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NMT as Green Mobility Solution for First/Last Mile Connectivity to Mass Transit Stations for Delhi

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ABSTRACT

The objective of this paper is to examine the role of non-motorized transport (NMT) as green mobility solutions in improving the last mile connectivity (LMC) to mass transit systems. There are evidences of its growing significance, which is established through various international experiences, and case studies. The paper discusses transport policies for Indian cities with respect to LMC, NMT and transit systems and their interface. The paper also presents the empirical findings of a study on NMT usage as first/last mile options for a few metro stations in Delhi, India. It analyses metro user characteristics and choices for the selected stations with a lens on NMT usage for covering the last mile. It is observed that NMT comes out as the most preferred option for covering the first/last mile to transit systems, despite the challenging situations under which NMTs operate. The study further points out that the type of NMT mode availed by commuters varies with varying situational context and depends on locational and user attributes. It is interesting to note that while introduction of "bicycles on hire" worked very well at a particular station, the same had no takers at another. The paper contends that resorting to standard solutions for LMC may not be the right approach; rather it must be based on user and other contextual analysis. The paper concludes with outlining a holistic policy approach that treats NMT planning as a non-negotiable component of transit planning to achieve higher ridership (for the transit operator), better journey experience (for the commuter) and larger sustainability goals.

1. Introduction

Concerns for sustainability and equity have seen transport policies, especially in the developing world evolve from being traffic-centric to people-centric. The paradigm shift in policy has been accompanied by metropolitan cities opting for mass rapid transit systems. Yet, the larger context of the entire journey experience that begins at the point one steps out of a place of residence to the final destination remains an area of neglect in most transit planning exercises. In Indian cities, policies till now have remained silent on last mile connectivity (LMC) but talk of low-carbon transport and non-motorized transport (NMT). Most cities take up transit system and NMT planning in isolation to each other. It is also true that while cities have been enthusiastic in introducing transit systems, there has been rather lackadaisical approach towards NMT planning and its integration with transit systems. It goes without saying that cities need to work towards more sustainable ways of addressing the mobility needs of people.

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 214 times (from 0.7 million to 142 million) increase. Of this, larger cities including metro and mega cities constitute the maximum share, with Delhi taking a clear lead.

The road space as percentage of total land area in Delhi is 21%, 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 personal 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. The metro ridership achieved for the year 2011 fell deficit by 1.5 lakh of that estimated for this year. So, while the city clearly identifies transit improvement for its long-term goal of sustainability, it is still grappling with ways to increase its transit ridership.

Yet, the larger context of the entire journey experience that begins at the point one steps out of a place of residence to the final destination remains an area of neglect in most transit planning exercises.

1.1 Significance of Last Mile Connectivity (LMC) in Mass Transit Planning

The Metro in Delhi is further expanding and is projected to have a much larger trip share than its existing patronage. The transport demand forecast and development of public transport network study prepared by RITES in October, 2010 recommends the total Metro length within Delhi to be 330 km by 2021 with an estimated modal share of 20.1%. Achieving this modal share from the present miniscule 4% would be overambitious and far-fetched, unless the city takes proactive measures to make the metro attractive enough to dissuade private mode users towards mass transit patronage. Given the fact that the transit system in itself is built with the state-of-art technology, mere expansion of network, services and overcoming technical glitches at the transit level may not be sufficient; the answer has to be probed elsewhere, in a larger perspective.

The answer also perhaps lies in understanding the limitations of transit system vis-à-vis private modes. Mass transit systems are limited by their lower accessibility, in terms of direct access from trip ends. On the other hand, private modes offer a variety of advantages such as demand mobility, comfort, status, speed, and convenience (Rodrigue, 2013). Stopher et al. (1974) suggested that the attractiveness of public transport can be decomposed into four generic elements: safety, cost, time, comfort and convenience. Unfortunately, most transit planning focus on improvement in these elements of the transit system per se and not of the overall transit journey which includes the first and the last mile connectivity (LMC).

