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PROMOTING LOW CARBON TRANSPORT IN INDIA

Case Study of Metro Rails in Indian Cities

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Abbreviations

BMRCL	Bangalore Metro Rail Corporation Limited
CAG	Comptroller and Auditor General of India
CBDs	central business districts
CISF	Central Industrial Security Force
CMRL	Chennai Metro Rail Limited
CO	Carbon monoxide
CO_2	Carbon Dioxide
CSE	Centre for Science and Environment
DAMEPL	Delhi Airport Metro Express Private Limited
DMRC	Delhi Metro Rail Corporation
DPR	Detailed Project Report
DTC	Delhi Transportation Corporation
FY	Financial year
GNCTD	Government of National Capital Territory of Delhi
GOI	Government of India
GVW	Gross vehicle weight
HUDA	Housing and Urban Development Authority
JBIC	Japan Bank of International Cooperation
JICA	Japan International Cooperation Agency
JJ	Jhuggi Jhopri
LCA	Life Cycle Assessment
NMT	Non Motorised Transport

NOIDA	New Okhla Industrial Development Authority
M	meter
MMOPL	Mumbai Metro One Private Limited
MMRDA	Mumbai Metropolitan Region Development Authority
MMTS	Multi-modal Transport system
MoUD	Ministry of Urban Development
MRTS	Mass Rapid Transit System
kg	kilograms
km/h	Kilometres per hour
km	Kilometer
kwh	kilowatt hour
NCR	National Capital Region
NO_2	Nitrogen Dioxide
NO_X	Nitrogen oxides
pkm	passenger kilometer
PM	Particulate matter
PM_{10}	Particulate Matter of diameter less than 10 micro meters
$PM_{2.5}$	Particulate Matter of diameter less than 2.5 micro meters
PPP	Public private partnership
RInfra	Reliance Infrastructure Limited
RITES	Rail India Technical and Economic Service
Rs	Indian rupee
RSPM	Respiratory Suspended Particulate Matter
RTI	Right To Information
SO_2	Sulphur Dioxide

SPV	Special purpose vehicle
TOD	Transit Oriented Development
USD	United States dollar
vkm	vehicle kilometer
VOCS	Volatile Organic Compounds


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1. Background

This study is part of a larger research project on "Promoting Low-Carbon Transport in India", a major initiative of the United Nations Environment Programme (UNEP), hereafter referred to as the Low Carbon Transport (LCT) project in this document. The overall context in which the LCT project has been undertaken is the critical role of the transport sector in reducing greenhouse gas (GHG) emissions. India is currently the fourth largest GHG emitter in the world, although its per capita emissions are less than half of the world's average. Further, India's transport sector accounts for 13% of the country's energy related CO_2 emissions (MoEF, 2010). It is evident that opportunities exist to make India's transport growth more sustainable by aligning development and climate change agendas. India's National Action Plan for Climate Change (NAPCC) recognizes that GHG emissions from transport can be reduced by adopting a sustainability approach through a combination of measures such as increased use of public transport, higher penetration of bio-fuels, and enhanced energy efficiency of transport vehicles. The key objectives for the LCT project are as follows:

1. Delineating an enabling environment for coordinating policies at the national level to achieve a sustainable transport system

2. Enhancing capacity of cities to improve mobility with lower CO_2 emissions

The LCT project has been endorsed by the Ministry of Environment and Forests (MoEF), Government of India. It is being jointly implemented by the UNEP Risø Centre, Denmark (URC); Indian Institute of Technology, Delhi (IIT-D); Indian Institute of Management, Ahmedabad (IIM-A); and CEPT University, Ahmedabad.

The case study of Metro rails is one of the four case studies being carried out under the LCT project. These studies cover transportation projects under implementation in India for passenger and freight transport. The objective of these case studies is to explain the economic, social and environmental impacts of selected transportation projects. While the current case study deals with Metro projects, the other three studies cover freight transport Bus Rapid Transit projects and Non-motorized transport projects. All of the above mentioned projects are perceived by policymakers as interventions that can contribute to sustainable development.

Case study

This study is based on the premise that metro rail projects in cities are considered inevitable for efficient urban transport by many planners and policy makers, however, these projects have major implications for achieving inclusive sustainable low-carbon development goals. The focus of the study is not whether or not to undertake the metro project, but rather explicitly discuss the costs and benefits to different stakeholders. This is an exploratory study that may help to identify the important linkages of this framework.

Purpose

The broad purpose of this study is to examine the costs and benefits of metro rail projects for achieving the twin goals of inclusive and sustainable development and low-carbon growth. The main goals of sustainable development are economic efficiency, sustainable growth (conserving resources, energy security, and energy efficiency) and inclusiveness. The major goal for low-carbon growth is to reduce GHG emissions in order to achieve global targets for minimizing threats of climate change. Energy efficiency gains associated with metro rail projects are known to policymakers in India. However, the implication of other costs and benefits based on life cycle methodology are less known. This study aims to provide a framework for short and long-term assessment of costs and benefits of transport infrastructure projects like the metro rail projects in cities.

Scope

This case study is broadly conceived to assess the potential of the Delhi-metro rail. When evaluating mass transit options for Indian cities, metro systems are given preference over surface systems due to the belief that a road-based bus system cannot cater to the capacity requirement as much as metro systems. In addition to this, metro rails are perceived to have higher levels of comfort, speed, and efficiency as compared to bus systems. Capital intensive construction and high operation cost of metro systems necessitates financial support from state and central governments, foreign loans, tax exemptions and other subsidies. However, no explicit analysis of these considerations is available and more elaborate studies would be required to understand each of these dimensions.

This study covers the following aspects of the Delhi metro rail project:

1. Overview of project demand estimation and financing plans

2. Impact on safety and CO_2 emissions

It is important to recognize that CO_2 emissions would occur in both the construction and operations phase of the project. The current study focuses on short-term assessment and briefly mentions the CO_2 impact based on life cycle methodology.

Photo credit: Nadir Hashmi

2. Overview of Metro Rail Projects in India

Metro rails are rail-based, mass rapid transit systems that operate on an exclusive right-of-way, which is separated from all modes of transport in an urban area. Most often, the right-of-way is either underground or elevated above street level. These systems generally operate at an average speed of 20–35 km/h, and are characterized by their high capacity (50,000–75,000 passengers per hour, per direction) and high frequency of operation. The capital cost of construction is between 20–30 times that of the Bus Rapid Transit system, depending on whether the metro systems are underground or elevated (Mohan, 2008).

There has been a growing interest among policymakers about the relevance of rail-based systems in India, to address the mobility needs of the expanding population in the cities. While evaluating different mass transit options for Indian cities, metro systems are often given preference due to the belief that road-based bus systems cannot cater to capacity requirements as much as metro systems. In addition to this, metr rails are perceived to have higher levels of comfort, speed and efficiency, than bus systems, making them more attractive to both policymakers and potential users of the system.

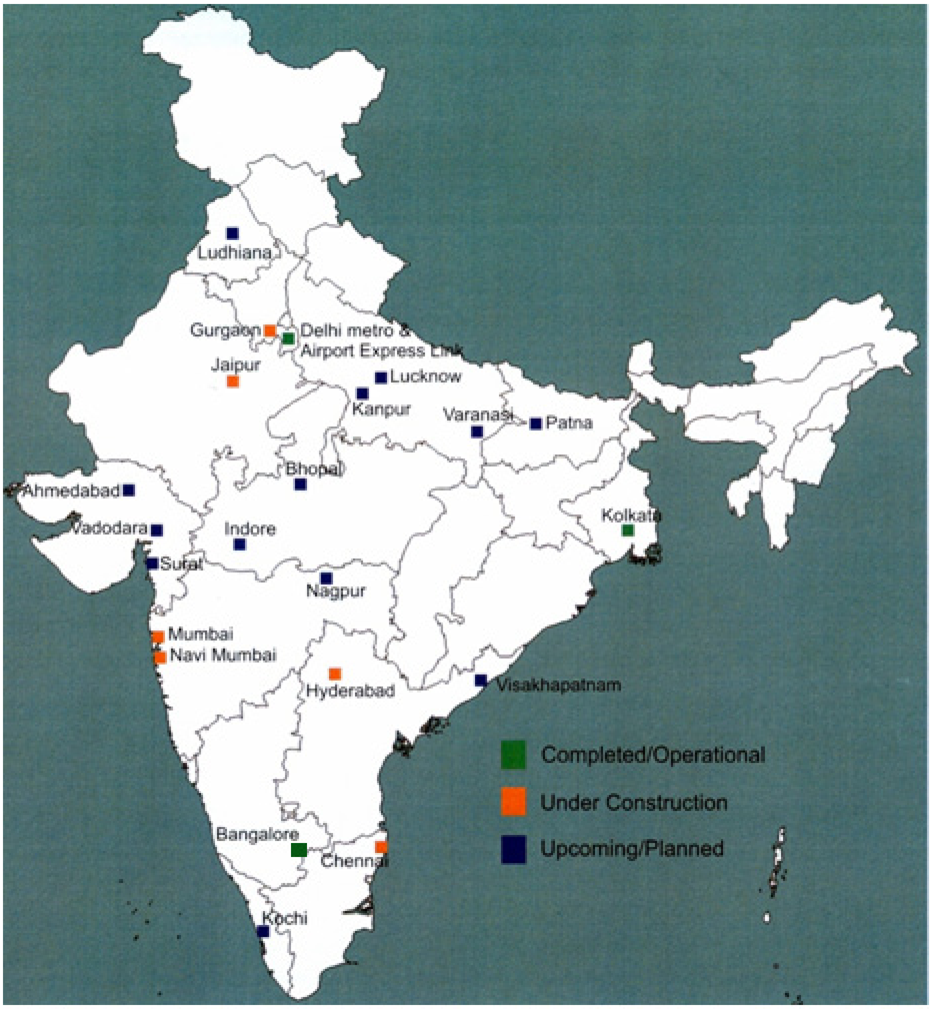
Promoters of metro systems often claim that one of the benefits of the metro is reduced congestion, due to the users' shift from road-based motorized modes to metro systems. This mode shift is then claimed to result in reduced air pollution and road accidents. However, the experience of metro rails in low and middle income counties around the world shows otherwise (Mohan, 2008). Due to the induced demand, the available road space fills up with motorized vehicles, and the modal shift to metro does not result in the reduction of congestion or air pollution.

A study done by the Centre for Science and Environment (CSE) on pollution levels in Delhi illustrates that in 2001 (Delhi Metro started in 2002) the annual average level of respiratory suspended particulate matter (RSPM, or PM10) in residential areas stood at 149 microgram per cubic metre. After registering a drop in 2005, the level rose to 209 microgram per cubic metre in 2008. The concentration is approximately three times higher than safe levels. Similarly, the eight-hourly maximum current level of carbon monoxide (CO) is touching 6,000 microgram per cubic metre – way above the safe level of 2,000 microgram per cubic metre – though the annual levels have registered a drop. Overall, these figures illustrate that the operation of the Delhi Metro has not led to a reduction in pollution levels in the city (Randhawa, 2012).

Due to the limited coverage of the city by rail-based systems[1], as opposed to road-based bus systems, a metro commuter spends significant time during access (from origin to metro station) and egress (metro station to destination). As a result of this additional time, even though the average main-haul (in-vehicle) speed of the metro is above 30 km/h, the average door-to-door travel speed gets reduced for a short trip on the metro system – as compared to a road-based system. Hence, metro systems have been found to be most favourable, in terms of saving time, if the trips are 10 km or longer. Due to mixed land-use and the polycentric nature of Indian cities with multiple central business districts (CBDs), however, the majority of trips remain below 5 km (Jain and Tiwari, 2011).

1 For instance, with 190 km of network, the Delhi Metro covers only 12% of the city within walking distance – i.e. 500 m.

Figure 1. Metro Rail Projects and their status in India (Source: IIR, 2011)



Flyberg et al. (2002, 2005) have found that mega projects involving large capital investments have often been justified around the world based on the exaggeration of benefits and underestimation of costs. Their study of more than 210 transportation infrastructure projects, worldwide, demonstrates that cost underestimation and exaggeration of benefits (both by an average factor of two) are common, especially for rail projects.

India currently has four operational metro rails – namely, Kolkata Metro in West Bengal, Delhi Metro and Delhi Airport Express Link in the National Capital Region (NCR) of Delhi, and Bangalore Metro in Karnataka. Similar rail projects are being planned and/or are under construction in Ahmedabad in Gujarat, Bhopal and Indore in Madhya Pradesh, Chandigarh, Ludhiana in Punjab, Jaipur in Rajasthan, Kochi in Kerala and Pune and Mumbai in Maharashtra, and Hyderabad in Andhra Pradesh. Figure 1 shows various metro rail projects in India at different stages of development.

The Planning Commission's proposal for the Twelfth Five-Year Plan for urban transport has recommended that all Indian cities with a population in excess of 2 million start planning rail transit projects, and cities with a population in excess of 3 million start constructing the metro rails. An estimated investment for the development of metro rails in Indian cities is USD 26.1 billion[2] (Planning Commission, 2011).

With billions of dollars to be spent on metro rail projects in the country, it is imperative to understand the need for, and effectiveness of, metro systems as a means of public transportation in the Indian context. Since metro systems are capital-intensive projects, the financial sustainability of these systems is also an important issue to be explored. This study examines the Delhi Metro, which started its operations in December 2002. Various aspects of the Delhi Metro have been discussed, including revenue sources, cost and debt streams, tax waivers and subsidies, ridership, and the different impacts of the metro. These impacts include, fatalities of labourers, displacement of households during construction, emissions attributed to the Delhi Metro operations (due to electricity production), and the real estate market. As part of this case study, an on-board survey of 1,100 Delhi Metro users has also been carried out to understand the travel characteristics of metro users and to get detailed insight on the access/egress aspects of their trips. Following these, major issues related to the Delhi Metro have been highlighted, along with the corresponding policy implications relevant to the operations of the Delhi Metro, as well as the metro projects which are under construction and/or at the planning stage. This study includes brief descriptions of other on-going metro projects in India, such as Bangalore, Chennai, Hyderabad and Mumbai.

