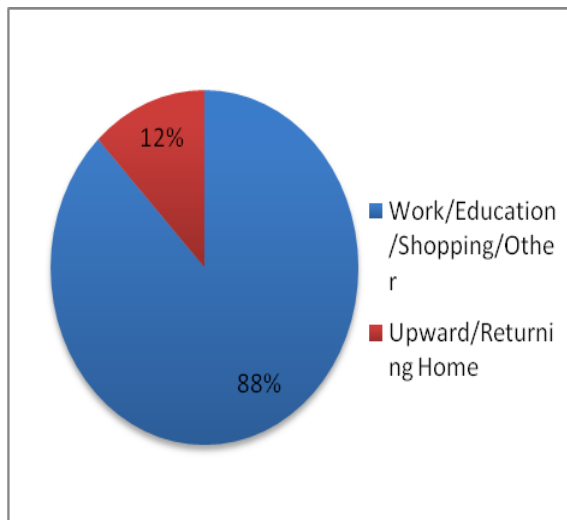


Figure 38 TRIP PURPOSE

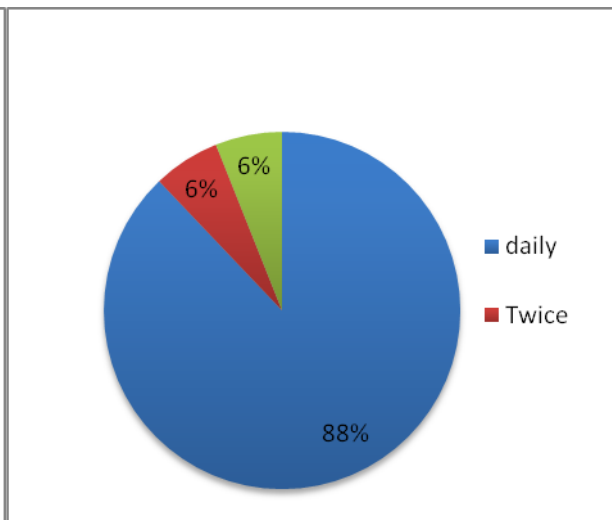


Figure 39 TRIP FREQUENCY

### Monthly Income And Ownership

Similarly from the monthly income point of view, most commuters are students who are unemployed so they have no income. As the area around hauz khas comprises of laxman public school , kalu sarai( mostly coaching centres), IIT Delhi etc , all institutional thus commuters mostly are students. Around 55% of commuters have income less than 10000, 30% have income ranging between 10000-20000 and 15% have income more than 20000. Also as commuters are mostly students and income less than 10000, so they don't own a vehicle. It is clear from the chart that 82% of the commuters don't own a vehicle which supports the above statement

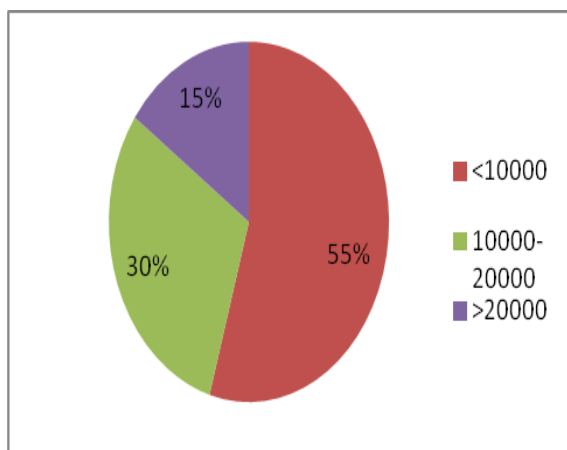


Figure 40 COMMUTER'S MONTHLY INCOME

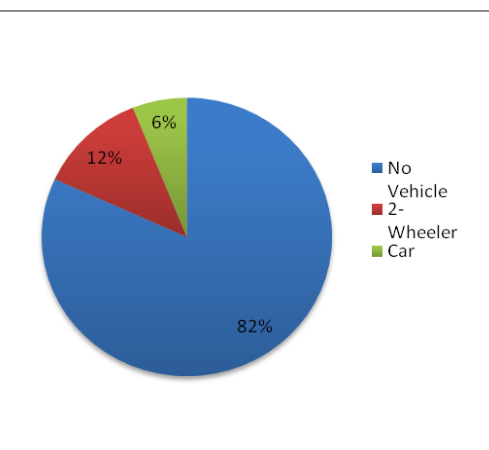


Figure 41 PERSONAL VEHICLE

## Rating for PT

As most the people do not own a vehicle they mostly depend on public transport for commuting. Commuters were asked to give rating 1-4 based on their satisfaction of the public transport. Most of them seem to be satisfied with the available facilities in the metro station with respect to journey time, waiting time etc. Around 70% of the people seemed to be satisfied but they are concerned about the access facilities to PT.