The origin of the term LMC can be traced to telecommunications and technology industries to describe the technologies and processes used to connect the end customer to a communications network. It is the final leg of delivering connectivity from a communications provider to a customer. Although the term reads `mile', the actual distance of this leg may be less or considerably more than a mile, especially in urban fringe and sprawl. In the context of urban transport, the term finds relevance in transit systems where it is referred to as both the initial and final leg of delivering connectivity - from origin to transit nodes and from transit nodes to destination. The term is severally referred to as 'last mile', 'first mile' or 'first and last mile' and has generated considerable interest in recent years over how it influences public transit usage.

A trip made on transit systems usually requires the commuter to utilize more than one mode of transport. The attractiveness of transit as a mode therefore depends not just solely on the quality and attributes of the main mode but also on the quality and attributes of the LMC. Researchers have found the connecting ends to be its weakest link and that they can significantly influence the overall appeal of transit systems given their substantial contribution in terms of travel time and travel discomfort (Krygsman, et al., 2004) (Rietveld, 2000).

1.2 Non-Motorized Transport (NMT) as Last Mile Option

Research also indicates that connectivity issues can arise out of lack of adequate walking and cycling infrastructure; unfavorable walking and cycling conditions; service reliability, waiting time and absence of direct route of feeder bus services; lack of adequate and economical modal interchange options; and the quality and facilities available at transit nodes. Collectively, these weak links can act as a deterring factor in the usage of mass transit modes compared to private modes (Hengky, 2012). While the type of mode used depends on the distance of the origin point to the transit station the use of NMT can greatly be influenced by other factors such as density, landuse, layout, overall environment, etc. (Loutzenheiser, 1997; Parsons Brinckerhoff Quade & Douglas et al., 1996). The use of NMT as a sustainable transport solution to cover the last mile to transits is gaining acceptance and being widely researched upon globally.

It is heartening that NMT (including walk, cycle and cycle-rickshaws) constitute about 40% of the modal share in Indian cities having population greater than 5 million (CSE, 2013). Yet, their potential in serving as last mile solution in a planned and concerted manner remains untapped. A World Bank report on "Demand, Constraints and Measurement of the Urban Pedestrian Environment" in 2008 remarks, "The urban poor make up a city's 'captive walkers,' but since this group has the least resources, it usually has the smallest political voice". In Delhi the lack of adequate walkable and cyclable environment accentuates the problem of mass transit users. Despite difficult conditions, several studies point towards the popularity of NMT, albeit declining, as the last mile option: 82% walked or used a cycle-rickshaw in 2008 (Gupta, Agarwal, 2008), 79% walked or used a cycle rickshaw for covering the first and the last mile in 2010 (Chidambara, 2010), and 37% walked, cycled or used a cycle-rickshaw (Dwivedi, Gupta, 2012). Absence of a safe, comfortable and convenient environment for NMT may be one of the reasons of the declining share of NMT as last mile option for mass transit systems.

2. Profile Of Delhi Metro

The DMRC opened its first corridor between Shahdara and Tis Hazari in December, 2002. Presently (2015), the Delhi Metro network consists of about 193 operational kilometers with 146 stations including that of the Airport Express Link.

The Delhi Metro has 7 lines developed under 3 phases. Phase I of the project consisted of 3 lines with 58 stations and total length of 65 kms. Phase II added 85 more stations with an addition of 125 km. The third phase which is ongoing will add another 159 km to the network. The total length, number of stations developed for various lines, and the average daily ridership for each line are indicated in Table 1. The yellow, red and blue lines carry the highest ridership. Out of the total metro stations only 23 stations have feeder shuttle services. The average daily ridership of metro has risen from about 124,000 in 2004/2005 to about 2,190,000 in 2013/2014, as indicated in Figure 1.

