

PROMOTING LOW CARBON TRANSPORT IN INDIA



NMT Infrastructure in India: Investment, Policy and Design

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August 2013

UNEP Risø Centre on Energy, Climate and Sustainable Development
Technical University of Denmark

This publication is part of the 'Promoting Low Carbon Transport in India' project

Supported by:



Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

based on a decision of the Parliament
of the Federal Republic of Germany

ISBN: 978-87-92706-19-5

Design and production:

Magnum Custom Publishing
New Delhi, India
info@magnumbooks.org

Photo acknowledgement:

Front and back cover: CEPT University

Disclaimer:

The findings, suggestions and conclusions presented in the case study are entirely those of the authors and should not be attributed in any manner to UNEP Risø Centre or the United Nations Environment Programme, nor to the institutions of individual authors.

Acknowledgements

This research has been done as part of the UNEP sponsored project on Low Carbon Transport in India. We are thankful to all our project partners for various discussions on non-motorised transport issues during the course of the project which have been discussed in this study. We thank all our colleagues at the Transportation Research and Injury Prevention Programme, specifically Prof. Dinesh Mohan for highlighting safety and security issues related to non-motorised transport. We acknowledge the contribution of Dr. Anvita Arora and her team of researchers at ITRANS who worked closely with us on bicycle issues in Asia earlier. Many of these issues were further studied for Indian cities. Data collected by Himani Jain on bicycles in India provided a very valuable source of information for this study. We would also like to thank Pradeep Sachdeva and Sandeep Gandhi for providing insights into infrastructure issues related to non-motorised transport. Our long discussions with Rajendra Ravi and Dunu Roy about non-motorised users, especially bicyclists and rickshaws, have been useful in understanding the broad livelihood issues related to these modes of transport. We thank the reviewers at UNEP Risø Centre, Dr. Jorge Rogat and Dr. Subash Dhar for going through earlier drafts of this report and providing very useful comments. Finally, we would like to thank Ms. Surabhi Goswami and Ms. Josephine Basch for providing valuable editorial inputs during preparation of the final report.

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Abbreviations

BRT	Bus Rapid Transit
CSO	Civil Society Organisation
DIMTS	Delhi Integrated Multi-Modal Transport System
DPR	Detailed Project Report
IPT	Intermediate Para-Transit
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
MOUD	Ministry of Urban Development
MV	Motorised Vehicle
NGO	Non-Governmental Organisation
NMT	Non-Motorised Transport
NUTP	National Urban Transport Policy
PT	Public Transport
ROW	Right of Way
ULB	Urban Local Body



Photo credit: Ekabishek, 2009

1. Background

This report presents a review of Non-Motorised Transport (NMT) projects in Indian cities. The study aims to highlight gaps in implementation of policy, and identify appropriate policy and design interventions required to encourage NMT use in Indian cities. The study is part of a larger research project – ‘Promoting Low Carbon Transport (LCT) in Indian Cities’, which is an initiative of the United Nations Environment Programme (UNEP).

At present, the CO₂ emission per capita in India is approximately one-fourth of the world average, with the transport sector contributing to about 10% of the total CO₂ emissions (IEA, 2010). At the global level, however, the emissions from transport had been constant between 2007 and 2008, while in India the emissions from the transport sector have been growing gradually. Besides CO₂ emissions, the transport sector is also responsible for negative externalities like road congestion, local air pollution, noise and accidents. In urban areas, the share of both public transport and NMT has been declining, resulting in increasing negative externalities. India’s National Action Plan on Climate Change (NAPCC) recognises that Green House Gas (GHG) emissions from transport can be reduced by adopting a sustainable approach, such as increased use of public transport, greater use of bio-fuels, and improved energy efficiency of transport vehicles. India’s goal for the future is to reduce CO₂ emissions per unit of GDP by 20–25%, as compared to the 2005 levels, by 2020 (Energy Information Association 2009). However, recent studies have shown that unless active transport use (pedestrians and bicycles) increases, CO₂ emissions cannot be reduced substantially (Woodcock et al., 2009). Increasing the use of active transport results in other health benefits such as reduction in Cerebrovascular and cardiovascular diseases, as well as the reduction in traffic accidents.

The focus of this project is to contribute to the efforts of the Government of India by:

- Creating an enabling environment for the coordination of policies at the national level to achieve a sustainable transport system.
- Building the capacities of cities to improve mobility with lower CO₂ emissions.

The project has been endorsed by the Ministry of Environment and Forests (MoEF), and will involve working in close consultation with the Ministry of Urban Development (MoUD) for the city component. It is being jointly implemented by the UNEP Risoe Centre, Denmark (URC); Indian Institute of Technology, Delhi (IIT-D); Indian Institute of Management, Ahmedabad (IIM-A); and Centre for Environmental Planning and Technology (CEPT) University, Ahmedabad.

The case study of NMT projects in Indian cities is one of the four case studies being carried out under the LCT project. Other case studies that have been done are: Bus Rapid Transit (BRT) system (CEPT), a Metro System (IIT-D), and Dedicated Rail Freight Corridor (IIM-A). These projects are perceived by policy makers as interventions that can contribute to sustainable development. The complexity of the transport sector and lack of reliable data make it mandatory to undertake these case studies. The objective of the case studies is to understand current realities, address gaps in data, and study the climate impacts of

typical interventions happening in the transport sector. The aim of this case study is to understand policy and design interventions for the implementation of NMT projects in Indian cities and their impact on road users.

1.1 Non-Motorised Transport in Indian Cities

Non-motorised modes include walking, bicycle and cycle rickshaw. In many Indian cities, cycle rickshaw is an important non-motorised mode of intermediate para-transit (IPT). These modes are not dependent on fossil fuels, and have minimal emissions. Thereby, they are truly low carbon modes. Low-income households are dependent on these modes to access employment, education and other essential services. Use of non-motorised transport (NMT) has health benefits, however, with the rise in incomes and poor infrastructure, use of NMT has been declining. Often its users are captive, as they cannot afford other modes of transport. These users are dependent on walking and bicycling, even for commuting longer distances (Mohan and Tiwari 2000). In the 1980s use of non-motorised modes of transport in Indian cities were correlated with income levels. The use of NMT later declined with the increase in income levels (Replogle, 1992). City authorities and state governments have not invested in upgrading NMT infrastructure, resulting in a degrading level of service and increasing risk to pedestrians and bicyclists. This has resulted in a declining use of NMT, with the increasing income levels throughout the years. Nevertheless, NMT dominates the modal share of Indian cities. Even in mega cities, with a population of over 8 million, the modal share of NMT ranges from 40–50% (walking and bicycling). This is attributed to the dense mixed land use patterns in Indian cities, resulting in shorter trip lengths and availability of NMT as the only accessible mode of transport for low-income households.

NMT is also a major mode of transportation to access the public transport system, especially by walking and cycle rickshaw. Typically, a public transport (PT) user is a pedestrian for at least one part of the trip – either during the access or egress part of the trip. Approximately 97% of the total bus commuters surveyed in Delhi walk to access bus service (Advani and Tiwari 2006). Provision of an appropriate well-integrated infrastructure for the use of NMT along with PT improves utilisation of the system and increases its catchment area. While developing infrastructure for pedestrians does not have a direct impact on their speed, such improvements result in easy, comfortable and safe access. The study conducted by Advani and Tiwari (2006) shows that about 96% of bicycle owners walk to access public transport. By providing appropriate parking facilities for bicycles at or near bus stops, and safe bicycle paths, it is likely that more commuters will be added to the bus service, with an increase to the catchment area.

To achieve the sustainability goals of the transport sector, it is necessary to promote use of NMT. This would require change in policies, plan implementations and fund allocations, in order to:

- Retain the existing modal share of NMT, and address the needs of captive users.
- Encourage potential commuters to use the NMT.

The provision of appropriate infrastructure for NMT provides equal access to all, and is a major factor in determining use of public transport in the city. Thus, a complete network plan must be in place for promoting use of NMT that is also well integrated with the existing and proposed PT system of the city.

1.2 Focus and scope of this study

As discussed, NMT is a sustainable mode of transport providing accessibility to all, while having minimum emissions. The purpose of the study is to identify lacunas in existing infrastructure, policies and design intervention, and to discuss appropriate policies and design required to encourage use of NMT in Indian cities. The study presents the role played by NMT in providing the mode choice in Indian cities, and trends in changing patronage for NMT modes. The study highlights gaps in data and issues related to infrastructure quality. The impacts of improving NMT infrastructure in other countries have also been studied. Additionally, a detailed study is presented on the impacts of NMT infrastructure provision along the Delhi BRT corridor on three essential indicators: travel time, accessibility and safety. Furthermore, one of the aims of the study is to understand the impact of improving NMT infrastructure on CO₂ emissions and fuel consumption. However, this has two limitations:

- Comprehensive and complete improvement of NMT infrastructure has not taken place in any of the Indian cities. Hence, the impact of a project on the resulting change in CO₂ emissions and fuel consumption cannot be studied.
- There are other modes of transport and sectors that have an impact on pollution levels. Therefore, the impact of improving only NMT infrastructure cannot be isolated for any city.

Given the limitations, the study discusses likely impacts of improving NMT infrastructure, and its improvement along with bus infrastructure, on CO₂ emissions and fuel consumption, through scenarios.

The objectives of this study are as follows:

- Objective 1:** Discuss the changing trends in walking, bicycling and rickshaw trips, and traffic injury risks faced by NMT users.
- Objective 2:** Identify issues related to infrastructure quality and data gaps.
- Objective 3:** Give an overview of investments by national and local authorities for improving NMT infrastructure.
- Objective 4:** Review existing policies and projects for improving NMT infrastructure.
- Objective 5:** Assess impacts of improving NMT infrastructure along the Delhi BRT corridor.
- Objective 6:** Assess CO₂ emissions under alternate scenarios.
- Objective 7:** Identify policy, and design requirement to encourage use of quality NMT infrastructure in Indian cities.