2 USD 1 = Rs 50 throughout the report unless otherwise mentioned.

Photo credit: Varun Shiv Kapur

3. Delhi Metro and Airport Link

The first significant mention of a mass rapid transit system for Delhi emerged from a 1969 traffic and travel characteristics study. Since then, many official reports by a wide variety of government departments have been commissioned to explore the issues related to technology (underground rail, surface rail, light rail, bus-based, etc.), route alignment, and whether urban mass transit is ultimately the jurisdiction of the National Government or the Delhi Union Territory Government. In 1984, the Delhi Development Authority and the Urban Arts Commission came up with a proposal for developing a multi-modal transport system, which would consist of constructing three underground mass rapid transit corridors, as well as augmenting the city's existing suburban and road transport networks (Sreedharan, 2002 cited in Siemiatycki, 2006). Following that, the Government of National Capital Territory of Delhi (GNCTD) commissioned Rail India Technical and Economic Service (RITES) Limited, in 1988–89, to study the feasibility of introducing an Integrated Multi-Modal Mass Rapid Transit System for Delhi. The study was completed by RITES in 1991, and recommended a 198.5 km predominantly rail-based network (http://delhigovt.nic.in/dmrc.asp#4). In July 1994, the Central Cabinet gave the go-ahead, in principle, for the MRTS for Delhi and directed the GNCTD to take up the preparation of a Detailed Project Report (DPR). RITES finalised (May 1995) the DPR for a 55.30 km MRTS comprising rail and metro corridors, for completion by March 2005. The Union Cabinet sanctioned the Delhi MRTS Phase I (Project) of 55.30 km in September 1996, at a total cost of USD 971 million – at April 1996 prices (CAG, 2008).

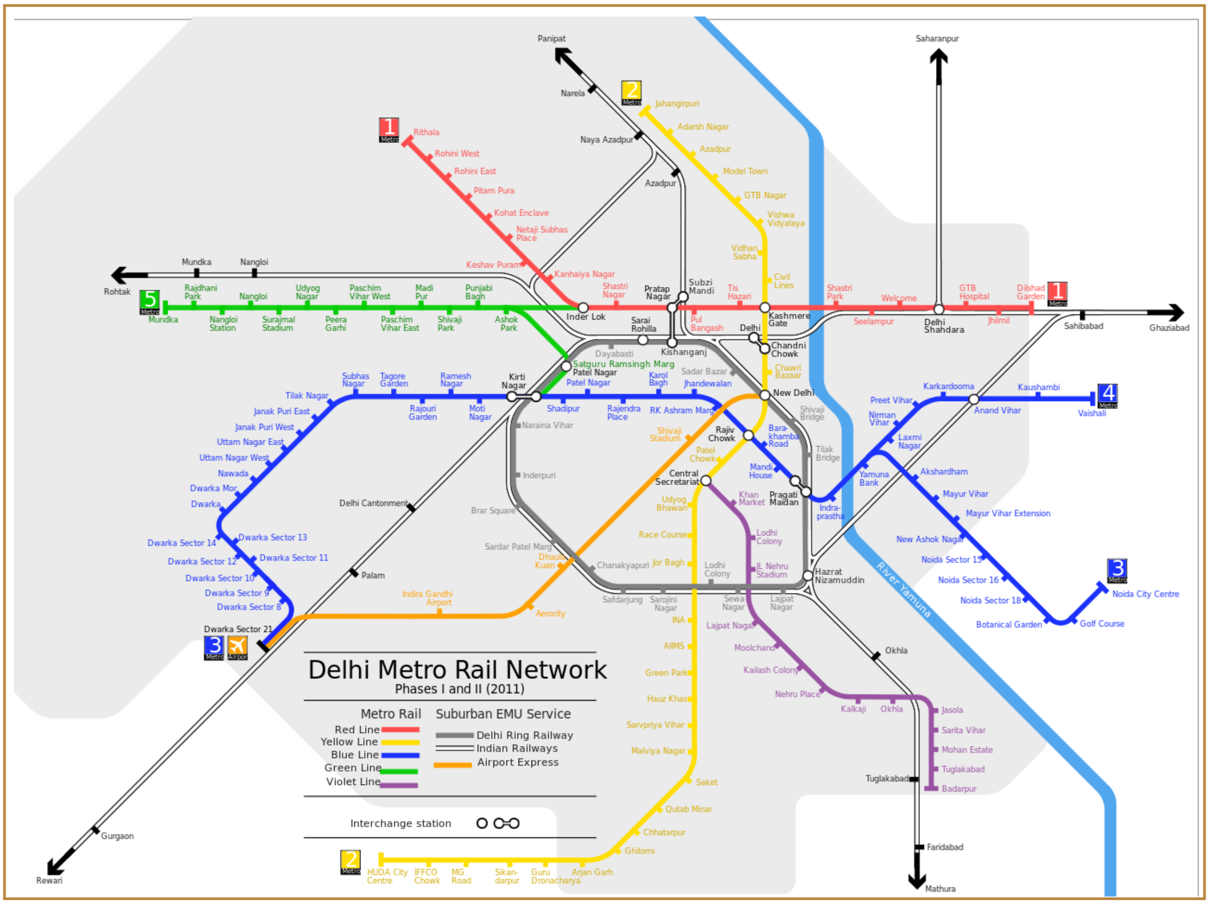
For implementation and operation of the project, the Delhi Metro Rail Corporation Limited was registered in May 1995 as a joint venture between the Ministry of Urban Affairs and the GNCTD. It started its operation in December 2002 with an 8 km line (CAG, 2008). The construction of the Delhi Metro has been carried out in phases. With the completion of Phase I and II of the Delhi Metro Rail project, the Delhi Metro currently has an operational network of 190 km[3] consisting of elevated, at-grade and underground lines (Figure 2).

The 22.7 km long – 16 km underground and 7 km elevated – airport line, or the Orange line, under the Delhi Metro network is officially called the Delhi Airport Express Line. It has been implemented using a public private partnership (PPP) model, through a special purpose vehicle (SPV) – the Delhi Airport Metro Express Private Limited (DAMEPL). The civil works were carried out by the Delhi Metro Rail Corporation (DMRC), while the system installations, as well as the rolling stock, was supplied, installed and operated by DAMEPL, which also developed, operated and maintained this Express Link. The shareholders of DAMEPL are Reliance Infrastructure Limited (RInfra) and a Spanish company. DAMEPL will be operating the line for 30 years, under a revenue sharing model[4]. It must pay DMRC a fixed concession fee of USD 10.2 million and a share of gross revenue – 1% for the first 5 years, 2% for the fifth to tenth year, 3% for the eleventh to fifteenth year and 5% thereafter (IIR, 2011).

3 Note that this network also consists of 22 km long Delhi Airport Express link.

4 http://www.delhiairportexpress.com/aboutus/abt_Delhi_Airport_Express-overview.htmlhttp://www.delhimetrorail.com/press_reldetails.aspx?id=KYCBFDTNGEYlld

Figure 2. Delhi Metro Rail Network – Phases I and II in 2011



3.1 Coverage

By the end of July 2011, the Delhi Metro completed its two phases – I and II – that comprised a total operational network length of 190 km (Table 1), consisting of elevated, at-grade and underground lines. Phase I consisted of three lines with a network of 65.1 km, with 73% of the length as elevated. The construction of this phase started in October 1998 and was completed in 2006. Phase II consisted of 13 sections covering 124.6 km, with almost 77% elevated, and was fully completed in July 2011 (IIR, 2011) – see Table 1 and Figure 3.

The DMRC has about 200 train sets, of which 42 are standard gauge and the rest are broad gauge. These make more than 2,500 trips per day on their seven operations corridors, including the Airport Express Link (DMRC Phase II handbook).

Figure 3. Timeline of total route length (km) of Delhi Metro Network excluding airport line of 22 km (Source: DMRC, 2011)

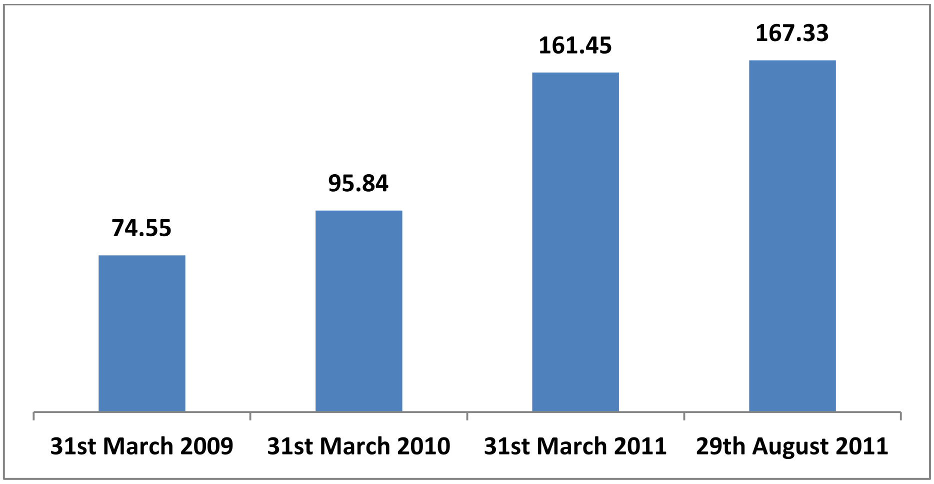


Table 1. Network details of Delhi Metro Rail – Phases I and II

Line	Length (km)	No. of Stations	Date of Completion
Phase I			
Shahdara – Tri Nagar – Rithala	22.0	18	March 2004
Vishwa Vidyalaya – Central Secretariat	10.8	10	July 2005
Indraprastha – Barakhamba Road – Dwarka Sub City	32.1	31	November 2006
Total Phase I	65.0	59	
Phase II			
Shahdara – Dilshad Garden	3.1	3	June 2008
Indraprastha – Noida Sector 32 City Centre	15.1	11	
Yamuna Bank – Anand Vihar ISBT	6.2	5	January 2010
Vishwavidyalaya – Jahangirpuri	6.4	5	February 2009
Inderlok – Kirti Nagar – Mundka	18.5	15	April 2010
Central Secretariat – HUDA City Centre	27.5	19	September 2010
Dwarka Sector 9 to Dwarka Sector 21	2.8	2	October 2010
Airport Express Line	22.7	6	February 2011
Anand Vihar – KB Vaishali	2.6	2	
Central Secretariat – Badarpur	20.0	15	January 2011
Total Phase II	124.6	83	
Total Network	189.6	142	

The corridors of the Delhi Metro network are divided into six lines, each identified by a specific colour, as shown in Table 2 below.

Table 2. Lines of Delhi Metro Network

Line Name	Terminals	
Red Line	Dilshad Garden	Rithala
Yellow Line	Jahangirpuri	HUDA City Centre
Blue Line	Noida City Centre	Dwarka Sector 21
	Yamuna Bank	Vaishali
Green Line	Inderlok	Mundka
	Kirti Nagar	Ashok Park Main
Violet Line	Central Secretariat	Badarpur
Airport Express (Orange Line)	New Delhi	Dwarka Sector 21

The Delhi Metro project proposes to cover the entire city of Delhi and the adjoining sub-cities (Gurgaon, Noida, Ghaziabad, etc.) with a network of 405 km, in four phases, by 2021. The Group of Ministers approved Phase III of the Delhi MRTS project in August 2011. The approved network has four corridors covering a route length of 103 km and 67 stations. The approved cost of the project is USD 7 billion. In addition, the extension of the Delhi Metro to Faridabad, covering a route length of 13.9 km and 9 stations, has been approved and will be funded by the Government of Haryana and the Government of India (GOI) (DMRC, 2011). Phase IV of the project has been proposed by the Delhi Metro, but has yet to be approved. This phase will consist of 108.5 km of network length. After the completion of Phase IV of the DMRC, only 35% of the Delhi population will be within walking distance of metro rail.

3.2 Finance

The following section on finance covers the funding pattern of different phases of the Delhi Metro, tax liabilities and exemption to DMRC, operating revenue and cost streams, as well as their different components. While mentioning the tax regime of the Delhi Metro, the tax liability of the bus counterpart of the Delhi Metro, the Delhi Transportation Corporation (DTC), has been discussed in order to provide a reference for comparison.

3.2.1 Funding Pattern

Phase I of the project was developed with a total investment of USD 2.1 billion, at an average cost of USD 32 million per km. Of this, the Japan International Cooperation Agency (JICA), formerly known as Japan Bank of International Cooperation (JBIC), funded about 60% in six tranches, with the first one in 1997. The loan was sanctioned at an annual interest rate of 1.2%, and a repayment period of 30 years – with a moratorium period of 10 years (Figure 4).