Table 1: *Line-wise characteristics of Delhi Metro*

Line	No. of Stations	Length (in km)	Avg. Daily Ridership
Yellow	34	44.65	962,144
Blue	51	58.67	730,983
Red	21	25.09	818,709
Green	16	18.46	73,542
Violet	18	23.24	153,191
Orange	6	22.7	
Total	146	192.81	2,738,569

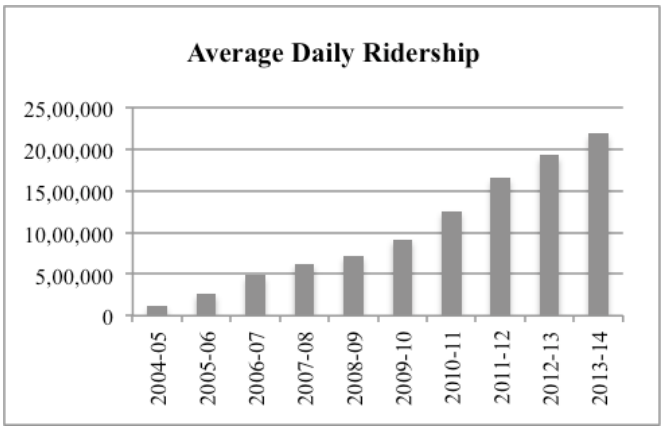

Figure 1: *Average Daily Ridership in Delhi Metro (2004/2005 to 2013/2014)*

3. Research Design and Data Base

The study was conducted on 6 metro stations of Delhi having varying characteristics. The selected stations are located on different lines of the metro network and parameters such as station typology (interchange, mid-block and terminal), ridership, density and type of land use in the surrounding vicinity were considered for selecting the stations. A rapid assessment of the shortlisted stations was conducted in terms of last mile modes availability and quality and stations exhibiting varying quality of last mile were selected. A sample of 30 commuters was taken at each station and surveys were limited to capture commuters alighting the metro station. As such, the last mile characteristic is representative of the sampled station whereas the first mile characteristic is not representative of any known station/locality. The last mile trip characteristics have been assessed in terms of their overall quality that includes the number of options (modes) available and their frequency (or waiting times), cost and time incurred, and other aspects such as safety, comfort, convenience and availability of infrastructure. Non-motorized transport (NMT) in this paper includes walk, bicycle, and cycle-rickshaw.

3.1 Station and its Surrounding Area Characteristics

Table 2 indicates the station characteristics in terms of ridership and typology and its surrounding area key characteristics in terms of density, land uses and availability of modes for LMC.

Rajiv Chowk is the busiest station of Delhi and falls in the CBD of the city with a heavily commercial and public/semi-public (PSP) land use in its vicinity. The average density although low at approximately 200 persons per hectare (PPH), the area attracts a huge number of trips. The fact that it is an interchange station for two of the highest ridership lines (blue and yellow lines) adds to its high ridership. The only LMC mode available is auto-rickshaw although bus is available after a short walk. The station has no cycle-rickshaw or cycle rent facility.

Chandni Chowk station falls in a very dense and congested part of the old city having primarily commercial and mixed land uses. The density is high with approximately 700 PPH. The area is an intense activity zone with its narrow streets and by-lanes, its cultural heritage and a rich variety of formal and informal retail and wholesale commercial activities. Daily commuters as well as a large number of occasional visitors and tourists throng the area. Rickshaws and autos are available at a little walking distance.

Noida City Centre station is on the blue line and falls in the National Capital Region (NCR). Being a terminal station, and a lot of people commuting between Noida and Delhi, the station's catchment area is much higher (averaging 4.2 kms) in comparison to the other stations. A lot of new residential development is in the vicinity of the station. Commercial development in the city center has also commenced which is likely to increase the ridership manifolds. It has a huge parking space for private vehicles and a large number of options, although unorganized, for last mile connectivity are available.

Chhatarpur station, although a mid-block station on the Delhi-Gurgaon line, is located at the periphery of Delhi. As such the station, like the one at Noida city center, has a larger catchment (3 km). The overall density around the station is average (350 PPH), with pockets of Like the 'Vikram' service in Noida the 'Gramin Seva' is an important last mile connectivity to far-flung and peri-urban pockets.