Photo credit: Jorge Royan

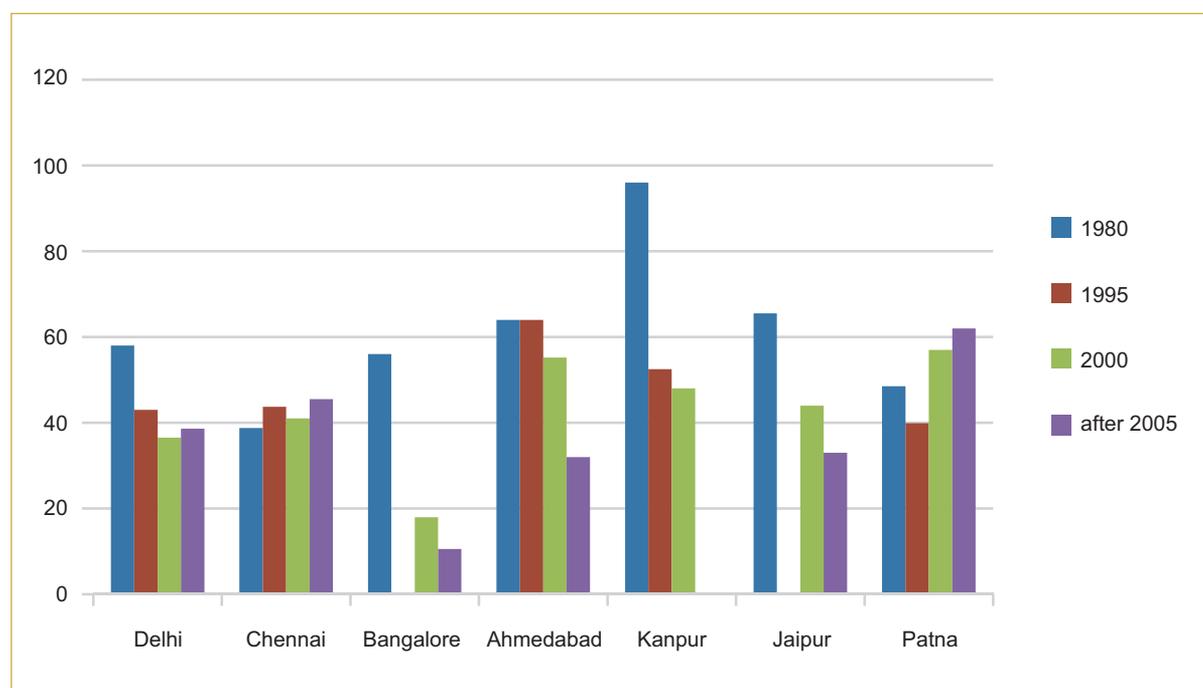
2. Trends in use of Non-Motorised Transport (NMT)

This section discusses changes in the use of NMT from the 1980s to 2010.

2.1 Modal share of NMT

In the early 1980s, NMT in Indian cities, i.e., bicycles and walking, combined, accounted for approximately 40–60% of the total trips. A trend study in seven Indian cities shows that the modal share of NMT has been declining in these cities since the 1980s, except in Chennai and Patna (Figure 1). Bicycles and walking trips follow different trends.

Figure 1: Trends in modal share of NMT (walking and bicycle) since the 1980s¹

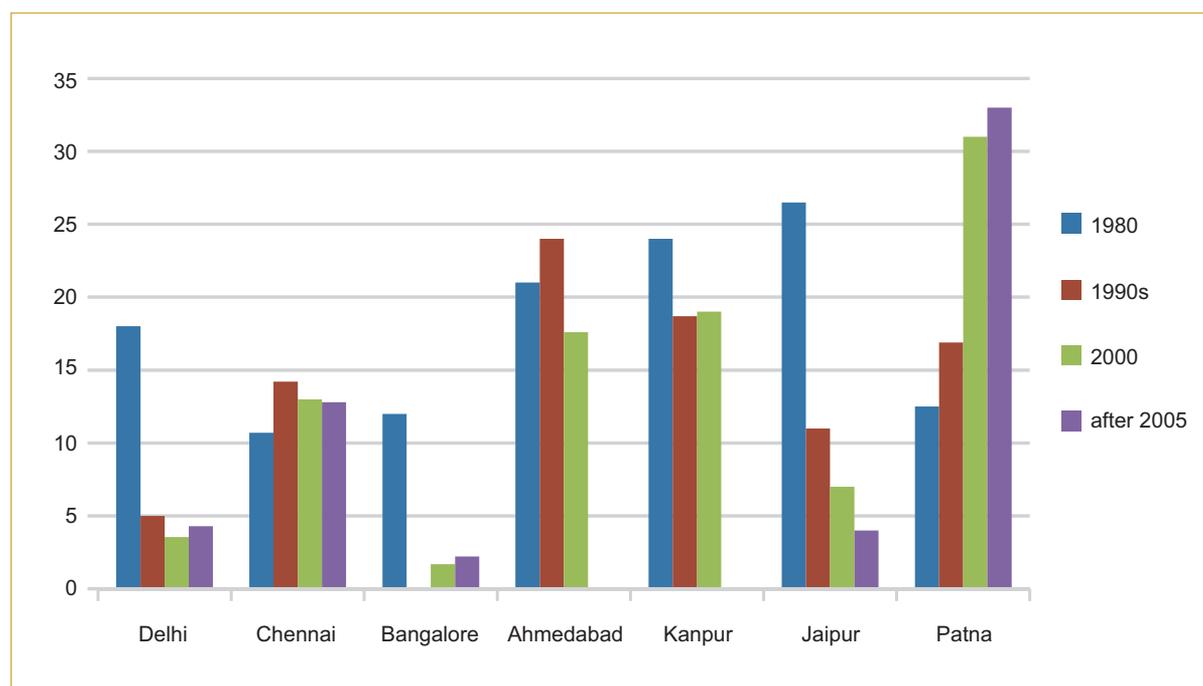


Source: Compiled from various sources – Delhi Metro Rail Corporation 2011; Leather et al., 2011; Itrans 2009; Cept University 2008; Rites 2008; State Level Committee on Road Connectivity & Traffic Improvements 2008; Tiwari and Jain 2008; Wilbur Smith Associates 2008; Rites 2007; Department of Urban Development 2006; Tiwari 2001; Rites 1998a; Replogle 1992; Maunder and Four acre 1989; Pendakur 1988

Of the total trips, the bicycle modal share accounted for approximately 10–30%; bicycle usage began decreasing in the 1990s (Replogle, 1992). In Kanpur, for example, the modal share of bicycles declined by 22% by 1995, as compared to Delhi, Jaipur and Bangalore, where the share of bicycles declined by 66%, 58% and 86%, respectively. The bicycle modal share in Chennai has remained unchanged, while Patna has witnessed an increase in the share of bicycles since 1990. The rate of increase has declined since 2000.

¹ Modal share after 2005 refers to different time periods as – Delhi (2007), Chennai (2005), Bangalore (2007), Ahmedabad (2008), Jaipur (2011), and Patna (2009).

Figure 2: Trends observed in modal share of bicycle trips since the 1980s



Source: Compiled from various sources – Delhi Metro Rail Corporation 2011; Leather et al., 2011; Itrans 2009; Cept University 2008; Rites 2008; State Level Committee on Road Connectivity & Traffic Improvements 2008; Tiwari & Jain 2008; Wilbur Smith Associates 2008; Rites 2007; Department of Urban Development 2006; Tiwari 2001; Rites 1998a; Replogle 1992; Maunder & Four acre 1989; Pendakur 1988

Trends observed in the bicycle modal share are different from those observed in walking trips. The share of walking trips has decreased in most cities compared to the 1980s. Bangalore, Kanpur, and Jaipur have experienced a sharp decline in walking trips, whereas in Delhi and Chennai the share of walking trips have remained unchanged. Patna shows a different trend since the mid 1990s; the share of walking trips have been gradually increasing. Of the total trips, walking trips account for approximately 30–40%, except in Bangalore where walking modal share had gone down to 8.33% in 2007, as compared to 44% in 1984. Moreover, in Kanpur drastic changes have taken place where the modal share of walking declined by 60% from 1984 to 2000. Delhi and Patna have shown similar trends where the modal share of walking first declined in the 1980s and then started to increase after 1995.

2.2 Bicycle ownership

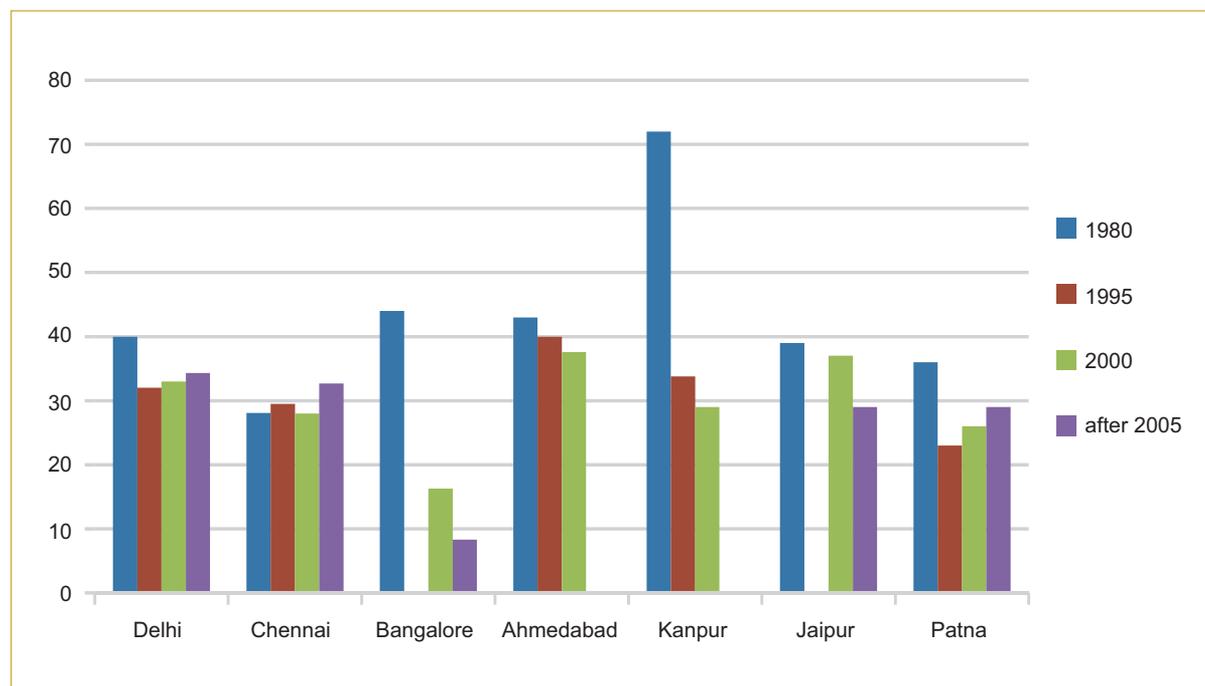
Bicycle ownership is very high in all Indian cities. Approximately 35–65% of households in most medium and large cities own one or more bicycles, according to the Census in 2001, whereas in smaller cities, it varies between 33–48% (the exception being Mysore, with only 27% of households owning bicycles). There are 54.43% of households in Ahmedabad, and 63.4% of households in Chandigarh owning one or more bicycles. In Delhi, 37.6% of households owned bicycles in 2001.