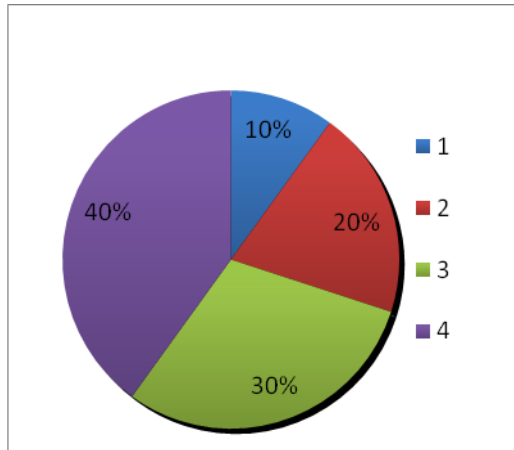


Figure 42 RATING ON PT

### 5.5.2 Commuter Analysis in off-peak hour.

#### Average Distance And Influence Zones

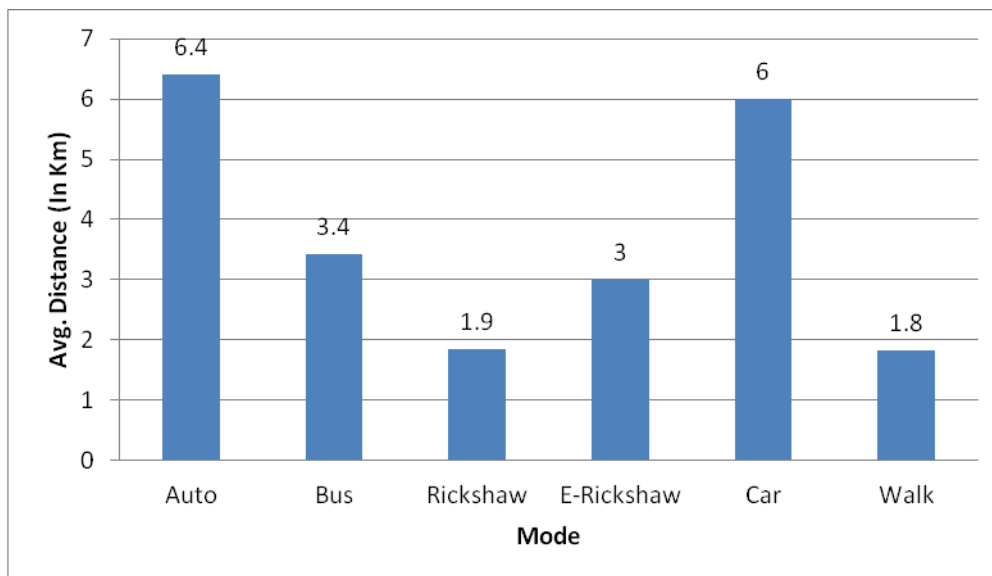


Figure 43 AVERAGE DISTANCE TO PUBLIC TRANSPORT



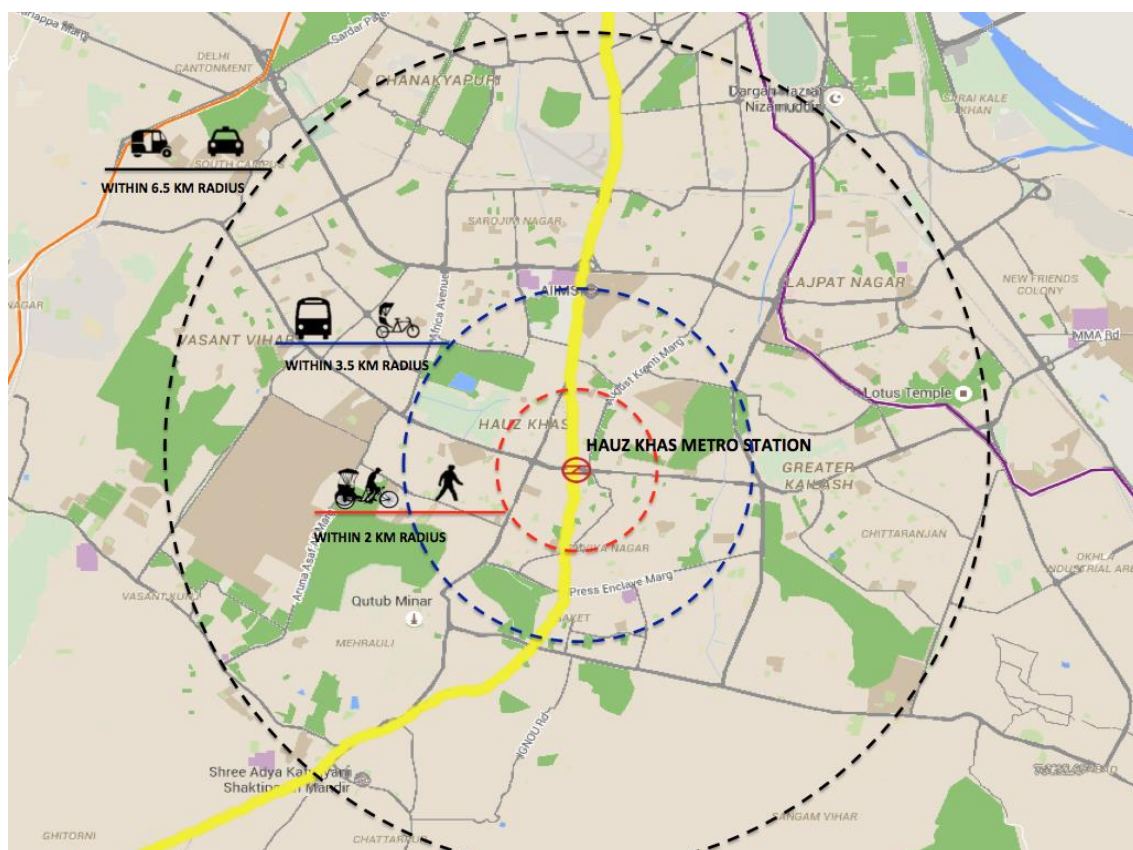


Figure 44 INFLUENCE ZONES DURING OFF-PEAK HOUR

During off-peak hour, people prefer to walk or take cycle rickshaw. This is because of less congestion on the road and less urgency to reach the destination. Also during off-peak feeder buses are reduced, so the number of commuters travelling by bus is reduced which has resulted in increase in use of hired auto-rickshaws and private mode, also walking and cycling are also increased. Thus the average distance travelled by auto rickshaws during off-peak hour is increased and that of buses is decreased. Since during the off-peak hour congestion is less, the influence zones for NMT i.e. walking and cycle rickshaws have increased. It is now 2km. Influence zone for buses is decreased for the same above reason.

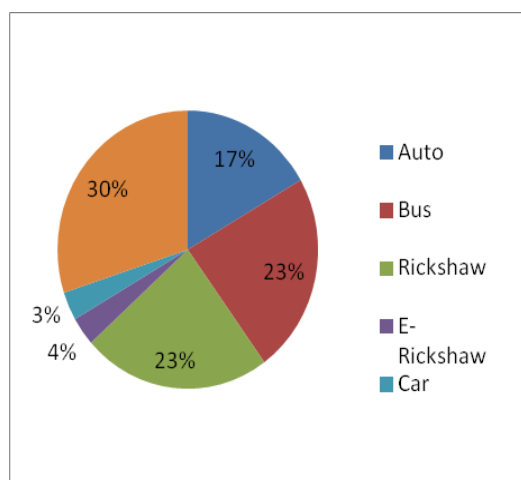
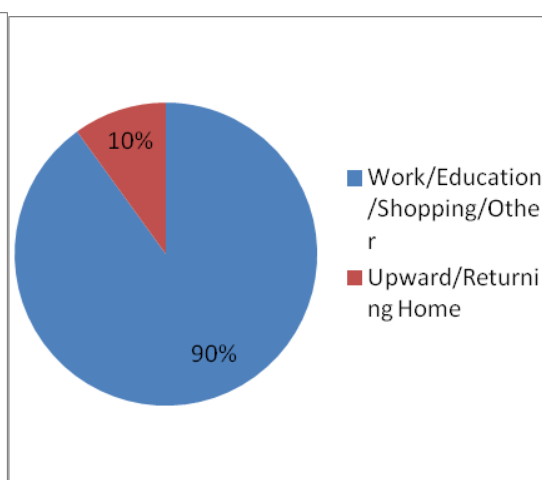