Figure 4. Funding pattern of Phase I of Delhi Metro (Source: IIR, 2011)

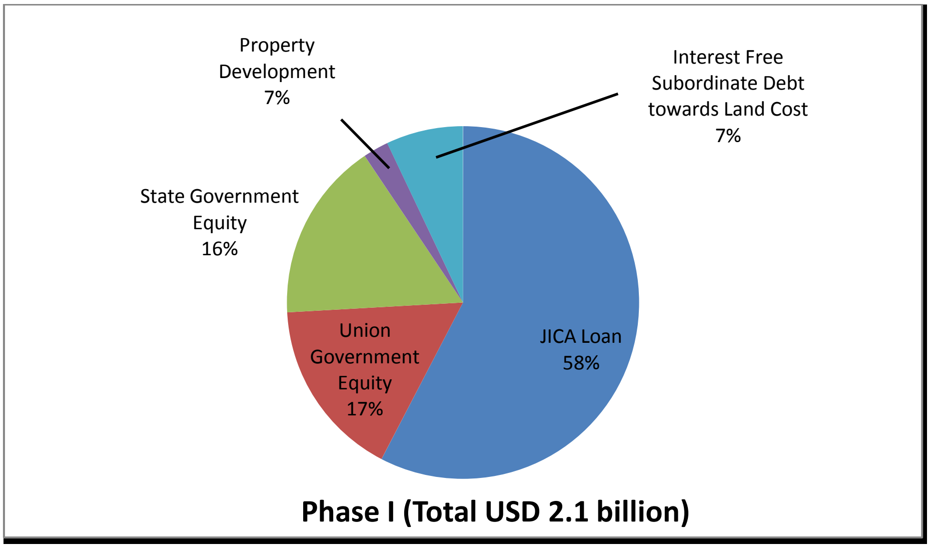
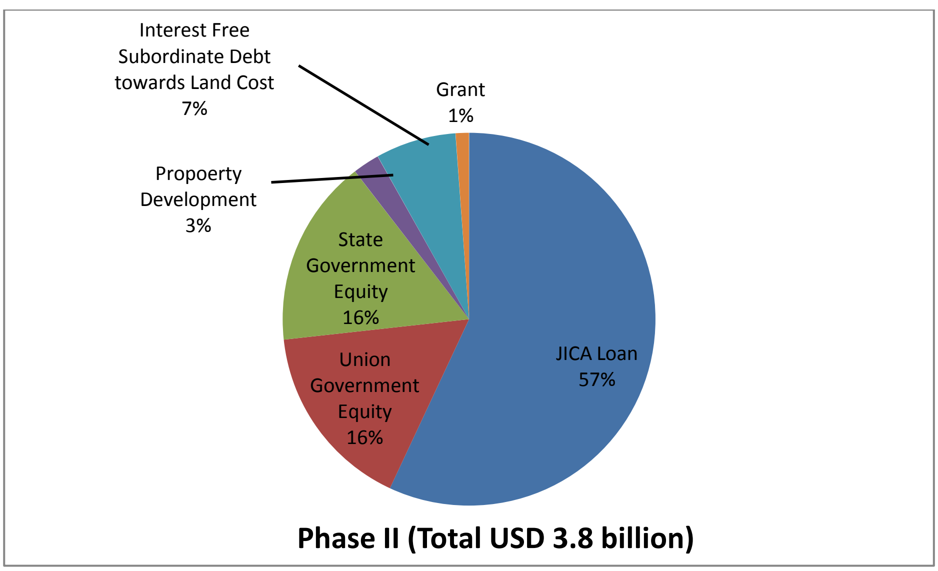


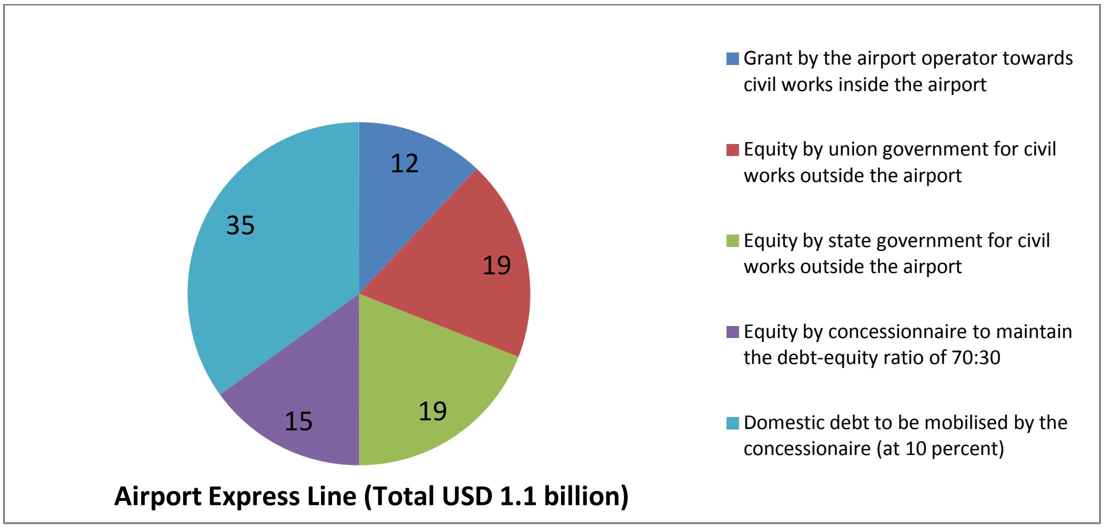
Figure 5. Funding pattern of Phase II of Delhi Metro (Source: IIR, 2011)



The Union Government and the GNCTD jointly financed 28% of the project cost through equity contributions, in addition to providing a subordinate loan to cover the cost of land acquisition, which was approximately 5% of the project cost. The remaining 7% of the funds were internally generated through property development.

Phase II of the project was developed at a cost of USD 3.8 billion, at an average rate of USD 31 million per km. Of this, 39.6% was financed through equity participation (shared equally by the Union Government and the GNCTD), and 49% was financed through the JICA loan. The remainder was funded through property development, grants and subordinate debt (see Figure 5).

Figure 6. Funding pattern of Airport Express Link (Source: IIR, 2011)



The Airport Express line was financed through a mix of debt and equity, with a debt-equity ratio of 70:30. It was built at a cost of USD 1.1 billion, of which Reliance Infra paid USD 0.6 billion and the government bore the balance (Figure 6).

3.2.2 Revenue and Cost Streams

The following section describes the revenue and cost streams of the DMRC, focusing only on the operational revenue and operational cost/expenditure. In this section, different components of revenue and expenditure have been elaborated, using the information obtained from the annual reports published by the Delhi Metro.

3.2.2.1 Revenue Stream

The Delhi Metro Rail Corporation (DMRC) has the following sources of revenue, as mentioned in the financial reports (DMRC, 2008; DMRC, 2009; DMRC, 2010; DMRC, 2011):

1. Traffic Operations: Income from train operation, feeder bus earnings, rental income of space for kiosks, parking, shops, restaurants, advertisements, sale of tender forms and sale of carbon credits.

2. Consultancy: Income from consultancy services to other metro systems in India, and abroad, and sale of tender forms.

3. Real Estate: Income from sales of land, and leases.

4. External Project Works: Income from works carried out in other metro projects.

5. Others: Deferred government grant, income from sale of carbon credits, sale of tender documents, etc.

Table 3 shows the different sources of revenue and their respective share in the total revenue from the financial year (FY) 2006–07 to 2010–11. Table 4 gives a further breakdown of revenue items from traffic operations.

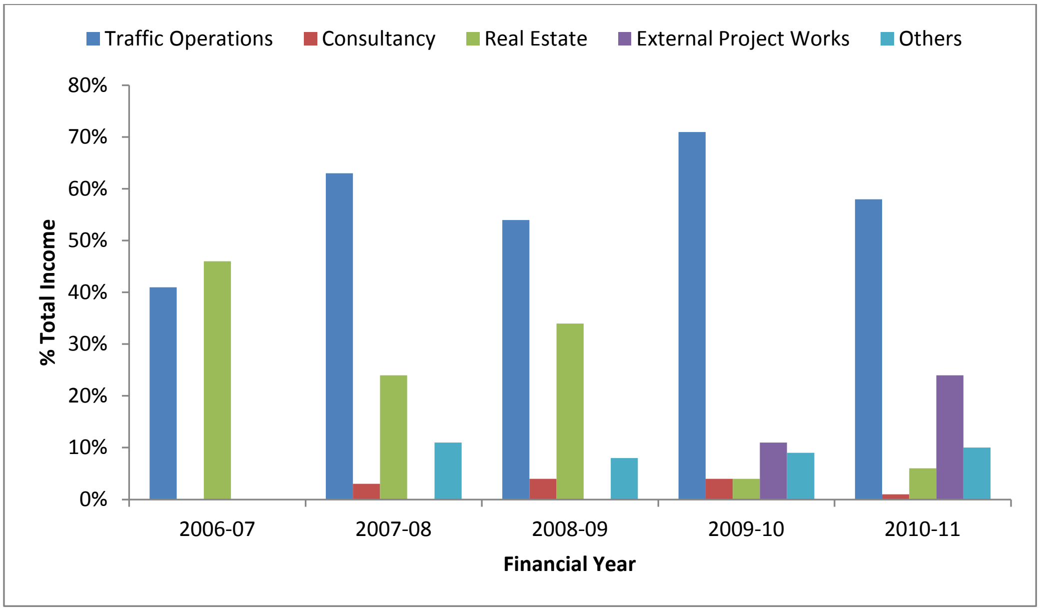
Table 3. Sources of revenue of DMRC

Income Source	2006–07		2007–08		2008–09		2009–10		2010–11	
	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total
Traffic Operations	44.5	41%	63.4	63%	78.6	54%	105.4	71%	187.7	58%
Consultancy	1.3	1%	2.7	3%	5.6	4%	6.4	4%	4.3	1%
Real Estate	50.4	46%	24.0	24%	49.0	34%	5.9	4%	19.7	6%
External Project Works	-	-	-	-	-	-	16.7	11%	76.9	24%
Others	12.3	11%	10.8	11%	11.6	8%	13.1	9%	33.0	10%
Total	108.6	100%	100.9	100%	144.8	100%	147.6	100%	321.6	100%

Source: DMRC (2007), DMRC (2008), DMRC (2009), DMRC (2010), DMRC (2011)

In the above table, the real estate income in the years 2006 to 2009 is comparatively higher because of the upfront income that is received when vacant land is given for commercial exploitation (Business Standard, 2008). During this time, the percentage income from traffic operations varied from as low as less than half (41%) to two-third (63%) of the total income. From 2009 onwards, the revenue income from real estate comes every year and, therefore, is comparatively lower.

Figure 7. Revenue sources of Delhi Metro and their percentage contribution to total income



In 2010–11, again, the percentage income from traffic operations is reduced due to the higher contribution of revenue from external project works taken by the Delhi Metro. Figure 7 shows the information from Table 3, graphically – revenue sources and their percentage contribution to total income.

In Table 4, the revenue under traffic operations has been further divided into traffic earnings (from fare collection), feeder bus earnings and rental earnings (from space for kiosks, parking, shops, restaurants, advertisements, sale of tender forms, and sale of carbon credits).

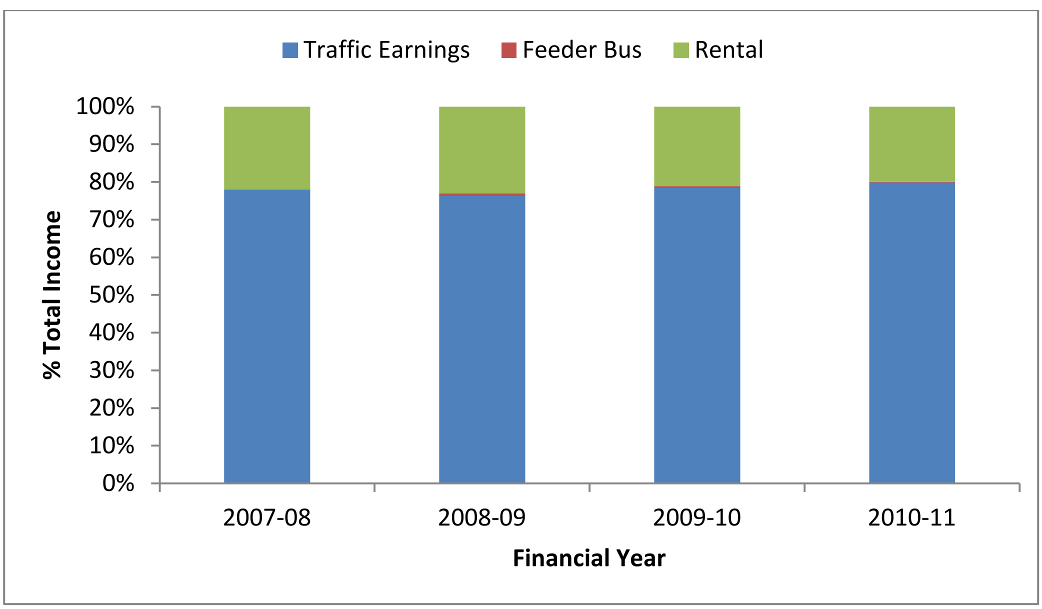
Table 4. Breakdown of the revenue items in traffic operations of DMRC

Income Source	2007–08		2008–09		2009–10		2010–11	
	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total
Traffic Earnings	49.3	78%	59.6	76%	82.7	78%	149.3	80%
Feeder Bus Earnings	0.1	0.1%	0.5	0.7%	0.5	0.5%	0.3	0.2%
Rental	14.1	22%	18.4	23%	22.2	21%	38.1	20%
Total	63.4	100%	78.6	100%	105.4	100%	187.7	100%

Source: DMRC (2008), DMRC (2009), DMRC (2010), DMRC (2011)

The percentage contribution of traffic earnings and rentals remains almost constant over the four years of 2007 through 2011 (Figure 8).

Figure 8. Traffic operations revenue sources and their percentage contribution



In order to calculate the percentage contribution of Delhi Metro's farebox revenue to the total income (see Table 2 for total income), the rental portion was removed from traffic operations. This reduces the proportion of traffic operations in the total income to 47% (2010–11), 56% (2009–10), 42% (2008–09) and 49% (2007–08) from 58%, 71%, 54% and 63%, respectively (see Figure 9). This highlights the fact that the income from the farebox contributes to less than half of the total revenue of Delhi Metro operations.

3.2.2.2 Cost Stream of DMRC

This section outlines the major cost components in the operations of the Delhi Metro. As shown in Table 5, the total operational cost of the Delhi Metro has more than doubled (2.4 times) from 2007 to 2010. Interestingly, the network length of the Delhi Metro has also increased by the same proportion (2.4 times), from 65 km to 156 km during the same period (2007–2010). Even though the total cost has increased, the percentage contribution of different cost components to the total operating cost remains almost the same throughout the years (see Figure 10).