Table 2: *Station Area Characteristics*

Station Name	Ridership	Typology	Adjacent area characteristics		Last mile modes available
			Land use	Density (in PPH)*	
Rajiv Chowk	64,415	Interchange	Commercial, PSP	200	Auto
Chandni Chowk	62,743	Mid block	Commercial, mixed use	700	Rickshaw
Noida City Centre	28,455	Terminal	Residential	250	Rickshaw, auto, shared auto (Vikram), bus
Chhatarpur	24,331	Mid block	Informal residential, PSP, informal commercial	350	Auto, shared auto (gramin seva), feeder shuttle, bus
Vishwavidyalay	23,182	Mid block	Residential, commercial, institutional	400	Rickshaw, auto, e-rickshaw, bicycle on rent, feeder shuttle, bus
Akshardham	14,589	Mid block	PSP, residential	350	Rickshaw, bicycle on rent, auto, feeder shuttle, bus

Source: DMRC and Primary Survey, 2015.
** the densities in persons per hectare (PPH) are approximate and generalized for the entire vicinity; it does not reflect the mix of high and sparse density pockets separately that may be present around the same station.*

Vishvavidyalay is a mid-block station located on yellow line. The station has Delhi University (institutional), and dense residential and mixed uses in its vicinity. The area is also popular amongst the youth for recreational and shopping purposes. The station has many options for transfer including a highly popular 'bicycle on rent' facility providing a comfortable last mile journey.

Akshardham station has a public/semi-public facility (Akshardham temple) with sparse development on one side and dense low-income residential on the other side. The station also has a parking facility for private vehicles, although the supply is much higher than the actual demand. The station is well-served by a number of options for last mile connectivity. Significantly, it has a 'bicycle on rent' facility, which has no takers.

4. First/Last Mile Trip Characteristics and Quality

4.1 User Characteristics

The maximum percentage of users fall in the category of monthly income ranging between Rs10,000 - Rs20,000 (28.3%) and Rs20,000-Rs50,000 (27.2%). This is followed by the income range Rs50,000 – Rs100,000 (18.9%), less than Rs 10,000 (14.4%) and greater than Rs 100,000 (11.1%). At Chandni Chowk commuters predominantly belonged lower to middle income category with no users captured in the highest income category whereas at Akshardham none of the commuters belonged to the lowest income bracket. [NOTE: Rs100=USD1.5]

4.2 Last Mile Trip Characteristics

The last mile trip characteristics can be analyzed in terms of several characteristics and not merely the availability of a mode. Table 3 represents a brief summary of the various components of LMC that different research have considered. These identified components have been discussed in the context of this paper.

4.2.1 Modes opted

The use of NMT for covering the first and last mile is popular (more than 50%) for all stations with the exception of Noida (46%) and Chhatarpur (27%). Better walkability conditions combined with shorter last mile trip lengths and non-availability of other NMT modes gives Rajiv Chowk the highest (87%) share of walk trips.

At Vishvavidyalay, where there is 'bicycle on rent' facility available, a significant percentage (13%) of commuters are using this mode for their last mile trip. This indicates that availability of a facility does impact user choices. However, one needs to be cautious and also take into considerations contextual factors while planning for a facility. The presence of a significant proportion of college-going and young age-group commuter at this station may account for the cycle's popularity. Whereas in the case of Akshardham, which has a similar and better quality 'bicycle on rent' facility it has no takers, as the area is largely visited by tourists (generally families) for recreational and religious purposes, who prefer cycle-rickshaws to cycling. The intensity of activity and the user group need to be considered while planning for such facilities.

4.2.2 Trip purpose

At Rajiv Chowk almost 97% trips work and recreation (that includes shopping) related with an almost equal distribution between the two. Chandni Chowk has higher share of work related trip (60%) and almost the entire rest as recreational. Noida City Centre shows a high work-related trip (73%) and almost the entire rest as educational. Chhatarpur has maximum share of work trips (56%), followed by recreational which is also on account of the Chhatrapur temple located in the vicinity. At Vishvavidyalay, there are almost equal share of trips for educational and recreational purpose (40% and 36% respectively) and the rest for work. Akshardham has 63% trips for recreation followed by work and education. The use of cycle increases when the