Figure 45 MODAL SPLIT



*Figure 46 TRIP PURPOSE*

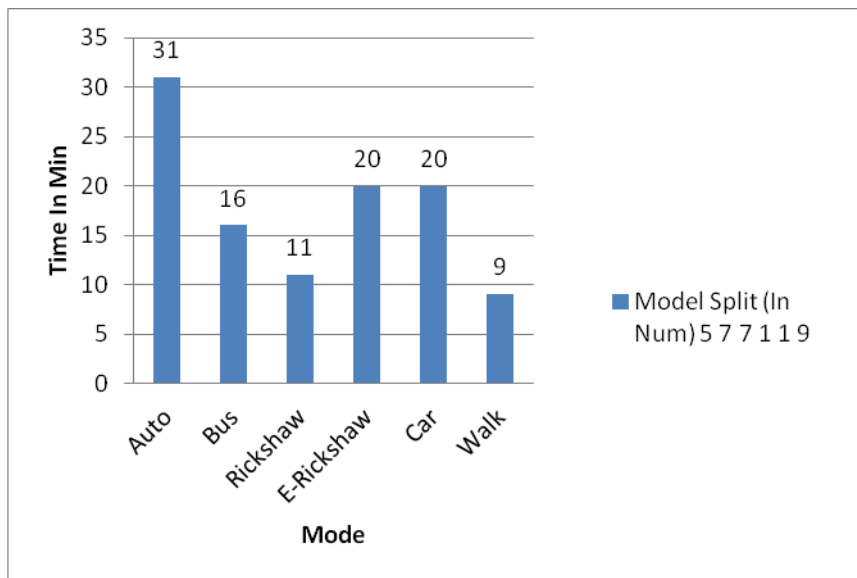


Figure 47 TRAVEL TIME

During off-peak , due to less availability of buses auto and other modes take over. They take more time to cover their journey but in off-peak people are not in a hurry. The average travel time in auto-rickshaws during off peak hour is 31 min compared to 18 min in peak hours. Though the number of buses were reduced during the period , their travel time remains the same along with walking. However, trip purpose remains the same. Mostly trips are made for work and educational purposes rather than home based trips during off-peak hour also.

### Average Fare for the Trips

Since , the number of trips made by auto-rickshaws has been increased , their average fare is also increased. The average fare of buses remains nearly the same nearly Rs.7, but the average fare for autos has been increased drastically from Rs.6 to Rs. 31. The main reason behind this is less or no availability of feeder buses which are operated by govt. and have less charges. Same is the case with other modes.

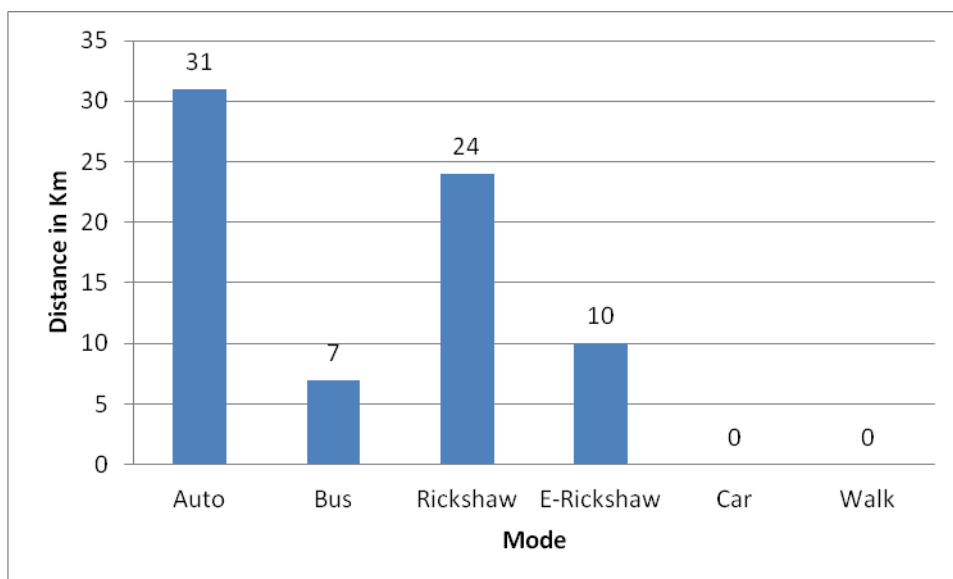


Figure 48 AVERAGE FARE WITH MODE

### Trip Frequency and Commuter Monthly Income

Since during off-peak hours , less commuters travel to hauz khas metro station, their trip frequency is also decreased. It has been brought down from 88% to 60%. Whereas people making trips once or twice during this time is increased from 12% to 40%. This is due to landuse of the area which have commercial and institutional buildings. The monthly income remains the same.