Figure 9. Contribution of traffic operations to the total income with and without rental income

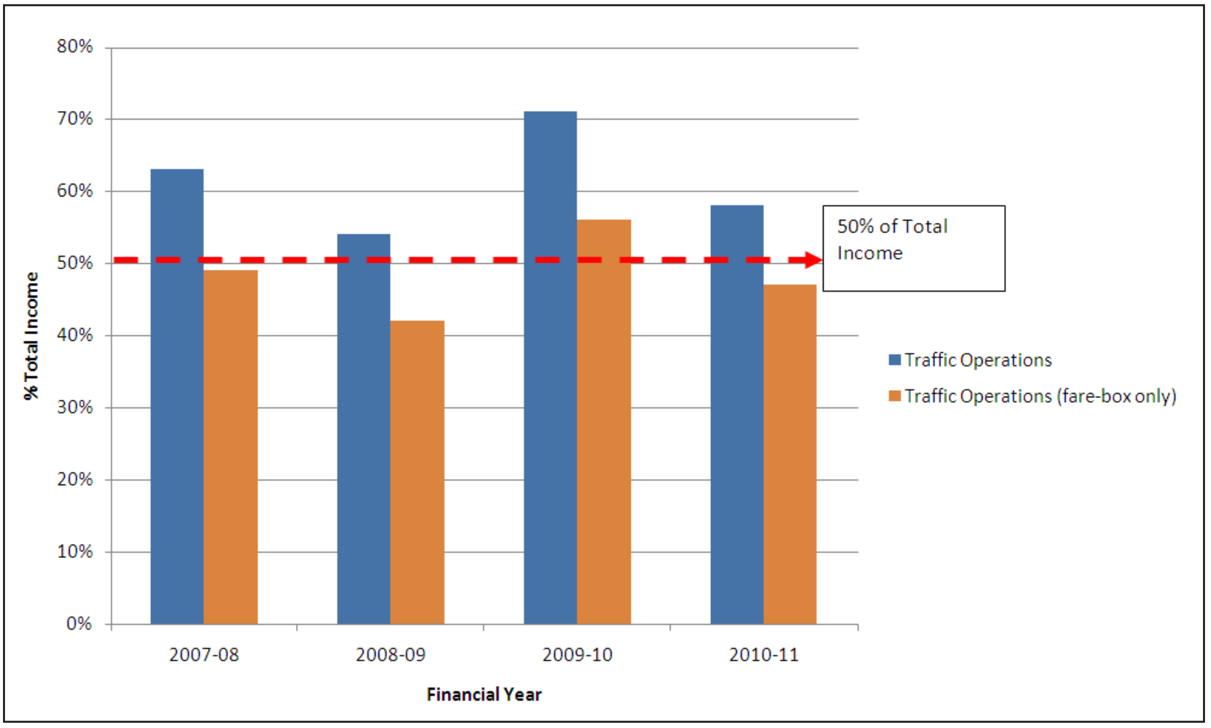


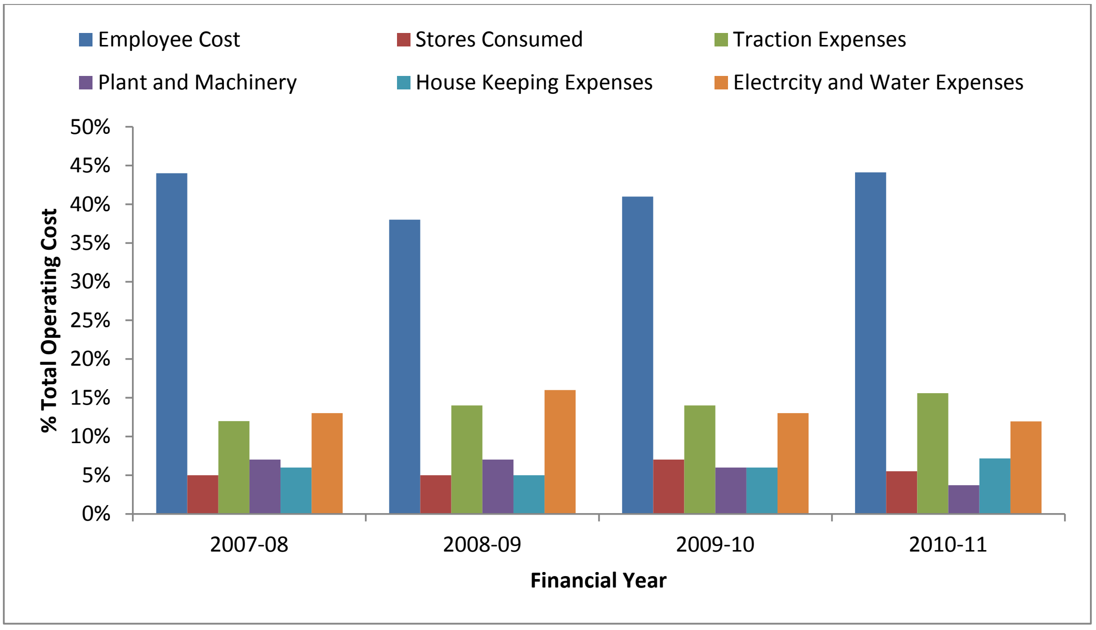
Table 5. Major components and their share in the total operating cost of DMRC[5]

Expenditure Head	2007–08		2008–09		2009–10		2010–11	
	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total	USD (million)	% Total
Employee Cost	17.8	44%	17.3	38%	23.5	41%	43.1	44%
Operations And Administration Expenses								
Stores Consumed	1.9	5%	2.3	5%	4.1	7%	5.4	6%
Traction Expenses	4.8	12%	6.4	14%	8.1	14%	15.2	16%
Plant and Machinery	2.6	7%	3.2	7%	3.5	6%	3.6	4%
Housekeeping	2.4	6%	2.5	5%	3.4	6%	7.0	7%
Electricity and Water	5.1	13%	7.1	16%	7.6	13%	11.7	12%
Total	40.1	100%	45.7	100%	57.8	100%	97.8	100%

Source: DMRC (2009), DMRC (2010), DMRC (2011)

The Delhi Metro has electricity consumption from traction – running of trains – and non-traction purposes, such as lifts and escalators, air-conditioning of underground stations, lighting of stations, etc. The former is under traction expenses and the latter is under electricity and water expenses in the operating cost components (see Table 5).

Figure 10. Major components of operational cost and their percentage contribution



5 Note: the above table only shows the major components of operational cost. The other components, not included in this table, contributed less than 1%.

As seen in Table 5, the two components (traction and electricity) contribute 25–30% of the total operational cost. It should be noted that this cost is incurred when the DMRC is supplied with a subsidized rate of electricity.

In addition to the costs mentioned above, the Delhi Metro has an additional liability of loan repayment, the interest incurred on it, as well as the depreciation cost, which is increasing rapidly with the expanding network. By 2012, the DMRC had a total debt of USD 3 billion (The Economic Times, 2012). During the financial year 2010–11, the interest and financial charges reached more than USD 36 million. Similarly, the depreciation value increased more than seven times, from USD 15.2 million in 2005 to USD 116 million in 2011.

3.2.3 Tax Regime of DMRC

The following section reviews the tax regime of the Delhi Metro. As the Delhi Metro project was not considered commercially viable6, the Government of India provided concessions to the DMRC (CAG, 2008), including many tax exemptions, as well as

1. Interest free subordinate loans from the GOI, GNCTD, HUDA, and NOIDA for supporting the cost of the land required for the project.
2. The long-term debt required for the project was raised by the GOI, through a loan agreement executed with JICA at concessional rates of interest and transferred to the company.
3. Immunity from exchange rate fluctuation – fluctuation risk for the period of repayment of foreign loans was to be shared between the GOI and the GNCTD, equally.
4. Exemption from property tax and electricity tax.
5. Exemption from import duty, excise duty, sales tax and works contract tax.
6. No dividend to be paid on government equity until the JBIC loan is fully repaid.

For example, for Phase I of the Delhi Metro project, the Government of India gave a customs and excise duty exemption amounting to more than USD 280 million to the DMRC in 2002 (Financial Express, 2006). In addition, the Delhi Government gave a tax relief of USD 92 million in the form of sales tax and works contract tax waivers, as well as a waiver of 1% cess, etc. (ET, 2003).

In addition to the above-mentioned concessions, the Delhi Metro is also provided electricity at a subsidized rate on a cost-to-serve basis (DERC, 2009; Business Standard, 2009) and at a lesser rate – at least 40% less, USD 0.06 versus USD 0.1 in 2011 – than other non-domestic consumers (Day & Night News, 2011).

3.2.3.1 Tax Exemptions

As listed above, the DMRC has been provided with many tax exemptions. In order to give a comparison of the taxes paid by a public bus transportation agency in Delhi (DTC), Table 6 lists the number of taxes paid by the DTC and DMRC. It can be seen that while the DTC pays a number of taxes imposed by the Central and State Governments, as well as the Municipal Corporation, the DMRC is exempted from most taxes – both by Central and State.

6 According to E Sreedharan, MD, DMRC, the financial rate of return of the Delhi Metro is very low, at about 3.5%, which essentially means a metro is not a financially profitable venture (Business Standard, 2011).

Table 6. Comparison of tax liabilities of DTC and DMRC

Delhi Transport Corporation (Kharola & Tiwari, 2008)	Delhi Metro Rail Corporation
1. Taxes on acquisition of immovable property: a. Tax on acquisition of land (State) b. Property Tax (Municipal Body) 2. Taxes on acquisition of buses: a. VAT (State Government) b. Central Excise (Central) c. Customs Duty in case of Imports (Central) d. Octroi (Municipal body) e. Entry Tax (State) 3. Taxes related to operations: a. Excise Duty on consumables (Central) b. VAT on consumables (State) c. Excise and VAT on spare parts 4. Tax on use of vehicles for transporting passengers: a. Motor Vehicle Tax (State) 5. Advertisement Tax (City)	1. Wealth Tax 2. Fringe Benefit Tax (DMRC, 2011) DMRC is “exempted” from the following taxes (TOI, 2004): 1. Property Tax 2. Sales Tax 3. Works contract Tax 4. Income Tax 5. Capital Gains Tax 6. Customs 7. Excise

3.3 Metro Ridership Trend

Delhi Metro’s average daily ridership increased from 82,179 in December 2002 to almost 1.4 million passengers in March 2011 (DMRC, 2011). Within the metro network, there is a large variation in the usage of different lines. For instance, by June 2011, 50% of the network under Line-2 (Jahangirpuri – HUDA City Centre), Line-3 (Dwarka Sector 9 to NOIDA City Centre) and Line-4 (Yamuna Bank to Anand Vihar) accounted for 75% of the total ridership (DMRC website, 2011).

The ridership of the Delhi Metro has been much lower than its estimated numbers. Table 7 shows the actual and projected ridership of the Delhi Metro for four years of operation. It can be seen that the actual ridership remained, at most, one-fourth of the projected figures.

Table 7. Projected and actual ridership of Delhi Metro in Phase I corridors (UNFCCC, 2011)

Year	Passengers Per Day		Actual as % of projected
	Actual	Projected	
2006	492,750	2,497,300	20%
2007	621,830	2,759,517	23%
2008	767,662	3,049,266	25%
2009	889,094	3,369,439	26%

Given the trend of much lower ridership of the Delhi Metro, the DMRC has revised its projected ridership many times since the completion of Phase I. The original feasibility study for developing a metro system for Delhi projected a daily ridership of 3.1 million passengers by 2005, which was later reduced to a projected demand of 2.18 million passengers per day on the first three corridors (65.8 km), upon completion in December 2005. This figure was further reduced to 1.5 million in 2005 (Mohan, 2008). The latest revision came in 2011 (DMRC, 2011), according to which the DMRC's target was to achieve an average ridership of 2 million passengers per day by the end of 2011, for a 190 km long network. It should be noted that this revised ridership is less than the projected ridership for the 65 km of network in 2006. The inaccuracy in the estimation of projected ridership figures has been accepted by the DMRC, which is clearly indicated by the following statement from the audit report of Phase I of the Delhi Metro by the Comptroller and Auditor General of India (CAG) office: "The fact that transport modeling for ridership was not carried out accurately by RITES, was accepted by the company (DMRC) as well as the Ministry of Urban Development (MoUD) before the Empowered Group of Secretaries in 2005" (CAG, 2008).

In order to estimate the usage of the Delhi Metro per unit length of the network, Table 8 shows the number of passengers per km of metro network, based on the actual ridership. It gives an average of 11,450 passengers per km. Moreover, the ridership stabilizes at about 11,000 passengers per km, and then drops with an increment of network length. Also, the revised projection of the ridership of 2,000,000 passengers per day for 190 km of network, gives 10,500 passengers per km.

Table 8. Passengers per kilometre ridership of Delhi Metro

Year	Network Length (km)	Passengers per km per day
2006	33	14,900
2007	65	9,550
2008	68	11,300
2009	76	11,600
2010	156	9,900
Average		11,450

It is imperative to learn lessons from the large variance of projected and actual ridership of the Delhi Metro. With more than USD 40 billion to be spent on metro rails in the next 10 years, in more than a dozen cities in India (HPEC, 2012), there is an urgent need to revise the existing travel demand models in order to project metro ridership closer to the realistic value.

The unrealistic projection of ridership for rail projects in not new, and has occurred numerous times in the past. There are many international (and one Indian) examples of metro projects for which the actual ridership remained only a fraction of what had been projected. The following examples have been cited from Flyvbjerg et al., 2002:

- By 1999–2000, the Kolkata Metro had a ridership of less than 10% of the projected ridership.
- A study of 10 rail projects in the US, done by USDOT, found that on average actual ridership was 65% lower than forecasted.
- A UK study, by TRR Laboratory, of 9 metro systems in both developing and industrialized nations found that the ridership forecast was over 100% above the actual ridership.
- A Denmark study, by Aalborg University, of 27 rail projects found that for two-thirds of projects, forecasts are overestimated by more than two-thirds.

3.4 Metro User Travel Characteristics

This section describes the travel characteristics of metro users, based on information obtained from a primary survey. In order to understand the benefits that can be achieved from a public transportation system, and get insight into its long-term effectiveness as a sustainable system, it is imperative to comprehend the characteristics of the users.

3.4.1 Metro User Survey

An on-board survey of Delhi Metro passengers was conducted during the month of November, in 2011 (see Annexure 1 for the questionnaire). The survey was carried out on all lines of the Delhi Metro network, except the airport line. It was conducted by six volunteers, with one volunteer in each coach of a six-coach train – the Delhi Metro runs four and six-coach trains. The volunteers consisted of five males and one female. This was done to cater to the five general coaches, where both male and female passengers are allowed, and one ladies coach, where only female passengers are permitted to enter. The survey was conducted during morning and evening peak hours of travel – starting at 8AM and 6PM, respectively. It consisted of the volunteers selecting respondents for the survey in a random manner and interviewing them. During the survey, care was taken to ensure that there was no bias in the selection of standing and sitting passengers. In total, 1,112 respondents took part in the survey[7]. The survey consisted of nine questions regarding, access and egress modes, origin and destination metro stations, auto ownership, alternative modes, and a question to investigate induced trips. The following sections describe the results from the different survey questions.

7 Although the total number of survey respondents is 1,112, the number of respondents for each question is less than that since some questions were not answered or the responses were found to be ambiguous when cleaning the data.

Access and Egress Modes

Respondents of the on-board survey were asked to mention the modes used to access their starting metro station, and the egress modes used after de-boarding the metro station. More than 50% of respondents (52% – access, and 57% – egress) mentioned using non-motorised modes (walk, cycle and rickshaw) for their access-egress trips – with almost 44% of respondents walking. Almost one-fifth and one-tenth of the respondents used autos and buses, respectively. The usage of motorcycles and cars differed in access and egress trips. For access trips, motorcycles were used by 4.3%, while cars were used by 12.3%. For egress trips, motorcycle usage reduced to 3% and car usage reduced to 7%.