2.3 Cycle rickshaw trips in Indian cities

Cycle rickshaws, both passenger and freight, exist in many Indian cities, however, transport planners, traffic police and policy planners do not recognise their role in the mobility system. RITES (1998b) conducted a study of 21 cities for the Ministry of Urban Development. The study showed a substantial

share of rickshaws in several cities. A similar study was commissioned in 2008 to understand the mobility trends in Indian cities by the Ministry of Urban Development (Wilbur Smith Associates 2008). The study covered 31 cities; however, rickshaws were not counted as a separate mode, and were combined with bicycles. Since the presence of cycle rickshaws were not taken into consideration in the data, there is no discussion about their positive contribution to the city mobility system, or the required infrastructure.

Figure 3: Trend observed in modal share of walking trips since the 1980s



Source: Compiled from various sources – Delhi Metro Rail Corporation 2011; Leather et al., 2011; Itrans 2009; Cept University 2008; Rites 2008; State Level Committee on Road Connectivity & Traffic Improvements 2008; Tiwari & Jain 2008; Wilbur Smith Associates 2008; Rites 2007; Department of Urban Development 2006; Tiwari 2001; Rites 1998a; Replogle 1992; Maunder & Four acre 1989; Pendakur 1988

Rickshaws are often blamed for creating congestion. However, Tiwari et al., (2007) show that if NMT is segregated from motorised traffic, road capacity can increase. Segregated lanes are possible on arterial roads where right-of-way is more than 30m. Rickshaws are an important feeder mode for public transport systems. Advani (2010) presented estimations for the Delhi metro for 2021. At least 24% of metro trips are dependent on cycle rickshaws, and it is possible to estimate and plan for the necessary infrastructure. The study has shown that in the future rickshaws can also be used as a feeder mode. Recognising the role of cycle rickshaws, not only as a mode of transport for short trips but also as an important feeder mode to public transport systems and adoption of favourable policies to integrate into the overall transportation planning, should be a requirement while planning a public transport system. At present, a number of cities in India are planning to implement either Bus Rapid Transit systems or metro systems. These cities have an opportunity to integrate rickshaw-friendly infrastructure at the planning stage of these systems.



Photo credit: Solutiva Consultores

3. Issues

NMT users (bicyclists and pedestrians) have the highest share of traffic accidents. With the increasing urbanisation and motorisation over the past decades, fatality rates have also increased across all cities where the share of NMT in traffic accidents is high. Injury data available at the national level does not report pedestrian and bicycle injuries correctly due to the reporting system used by the police. Victims are classified by the road use responsible for causing the crash; therefore, the number of pedestrians and bicyclists are shown as 13% and 6%. In reality, the number of pedestrians and bicyclists as traffic crash victims are much higher. This information is available in few city-level detailed studies (Mohan et al., 2009). The number of road users killed in the cities of Mumbai, Delhi, Kota, Vadodara and selected highway locations show that car occupants were a small proportion of the total fatalities. Pedestrians, bicyclists, and motorised two-wheeler riders accounted for 60–90% of all traffic fatalities (Mohan & Tiwari 2000). Bhalla et al., (2007) show that the impact of increased trip length by pedestrians and bicyclists increases their probability of fatal crashes. Recent policies in Delhi, Mumbai and Chennai have resulted in relocating poor households away from the central city. This has increased the travel distance for households relocated to the new areas (Anand 2007). Therefore, the risk of fatal crashes has increased. The mobility indicators for travel to work – distance, time and cost – have increased for 83%, 82% and 61% of the households, respectively, in Delhi (Anand 2007). The relocated households are travelling longer distances than before on arterial or national highways coming into the city. These roads do not have dedicated facilities for pedestrians, bicycles or buses, and have high rates of fatal crashes per km per year based on five years of traffic fatality data in Delhi (Rankawat et al., 2012), resulting in an increasing risk to their lives.

Table 1: Pedestrian and bicyclist fatalities in Indian cities

City	1990s	2000s
<i>Share of pedestrian fatality</i>		
Delhi	42%	55%
Chennai	26.8%	42%
Bangalore	37.1%	44%
<i>Share of bicyclist fatality</i>		
Delhi	14%	10%
Chennai	17.3%	10%
Bangalore		5%

Source: Compiled from various sources – IDES 2008; State Level Committee on Road Connectivity & Traffic Improvements 2008; Tiwari & Jain 2008; IL&FS Ecosmart Limited 2006

3.1 Quality of infrastructure

There is a need to plan and provide safe and comfortable facilities and urban environment for both pedestrians and bicyclists. Various studies have been done so far that identify the change in policies and the infrastructure required, in the Indian context, to provide safe, secure and comfortable movement for pedestrians and bicyclists in the cities. Table 2 summarises infrastructure quality for both pedestrians and bicyclists in different Indian cities, and the initiatives planned by local bodies for improvement during different time periods.

Table 2: Summary of findings from relevant studies: NMT infrastructure quality in Indian cities

City	Infrastructure quality		Source
	Pedestrians	Bicyclists	
Delhi, Vadodara, Jaipur & Patna	Non-existent or poorly maintained footpaths. Pedestrians are, therefore, directly conflicting with motorised traffic.	Non-availability of specific infrastructure.	(Maunder & Four acre 1989)
	Government authorities least concerned with low income groups who are highly dependent on NMT.		
India, Pune		Increased use of MV resulting in increasing risk to bicyclists. Pune has been working to develop bicycle network.	(Replogle, 1992)
Kanpur		City authorities experimented with yellow lane markings on certain main streets.	(Kuranami et al., 1995)
India	There is little provision of facilities for pedestrians and bicyclists. The existing transport infrastructure development programmes are designed for faster modes of transport claiming ROW by displacing NMT.		(World Bank 2002)
Chennai and Bangalore	Non-existent, broken-down, and/or obstructed sidewalks; large height differences between sidewalks and frequent driveways/alleyways; danger at street crossings and distance between crosswalk locations; and flooding in monsoon seasons.	Few exclusive-use lanes, and on other roads bicyclists being pushed off of busy roads by motor vehicles.	(World Bank 2005)

City	Infrastructure quality		Source
	Pedestrians	Bicyclists	
Chandigarh	On some arterials, special pedestrian paths have been constructed.	Constructed 160 km of wide cycle paths between 2001 and 2003.	(Pucher et al., 2005)
Bangalore	Most of the footpaths along the major arterial and sub-arterial roads need extensive repairs and upgradations.		(IDES 2008)
	The footpaths lack continuity, with major portions being in bad shape due to utility repairs and maintenance.		(Kumar and Sudhir 2008)
Delhi	Presently, 40% of roads in the city do not have a pavement refuge, and those that do exist are often unusable, especially by the mobility impaired. Zebra crossings are routinely ignored, and there is large spacing between light controlled crossings. More focus is on providing hurdle-free mobility to MV by building foot over bridges and subways.		(Ghate and Sundar 2010)

Table 2 shows a lack of investment by the city authorities in developing and improving infrastructure for pedestrians and bicyclists. In cities like Pune and Chandigarh, some action plans had been taken up to improve infrastructure, however, their implementation remains incomplete. The major focus of the authorities is on the provision of a transport system to enable uninterrupted flow of MV. This approach has resulted in construction of foot over bridges and subways, consequently increasing the distress of the vulnerable group – i.e., pedestrians. To retain the modal shares for walking and bicycling, and encourage them by choice, it is necessary to withdraw focus from providing service that improves mobility of MV. Instead, it is necessary to prioritise NMT on urban streets and provide an environment conducive to their use that will enable an increase in accessibility and safety for all.

Given the land use pattern and travel behaviour in Indian cities, the following observations are important in order to understand the requirements of NMT users:

- Indian cities have mixed land use patterns, high residential densities, and low-income people who live close to their place of work. Therefore, the majority of the trips, even in mega cities, are shorter than 5 km. This represents a high potential for the use of NMT in Indian cities.

- Indian cities have a large share of NMT users, however, the share – particularly of bicycle trips – has been reducing, despite high ownership of bicycles.
- The majority of the NMT users are not so by choice, but rather out of necessity. With increase in income and poor quality of infrastructure, their share is likely to reduce.
- There is a need to improve safety and convenience for pedestrians, bicyclists and cycle rickshaws, in order to retain the current modal share and attract potential users from other modes of transport who are using motorised vehicles for short trips.