Table 3: *Components of Last Mile Connectivity*

Literature Source	**Identified Components**				
	Mode	**Time**	**Dis-tance**	**Cost**	**Other**
Iseki, Taylor, Miller (2006)	√	√	√	√	Frequency, reliability, safety, amenities, walk/cycle environment
Tay (2012)	√	√	√	√	Experience (including waiting)
Nelson/Nygaard (2009)	√	√	√	√	Safety, frequency, reliability
Wang/Odoni	√	√	√		Frequency, reliability
Puello, Geurs (2015)	√				Quality of infrastructure, safety
Giovani, Rietveldt (2008)	√	√	√	√	Service schedule, reliability, comfort, safety, information, infrastructure

Table 4: *Average Trip Length*

Station Name	Main Haul		First mile		Last mile		First & Last mile		Total trip
	in kms	in %age	in kms	in %age	in kms	in %age	in kms	in %age	in kms
Rajiv Chowk	12.6	79.8	2.2	13.9	1.0	6.3	3.2	20.2	15.8
Chandni Chowk	10.6	81.2	1.3	9.8	1.2	9	2.5	18.8	13.1
Noida City Centre	18.4	77.3	1.2	5	4.2	17.7	5.4	22.7	23.8
Chhatarpur	20.8	80.3	2.1	8.1	3	11.6	5.1	19.7	25.9
Vishwavidyalay	21.3	80.1	2.7	8.1	2.6	9.7	5.3	17.8	26.6
Akshardham	17.3	86.5	2	10	0.7	3.5	2.7	13.5	20.0

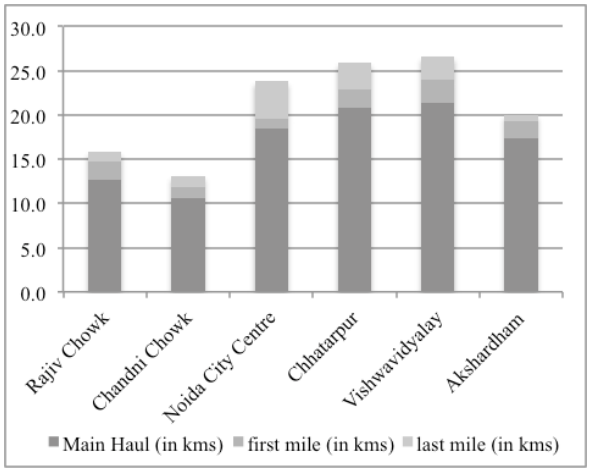

Figure 2: *Average Trip Lengths (in kms)*

educational trips are higher. Walking and cycle-rickshaw are more preferred modes for recreational purpose. However, it cannot be concluded that the overall use of NMT varies much with respect to the trip purpose; rather it appears to vary with the station characteristics and availability of modes, facilities and walking conditions.

4.2.3 Average Trip Length

Table 4 gives the average trip lengths of the different sections of the trip including the transit main haul, the first and the last mile and for the entire trip for the different stations. The average trip length for the first and last mile, although relatively lesser for stations located in the center of the city (2.5 km for Chandni Chowk and 3.2 km for Rajiv Chowk), it yet constitutes a significant percentage of the total journey (18.8% and 20.2% respectively). It is also interesting to note that commuters prefer at least one end of the journey to be shorter, preferably less than 2 kms, which is an easily negotiable distance for NMT.

It can be seen from Figure 2 that the last mile distance is higher for stations located in outlying areas (Noida city center, Chhatarpur), both in terms of absolute numbers (4.2 km and 3 km respectively) and as a proportion of the total trip length (17.7% and 11.6% respectively). The applicability of using NMT as the last mile option would thus vary with varying station area characteristics.

4.2.4 Cost and Time

The time and cost incurred in the last mile are important reflections of the last mile connectivity. Figure 3 (a) & (b) indicate the proportion of cost and time spent in the first and last mile to the total journey. The time for each trip segment is inclusive of the waiting time incurred in that segment. It can be seen from the figure that in terms of absolute numbers, the cost and time spent in the last mile is maximum for stations located in outer areas, i.e., Noida City Centre and Chhatarpur. This accrues from the larger trip lengths in these areas. However, for all stations combined, the average cost and time spent in the first and last mile is almost 50% of the total journey (49.7% and 47.7% respectively), indicating a poor quality of the last mile.