Table 9. Access Mode – What is the mode you took to reach your starting metro station from your starting place? (Total respondents – 1,077)

Mode	Percentage of Respondents	Number of Respondents
Walk	43.9	473
Cycle	1.6	17
Rickshaw	6.5	70
Motorcycle	4.3	46
Auto	20.7	223
Bus	11.2	121
Car	12.3	132

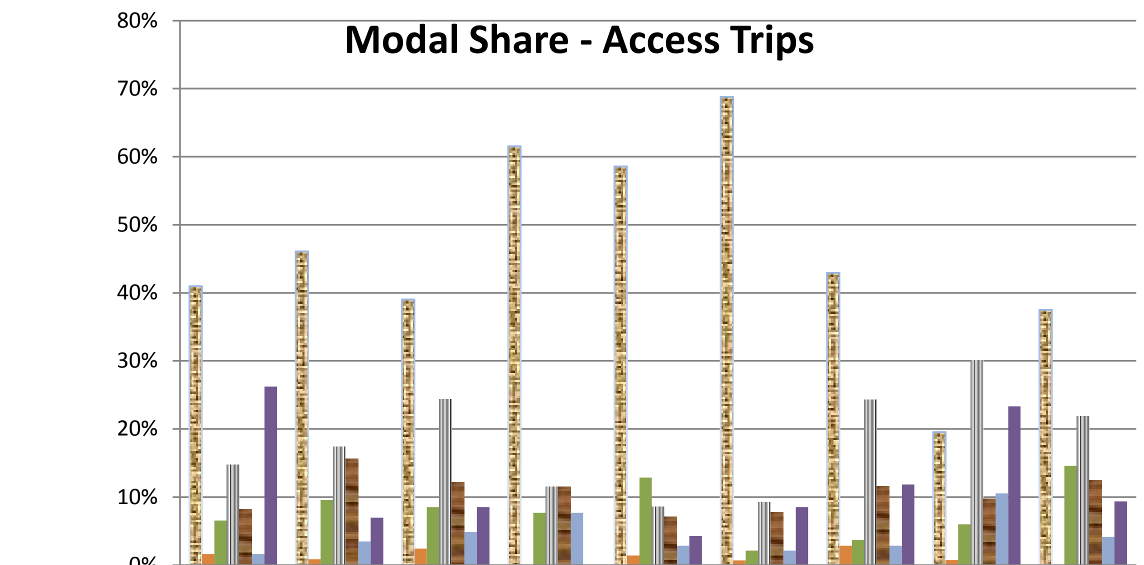
A majority of the respondents using non-motorised modes for the last-mile connectivity of their metro trip underscores the importance of infrastructure, which could provide safe movement of non-motorised modes and augment the current metro ridership. Moreover, the smaller share of bus use for access/egress trips (~11%) may be an indicator of inconvenience, due to the changing of modes, additional wait times and out-of-pocket expenses.

Table 10. Egress Mode – What is the mode you will take after reaching your destination metro station to get to your destination place? (Total respondents – 1,100)

Mode	Percentage of Respondents	Number of Respondents
Walk	43.4	477
Cycle	0.5	5
Rickshaw	12.9	142
Motorcycle	2.9	32
Auto	23.1	254
Bus	11.4	125
Car	7.1	78

In order to understand the spatial variation of the characteristics of access trips for the Delhi Metro network, in Delhi as well as the satellite towns of Noida and Gurgaon, all the metro stations were classified into different districts.

Figure 11. Modal share for access trips by different areas in National Capital Region of Delhi



	Northwest	North	East	Central	West	New Delhi	South	Gurgaon	Noida
Walk	41%	46%	39%	62%	59%	69%	43%	20%	38%
Cycle	2%	1%	2%	0%	1%	1%	3%	1%	0%
Rickshaw	7%	10%	9%	8%	13%	2%	4%	6%	15%
Auto	15%	17%	24%	12%	9%	9%	24%	30%	22%
Bus	8%	16%	12%	12%	7%	8%	12%	10%	13%
Motorcycle	2%	3%	5%	8%	3%	2%	3%	11%	4%
Car	26%	7%	9%	0%	4%	9%	12%	23%	9%

As can be seen from Figure 11, the modal share of access trips for metro users varies with location. The share of walking trips is predominant in almost all the districts of Delhi – ranging from approximately 40 to 70%. The Delhi, Central, West and New Delhi districts have at least 60% of access trips by walking, while other districts, including Noida city, have up to 45%. Gurgaon has the lowest share of walking trips (one-fifth), which is even less than its share of auto rickshaws (30%). It also has one of the highest shares of car access trips, 23%, next to the Northwest district, which has up to one-fourth of access trips by car. The modal share of rickshaws is also greatly varied, with Noida having the highest share at 15% and the New Delhi area having the lowest share at 2%. Furthermore, Gurgaon, South, and Northwest districts of Delhi have a low share of cycle-rickshaws.

Figure 12 shows a similar analysis for egress trips, although there is less variation of modal shares than in the access trips. Among the egress trips, walking reaches a maximum of 50% and a minimum of 37%.

Interestingly, the share of rickshaws in the egress trips are much higher than the access trips, with a maximum of up to 20% in Noida and a minimum of 5%. While New Delhi only has 3% of access trips by rickshaws, it has up to 10% for egress trips.

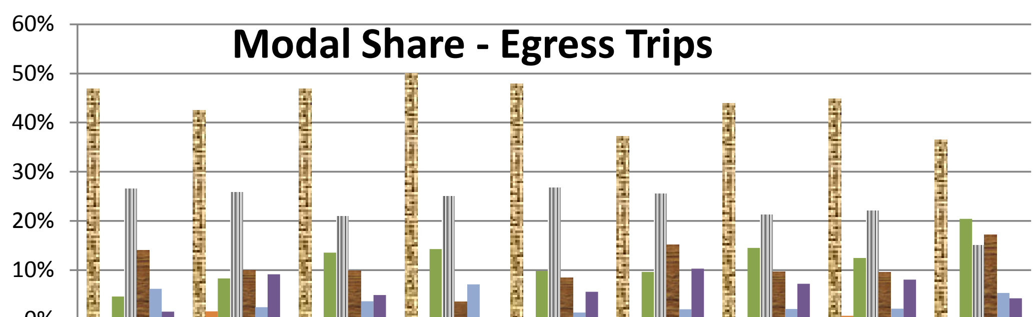
Access Time Within Metro Stations

The access time of a public transportation system (bus or metro) includes the time that a commuter takes to arrive from their point of origin to the bus stop or metro platform. By this definition, the metro has additional waiting/walking components once the passenger reaches the entry of the station. It includes walking down the stairs/escalators, waiting in the queue to buy a token (an estimated 55–60% of passengers use smart cards), waiting to be frisked by the security forces leading to long queues followed by baggage checks using scanner machines, similar to those at Airports. Following this, passengers proceed to the gates, which open after the tokens are deposited or smart cards are scanned. It should be highlighted here that the metro system's components of walking within the station, buying a token, frisking and baggage scanning are absent from the bus system, since tickets are bought once the passengers board the bus – overlapping with the in-vehicle time – and there are no security checks at bus stops.

Alternative Modes

When respondents were asked what alternative modes they would take for their trip, other than metro, less than 2% of non-motorised modes were mentioned, while almost half of the respondents mentioned buses. Auto rickshaws were mentioned by 12%, while private vehicles, i.e. motorcycles and cars, were mentioned by 14% and 23%, respectively.

Figure 12. Modal share for egress trips by different areas in National Capital Region of Delhi



	Northwest	North	East	Central	West	New Delhi	South	Gurgaon	Noida
Walk	47%	43%	47%	50%	48%	37%	44%	45%	37%
Cycle	0%	2%	0%	0%	0%	0%	0%	1%	0%
Rickshaw	5%	8%	14%	14%	10%	10%	15%	13%	20%
Auto	27%	26%	21%	25%	27%	26%	21%	22%	15%
Bus	14%	10%	10%	4%	8%	15%	10%	10%	17%
Motorcycle	6%	3%	4%	7%	1%	2%	2%	2%	5%
Car	2%	9%	5%	0%	6%	10%	7%	8%	4%

Vehicle Ownership

The survey respondents were asked to mention the type of vehicle they own. While 46% mentioned having no vehicles, an almost equal number of respondents – 28% – mentioned owning motorcycles and cars.

Table 11. Alternative Mode – Other than Delhi Metro, what is the other mode for this trip? (Total respondents – 1,053)

Mode	Percentage of Respondents	Number of Respondents
Walk	0.9	9
Cycle	0.4	4
Rickshaw	0.3	3
Auto	11.9	125
Bus	49.4	520
Motorcycle	13.7	144
Car	22.5	237

Table 12. Vehicle Ownership – Which mode do you own? (Total respondents – 1,104)

Mode	Percentage of Respondents	Number of Respondents
None	45.8	506
Cycle	1.4	16
Motorcycle	28.8	318
Car	28.3	312

Induced Trips

In order to estimate the number of trips that are induced by the availability of the Delhi Metro, respondents were asked whether they would still make this trip, if the metro were not available. Almost 14% of respondents said they would not make the trip, and about 4% said maybe.

Table 13. Induced Trips – Would you still make this trip if metro were not available? (Total respondents – 1,089)

Response	Percentage of Respondents	Number of Respondents
Yes	82.9	903
Maybe	3.6	39
No	13.5	147

Average Trip Length

In the survey, respondents were asked to mention their starting and destination metro stations. Using this information, travel distance on the metro route has been calculated. This was done by first determining the latitude and longitude of all the metro stations. The distance between each consecutive metro stations was determined by calculating the straight line between the two stations. This is a safe approximation because the alignment of metro stations is mostly made as a straight line between two consecutive stations.

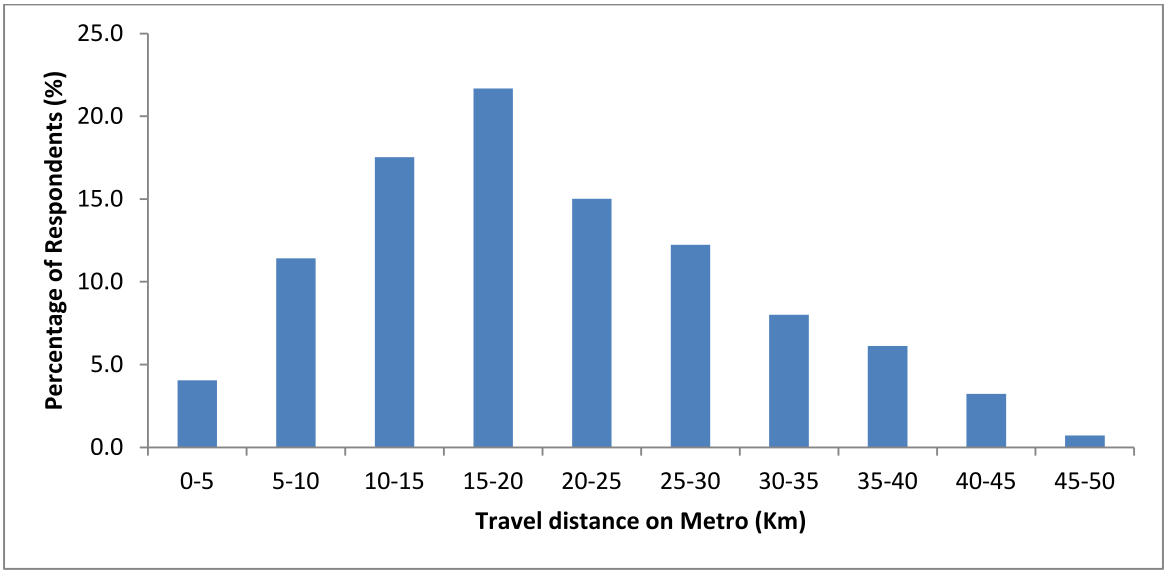
A distance matrix was formed using the distance of the consecutive metro stations, as calculated above. Using MATLAB software, a program was made to measure the travel length for the origin-destination pair, corresponding to each survey respondent. The table below shows the percentage of survey respondents for the different distance categories.

Table 14. Percentage of respondents for different travel distance categories (Total Respondents – 1,112)

Distance (km)	Percentage of Respondents	Number of Respondents
0-5	4.0	53
5-10	11.4	127
10-15	17.5	195
15-20	21.7	241
20-25	15.0	167
25-30	12.2	136
30-35	8.0	89
35-40	6.1	68
40-45	3.2	36
45-50	0.7	8
Mean		20.2
Standard Deviation		9.75

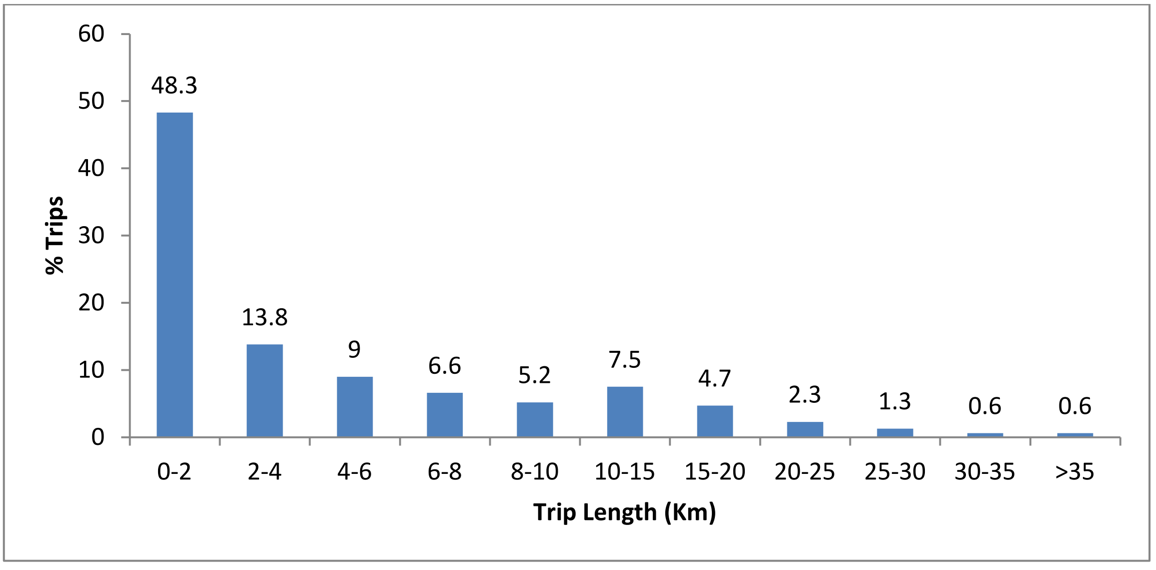
On average, survey respondents travelled a mean distance of 20.2 (± 0.57) km at a 95% confidence interval. Using origin-destination metro stations and the fare chart, the fare paid by respondents for their current trip has been determined. The average fare paid by survey respondents is INR 20.7 ± 0.3 (USD 0.41). Moreover, a similar value of average fare (INR 19.3/USD 0.39) is obtained using total revenue, USD 772,000, and corresponding ridership, 2,006,949, for January 9, 2012 – reported by the Delhi Metro. This corroborates the results of the survey and indicates that the survey sample is representative of the population.