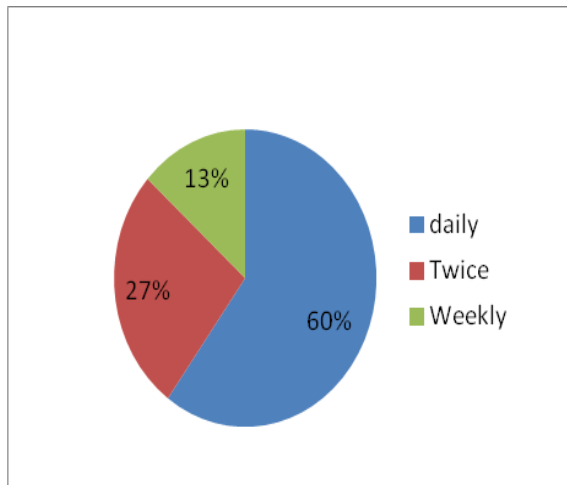


Figure 49 TRIP FREQUENCY

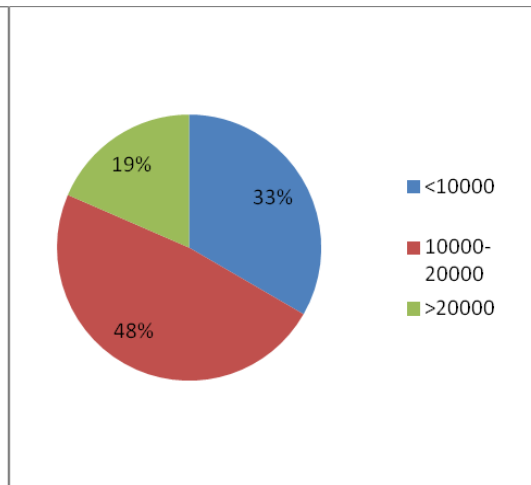


Figure 50 COMMUTER MONTHLY INCOME RANGE

The people owning a vehicle has been increased , as number of buses are reduced. People started preferring private vehicle which may accounted to different reasons like non availability of buses, more travel time and fare in auto, comfort etc. The percentage of 2wheelers has also been increased.

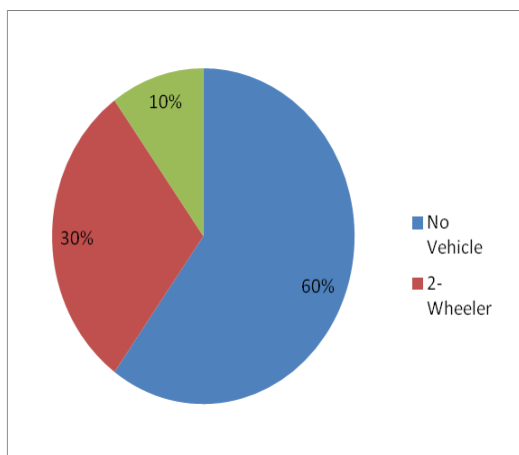


Figure 51 PERSONAL VEHICLE

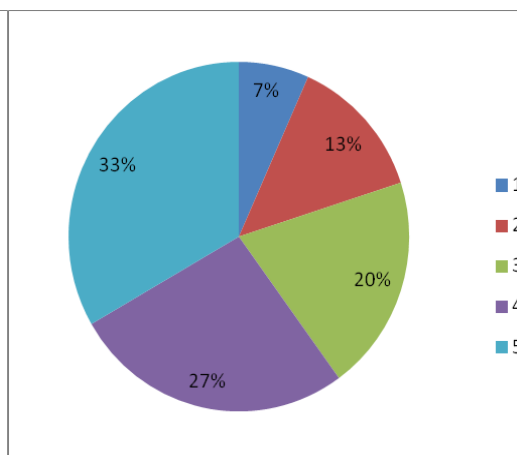


Figure 52 RATING FOR PUBLIC TRANSPORT

Due to no congestion and more comfort in metro during off-peak, commuters are more satisfied with the available services of metros. Thus the rating given by them is also increased. About 1/3 people gave 5 out of 5 rating to metro . About 80% people are satisfied with available facilities. However the only concern remained is last mile connecting modes. People have to walk or take costly auto to reach their destination.

### 5.5.3 Non- Commutes: IPT Operators survey

For Intermediate Private Transport, survey operators within a kilometer radius were interviewed within chosen metro stations. Out of all operators surveyed, 20% were bus operators , 30% were auto-rickshaws and 50% were Gramin Sewa Auto. Apart from feeder bus which is 100% subsidized by govt. the auto-rickshaws and gramin sewa auto are both privately owned and rented. About 80% of the IPT are rented and 20% are owned. Since

these are operated by economically weaker group people, so renting is considered a better option by most of the operators

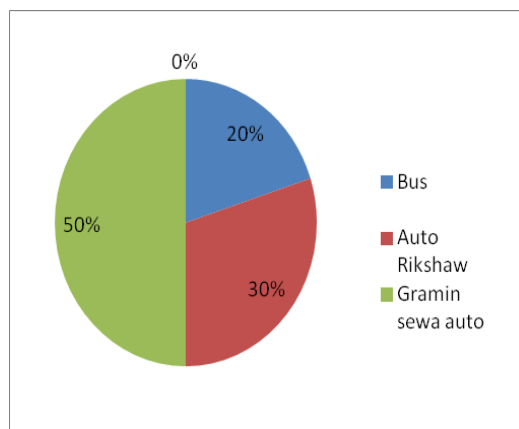


Figure 53 MODAL SPLIT

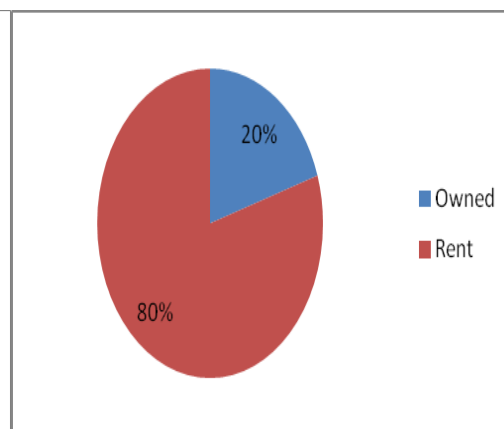


Figure 54 OWNERSHIP

For the owned vehicles the main concern is the permit for operating which takes almost half of the total operating cost. A operator has to pay nearly Rs. 10000 for permit whereas on the rented vehicle operators need not to be worried about it. In the rented vehicles the main concern is the average running cost which is more than 75% of the total operational cost and more than 3 times the running cost of owned vehicle. For rented vehicle, maintenance cost is also more along with the parking charges.