It can also be inferred from the figure that commuters try to balance the cost and time by keeping it low for one leg of the journey when the other leg gets considerably high, as is very clear in the case of Noida and Rajiv Chowk. This further gives potential to develop proper NMT facility and infrastructure.

4.2.5 LMC quality with respect to NMT

The quality of the last mile to a great extent influences transit ridership and the choices opted by users. Nelson/Nygaard (2009) talk of first mile/last mile barriers for commuters who "could potentially take transit but whose starting point or final destination cannot be conveniently accessed from the nearest transit stop/station due to distance, terrain (hills, street patterns), or real or perceived safety issues (traffic, crime)". As mentioned in the introductory section, poor walking and cycling infrastructure and conditions are significant deterrents to use of public transport.

The study analyses the quality in terms of service connection (frequency, reliability), comfort, accessibility (including walking/cycling environment), safety (in terms of crime and traffic), attractiveness, and amenities. These aspects are being discussed in the paper with respect to NMT.

At Rajiv Chowk, despite recent efforts to improve walking infrastructure, the infrastructure is far from satisfactory. The condition of sidewalks is poor. Pedestrians have to negotiate vehicular traffic to cross roads. However, the crossing is not critically dangerous because of relatively low vehicular speeds and well-located tabletop at-grade crossings. Undesignated spaces for auto-rickshaws restrict the free movement of pedestrians. While there is a bicycle parking facility, there is no facility for 'bicycle on rent', which given the short last mile trip lengths, the user categories and the weekly "raahgiri" activity held in the

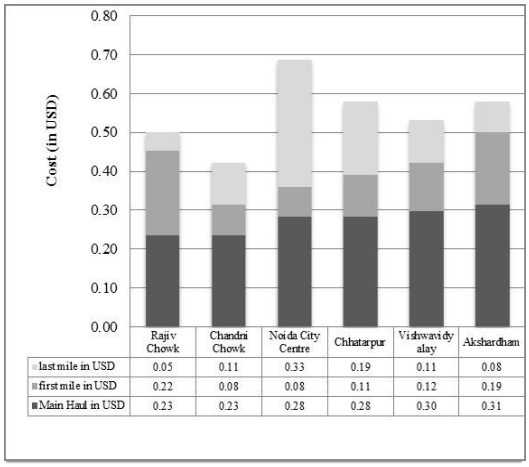

Figure 3(a): *First/Last Mile Travel Cost*

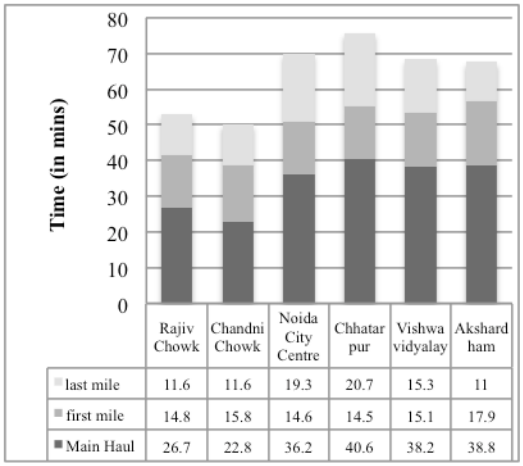

Figure 3(b): *First/Last Mile Travel Time*

area has tremendous potential. The overall safe feeling in this area is good.

Chandni Chowk has a huge potential for NMV facilities improvement. Safety from the point of view of traffic is rated as good as pedestrians do not come in direct conflict with vehicles, but the overall safe feeling is ranked as poor. There is a lot of encroachment on road making it difficult for pedestrians to move freely and also creating conditions conducive to petty crimes such as pickpocketing. Sidewalks and crossings are not available but these are not required as the entire street is pedestrian dominated with minimal vehicular traffic. However, the surface condition of the road is poor and extremely unfriendly for people with special needs. Also there is scope for improvement of sidewalks in the surrounding areas. The cycle-rickshaws are parked in a chaotic manner. Bicycle on rent facility is not available although there is opportunity, given the low-income category and heavy tourist ridership.