3.2 Gaps in data

The data related to NMT (pedestrians, bicycles and rickshaws) are poorly collected, compiled and presented. Table 3 shows inconsistencies in data gathered for the same city, for the same time period, by different agencies. Most of the city-level traffic studies project the travel demands for motorised modes in the future (Table 4). However, the models applied and results obtained miss the component of projecting travel demand for NMT. Accident data is collected from traffic police, however, the identification of victims and impacted vehicles are not presented.

Table 3: Discrepancies in modal shares in Chennai and Bangalore

	Bus	Car/ Jeep	2-wheeler	IPT	Cycle	Train	Walk	Other	Source
Chennai	29.00	4.00	18.0	2.00	13.00	5	28.00	1.00	CDP 2006
	32.00	20.00	20.0	8.00	9.00		22.00		WSA 2008
Bengaluru	41%	4.56	30.4	5.77	1.68		16.26	0.37	CDP 2006
	41.91	6.62	29.4	11.56	2.22		8.00		CTTS 2007

Table 4: Existing and future transportation demands in Chandigarh

Existing modal share in 2009			
S.No.	Mode	No. of trips/day	Percentage
1	Car	358352	15.07
2	T.W.	841025	35.38
3	Auto	30728	1.29
4	S. Auto	139040	5.85
5	Bus	267268	11.24
6	Cycle	260139	10.94
7	Risk	68160	2.87
8	Walk	412417	17.35
	Total	2377129	100.00

Transport demand forecast for Chandigarh urban complex					
S.No.	Item	Figures (Lakh)			
		2014	2021	2031	2041
1	Population	24.50	31.28	39.42	46.93
2	Employment	9.10	11.64	14.94	17.84
3	Per capital trip rate (motorised)	1.00	1.10	1.20	1.30
4	Total trips	29.34	40.56	56.31	73.40
5	Intra city trips	24.50	34.41	47.30	61.01
6	Inter city trips	4.84	6.15	9.01	12.39
7	Modal split (Share by public transport for total intra city trips)	54%	60%	65%	70%

Source: Rites 2009

NMT plays an important role in providing access to public transport modes (bus and metro), however, details regarding access trips are not recorded. Various categories of NMT (bicycles, rickshaws) are merged together; therefore, at the analysis level, specific requirements of bicycles and rickshaws are not discussed.

Injury data at the national level, presented in NCRB reports, does not provide correct information as the reporting system adopted by the police lists the road user causing the crash as victims.



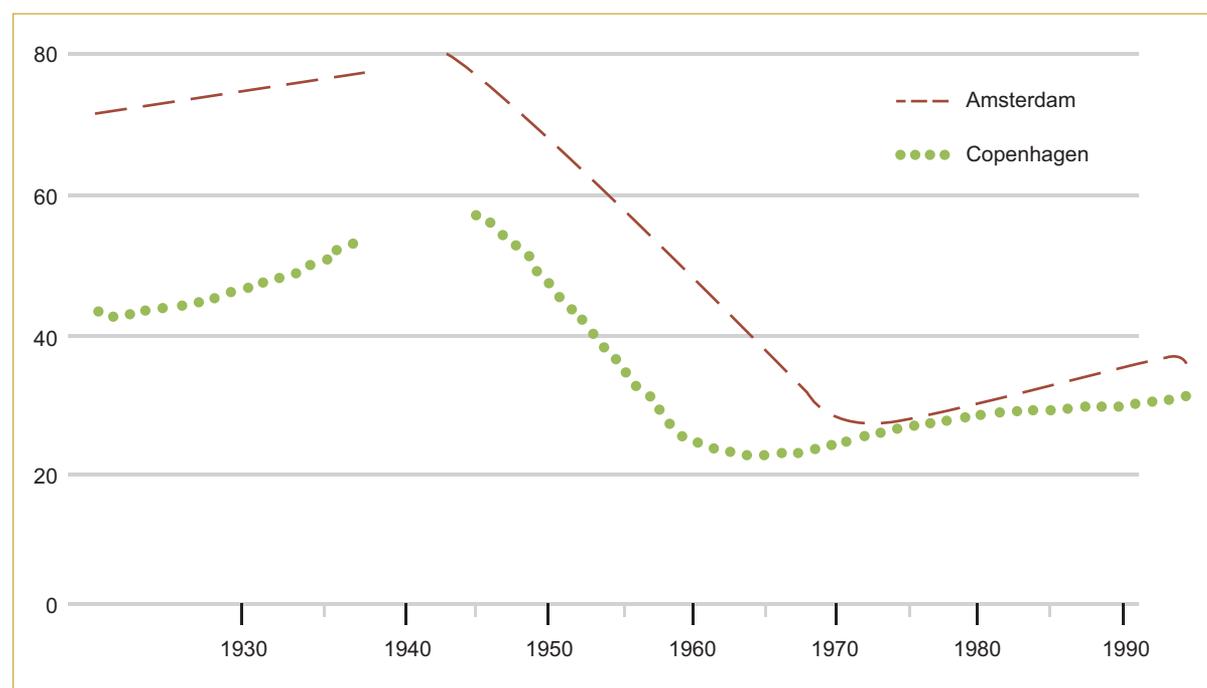
Photo credit: Mathieu Bertrand Struck

4. Policies and infrastructure design for promoting NMT – Experiences from other countries

4.1 Trends in the use of NMT in European countries

The policy changes in both Denmark and The Netherlands have resulted in shifts in modal shares over time. In both countries, as shown in Figure 4, the modal share of bicycles had constantly declined until the 1970s. However, with the help and combined efforts of the community and government, the trend has been reversed over time, despite the harsh climatic conditions in the countries (rain and cold winters).

Figure 4: Trends in bicycle use in The Netherlands and Denmark



Source: Servaas 2000

In Denmark fatalities of bicyclists have reduced by 35%, and in The Netherlands bicycling has increased by 50% between 1980 and 1997. In Copenhagen, about 37% of the residents bicycle, resulting in 90 ,000 tons of CO₂ emissions reduction per year (Kim and Dumitrescu 2010).

From Figure 4 it is evident that the appropriate provision of infrastructure for NMT reduces the obstacles for its users, and encourages both captive and potential users. The policy framework adopted to encourage use of NMT rests on safety and built environment issues. Below are descriptions of policy interventions from countries that have been able to reverse the trend in declining shares for NMT.

4.2 NMT infrastructure in The Netherlands

On average, 19% of the trips in The Netherlands are being made by bicycles and 27% by walking, during which a person cycles for 1,000 km and walks for 250 km per year. This is attributed to the development of appropriate NMT infrastructure that is well integrated with public transport, along with strong cultural and political will. The movement of NMT is prioritised at intersections, and NMT users are protected legally in case of a crash. Moreover, restrictions have been placed on the use of MV in certain parts of the city. The responsibility of developing NMT infrastructure lies with municipal corporations, who can have different approaches and expenditure patterns (Brussel and Zuidgeest 2012).

4.3 NMT infrastructure in Denmark

In Denmark, car use increased up until the 1970s, before reorienting transportation policies like provision of limited parking for automobiles in city area to give priority to bicycling and walking. Other land use policies in the city of Copenhagen, such as allocating work space near PT, have also been encouraged.

Figure 5: Car waits for bicyclists to pass before turning right, in Denmark



Source: Fischer et al., 2010

Street designs have been developed by first allocating the required space for pedestrians and bicyclists, then providing the remaining space for cars. The approach shows the clear set priorities of authorities for different mode users (Fischer et al., 2010). Along with this, the provision of infrastructure was made

to allow access for people with visual disabilities, who are more likely to use personal MV in case of the unavailability of barrier-free designs. For movement of bicycles, raised cycle tracks separated from MV lanes using kerbstone have been provided in cities, except for some old interior roads where the bicycle lanes are separated using a white line.

4.4 NMT infrastructure in a developing country – Bogota, Columbia

A new transport model for the city of Bogota was planned with an objective to alleviate poverty and promote social justice. Subsequently, an intensive 300 km long network for bicyclists was planned, and infrastructure for both pedestrians and bicyclists have been integrated with the public transport system. In terms of improvement in bicycle infrastructure, these changes have caused a modal shift towards bicycles from 0.9% to 4%. Also, the development of appropriate infrastructure has resulted in reduced carbon monoxide levels in the city by 28% between 1998 and 2002 (Santos et al., 2010).



Photo Credit: John Walker

5. Infrastructure design for NMT

This section briefly discusses some of the specifications for design of infrastructure to enable safe, secure and comfortable movement for pedestrians and bicyclists.

5.1 Infrastructure for pedestrians

The provision of continuous foot paths creating barrier-free access both at footpaths and intersections is important for enabling comfortable movement of pedestrians on roads (UTTIPPEC 2010). While designing footpaths, it is necessary to understand that a walk space not only provides space for walking but also supports many street activities. In Indian cities footpaths must be well shaded with trees, and amenities like seating and standing areas for hawkers are provided. Footpaths should be wide enough to support existing and future demands, and be well lit, safe and secure to walk on. They should be free from both obstructions and barriers hampering the free movement of pedestrians. A footpath must be appropriately separated from motorised vehicle traffic using kerbstone and buffer zone, in order to avoid pedestrian accidents.

Since the physical distance of pedestrians is an important aspect, the provision of Foot Over Bridge and subways leads to detours and increased distance. Thus, for pedestrians, both at intersections and mid-block, it is required to provide at-grade raised/level crossings with pedestrian accentuated signals. Wherever there is an important point of interest or activity and the intersection crossing is farther, mid-block crossing is provided. Also, it is necessary that at intersections the footpaths meet the marked pedestrian crossing to provide continuous movement of pedestrians. At entry points for both properties and intersections, it is required to provide traffic-calming measures like stop line or speed breakers for motorised vehicles.

A complete walkway system is essential for providing access to PT systems. PT stops must be clearly marked and highlighted, and accessible to all including the physically disabled. Placement of bus stops, with respect to intersections, also plays an important role in determining the safety and comfort level of pedestrians accessing it.