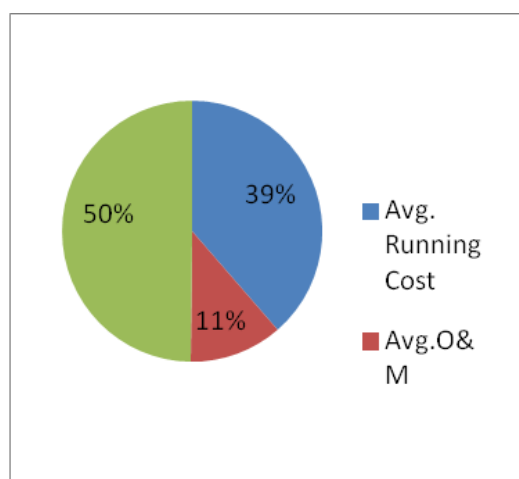


Figure 55 OWNED OPERATIONAL COST

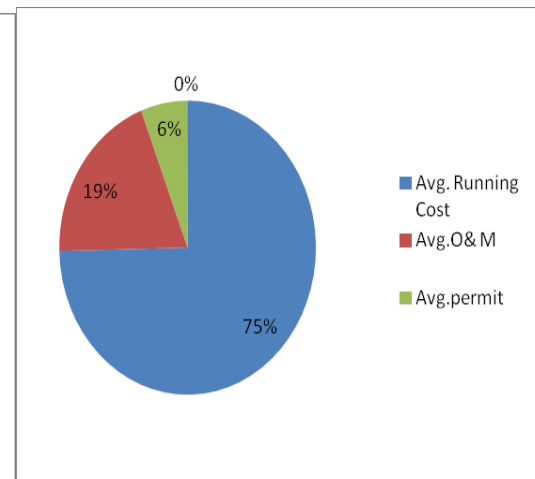


Figure 56 RENT OPERATIONAL COST

#### 5.5.4 Non- Commutes: Private commuter survey

For non commuters private vehicle user survey was also conducted. Mainly the survey location was the parking stations the metro, since the vehicles are more readily available there. They use their own vehicle to travel to the work or other activities rather than using public transport. There was nearly an equal distribution between the 2 wheelers and car

users. Out of 24 users surveyed 13 were 2 wheeler and 11 were car users.

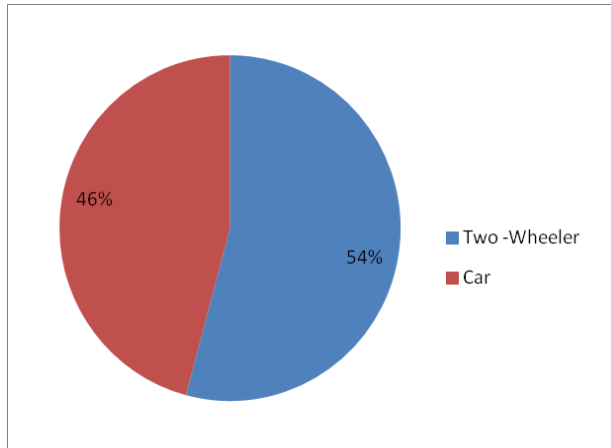


Figure 57 TYPE OF VEHICLE

### Travel Distance and Travel time

The distance travelled by the private commuters varies, depending upon the destination. However the average distance is nearly 19km. Also the average travel time depend upon the route, peak/off-peak hour, congestion etc. They avoid the PT and take the whole journey in the comfort of their own vehicle. So the travel time also depend upon their destination which may differ. Mostly the private journey took more than 30 min. However the average travel time is nearly 38 min costing them Rs.3000.

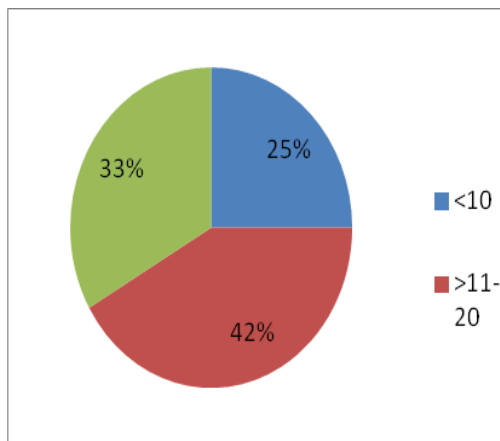


Figure 58 TRAVEL DISTANCE

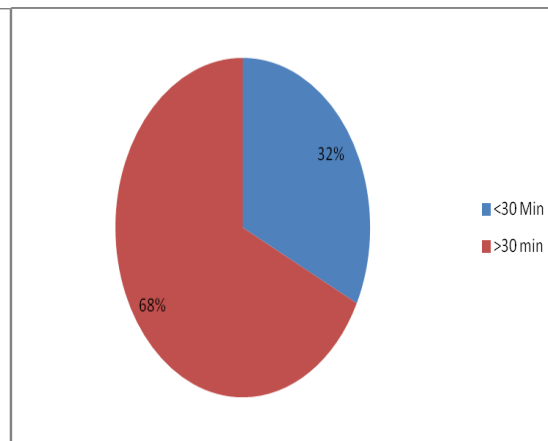


Figure 59 TRAVEL TIME

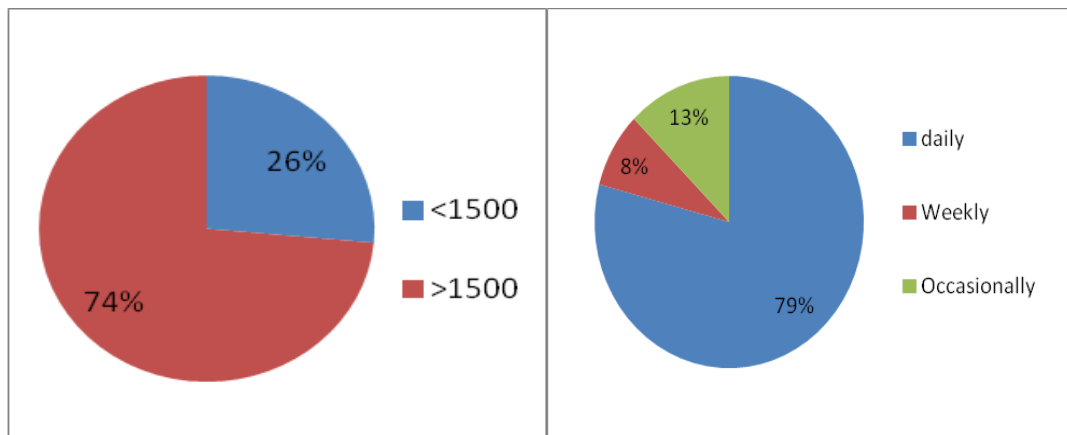


Figure 60 TRAVEL COST

Figure 61 TRIP FREQUENCY

The trips were almost 100% work related trips, all 24 trips. 19 trips were made daily, 2 weekly and 3 occasionally. Daily trips were mainly for work and educational purposes. The private vehicle owners belong to mostly middle and high income groups.