Noida City Centre is one of the worst when it comes to provision of NMT infrastructure. The only good feature here is a designated place for cycle rickshaws. However, commuters have to negotiate through unsafe vehicular traffic movement to access the cycle-rickshaws. The condition of the sidewalks is not good and not at all designed with consideration for universal accessibility. Being located right near an intersection of an arterial and a sub-arterial, there is heavy pedestrian crossing negotiating through heavy vehicular movement. The level of illumination and low level of street activities in the surrounding areas, presence of a bus depot at another end of the crossing with buses queuing up on roads, rash driving and chaotic parking by shared auto-rickshaws, gives the area an overall unsafe rating.

At Chhatarpur, while the condition of pedestrian infrastructure within the station premise is satisfactory: the sidewalks and crossings are good and there are tactile pavement and escalators; the same cannot be said of its surrounding vicinity. The overall safe feeling of this area is ranked poor. Lack of NMT modes, poor walking and cycling conditions in the vicinity and unsafe feeling result in heavy dependence on motorized modes for last mile connectivity.

The Vishvavidyalay station has a fair quality of NMT facilities. The NMT options available are higher. The walking and cycling conditions are comparatively good and the overall safe feeling is rated good. However, there is scope for improvement in terms of more and better quality provisions for "bicycle on rent" as the present supply runs short of the huge demand.

In almost all the stations, barring Chhatarpur, there is significant usage of NMT to cover the last mile. Despite the heavy patronage, there is little attention given to creating a reasonably good environment for NMT.

5. Policy and Planning Environment

Transport policies in the past were almost silent on the importance of last mile connectivity for transit systems. While transport policies did talk of promoting public transit systems, multi-modal integration and non-motorised transport, they were by large silent on the LMC aspect of transit systems.

In recent years, however, policies do recognize the significance of both LMC and NMT. The Working Group on Urban transport for the 12th FYP does not deal separately with the aspect of LMC but it does point out its significance in the context of integration. "The most critical requirement is the creation of multimodal interchange facilities where commuters can change modes or routes without much time penalty and in safety without coming in conflict with other vehicular modes. Such locations occur at the point where two public transport services cross and at various road junctions where commuters may need to change direction or to take a feeder service. In addition commuters will need to interchange at inter-state bus terminals, railway terminals and airport. All these interchange points will also need to cater to interchange with personal modes, from the surrounding areas, such as car, 2-W and bicycle and public modes i.e. para-transit, autos, taxis and cycle rickshaw etc., by providing 'Park and Ride' and 'Pick up and drop off" facilities."

The report further recognizes the role of "cycle rickshaw as an intermediate public mode of transport and best suited to provide the last mile connectivity in an integrated citywide multimodal public transport network".

The new National Urban Transport Policy (NUTP) for the first time talks explicitly on "last mile connectivity". It broadens the scope of multi -modal integration to include "private modes of transport i.e. walk,

cycle, cars and 2-wheelers and para transit modes i.e. tempos, autos, mini bus and cycle rickshaw to the mass rapid transit network" which was previously "limited to integration of buses with Metro rail" (IUTI, 2014). The policy also recognizes the significance of improving last mile connectivity to public transport through provision of footpaths and cycle lanes, provision of feeder services, and incorporating design principle to promote safety, accessibility, reliability and affordability, amongst other measures.

However, the realization of policy to planning is yet at a very nascent stage in most Indian cities including Delhi. Most cities take up transit system and NMT planning in isolation to each other. It is also true that while cities have been enthusiastic in introducing transit systems, there has been rather lackadaisical approach towards NMT planning and its integration with transit systems. There is very little work done in the field; and little of what has been done, has focused on mere provisioning of feeder services, and that too in bits and pieces, without understanding user behavior with respect to varying conditions.