5.2 Design of NMT infrastructure

Bicyclists require a complete network, which may consist of bicycle tracks (physically segregated from motorised traffic), bicycle lanes (painted segregation on lower speed roads), and mixed facilities where speeds can be kept below 30 km/hr by traffic-calming measures. The type of segregation depends on the speed of motorised vehicles. In Indian cities bicycle lanes also need to allow movement of cycle rickshaws. Accordingly, the width of the lane/track must be at least 2.5m. Socially safe, lively and well-lit routes are preferred for riding. Routes across parks and leisure routes can further attract ridership of recreational bicyclists. Other facilities for cyclists can also be provided, especially in Indian cities that include bicycle repair shops, kiosks for drinking water and space for street vendors along the bicycle routes.

Special treatment of intersections is required as this is a major point of conflict between bicyclists/NMT users and MV. There is a requirement of traffic signals, advanced stop lines, and bicycle boxes. It is also important to carefully consider the position of the approaching bicycle lane at intersections. Additionally, at the intermediate points of conflict, such as access points to properties, speed ramps should be provided to control the speed of the approaching MV. Bicycling should also be integrated with activity locations and PT systems. This requires provision of appropriate parking facilities. Rent and ride services can also be an important factor in encouraging the use of public transport and bicycles in the city.



Photo Credit: Karl Fjellstrom, itdp-china.org

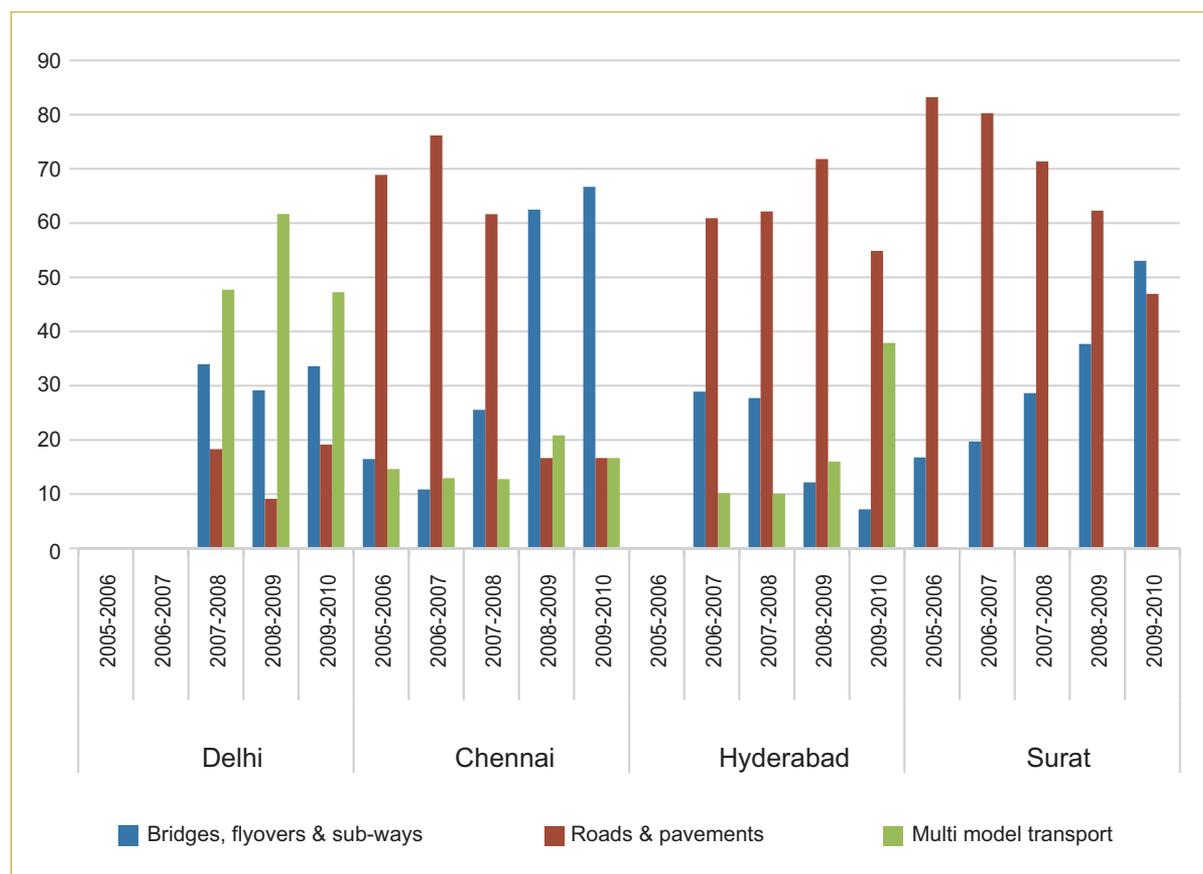
6. Policies and investments

Until 2006, urban and national policies were not aimed at improving infrastructure for non-motorised transport (NMT), resulting in a degraded level of service for NMT users. In 2006, the National Urban Transport Policy (NUTP) was adopted by the Ministry of Urban Development (MoUD). It outlined the steps required to promote the use of public transport systems in cities, such as prioritising public transport, developing infrastructure for safe use of NMT, and transport demand management strategies. Direct projects aiming at improving infrastructure for NMT have not been undertaken, and are restricted to cities where Bus-Rapid Transit (BRT) projects are under implementation – and only along the proposed BRT corridor. Therefore, a holistic approach for NMT is lacking. This study highlights the aspects related to project proposals and the implementation of projects related to improving infrastructure for NMT in the Indian context.

6.1 City budget analysis

Although transport is a state subject, the responsibility of local road improvements and implementation of projects related to road infrastructure development lies with cities or urban local bodies (ULB). Over the past decade, urban travel needs have become more dependent on motorised transport, resulting in accentuated problems related to congestion, pollution, health and safety. The main focus of urban local bodies has been on relieving congestion by increasing road width, building flyovers and enabling uninterrupted flow of motorised vehicles on the road. This section discusses the expenditure pattern of urban local bodies in the transport sector. Four cities have been selected for this purpose: Delhi, Chennai, Hyderabad and Surat – representing three different population size categories for which data was available through publicly accessible resources. The analysis has been compiled from CoC 2009; GHMC 2009; Government of NCT of Delhi 2009; SMC 2009; CoC 2008; GHMC 2008; Government of NCT of Delhi 2008; CoC 2007; GHMC 2007; Government of NCT of Delhi 2007; CoC 2006; GHMC 2006; CoC 2005. Results of the analysis are presented below.

Figure 6: Percentage breakup of capital expenditure in transport



Of the four cities' budget, only Delhi specifies breakup of the expenditures made in transportation for different projects. An analysis can be drawn from Figure 6 that in both Chennai and Surat focus towards construction of bridges, flyovers and sub-ways is increasing. Greater Hyderabad is focusing on multi-modal transport, and in Delhi no particular trend can be determined. As such, improvement of infrastructure for NMT is not separately accounted for in city budgets.

6.2 Budget allocation of JnNURM in transport sector

Of the 4,378 urban agglomerations (as per census 2001) and towns, the Jawaharlal Nehru National Urban Renewal Mission (JnNURM) scheme by the government of India has identified 63 cities in the first phase of urban renewal and reforms, to assist the ULB in upgrading and providing adequate infrastructure services. Among the basic civic amenities required are access to clean water, sewage disposal and transport infrastructure (MUD, 2006). Some of the transport infrastructure provision and upgradation projects include procurement of new buses, planning and optimisation of bus routes, planning other supportive PT systems, road widening, etc.

Table 5 presents the detailed analysis of the number of cities and the types of projects taken up under the scheme, and the amount of investments to be made. As per Table 5, BRTS corridors have been planned and approved for 9 cities, bus procurement has been sanctioned for 53 cities and other projects related to infrastructure expansion have been approved for 21 cities. However, it is understood that the projects

related to improving the safety of NMT users are not the focus of the scheme. Only projects in Nanded and Bangalore have been exclusively taken up for improvement of infrastructure for NMT users.

Table 5: Cities approved for different transport projects funding under JnNURM

Category of cities as per WSA (2008)						
Types of projects	1	2	3	4	5	6
CMP	Ajmer-Pushkar	Trivandrum	Coimbatore Kochi Madurai Jabalpur Amritsar	Pune Surat		Kolkata
NMV	Nanded				Bangalore	
BRTS			Indore Bhopal Vishakhapatnam Vijayawada Rajkot	Pune Surat Jaipur	Ahmedabad	
Bus procurement	Nanded Ujjain Ajmer-Pushkar Mathura Imphal Aizwal Haridwar Agartala Puri Shimla Panaji Nainital Bodhgaya Itanagar	Trivandrum Ranchi Guwahati Chandigarh Mysore Raipur Bhubaneshwar Dehradun	Patna Indore Coimbatore Bhopal Ludhiana Kochi Vishakhapatnam Agra Madurai Varanasi Meerut Jabalpur Allahabad Asansol Dhanbad Faridabad Vijayawada Amritsar	Pune Surat Kanpur Jaipur Lucknow Nagpur	Chennai Hyderabad Bangalore Ahmedabad	Mumbai Kolkata Delhi
Other projects (roads, flyovers, ROB, etc.)	Nanded Haridwar Shimla Kohima Itanagar	Mysore Dehradun	Indore Baroda Kochi Vijayawada Amritsar Rajkot	Surat Nagpur	Chennai Hyderabad Bangalore Ahmedabad	Mumbai Kolkata

Source: Compiled from LEA Associates South Asia Pvt.Ltd. 2009; JNNURM 2009a; JNNURM 2009b