Figure 13. Trip length distribution of metro user survey respondents



Over 80% of all the respondents travelled more than 10 km of distance on the metro, with 54% in the 10–25 km range. These results provide important insight into the travel characteristics of metro users. With only 15% of trips less than 10 km, metro users travel longer distances. Figures 13 and 14 compare the trip length distribution of metro survey respondents with the survey conducted by RITES in Delhi, in 2007–08, for a sample of population of the city.

Figure 14. Trip length distribution of all modes in Delhi (including walk mode) (RITES, 2007–08)



There is a clear difference between the trip length distribution of metro users and that of the Delhi population, in general. While over 80% of all the respondents travelled more than 10 km of distance on the metro, only 17% of trips in Delhi are more than 10 km long. This indicates that the metro, as a public transport, caters to a small proportion of the population in Delhi, with more than 10 km of trip lengths.

Trip Fare

Applying the information of the origin and destination metro stations, the fare paid for each trip was calculated using the fare chart available on the Delhi Metro website.

Table 15. Percentage of respondents for different fare categories (Total Respondents – 1,112)

Fare (INR)	Percentage of Respondents	Number of Respondents
<10	1.9	21
10-15	5.9	66
15-20	37.7	419
20-25	28.0	311
25-30	26.5	295
Mean		20.6

On average, survey respondents paid USD 0.4, and over 54% of respondents paid more than the average fare. This indicates that, on average, a metro commuter making two trips per day, for 22 working days in a month, pays at least USD 18[8]. Taking into account the 10% discount provided by the Delhi Metro for Travel Card users (http://www.delhimetrorail.com/metro-fares.aspx), the average fare paid is USD 16 per month. It should be noted that these costs do not include the out-of-pocket expenses for using motorized access/egress modes, such as bus fare, or parking fee for motorcycles and cars.

A study by Advani in 2010 developed a travel demand model for public and private transport modes in Delhi, including the Delhi Metro network. The study highlighted the following issues:

Role of cycle-rickshaws: The study found that nearly 27% (if the vehicular speeds increased by 10% due to investments in road expansion schemes) to 38% (if the vehicular speeds decreased by 10% due to growing traffic congestion) of metro trips are dependent on rickshaws. If the Delhi Government's present policy on restricting rickshaws in several parts of the city continues, metro ridership will be adversely affected.

Transport policies: The study gives insights into the impact of policies that may lead to an increase in speeds of cars and two-wheelers. Public transport trips reduce when the speeds of cars and two-wheelers increase. Moreover, there is a greater reduction of metro trips than bus trips. However, when the speeds of cars and two-wheelers reduce by 10%, metro trips increase. These results are expected, and highlight the fact that rail-based systems will become attractive when roads are congested.

8 For reference, the minimum daily wage rate for a skilled labourer in Delhi is USD 6.2. (http://www.paycheck.in/main/salary/officialminimumwages/delhi)

Importance of bus system: The study has highlighted the importance of the bus system. Even after the completion of 256 km of metro network, according to the travel demand model, at least 64% of public transport trips are made by buses. In addition to this, 31 to 38% of metro trips are dependent on bus feeder trips. Despite an extensive network of metro system, the bus system must be improved and made efficient if public transport is to be promoted in a city.

Based on these findings, it can also be argued that bus routes parallel to the metro system should not be discontinued, since those buses can act as a feeder mode for the parallel metro line stations.

3.5 Access Audit of Metro Stations

Accessing metro stations contributes to a significant proportion of disutility (or inconvenience) for a trip by metro. There are several reasons for this. First, the access and egress parts of a public transportation trip involve the most physical effort for walking, transferring, etc. Second, unlike bus networks which have a much higher coverage and smaller catchment areas for each bus stop, metro stations have much larger catchment areas. Consequently, there is a large portion of the city's population for which access and egress distances are longer than a comfortable walking distance of 500–700 metres. Third, as the access and egress trips become longer, individuals have to interact with more elements of road infrastructure, such as footpaths and pedestrian crossings. Pedestrian infrastructure has an important implication for the safety of public transport users and, thus, determines, to some extent, the willingness of individuals to use public transportation. Therefore, the disutility of a metro trip increases even further if the pedestrian infrastructure is inconvenient or absent from the roads.

In order to measure the accessibility of Delhi metro stations, accessibility audits were carried out at three major stations – Hauz Khas, Kashmere Gate and New Delhi Railway. All three stations are on the Yellow Line, which runs North-South, and are located in three different parts of the city. Hauz Khas is located in the southern part, Kashmere Gate is in the northern part, and New Delhi Railway is in the central part of Delhi.

Hauz Khas Metro station predominantly caters to the residential and educational institution areas of Hauz Khas, Kalu Sarai, Swami Nagar, Panchsheel Park, Katwaria Sarai and Munirka. Kashmere Gate is the largest metro station and is located near an inter-state bus terminal, since it is a major interchange station between buses and metros. In addition to inter-state buses, there is a terminal for intra-city buses located at Kashmere Gate. Therefore, the area around this metro station is a major pedestrian hub. Furthermore, it is a transfer station between two metro lines – Yellow and Red. New Delhi is also a major multi-modal hub since it is located at the New Delhi Railway Station, which is one of the busiest railway stations in India. Audits have been carried out at these stations, to evaluate the accessibility of metro stations by pedestrians. In the audits, an assessment was done for footpaths and pedestrian crossings. The following are major parameters, which were objectively assessed and rated (see Annexure 2):

1. Pavement quality
2. Geometry of pavement – width and height
3. Lighting quality (especially for pedestrians)
4. Barrier-free design standards – ramps and other facilities

Hauz Khas Metro Station

There are three entry gates for Hauz Khas station. Two of them are located at either side of a major arterial (outer ring road), and one is located at a collector road within a residential area of Hauz Khas. The audit has been carried out for station accessibility from the former two entry gates. Since the entries to the metro station are located at both sides of the major arterial road, this eliminates the need for commuters to cross the road in order to access the metro station. The following description focuses on the pedestrian facility.

While footpaths are present, their discontinuity discourages pedestrians from using them. The major obstructing factors are: potholes, open manholes, poor maintenance of paver blocks, trees, parked vehicles, street furniture like light poles, electric wires, and discontinuity due to driveways. The discontinuity is made worse with more elevated footpaths and no ramps. For instance, the height of footpaths varies from 0.15 metres to 0.6 metres, while the standard is 0.15 metres. This is a major impediment for the disabled, elderly, and people carrying babies. Since the station entry is located along a high volume and high-speed arterial road, it poses a threat to pedestrians walking on the vehicular carriageway, in the absence of pedestrian infrastructure. It has been observed that the pedestrian facilities are adequate near the station entries. In terms of barrier-free design standards, pedestrian facilities fail to meet the standards with their lack of ramps. There is a consistent pattern of poor available lighting for pedestrians, along the footpaths, and adequate lighting is only available near the entry gates of metro stations.

Kashmere Gate Metro Station

Access to Kashmere Gate station is through two roads, which are enclosed from the northern and eastern side. Pedestrians must cross the road in order to move between the inter-state bus terminal and the metro station. However, no dedicated pedestrian facilities are present for this crossing. In the absence of a zebra crossing, pedestrians are forced to jaywalk. Moreover, the absence of ramps makes it highly inconvenient to move from carriageway to footpath, especially for the disabled and elderly. The northern side of the metro station has footpaths, and the need for crossing is eliminated due to the presence of entry gates on both sides of the road. From the south side, pedestrian movement occurs between the intra-city bus terminal and the metro station. The access facilities from this side of the metro station are very inadequate. Footpaths are absent, broken, encroached on by parked vehicles, or rendered useless because of urination. The entry gates do not have ramps to provide barrier-free access.

New Delhi Metro Station

A large number of commuters move between the New Delhi Railway station and metro stations. Access to metro stations from the railway station is available from within the railway station area, and, therefore, there is no interaction with roadway traffic. However, pedestrians have to make their way through taxi aisles. Furthermore, as there is an absence of ramps, barrier-free standards and accessibility are poor. Commuters who access the metro station from outside must interact with vehicular traffic, in the absence of safe pedestrian crossing facilities. Additionally, there are no footpaths available for pedestrians.

Major Findings from the Accessibility Survey

1. It has often been observed that footpaths are present, physically, but are rendered useless because of their frequent discontinuity and height, which is much higher than the standard – 150 cm. The discontinuity occurs due to the presence of driveways in front of residences, cross-streets, street furniture, trees, construction materials, potholes, manholes, and the encroachment of footpaths by

parked vehicles. This encourages pedestrians to walk on the carriageway, where they are exposed to risks from fast moving traffic.

2. There is a lack of pedestrian infrastructure along the roads providing access to metro stations. This has been found consistently, regardless of the region in Delhi.

3. Adequate pedestrian infrastructure is available outside the station entry gates. However, the infrastructure does not have barrier-free standards, and ramps are missing from all the metro sections that were audited. This makes it difficult for people with disabilities, or the elderly, to access stations.

4. In cases where the entry of the metro station is located mid-block, dedicated pedestrian signals or zebra crossings are absent. Such a situation is only eliminated when the entry is located at both sides of the road.

5. There is a consistent finding of the absence of lighting for footpaths. Most often, the lighting provided for carriageways, meant for vehicular traffic, is obstructed by trees or other street furniture, which leads to darkness along the paths.

3.6 Security of Delhi Metro

As the Delhi Metro was considered a soft target for terrorists, starting in April 2007, Central Industrial Security Force (CISF) personnel were deployed at different stations in its network (TOI, 2007). In 2011, there were 4,500 CISF personnel deployed at various stations of the Delhi Metro (Zeenews.com, 2011). With the expanding network in satellite towns, the DMRC needs a total of more than 7,000 CISF personnel (Indian Express, 2009). It should be noted that the CISF is a Federal Government funded agency, and the cost of security by the CISF is not absorbed by the Delhi Metro.

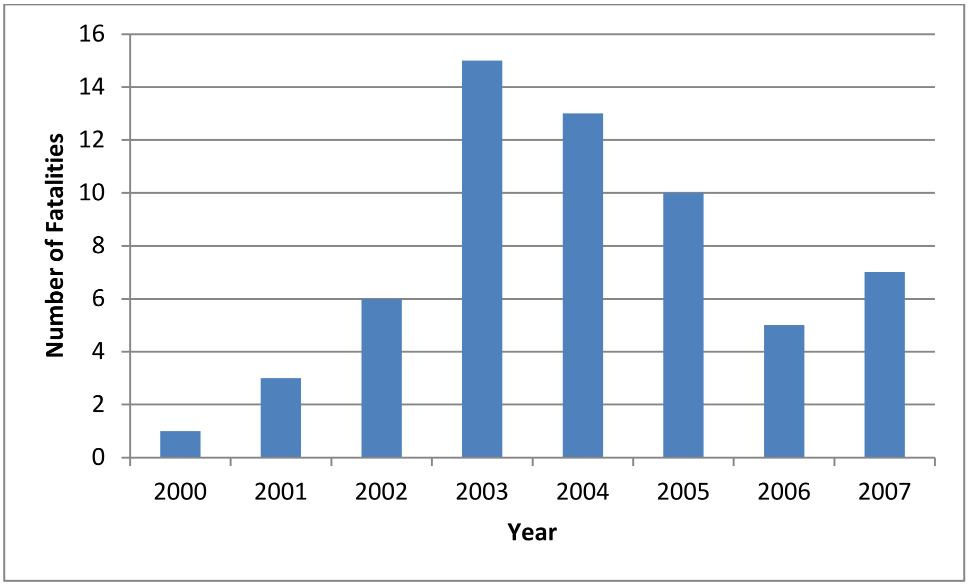
3.7 Negative Externalities of Delhi Metro

This section highlights the negative externalities of the Delhi Metro, which are often not included when accounting for costs and benefits. The main negative externalities include: injuries during construction, the displacement of households due to land requirements for the construction of the Delhi Metro, as well as the related emissions and impact on the environment during the construction, operation, maintenance of metro operations and production of the attributed electricity.

3.7.1 Fatalities and Injuries During Construction

From the information obtained using the Right to Information (RTI) Act, 2005, in December 2007, there were 60 fatal accidents during the construction of the Delhi Metro – from 2000 through 2007. Moreover, there were 26 major non-fatal accidents during the same period. Figure 15 shows the yearly trend of fatalities, obtained from the RTI data. Another source (Civil Society, 2009) which obtained information on accidents during metro construction, using RTI from police records, puts the total deaths at 261 and total injuries at 481, by 2009.

Figure 15. Number of fatalities during the construction of Delhi Metro



Source: RTI No. xxx

3.7.2 Displacement of Households

A significant proportion of people living in poverty continue to live in informal settlements without water and sanitation services, in many Indian cities. It is estimated that nearly 3 million people live in Jhuggi Jhopri (JJ) clusters in Delhi – unplanned squatter or slum settlements – which was projected to increase to 4.5 million by 2011 and 6 million by 2020 (Anand, 2007; Tiwari 2003). Figure 16 shows the geographical spread of the JJ clusters in Delhi, and the citywide occurrence of these low-income settlements.