More than 10 years since its first operation, Delhi metro is yet to prepare a plan, which addresses LMC issues in a holistic manner. Ad -hoc efforts in the form of starting feeder routes, which cover a miniscule percentage of total stations (less than 15%) and public bike sharing at 3-4 stations, do not indicate of the seriousness that the issue requires. The callousness of transport agencies towards lack of provision or demarcation of spaces for IPT and NMT modes at stations, while ensuring private vehicle parking spaces wherever possible also speaks volumes of the attitude towards NMT users. The key challenge, thus is to create sensitivity amongst transit planning agencies towards the role that good LMC can play in increasing the overall transit ridership and thereby profitability. Another challenge is perhaps in building safe and comfortable NMT friendly environment in the larger context, given that most of Delhi roads lack even the basic pedestrian infrastructure, that is, sidewalks. The good intentions in the policy can only be realized through better and sincere planning efforts.

6. Conclusion

The study comes up with a few significant findings that need to be considered while planning for last mile connectivity to mass transit systems. Firstly, for shorter last mile trip lengths, there is greater tendency amongst commuters to opt for NMT. Secondly, in absence of walking-friendly environment or other NMT modes, higher percentage of polluting and unsustainable modes are used even for shorter distances. The propensity to resort to private motorized modes for LMC also increases with lack of or sub-standard para-transit and NMT options. Thus, a significant amount of last mile travel to and from metro stations is being undertaken by unsustainable personalized mechanized modes. NMT have a clear edge over other motorized modes, especially for short distance trips as they have zero carbon emission, and greater flexibility and accessibility. Non-provision of safe and adequate environment for these modes leads to congestion around metro stations, pedestrian and cyclist accidents and fatalities and higher levels of crime against the more vulnerable groups. A report by Centre for Science and Environment (CSE, 2014) shows rise in accidents by 1.3 to 4 times around public transport nodes, markets, etc. The report also cites high percentage of NMT users (44.5% pedestrians and 6.1% cyclists) as victims in road accidents (MORTH,2012 in CSE, 2013).

Provision of safe and convenient environment for NMT is important for long-term sustainability of transit systems. Previous researches (Clever, 2011) also indicate that commuters have a clear preference to walk at least one leg of their transit journey. This fact is reinforced by this study where a large percentage of commuters are seen to have opted for walking and other NMT modes for first/last mile connectivity, despite inadequate infrastructure and conditions. A large majority of the NMT users are captive and for them walking or cycling or negotiating through risk-prone areas to catch a cycle-rickshaw, may not be a pleasurable experience. If NMT operating conditions continue to remain unfavorable it is more likely that commuters would shift to private automobiles or other motorized transport for LMC, the moment it becomes affordable to them.

The attractiveness of the mass transit lies not just within the transit system (and station) but in the entire surrounding that leads to it. Thus creating a network of safe and people-friendly streets in the vicinity of transit stations is imperative for long-term sustainability. One can learn from Singapore policy on transport connectivity that lays focus on improvement of services not just at the hubs but enhancing accessibility of these hubs from the areas surrounding it, thereby improving the last mile experience. The city has also successfully translated policy to planning by not only making all stations barrier-free but through creating at least 2 barrier-free access routes for more than 80% of the hubs.

It is also not sufficient to merely create sidewalks and cycle lanes. The walking and cycling conditions will determine how well these facilities are put to use. Cities like Singapore, Guangzhou have created extensive networks of sheltered or landscaped walkways connecting the transit hubs. This is of utmost significance for Indian cities, given our harsh climatic conditions.

It is important to give commuters choices of modes. The study also points out that standard prescriptive solutions cannot be implemented across all mass transit systems. Contextual planning is important. While certain NMT options may be extremely suitable for a particular situation, the same may be meaningless in other circumstances. Local context specific planning guideline for LMC is required. Environment-friendly and people-friendly modes such as cycle-rickshaw, battery operated rickshaws (which are already plying in certain parts of the city) can play a great role in enhancing LMC in Delhi and many other Indian cities. If cities are serious about reducing vehicular pollution and congestion and making their mass transit systems work effectively, the potential of NMT as green mobility solution for last mile connectivity needs to be duly tapped. Inclusion of NMT in last mile planning has to be a non-negotiable component, to achieve higher ridership (for the transit operator), better journey experience (for the commuter) and larger sustainability goals.

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