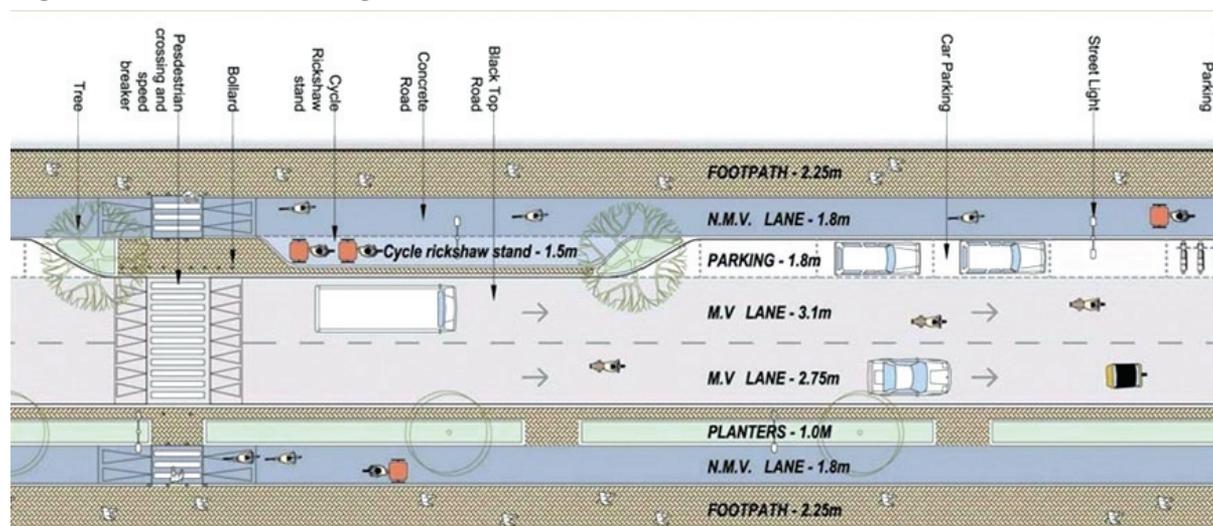
Photo Credit: Rsrikanth05, 2011

7. Projects undertaken to improve NMT infrastructure

7.1 Nanded street improvement strategy

In Nanded, about 50 km of the street has been redesigned to provide a better level of service to different types of road users. A master plan of the road network proposed for Nanded city includes: rationalisation of MV lanes to accommodate all users, separate lanes for NMT, pedestrian precinct around the Sachkh and Gurudwara, and innovative street cross-sections to incorporate tree plantation, hawkers, on-street parking, para-transit stands, street furniture, bus shelters, public toilets etc., (Figure 7). The project has been taken under the JnNURM scheme through a public-private partnership between IL&FS and the Nanded Waghala Municipal Corporation (Pradeep Sachdeva Design Associates 2012).

Figure 7: Cross section design of Nanded streets



Source: Pradeep Sachdeva Design Associates 2012

An important component of the proposed design is equitable allocation of space with a specific focus on providing appropriate infrastructure for walking and cycling. Along with this, depending on the space available, multi-utility zone of width ranging from 2.25m to 2.5m has been provided to accommodate various street activities existing on the roads (Figure 7). The total sanctioned cost for the project is USD 55.2 million, and out of the 35 roads proposed for upgradation, 18 were completed by 2009.

7.1.1 Details of footpaths

Various widths for footpaths have been allocated for different streets depending on their usage. A minimum of 1.8m width to 3.5m width has been assigned for this purpose. The designs of footpaths enable accessibility for all. Additionally, appropriate traffic-calming measures have been incorporated to make streets safer and walkable (ADB 2008).

7.2.2 Details of NMV lanes

Movement of NMT (bicycles, cycle rickshaws and other goods carrying modes) has been segregated from MV by providing one-way and two-way lanes of 2.0m and 2.8m width, respectively, on all roads, except in a few residential areas. The provision of high quality cycle lanes is likely to encourage the use of greener modes of transportation.

Figure 8: Upgraded streets of Nanded



Source: Pradeep Sachdeva Design Associates 2012

7.2 Bangalore City

In Bangalore, upgradation of sidewalks, and asphaltting work of roads surrounding the M.G. Road area has been taken up, costing approximately USD 8.7 million, of which USD 3.05 million was sanctioned under the JnNURM scheme in 2007. However, the aim of the project is to improve traffic management and reduce travel time. An example of the completed section of M.G. Road is shown in Figure 9. The outcomes of the project have been with respect to reduced travel time, vehicle operation cost and accident rate.

Figure 9: M.G. Road, completed footpath and road



Source: Indian Urban Portal 2012

7.3 Improvement of NMT infrastructure along BRT projects sanctioned under JnNURM

Appropriate provision of NMT infrastructure for creating access to PT stations not only increases the catchment area but also the willingness of people to use the system. In nine Indian cities BRT projects have been approved under the JnNURM scheme, as listed in Table 6. Except in Ahmedabad and Pune, only a small stretch of the corridor has been approved for implementation.

Table 6: BRT network plan in Indian cities

City	Planned length of the corridor (km)	Approved length of the corridor by MoUD (km)	Criteria for selection of first corridor
Ahmedabad	88.80	88.80	ROW
Pune	117.00	117.00	ROW
Surat	125.00	30.00	
Jaipur	138.00	42.00	
Indore	106.00	11.50	
Bhopal	44.00 (phase-1)	21.70	High Density
Vishakhapatnam	105.70	42.00	Travel demand, ROW
Vijayawada	42.45	15.50	
Rajkot	63.00	29.00	

Source: Tiwari and Jain 2010

The Detailed Project Report (DPR) of the proposed projects submitted, states the provision of NMT infrastructure along the corridor, as shown in the table below.

Table 7: Infrastructure provision to integrate BRT with NMT

Cities	Proposed integration		Implementation status
	Walk	Cycle & cycle rickshaws	
Ahmedabad	2m wide footpaths, both sides, signalised level crossing and sub-ways at mid-block	2m wide cycle track with signalised crossing	Obstructed and discontinuous footpaths and bicycle tracks. Designed widths do not meet standards. As in 2011, bicycle tracks to be removed to give space for motorised vehicles (TNN 2011).
Pune	Continuous min. 1.5m wide barrier-free footpaths, with signalised raised zebra crossing	1.5m for cycle lanes and 2.5m for cycle tracks, and free parking 60m from bus stops	Continuous footpaths; discontinuous bicycle tracks at certain patches, obstructions and lack of enforcement on using footpaths and cycle tracks by MV users.
Surat	3 to 5m wide pedestrian activity areas & elevated mixed traffic lanes at mid-blocks	2m wide cycle tracks	
Jaipur	2m wide footpaths with signalised crossing	2.5m wide cycle tracks with parking	No dedicated bicycle tracks, and width of footpaths do not match the proposed width
Indore	Barrier-free minimum 1.5m wide footpaths, Signalised crossing	Minimum 1.5m wide cycle tracks, where ROW is not available to be combined with footpaths with cycle box for crossing. Parking near intersections.	
Bhopal	ROW \leq 20m: 1.5m wide footpaths, no provision for bicycles ROW 24 and 30m: 3m wide combined space for pedestrians and bicycles ROW \geq 45m: 2m wide footpaths and 3m wide bicycle lanes Signalised zebra crossing and foot over bridge and sub-ways at mid-blocks where demand is high		

Cities	Proposed integration		Implementation status
	Walk	Cycle & cycle rickshaws	
Vishakhapatnam	Min. 2m wide barrier-free footpaths, signalised zebra crossing	2.5m wide cycle tracks, parking at bus stops	
Vijayawada	2m wide barrier-free footpaths with signalised pedestrian crossing, at high demand locations grade separated facility	2m wide cycle lanes	
Rajkot	1.8m wide footpaths, zebra crossing at junctions	2.2m wide cycle tracks, parking near bus stops	

7.3.1 Walking

- 1 As per Table 7, except in Ahmedabad, continuous footpaths have been planned for the safe movement of pedestrians along the corridor, separate from the bicycle lanes. In Bhopal, where ROW is less than 20 metres, a combined 3 metre wide space has been provided for both pedestrians and cyclists.
- 2 Zebra crossings with pedestrian activated traffic signals have been provided in all the cities, both at junctions and mid-blocks, where bus stops have been planned. Also, at mid-block bus stops, where demand is high, grade separated facilities have been planned in cities like Ahmedabad and Pune. In Surat, the main carriage way has been elevated to provide at-grade crossing for pedestrians. Dedicated routes in all the cities are planned on the central lane, thereby reducing the crossing distance for pedestrians.

7.3.2 Bicycles and cycle rickshaws

Cycle tracks have been planned in the areas, based on the availability of ROW. Moreover, 2–2.5 metre wide cycle tracks have been provided, as well as 1.8 metre wide cycle lanes along the corridor depending on the ROW. Bicycle parking has been planned along the corridor near bus stops and junctions in cities like Pune, Jaipur and Indore.

7.4 Discussion

According to the JnNURM strategy, transport infrastructure improvement projects should comply with the objectives of NUTP. However, as per the study, it is understood that the complete integration of multi-modal systems including NMT are missing. Improving NMT infrastructure requires the provision of facilities extending to the city areas, comprehensively, with direct, safe, secure and comfortable access to all NMT users. By contrast, the development of NMT infrastructure is restricted to the planned corridors of the BRT. Moreover, even after NUTP has been adopted, changes have not been observed in the investment pattern of the respective local authorities. This represents a gap in planning and implementation of a strategy, scheme and policy.



Photo Credit: Subhashish Panigrahi

8. Case study – NMT integrated BRT system, Delhi

The BRT corridor in Delhi is an open BRT system operating since April 2008, from Ambedkar Nagar to Moolchand flyover on a stretch of 5.8 km. The corridor is supported with footpaths and bicycle lanes, along with other supportive facilities such as pedestrian signalised crossings, spaces for street vendors, parking facilities for bicycles and three-wheeled taxis, to provide safe commuting for both NMT and bus users.

Table 8: NMT infrastructure along Delhi BRT corridor

Cities	Walking	Cycle & cycle rickshaws
Delhi	Continuous 2m wide barrier-free footpaths on both sides with signalised raised zebra crossing.	2.5m wide cycle tracks on both sides with signalised crossing and parking near intersections; rent and ride service also available.