### Reasons For Not Opting PT

The private vehicle users were also asked the reason for not opting PT for their trips. Some were uncomfortable in travelling in PT, while some blame the journey and walking time for it. Some gave other reason like the uncertainty being main factor. As they cannot be sure of waiting time or arrival time of PT. They know all the conditions beforehand while travelling with their own vehicle.

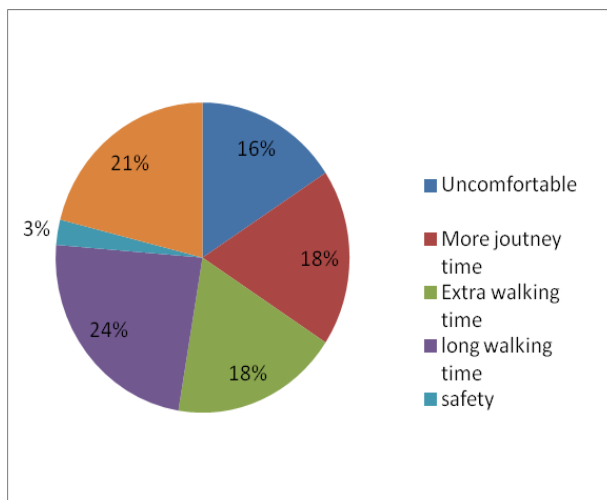


Figure 62 REASONS FOR NOT USING PUBLIC TRANSPORT

Almost 58.62% commuter willing to pay extra Rs.2-8 if services are improved and 58.62% commuters are willing to use PT if Park & Ride facilities are available

### Monthly Income

Since the land use around Hauz khas is mostly institutional and users mostly were students thus income range tilted towards less than 20000. Just an average travel cost of over Rs.2500 per month for the private travelers. The highest travel cost is Rs.6000 per month and minimum is about Rs. 200 per month. About 70 percent private travelers are spending more than

Rs.1500 per month. These values are giving idea and representing those expensive travel fares of Delhi scenario.

When the travel cost is compared to monthly income of private vehicle users more than 50 percent of the people are having below Rs. 20,000 per month, which means these are spending more than 20 percent of their spending their monthly income on travel only. Followed by 30 percent are by people who are earning more than Rs.40, 000 and between Rs. 20,000 to Rs. 40,000 per month

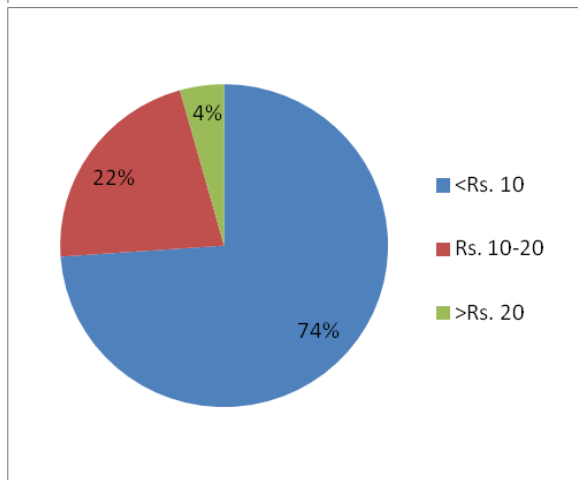
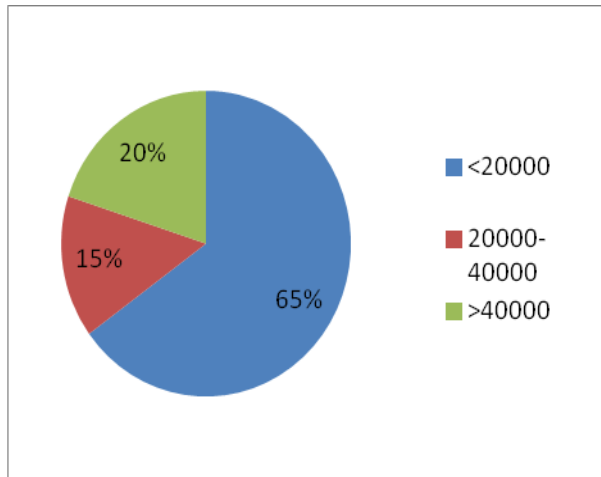


Figure 63 MONTHLY INCOME MIN

Figure 64 MONEY VALUE FOR 10

## 5.6 Conclusion

The study clearly indicates the lack in treatment given to last mile connectivity for the overall functioning of a public transportation system. Commuters, however view it as an important component of rapid transit systems, which is often the most uncomfortable and tiresome part of their whole trip. Its significance can be identified from the fact that:

- More than 70% of current metro users (in the survey conducted) mentioned problems related to LMC.

- The average time spent and cost incurred in LMC is considerably significant (more than 15 minutes).
- Lack of robust pedestrian infrastructure is also a major issue for commuters.
- More than 55% of private mode users point to reasons directly or indirectly related to LMC, for not using metro.
- Almost 58% private mode users are willing to use metro if provided efficient feeder services along with Park & Ride facilities.
- Major technological innovations needed in the sector as E-Rickshaws previously banned in Delhi were opted as most suitable, affordable and comfortable among all the above modes by the commuters. Also, besides the conventional cycle rickshaw, E-Rickshaws are the only non-polluting mode.

But a minuscule percent of transit commuters use private modes for last mile connectivity; the majority relies on Para-transit modes or on walking and cycling. Despite this, main focus has been on providing dedicated private mode parking at several subway stations. At the same time, properly planned and comfortably-designed parking spaces allocated to auto-rickshaw/bicycle-rickshaw at the metro stations are a curiosity. These modes find spaces in a more organic nature themselves: near traffic islands, service lanes, and quite habitually, distributed over onto the main carriageway. In the process, they not only create traffic bottlenecks, but also make it hard for pedestrians to negotiate their way safely amidst all this pandemonium. In many areas where bicycle-rickshaws are not permitted to bear near the subway station, the road being an arterial, they stand on the minor intersecting roads and pedestrians have to again negotiate speeding traffic to access them.

Last, but not the least, provision of pedestrian friendly infrastructure and environment on all major and minor roads leading to transit stops are paramount for enhancing efficiency of rapid transportation schemes. Giving due weightage to LMC planning may not merely draw more users to shift from private modes of public transport, it may also in the long run help retaining its existing riders hence increasing the overall efficiency of a public transit system. Rather clearly, LMC needs to be an entire element of rapid transit schemes and urban transport planning process.