As the city carries out its development process, it leads to the eviction of people living in low-income households. This, in turn, leads to their loss of access to regular employment and livelihood opportunities, in addition to education, health care, and other social necessities. Between 2000 and 2004, more than 100,000 Jhuggies in Delhi have been displaced 10–25 km away from their original location (Tiwari, 2003). Similar eviction and relocation of Jhuggies took place with the development of the Delhi Metro, which acquired large tracts of land along its lines. According to the Environmental Impact Assessment report of Phase I of the Delhi Metro, the project required 348.45 hectares of land and needed to relocate 2,502 Jhuggies (Hazards Centre, 2006).

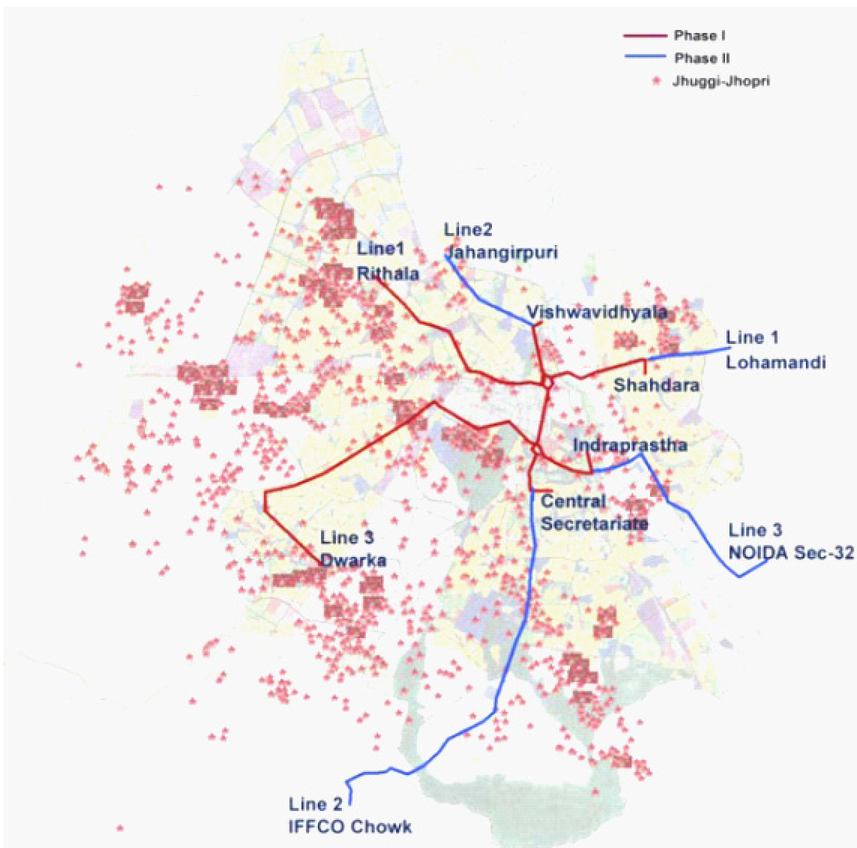
1. Several households from different slum settlements were relocated to a designated resettlement colony called Holambikalan, located at the North-West periphery of Delhi. A survey of 201 households in the resettlement colony was carried out in 2004 (Anand, 2007). The survey found impacts on the accessibility and the socio-economic profiles of the relocated households. The following are different impacts that were found to be statistically significant:The bus route availability and frequency reduced after relocation – from a 5-minute headway to 63 minutes (13 times).

2. For 19% of the households the income remained the same after relocation, while for 66% it decreased, and for 15% it increased. On average, household income reduced from INR 3,145 (USD 78.6) to INR 2,514 (USD 62.85) after relocation.

3. Nearly 99% of the households did not have availability/need of using RTVs for access before relocation, but all households use RTVs to travel after relocation.

4. The daily travel distance after relocation increased from an average of 4.4 km to 15.4 km, resulting in an increase in travel time as well as cost.

Figure 16. Jhuggi Jhopri Clusters and Metro Network under Phases I and II



3.7.3 Real Estate

With the alignment of the Delhi Metro being guided by locations that can be most profitably developed for high-end business parks, the DMRC has become a major property developer with plans to develop the plots of land it has acquired along the route (Siemiatycki, 2006). This is further confirmed by reviewing the funding pattern of the Delhi Metro project (3–7% from property development) as well as the revenue streams, according to which revenue from real estate contributed as much as half of the total operating revenue (see Table 3) during its initial years of operation.

The arrival of metros at different locations in Delhi has led to an increase in the real estate prices of areas adjacent to the metro line. According to studies done in 2007–2008 (Swamy, 2008), for residential and commercial areas, on average, land value within 500 m of a metro line increased by 11.3% and 18.1%, respectively. Moreover, land value changes are more consistent and higher after a metro is operational, as compared to the construction and planning stage, and increase by 2–4% every year. It was observed that the increase in land value is highly dependent on the income of the people occupying the area, and whether the area has planned development or not.

Another study, by Magicbricks.com in 2012, found that areas such as Model Town and Azadpur, in North Delhi, witnessed an average appreciation of 30% in capital values after the advent of metro rail services. Similarly, in areas like Rajouri Garden, Punjabi Bagh, Vikaspuri and Janakpuri, in West Delhi, property values appreciated by 25–30% as a result of the metro rail services in the area. Additionally, similar to the study by Swamy in 2008, it was observed that in the residential segment, houses within a radius of 500 m from a metro station fetch higher capital and rental values than those that are farther – at a radius of 1 km from the metro stations. The Delhi Government is proposing a policy on Transit Oriented Development (TOD) to capture the benefits of the increase in land value around metro stations.

3.7.4 Emissions from Electricity Used in Metro

The Delhi Metro is a system that runs mainly on electricity. It has electricity consumption from traction – running of trains – and non-traction purposes, such as lifts and escalators, air-conditioning of underground stations, lighting of stations, etc. As seen in the section on Cost and Revenue Streams, electricity contributes 25 to 30% of the total operating cost of the Delhi Metro. To evaluate such a system, it becomes essential to estimate the emissions attributed to its operation. According to a 2007 estimate, electricity generation in India contributes 37.8% of CO_2 eq. emissions – CO_2, SO_2, NO_2 (MOEF, 2010). This is because India's production of electricity is mainly by coal-based thermal power plants. In 2009, 69% of electricity in the country came from coal (IEA, 2011). Since the coal in India has a higher fly ash content (30–40%), electricity generation leads to the formation of particulate matter (PM_{10} /$PM_{2.5}$) – a source of air pollution in the form of fly ash (Senapati, 2011). Therefore, the Delhi Metro has no direct emissions from its operation, but contributes to carbon emissions at power plants during the generation of electricity used for its operation.

Considering the per unit cost of electricity for the Delhi Metro as Rs 3[9] (USD 0.06), and the cost of electricity for the financial year (FY) 2010–11 as USD 27 million (Traction and Electricity/Water Expenses in Table 5), the result is approximately 450 million units of electricity consumption per annum for the Delhi Metro. For the same year, the average annual ridership of the Delhi Metro was 1.42 million (ridership in March 2011 from DMRC, 2011), and the average trip length was 20 km, as estimated from the on-board survey of 1,112 metro users.

Using the electricity emission factor for India from the United Nations Greenhouse Gas Calculator[10] as 0.943 kg per KWh and a transmission and distribution loss of 32%, as provided by the Central Electricity Authority (IEA, 2011a), gives 61 g of CO_2 equivalents per passenger km of travel on the Delhi Metro. Sperling et al. (2004)[11] have estimated CO_2 equivalent emissions per passenger km from rail transit in developing countries to be in the range of 20–50 g. It should be noted that these emissions values

9 www.teriin.org/

10 http://www.unemg.org/LinkClick.aspx?fileticket=KZlC5tw7Xro%3d&tabid=3975&language=en-US

11 Sperling, Daniel et al., (2004) Environment Impact Due to Urban Transport, In The Urban Transport and The Environment, WCTR, edited by H. Nakamura, Y. Hayashi and A. May, Elsevier.

include only the operational aspect of the Delhi Metro, and not the life cycle emissions during vehicle manufacturing, station construction, steel manufacturing for tracks, etc.

3.7.5 Emissions Based on Life Cycle Assessment Method of Delhi Metro and CNG Bus

The analysis of the total energy over the life of a vehicle is known as life cycle assessment. In order to give the most complete description of the environmental problems related to transport, the entire transport system must be analysed in a holistic way, which includes a life cycle approach. The life cycle approach analytical system includes not only the transport vehicle, but also the entire infrastructure needed by the transport logistics. The environmental impacts of passenger transportation modes are only understood at the operational level. In quantifying energy impacts and emissions, these modes have been analysed at the vehicle level. To fully understand the system-wide, comprehensive environmental implications, analysis should be performed on the other life cycle phases of these modes, as well – design, raw materials extraction, manufacturing, construction, operation maintenance and end-of-life of the vehicle infrastructure. Chester, M.V., Horvath, A., and Madanat, S. (2010) compared the life cycle energy and emissions (greenhouse gases, CO, NO_X, SO_2, PM_{10}, and VOCs) inventory for three U.S. metropolitan regions: San Francisco, Chicago, and New York City. The inventory captures both vehicle operation – direct fuel or electricity consumption – and non-operation components – e.g., vehicle manufacturing, roadway maintenance, infrastructure operation, and material production, among others. The study shows the inclusion of life cycle processes, necessary for any transportation mode results in significant increases (as large as 20 times that of vehicle operation) for the region. Two recent studies on the Delhi Metro – The life cycle assessment of CNG buses and metro in Delhi, an M. Tech thesis by Ashok Kumar at the Indian Institute of Technology Delhi in 2012, and LCA for Transport Modes, an on going study at TERI[12] – show similar results. Therefore, it is important to compare emissions from different modes of transport, based on LCA methodology.

12 www.teriin.org/

Photo credit: Maciej Janiec

4. Issues and Policy Implications

Table 16. Major issues of Delhi Metro and their policy implications

Issues	Description	Implications
Revenue	The farebox contributes less than 50% of the total revenue of the Delhi Metro.	It has a significant implication on the self-sustainability of metro systems. This leads to the metro systems' dependence on real estate development and, hence, a permanent change in the city's structure. While bus systems can become self-sustainable with the city's support, it does not alter the city's structure.
Costs	The DMRC has a current debt of USD 3 billion, while the annual interest and financial charges reached more than USD 36 million in 2011.	With the increasing cost of operations and debt repayment, and an expanding network size, the cost burden of the Delhi Metro is going to rise significantly.
Ridership	Actual ridership of the Delhi Metro is, at most, one-fourth of the projected ridership, leading to an overestimation of the benefits (and unfair justification) of the metro system in the DPRs, during the planning phase.	Future planning of metros in other cities should address this issue, and the travel demand models should be improved in order to provide a realistic projection of the demands, and, hence, the benefits of metro systems.
Long trip lengths	While over 80% of all respondents travelled more than 10 km of distance on metros, only 17% of trips are more than 10 km long in Delhi.	While the metro can cater to long trips (10 km or more), transport policies should focus on improving non-motorised transport (NMT) and bus transport infrastructure in order to cater to shorter trips, which comprise more than 80% of all trips in Delhi, as well as other Indian cities.
Availability of cycle-rickshaws	Cycle-rickshaws are an important feeder mode for metro users. The study shows that nearly 27% to 38% of metro trips depend on rickshaws for their last-mile connectivity. At present, there are 15% rickshaw users due to restrictions posed on plying of rickshaws in many parts of Delhi.	If rickshaws are permitted to ply all over Delhi, metro ridership can be significantly augmented. Rickshaw parking near metro stations is also required, to facilitate the use of rickshaws for access and egress trips to metros.

Issues	Description	Implications
Availability of NMT infrastructure	Safe pedestrian and bicycle paths and crossing facilities do not exist near metro stops. This makes access to metro stops difficult.	A focus on NMT infrastructure improvement in the city has a great potential to increase the access to metros and, hence, the metro ridership.
Transport policies for private motorized vehicles	The study shows that an improvement of the speed of cars and two-wheelers leads to a significant reduction in metro ridership.	Transport policies like flyovers, road widening, and increased parking may lead to a reduction in the ridership of public transport, in general, and metro use, in particular.
Emissions based on life cycle assessment	Operation of metros, operation/ maintenance of infrastructure, and construction of rail tracks have the largest influence on metro rail energy consumption and emissions. The metro's total negative impact on the environment is 1.5 times more than the CNG-run bus systems in Delhi.	Metro rails cause a higher negative impact on the environment compared to bus systems. Emissions and adverse impacts on the environment during the infrastructure construction phase should be considered when accounting for total emissions of transport systems.

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Annexures

Annexure 1

INDIAN INSTITUTE OF TECHNOLOGY, NEW DELHI

भारतीय प्रौद्योगिकी संस्थान, नई दिल्ली

This survey is for research purposes only.Thank you for your help.

यह सर्वेक्षण शोध कार्य हेतु किया जा रहा है।आपके सहयोग के लिए धन्यवाद।

1) Where did you start this trip? Please give address of the school/college/office/home/market (example: Sector-21, Rohini, New Delhi).

____

आपकी यात्रा कहाँ से शरु हुई? कृपया स्कूल/कॉलेज/ऑफिस/घर/मार्केट का पता बताईये (उदाहरण: सेक्टर -21, रोहिणी, नयी दिल्ली)

____

2) How did you get to the metro station? (Tick one)
[ ]walk; [ ]auto; [ ]rickshaw; [ ]car; [ ]bus; [ ]cycle; [ ]motorcycle/scooter
आप मेट्रो स्टेशन तक कैसे पहुँचे?
[ ] पैदल; [ ] साइकिल; [ ] साइकिल रिक्शा; [ ] मोटर साइकिल/ स्कूटर;
[ ] कार; [ ] बस; [ ] ऑटो

3) What is your starting metro station? ______________
आपने किस मेट्रो स्टेशन से यात्रा शुरू की ? ______________

4) Which metro station are you going to? ______________
आप किस मेट्रो स्टेशन तक जा रहे हैं ? ______________

5) What is your destination? Please give address of the school/college/office/home/market (example: Sector-21, Rohini, New Delhi).