8.1 Design features

8.1.1 Walking

Continuous foot paths are provided on both sides of the road that are wide enough to support existing pedestrian flows. At intersections, footpaths adjoin marked crossings for pedestrians – this maintains a continuous path for pedestrians. Pedestrian holding are as are provided at the curb side, at each intersection, where pedestrians can wait before crossing the road. This area is also designed for street vendors. For pedestrian crossings, a 5m wide zebra strip is designed across all intersection arms. This is preceded by a stop line (3m away), which provides a safe zone for pedestrians to cross in front of the stopped vehicular traffic.

Figure 10: People safely crossing road, using zebra crossing on Delhi BRT corridor



Source: DIMTS 2012

Figure 11: At-grade pedestrian crossing mid-block



8.1.2 Bicycles

Bicyclists move on 2.5m wide segregated lanes on the left side, on both sides of the corridor. Special design features to reduce vehicular speed have been incorporated at the entrance of bicycle paths, and wherever a side road meets the main road, to ensure the safety of bicyclists. These lanes have been segregated from the MV lanes (in addition to 0.115m wide and 0.15m high curbs) by a 0.75m wide median/unpaved zone on 75% of the length, more than 0.75m wide greenbelt/footpath on 20% of the length, and 0.3m wide median on 4% of the length of the corridor.

Figure 12: Bicycle track along Delhi BRT corridor



Figure 13: Special traffic signal for NMT on Delhi BRT corridor



Source: Transport Department Delhi and DIMTS 2008

8.2 Assessing the impacts

The Delhi BRT corridor stretch of 5.6 km has been in operation since April 2008. It is too short of a period and stretch to estimate resulting impacts on the modal shares of the city due to the corridor. However, the following impacts have been determined and perceived – data related to speed and flow, and accidents for the stretch of 5.6 km were collected for the period of 2001–2009 from the Delhi Integrated Multi-modal Transit System (DIMTS) and Delhi Police. Some of the findings of the Delhi BRT corridor evaluation, conducted by Tiwari and Jain (2012), have been used in the study.

8.2.1 Impact on speed

As per Table 9, average speeds of buses and bicycles have increased, whereas the speed of other motorised vehicles in mixed lane has decreased. Reduced conflict between bicycles and other motorised vehicles has resulted in increased speed of bicycles on the corridor.

Table 9: Average speed of vehicles on mixed and BRT corridor

Mode	Average speed (kmph)	
	Mixed traffic (before implementation of corridor)	BRT Corridor (after implementation)
Walk	4	4
Cycle	8	12
Bus	12	17
PMV	16	14

Source: Tiwari and Jain 2012

8.2.2 Impact on travel time

Different types of road users have different time saving depending on the mode and length of the corridor they use. Cyclists save the maximum time by using the corridor, followed by bus users (Table 10). However, with the reduced speed of other personal MV, the travel time using the corridor has increased by 0.5 minutes per kilometre of the corridor.

Table 10: Time (minutes) saving after implementation of Delhi BRT corridor for different modes

Mode	Kilometres of the corridor used					
	1 km	2 km	3 km	4 km	5 km	6 km
Cycles	2.5	5.0	7.5	10.0	12.5	15.0
Bus	1.7	3.3	5.0	6.7	8.3	10.0
Personal MV	-0.5	-1.1	-1.6	-2.1	-2.7	-3.2

Source: Tiwari & Jain 2012

Given the traffic volume count survey at the Chirag Delhi intersection in 2008, the total travel time saved by using the entire stretch of the corridor by all the users is 19.7% (Table 11).

Table 11: Total time saving by all the users after implementation of the corridor

Mode	Travel time using the entire stretch of the corridor (min)		Total no. of users	Total travel time (min)	
	Without project	With project		Without project	With project
NMT	45	30	2500	112500	75000
Bus	30	20	12369	371070	247380
Motorised vehicle	22.5	25.7	11790	265275	303171.4
Grand total			26659	748845	625551.4

Source: Tiwari & Jain 2012

8.2.3 Impact on accessibility

For assessing impacts on accessibility, ArcGIS 9.1 is used where multiple ring buffers were created in each mode to help save time when travelling extra distances, with the activities within the buffer area counted. The analysis is conducted to identify primary and secondary beneficiaries of the transport project, i.e., the users for whom accessibility has increased, and those benefiting from increased catchment areas for their destinations.

Table 12: Extra distance (metres) that can be travelled for access/egress due to time savings, using different modes on the Delhi BRT corridor, as per Table 8

Mode	Kilometres of the corridor used					
	1 km	2 km	3 km	4 km	5 km	6 km
Trip by bicycles only	333.3	666.7	1000.0	1333.3	1666.7	2000.0
Time saved in bus and access by bicycles	222.2	444.4	666.7	888.9	1111.1	1333.3
Time saved in bus and access/egress by walking	111.1	222.2	333.3	444.4	555.6	666.7
Time saved in bus and access by PMV	444.4	888.9	1333.3	1777.8	2222.2	2666.7

Source: Tiwari & Jain 2012

Table 12 shows extra distance that can be travelled by different modes due to time saving by using the Delhi BRT corridor for different distances. Based on this, two types of beneficiaries can be identified: primary beneficiaries, who can benefit from the shorter travel times by participating in other activities, and secondary beneficiaries, who travel longer distances, and can benefit from access to more opportunities, as shown in Table 12.

Table 13: Identified beneficiaries using bicycles only; using bicycles to access the BRT corridor and walking to/from the BRT corridor

Types of Beneficiaries			Stretch of the corridor used by different modes						
			Primary	1 km	2 km	3 km	4 km	5 km	6 km
Bicycle users only									
Origins	Slums	Number Population	29 28197	41 32120	52 34552	65 46148	81 55791	94 58447	106 62070
Destinations	Schools	Number Area	19	19	29	34	40	50	54
	Shops/MLU		117 154797	178 202482	212 259170	237 294586	267 339180	302 390535	331 425978
	CC/DC		5	5	6	6	10	11	12
	Government offices		–	0	0	0	1	1	1
Using bicycles to access bus on the BRT corridor									
Origins	Origins	Number Population	29 28197	40 31985	46 32956	52 34552	60 39697	71 51017	81 55791
Walking to access or egress bus on the BRT corridor									
Origins	Slums	Number Population	11 3391	13 3673	17 4949	21 17299	22 17362	25 27458	29 28197
Destinations	Schools	Number Area	6	6	9	12	16	17	17
	Shops/MLU		67 82758	71 94297	73 99849	79 104874	95 124319	110 141832	117 54795
	CC/DC		1	1	1	1	1	3	4
	Government offices		0	0	0	0	0	0	0

Source: Tiwari & Jain 2012

Three types of users benefit from the implementation of the project: those who use bicycles only, commuters using bicycles to access the bus service on the corridor, and people walking to access or egress the BRT corridor. As per Table 13, of the three user types, people using bicycles only benefit the most from the implementation of the corridor (based on the number of opportunities in reach). However, the destinations catchment areas have increased the most for those using the bus service on the corridor and walking for access. If the entire stretch of the corridor were used, it is believed that the total population within reach of activity centres would increase by 120% if only bicycles were used, by 100% if bicycles were used to access bus service on the corridor, and by 73% if people would walk to access the bus service. The greater the stretch of the corridor used, the more destinations become accessible using different modes. The evaluation could be extended further if the mode-wise trip length distribution on the corridor were known.

8.2.4 Impact on safety

Table 14 gives a detailed analysis of the risk to which different groups of users are exposed to, and the risk imposed by them. In general, NMT users are highly exposed to the risk of being involved in a fatal accident. The risk imposed by buses is greater than that of personal MV on other road users. This is attributable to the fact that impact vehicles in some of the fatal accidents are unknown. The risk imposed by buses had come down to zero in 2009.

Table 14: Impact on safety indicators as described in the LCMP toolkit

	2003	2005	2006	2008	2009
Risk exposure to NMT users	0.263	0.055	0.031	0.033	0.002
Risk exposure to bus users	0	0	0	0	0.000
Risk exposure to MV users	0.012	0.010	0.003	0.000	0.000
Risk imposed by MV on other road users	0.006	0.002	0.002	0.001	0.002
Risk imposed by bus on other road users	0.006	0.002	0.001	0.002	0.000

Source: Tiwari & Jain 2012



Photo Credit: Karl Fjellstrom, itdp-china.org

9. Impact on fuel consumption and emissions

A recent study by Jain and Tiwari (2011) examined the impact of various strategies related to infrastructure development for transport on fuel consumption and emissions. In the study, three scenarios – improving only bus infrastructure, improving only NMT infrastructure, and improving both bus and NMT infrastructures – were developed and compared with the baseline scenario for three cities: Delhi, Pune and Patna. In the scenarios modal shifts for different ranges of trip length were assumed. As per the scenarios:

Improving NMT infrastructure in cities is likely to shift 30% of the trips shorter than 5 km from MTW, three-wheelers and buses to NMT, and;

Improving infrastructure for buses is likely to shift 50% of the trips longer than 5 km from MTW and three-wheelers to buses.

The scenarios are based on earlier state preference studies conducted in different Indian cities (Arasan and Vedagiri 2011; Jain et al., 2010; Rastogi 2010; Vedagiri and Arasan 2009).

As per the analysis by Jain and Tiwari (2011), maximum reduction in emissions is achieved when NMT infrastructure is improved along with bus infrastructure for all three cities. Developing an NMT infrastructure in Delhi results in an overall reduction in fuel consumption by 6% and equivalent CO₂ emissions by 1%. This is attributed to a major shift from three-wheelers to NMT, which has negligible contribution to CO₂ emissions. While improving NMT infrastructure along with bus infrastructure is likely to result in emissions reductions by 11% in Delhi.

The impact of NMT and bus infrastructure improvements on CO₂ emissions is highest in Patna, followed by Pune and Delhi. This is because three-wheelers in Patna cater to longer distances, whereas the MTW caters to shorter trip lengths with considerable contribution to CO₂ emissions.