## 6 RECOMMENDATIONS

### 6.1 Long Term Recommendations

- Founding of a Unified Metropolitan Transport Authority with responsibilities for land-use planning and transport investment with the charge of securing Transit Oriented Development.
- Re-balancing of investment in line with good words of the National Urban Transport Policy towards public transportation, walking, and cycling and away from road capacity enhancement schemes in urban regions.
- Conception of an NMT Centre of Excellence, part of the Urban Metropolitan Transport Authority (UMTA) mooted for Delhi and tooled with adequate support to invest in cycle and walking infrastructure.
- Standards of design to accord with those of the Pedestrian Design Guidelines set by the United Traffic and Transportation Centre (UTTIPEC) in Delhi and forthcoming Indian Cycle Design Guidelines based on Dutch CROW Cycle Design Manuals.
- A significant thrust towards greater road safety, including the development of objectives for the NMT Centre of Excellence and targets for the Traffic Police to cut road casualties while increasing cycling and walking mode share.
- Local bodies to be consulted on measures to improve road safety in their arena and to be involved in small-scale adequately resourced local transport (walking/cycling/public transport access) audits, improvement, and road safety schemes.
- First appearance of demand management schemes to promote usage of public transport, walking and cycling such as road pricing, stricter parking control, and taking out subsidies on fuel and parking.

### 6.2 Short Term Recommendations

To facilitate multimodality of the type needed to boost public transit usage, a number of different kinds of integration are needed:

#### Integration with land-use planning

- Making public transit links first and then developing high-density, mixed land use areas around them, thereby reducing the need to move around, particularly by private vehicles.
- Opting for Transit-Oriented Development so that providing different services around stations can be economically viable

#### Integration within and between different modes of conveyance

- **Physical Integration:** Facilitating direct, easy, convenient, and safe approach to public transport (providing secure, direct road crossings, tree-shaded paths, refreshments, cycle and rickshaw parking, differently-able pavements and access levels).
- **Fare Integration:** Enabling the public transit user to pay only once for a journey involving different modes of transport.
- **Path Integration:** Facilitating logical interchange points where passengers are able to change from one vehicle or style to another conveniently and safely.

- **Data Integration:** Enabling a ‘one-stop-shop’ for public transit users, bicyclists, and pedestrians to clear data on whatever journey they wish to transmit using these styles.
- **Institutional Integration:** Ensuring that different public transit providers see themselves as part of a network and offer connections to other types of transit, walking, and cycling for seamless connectivity.
- **Service (timetabling):** Reduce waiting times through synchronizing time tables of complementary modes.

#### **Recommendations for a better walking environment for pedestrians**

- Insertion of a suitable methodology and plan to alter streets in business with the Pedestrian Design Guide- lines
- Safety buffer for pedestrians..
- Better quality street furniture.
- Tree shading.
- Spaces for hawkers to provide road users with refreshments,
- Spots to congregate, and require a breath away from traffic.
- Walking infrastructure like sidewalk, crosswalk skywalk, subway etc.

#### **Recommendations for a better cycling environment**

- Infrastructure should be developed. Separate cycle lanes should be provided
- Smart card facilities should be provided at all stations.
- Intermediate stations should be provided at major city centre so that cycle need not to be returned at the same stations
- Organizing cycle rally and creating awareness will attract many youth.
- Provide showers and lockers at offices to those who cycle to work.
- Proper incentives can be given to people who use cycle to work.
- Government can declare Sunday as a bicycle compulsory day.

#### **Recommendations for a feeder buses**

- Provide feeder buses for the 5km radius around metro.
- Increasing the number of buses during off-peak hour.
- Currently feeder buses are not operating on all routes, so government should at least provide at major routes

#### **Recommendations for a better infrastructure for roads**

- Establish signage boards and marking to reach metro stations
- Provide curbs and ramps at all crossing with gentle crossings
- Clear and safe crossing
- Adequate lighting during night.

#### **Station Area planning (SAP)**

A station area is more than just an area adjacent to a transit node. It is a place of connectivity where different modes of transportation – from walking to riding transit – come together seamlessly and where there is a concentration of working, living, shopping and playing (Metrolinx 2011). More than its adjacency to a mass transit station defines a well functioning station area. A station area is described by the ease and number of connections it offers its users and the multiple activities that occur here. Station area plans must take into account transportation and circulation issues,

urban design and place making, and the public infrastructure that make for great neighborhoods and high quality transit-oriented Development.

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## 7 ANNEXURES

### 7.1 Annexure 1: Questionnaire for Origin-Destination Ground Survey

#### COMMUTER SURVEY

##### 1. Commuter Details

Name

Phone Number

##### 2. Survey Timings

Date / Time  DD  MM  YYYY  hh  mm  AM/PM

##### 3. Commuter Location

- ☐ Metro
- ☐ City Bus
- ☐ Inter State Bus
- ☐ Inter City Train
- ☐ Auto Rickshaw

##### 4. Name of Location

##### 5. Trip Information for the journey from Origin/Home/Work to Public Transport

Origin

Distance from Origin to Public Transport (Km)

Mode

Travel Time (Min)

Fare (Rs)

##### 6. Trip Information for the journey from Public Transport to Destination/Home/Work

Destination

Distance from Public Transport to Destination (Km)

Mode

Travel Time (Min)

Fare (Rs)

7. What is the Average Waiting aTime?

- ☐ Nil
- ☐ 5-10
- ☐ 15
- ☐ More

8. Trip Purpose

- ☐ Work/Education/Shopping/Other
- ☐ Upward/Returning Home

9. Trip Frequency

- ☐ Daily
- ☐ Twice
- ☐ Weekly
- ☐ Occasionally

10. Monthly Income

11. Do you own a personal vehicle?

- ☐ Nil
- ☐ Two Wheeler
- ☐ Car
- ☐ If not, why?

12. How much money value do you give of your time for each 10 min delay ?

- ☐ Rs.2-8
- ☐ Rs.10-15
- ☐ Actual

13. How do you rate access to the Public Transport Facility on a scale of 1 to 5?

14. What suggestions would you like to give for Seamless Service?

## 7.2 Annexure 2: Questionnaire for Origin-Destination Ground Survey

### PRIVATE VEHICLE USER SURVEY

#### Questionnaire for Origin-Destination Ground Survey

##### 1. Commuter Details

Name

Phone Number

##### 2. Name of Location

##### 3. Survey Details

Date / Time      DD      MM      YYYY      hh      mm      AM/PM  
 /  /      :    

##### 4. Survey Location

- ☐ Petrol Pump
- ☐ Parking Areas
- ☐ Other

##### 5. Type of Vehicle

- ☐ Two Wheeler
- ☐ Car
- ☐ Company Provided

##### 6. Trip Information

Origin

Destination

Distance (Km)

Travel Time (Min)

Amount Spent (Rs)

##### 7. Trip Purpose

- ☐ Work/Education/Shopping/Other
- ☐

Upward/Returning Home/Both Ways

8. Trip Frequency

- ☐ Daily
- ☐ Twice a Week
- ☐ Weekly
- ☐ Occasionally
- ☐ Other, Please specify

6. Monthly Income

7. Why don't you use public transport? Give one or more reason.

- ☐ Uncomfortable
- ☐ More Journey Time
- ☐ Extra Walking Needed
- ☐ Long Waiting Time
- ☐ Safety
- ☐ Other, Please Specify

11. How much money value do you give of your time for each 10 min delay?

- ☐ Rs.2-8
- ☐ Rs.10-15
- ☐ Rs.20

12. How much do you actually spend on transportation?

13. Would you like to use public transport if park and ride facility is available? If not. Why?

14. Suggestions for improvement if any.

### 7.3 Annexure 3: Questionnaire for Origin-Destination Ground Survey

#### IPT OPERATOR SURVEY

#### INTERMEDIATE PUBLIC TRANSPORT OPERATOR

##### 1. Operator Details

Name

Phone Number

##### 2. Type of vehicle

- ☐ Bus
- ☐ Auto Rickshaw
- ☐ E-Rickshaw
- ☐ Mini Van

Other (please specify)

##### 3 Area of Operation and Corresponding Charges (Flat/Variable)

##### 4 Do you get any subsidy from the government?

##### 5 Whether the vehicle is owned or rented?

If Rented, how much do  
you pay?

If Rented, who is  
responsible for O&M?

##### 6. Cost of operation of vehicle

Running Cost

Operation & Maintenance

Parking

Permit



7. What suggestions do you have for improving intermediate public transport

## 7.4 Annexure 4: Survey Data Analysis

### i) COMMUTER SURVEY

Field	Criteria	Frequency	Percent	Remarks
1. Modal Split for Origin to PT(Peak Hours)	Auto	35	20	
	Bus	48	27	
	Rickshaw	43	25	
	Private(2W+Car )	2	1	
	Walk	35	20	
	E-Rickshaw	13	7	
2. Modal Split PT to Destination (Peak Hours)	Auto	27	16	
	Bus	21	12	
	Rickshaw	39	22	
	Private(2W+Car )	3	2	
	Walk	78	45	
	E-Rickshaw	5	3	
3. Modal Split for Origin to PT(Off-Peak Hours)	Auto	39	25	
	Bus	40	25	
	Rickshaw	26	16	
	Private(2W+Car )	7	4	
	Walk	38	24	
	E-Rickshaw	10	6	
4. Modal Split PT to Destination (Off-Peak Hours)	Auto	43	27	
	Bus	25	16	
	Rickshaw	16	10	
	Private(2W+Car )	4	2	
	Walk	69	43	
	E-Rickshaw	4	2	
5. Average Waiting Time(Peak Hours) in Minutes	0	68	37.77	
	5-10	88	48.88	
	15	20	11.11	
	More	4	2.22	
6. Average Waiting Time(Off-Peak Hours) in Minutes	0	43	17.68	
	5-10	89	30.48	
	15	20	9.14	
	More	13	5.48	
7. Trip Purpose	Work/Education	320	92.7	
	Upward/ Onward	25	7.3	
8. Trip Frequency	Daily	254	80.55	
	Twice	33	6.66	
	Weekly	43	11.11	
	Occasionally	15	1.66	
9. Money Value For Each 10 min Delay (in Rupees)	2-8	179	48.33	

	10-15	37	8.88	
	Actual Fare	129	42.77	
10. User Rating For LMC	1	72	17.77	
	2	82	24.44	
	3	140	44.44	
	4	43	12.12	
	5	6	1.11	

## ii) PRIVATE VEHICLE SURVEY

Field	Criteria	Frequency	Percent	Remarks
1. Survey Location	Petrol Pump	1	1	
	Parking	35	60.34	
	Traffic Signal	22	37.93	
2. Trip Information	Average Distance(Km)	18.22		
	Average Time(Min)	41.78		
	Average Expenses(Rs.)	3156.316		
3. Trip Frequency	Daily	48	82.75	
	Twice	1	1.72	
	Weekly	6	10.34	
	Occasionally	3	5.17	
4. Average Monthly Income(Rs.)		32189.56		
5. Reasons For Not Using PT	Uncomfortable	28	48.27	
	More Journey Time	26	44.82	
	Extra Walking Needed	19	32.75	
	Long Waiting Time	25	43.10	
	Safety	6	10.34	
	Other	8	13.79	
6. Money Value For Each 10 Min Delay(in Rupees)	2-8	34	58.62	
	10-15	24	41.37	
	20	0	0	
7. Willingness To Use PT if Parking is Provided	Yes	34	58.62	
	No	24	41.37	

iii) **INTERMEDIATE PUBLIC TRANSPORT USER**

Field	Criteria	Frequency	Percent	Remarks
1. Type of Vehicle	Bus	2	4.447	
	Auto	18	40	
	E-Rickshaw	3	6.66	
	Minivan	5	11.11	
	Cycle Rickshaw	17	37.77	
2. Any Subsidy from Government?	Yes	0	0	
	No	45	100	
3. Vehicle Owned or Rented?	Yes	24	53.33	
	No	21	46.66	
4. Average Cost Of Operation of Vehicle(in Rupees)	Bus	62500		
	Auto	6963.88		
	E-Rickshaw	2583.3		
	Mini Van	15190		
	Cycle Rickshaw	1659.41		
5. Average O&M Cost of Vehicle(in Rupees)	Bus	7000		
	Auto	2309.44		
	E-Rickshaw	533.33		
	Mini Van	1400		
	Cycle Rickshaw	68.18		