While in Pune improving infrastructure for NMT results in reduced consumption of gasoline by 3%, CNG by 22% and diesel by 8%, in Patna it results in reduced consumption of gasoline by 11% and diesel by 7%. In terms of CO₂ emissions reductions, the maximum percentage of reduction is achieved in Patna by 11%. This is attributed to the fact that the shift is made from three-wheelers that operate on gasoline. Conversely, in Pune the percentage of reduction in CO₂ emissions would be nearly 3% when NMT infrastructure is improved. Even though the maximum percentage of reduction is in Patna, quantitatively a large amount of CO₂ emission is reduced in Delhi – i.e., about 55,000 kg of CO₂ daily.



Photo Credit: Bernard Gagnon, 2006

10. Conclusion and policy recommendations

This study shows the declining shares of walking and bicycling in India over the past two decades. Various studies show increasing risk to pedestrians and bicyclists and deteriorating quality of infrastructure for them. Despite the given conditions and declining share of bicycles, NMT dominates the modal share in Indian cities. Since bicycle ownership is generally high in India and the majority of trips made are short (<5 km), there are a significant number of potential users. Cycle Rickshaws are an important non-motorised mode of transportation, used both for passenger and freight traffic. Pedestrians, bicyclists and rickshaws are also main modes of access to public transport systems. There are major gaps, however, at the level of data collection and demand estimation for non-motorised traffic. Injury data at the national level does not present correct information regarding risks to NMT users.

10.1 Discussion

Even though Delhi BRT corridor has been successful in improving the level of service for NMT and bus users, the implementation of the project is limited to a 5.6 km stretch constructed in 2008. Further steps into implementation of the project have not taken place due to a lack of political will, as well as increasing agitation from small groups of car users. Since the implementation of the BRT corridor in Delhi, there have been ongoing debates regarding road space allocation for different types of commuters. In May 2008, RITES proposed merging footpaths with cycle tracks in order to have 1.9m wide footpaths on either side of the road, and to provide the same for cars (Rao 2008). Issues raised for consideration regarding the implementation of the BRT corridor in Delhi included:

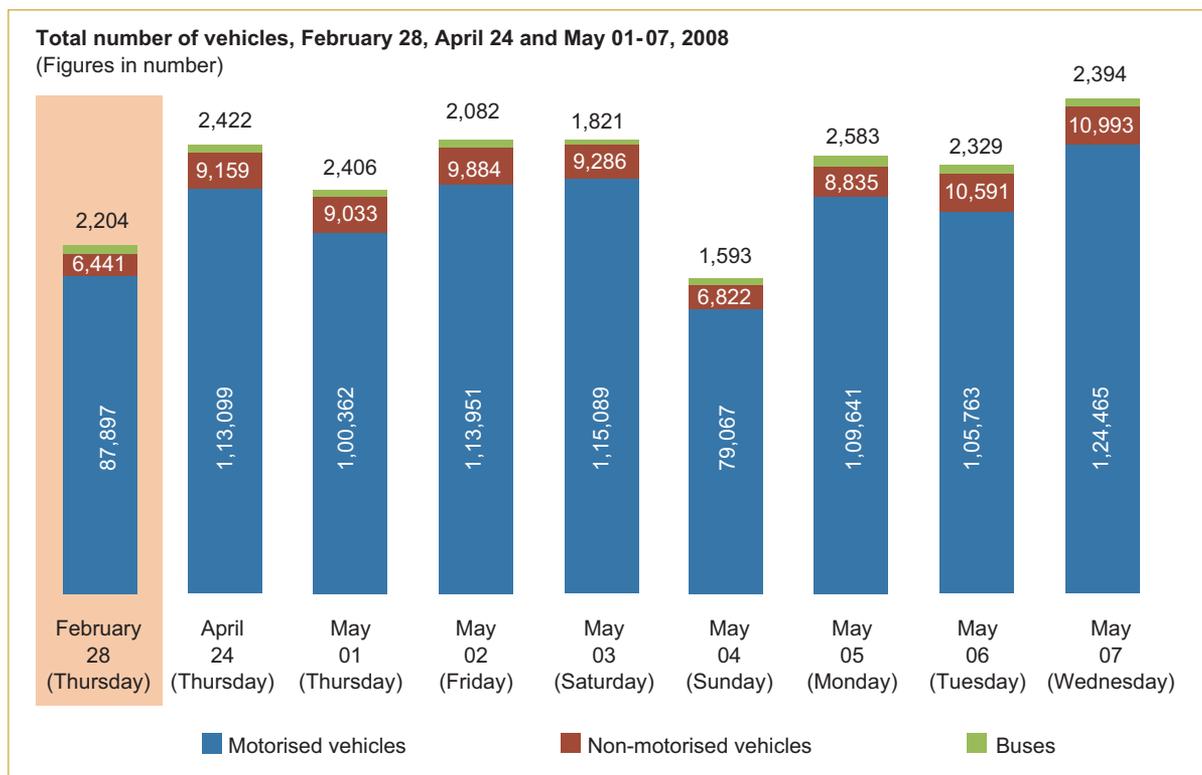
10.1.1 Where is the space?

As learned from various experiences, there was a need to have equitable allocation of road space to different types of users. Also, there was a need to first allocate space to pedestrians, bicyclists and public transport, and then to personal MV users, in order to promote and encourage the use of a sustainable transport system in the city. Thus, the existing infrastructure needs to be redesigned, as has been done in the case of the Delhi BRT corridor.

10.1.2 Will NMT users utilise the provided infrastructure?

There was a general concern about the provision of an infrastructure for bicyclists that would remain unused. As per the data collected from the DIMTS and Traffic Police, the number of NMT users on the corridor increased from 6,441 to 10,993 following the implementation of the corridor – i.e., from February 28, 2008 to May 07, 2008, respectively (Figure 14). This means a total increase of users by 71% in a span of 2 months. Moreover, the risk exposure to NMT users has decreased by 94% between 2008 and 2009.

Figure 14: Number of users on the Delhi BRT corridor before and after implementation of the project.



Source: DIMTS, 2012

10.1.3 Barriers in realising the full benefits from NMT infrastructure in Delhi

The NMT infrastructure was restricted to the Delhi BRT corridor only, and there was a distinct lack of a comprehensive network in the city, both for pedestrians and bicyclists. Enforcement issues have been identified against the encroachment of the NMT infrastructure by other users, as shown in Figure 15.

Figure 15: Cars parked and moving on footpath and bicycle track pushing cyclists out



Short-term and long-term benefits can only be achieved when appropriate infrastructure and urban environment for pedestrians and bicyclists are developed. This requires a paradigm shift in the way safety and security aspects for all users are taken into account. There is a need for a comprehensive network to realise the complete benefits of the system.

Some of the key findings of the study have been summarised as follows:

- Experience from other countries shows the impact of developing safe infrastructure for NMT results in increased commuter use, fuel savings and reduced emissions, even where car ownership is high, like in European cities.
- Examples from Delhi and Nanded show benefits to NMT users when dedicated infrastructure is created for it.
- In Indian cities the focus of the local governing bodies is towards construction of bridges, flyovers and sub-ways contributing to the increasing flow of motorised vehicles, leading to increased risk and detours for NMT users.
- Even after the adoption of policies at the national level (NUTP) and availability of funds through JnNURM, there seems to be a lack of will to improve the NMT infrastructure. No projects directly related to the development of NMT have been proposed. Also, the lack of understanding of the need for NMT infrastructure has resulted in their discontinuity and removal even where they had been approved and constructed.
- While some projects have been approved through JnNURM for the improvement of the NMT infrastructure, the objective of the authorities is still to provide smooth and easy flow of traffic for motorised vehicles (for example in Bengaluru). The priorities need to change in order to develop an appropriate environment for the movement of NMT users.
- Relatively small stretches of BRT projects have been approved for implementation along which NMT infrastructure is to be improved. However, provision of a good level of NMT infrastructure requires a dedication to continuity, contiguity, safety, security and directness. Small stretches are insufficient to achieve any significant improvement. There is a need to develop a comprehensive network throughout the city.
- The focus of local authorities is to reduce traffic congestion and provide uninterrupted flow to motorised vehicles. This approach is resulting in the removal of NMT infrastructures where they had been introduced, like in Ahmedabad and Delhi.
- Provision of appropriate infrastructure for NMT has short term and long-term benefits, as studied in the case of Delhi. Nevertheless, the strong enforcement and development of a comprehensive network is important in order to achieve the set objectives.
- A scenario-based study done to understand the implications of improving NMT infrastructures in Delhi, Pune and Patna shows that there was maximum impact realised in Pune, in terms of reduced CO₂ emissions. However, in Delhi, while the percentage of reduction was not as great, quantitatively there is high potential for the reduction of large amounts of CO₂ emissions once the NMT infrastructure is developed.

Some of the specific policy recommendations are highlighted in the box below to address the issues identified with the help of the case study.

Box-1: Policy Recommendations

Surveys done for data collection at the city level need to account for all trips, including walking, bicycling and cycle rickshaws. Also, reporting needs to be done for access and egress trips made to use public transportation in a city.

Safety data needs to be collected appropriately by the relevant authority, accounting for victims as type of user affected during accidents.

Investments made for improving NMT infrastructure in cities needs to be accounted separately in annual city budgets, and the needs of NMT users should be considered in all transport infrastructure improvement projects.

Transport plans should integrate improvements of NMT infrastructures along with the public transport system of a city.

Despite the high number of NMT commuters, the use of NMT is declining in Indian cities. With deteriorating infrastructure quality, increasing risks to NMT users, and increasing income levels the use of NMT is likely to decline at a higher pace in the near future. Even though policies have been suggested for prioritising NMT in cities, the implementation is still in question. The case study has shown how improvements in NMT infrastructure have resulted in reduced fatalities, increased social justice and reduced emission levels in cities worldwide. Even in the case of Delhi, though a relatively small stretch has been installed with NMT infrastructure, the benefits achieved in terms of increased safety and accessibility are significant. There is a need to mobilise the concept of improving NMT infrastructures amongst decision makers and help them understand the possible benefits that could be achieved through the approach.

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