____

आप मेट्रो से उतर कर किस स्थान पर जायेंगे? कृपया स्कूल/कॉलेज/ऑफिस/घर/मार्केट का पता बताईये (उदाहरण: सेक्टर -21, रोहिणी, नयी दिल्ली)

6) How will you get from the metro station to your destination?
[ ]walk; [ ]auto; [ ]rickshaw; [ ]car; [ ]bus; [ ]cycle;
[ ]motorcycle/scooter
आप मेट्रो स्टेशन से उतर कर उस स्थान तक कैसे जायेंगे?
[ ] पैदल; [ ] साइकिल; [ ] साइकिल रिक्शा; [ ] मोटर साइकिल/ स्कूटर; [ ] कार; [ ] बस; [ ] ऑटो

7) Do you own a vehicle?
[ ] no; [ ] cycle; [ ] motorcycle/scooter; [ ] car

क्या आपके पास कोई वाहन है ?

[ ]नहीं ; [ ] साइकिल; [ ] मोटर साइकिल/ स्कूटर; [ ] कार

8) Before metros, how did you make this journey?
[ ]walk; [ ]auto; [ ]rickshaw; [ ] motorcycle/scooter; [ ]car; [ ]bus

मेट्रो सुविधा से पहले आप इस यात्रा को कैसे करते थे ?

[ ] पैदल; [ ] ऑटो; [ ] साइकिल; [ ] मोटर साइकिल/ स्कूटर;[ ] कार; [ ] बस

9) Would you still make this trip if metros were not available?
[ ]yes; [ ]no; [ ]maybe

क्या आप इस यात्रा को तब भी करते अगर मेट्रो नहीं होती?

[ ]हाँ; [ ]नहीं; [ ]शायद

Annexure 2

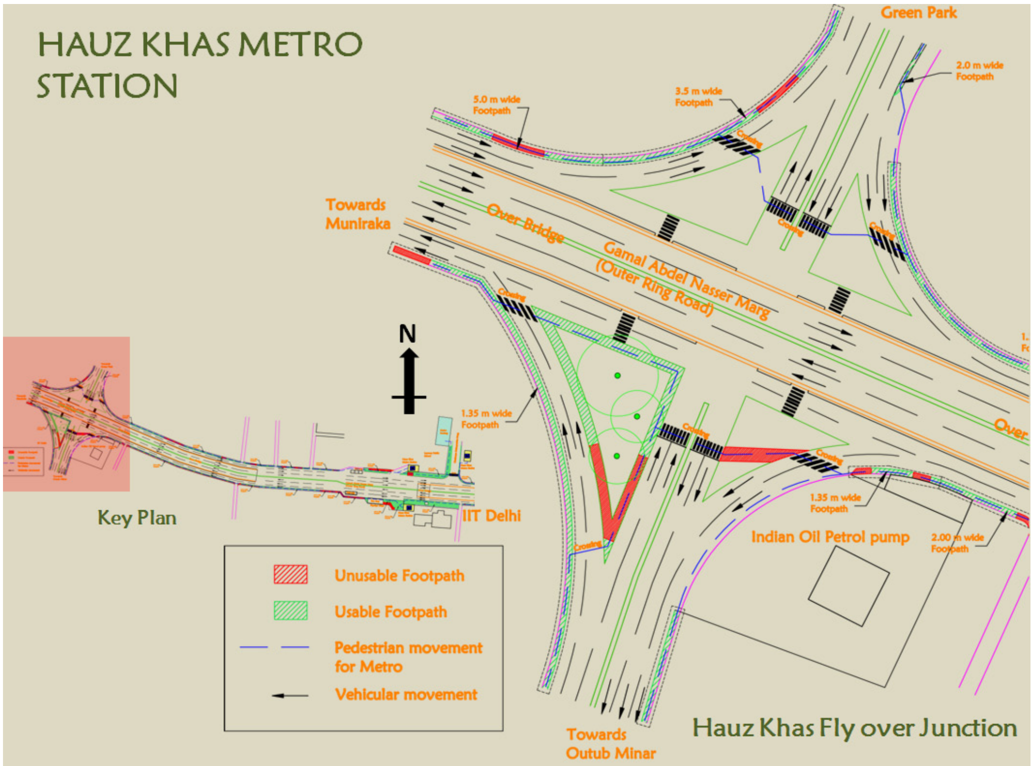
Hauz Khas Metro Station

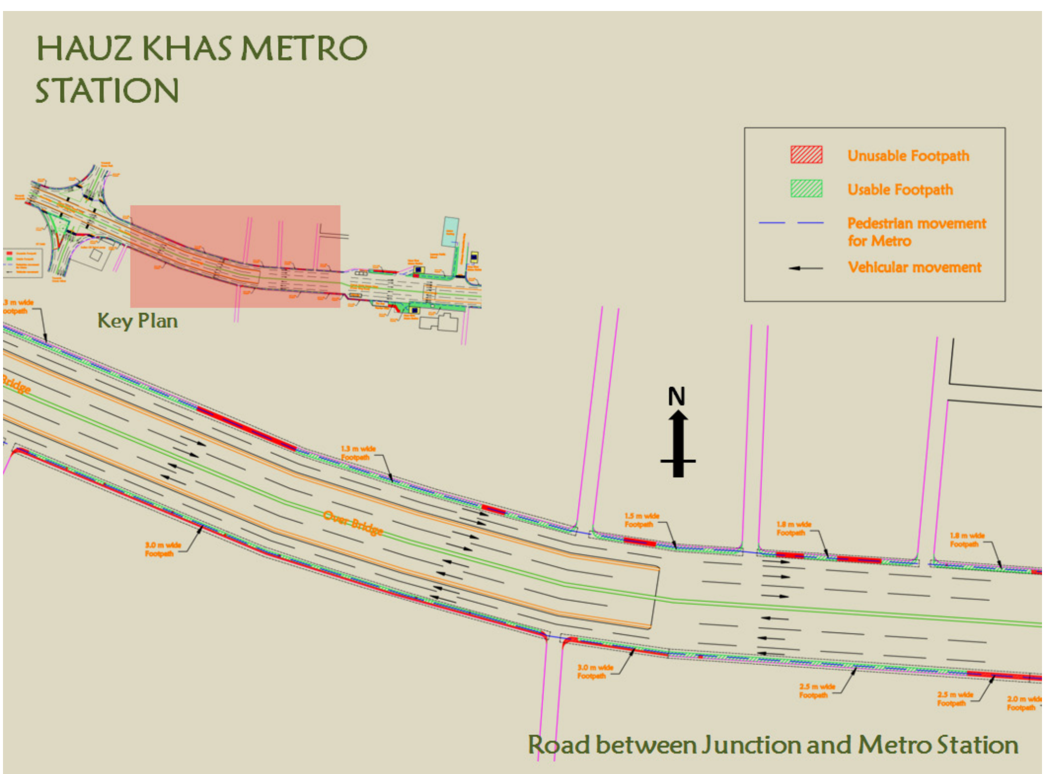
DIRECTION : IIT DELHI TO HAUZ KHAS METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes		✓		0.5	Uneven, broken at some places, Rough textured. Usable footpath -78% , Unusable footpath -22%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes		✓		0.5	Variable widths from 1.0 m to 5.0 m. 10.0 m wide in front of metro station. Height of footpath varying from 0.15 to 0.60 m.
	3) Lighting (Street lights especially for pedestrians)	Yes			✓	0.2	Insufficient lighting facility (i.e. street lights along the footpath). Light poles for pedestrians are present only near metro station.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath. Also Electric wires, broken poles, open drainage line, 2-wheeler parking makes footpath unusable and not barrier free.
	Overall				✓	1.2 /4.0	

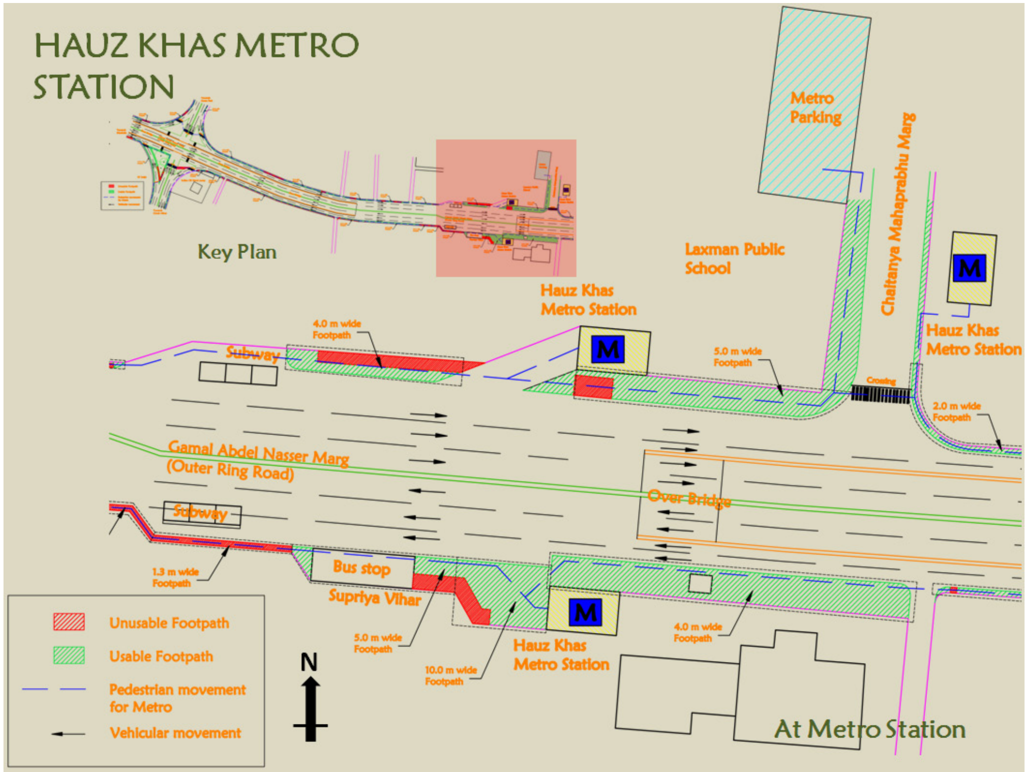
DIRECTION : HAUZ KHAS METRO STATION TO IIT DELHI							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes	✓			1.0	Footpath surface of is smooth. Usable footpath -90% , Unusable footpath -10%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes			✓	0.2	Variable widths from 1.0 m to 5.0 m. 7.0 m wide in front of metro station. Height of footpath varying from 0.15 to 0.60 m.
	3) Lighting (Street lights especially for pedestrians)	Yes			✓	0.2	Insufficient lighting facility (i.e. street lights along the footpath). Light poles for pedestrians are present only near metro station.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath. Also tress on footpath, electric poles, 2-wheeler parking makes footpath unusable and not barrier free.
	Overall				✓	1.2 /4.0	

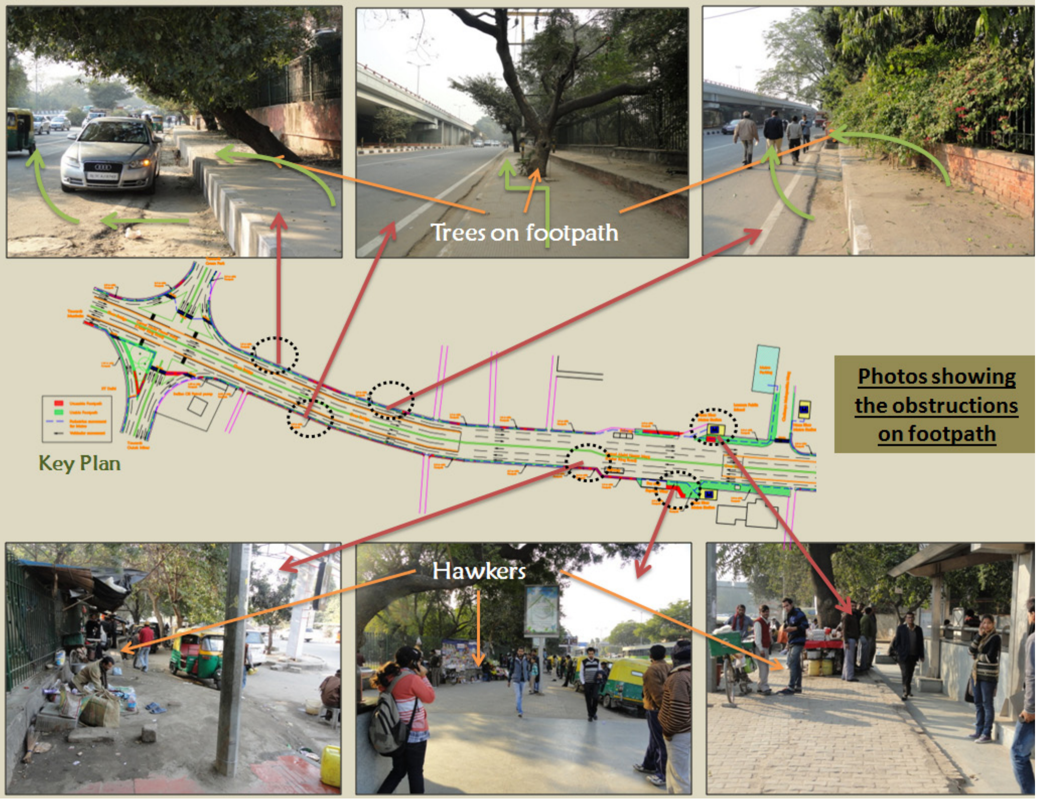
AT HAUZ KHAS METRO JUNCTION (near IIT flyover)							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	1) At Junction						
	Geometric standard (Width of zebra crossing should be between 3.0 m to 5.0 m)	Yes	✓			1.0	**Zebra marking** (3m wide) is in Good condition on both side. Total zebra marking length- 100 m.
	Lighting (Street lights especially for pedestrians)	Yes		✓		0.5	Moderate lighting facility (i.e. street lights along the pedestrian crossing).
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath on the both sides of zebra crossing.
	Overall					1.5/3.0	Fair quality of pedestrian crossing at hauz khas junction

AT HAUZ KHAS METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	2) Near Metro station						
	Geometric standard (Width of subway should be between 1.0 m to 1.5m)	Yes	✓			1.0	**SUBWAY**, Length-35 m, Width-6m, Ramp - width 1m, slope-1:8.5, 1.25 min (walking time to cross the road by subway)
	Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	
	Barrier free (Ramps and other facilities according to barrier free design standards)	Yes			✓	0.2	As minimum slop of ramp required according to barrier free design standard is 1:20. And existing slop of ramp in subway is 1:8.5.
	Overall					2.2/3.0	Pedestrian crossing at hauz khas metro station is good.

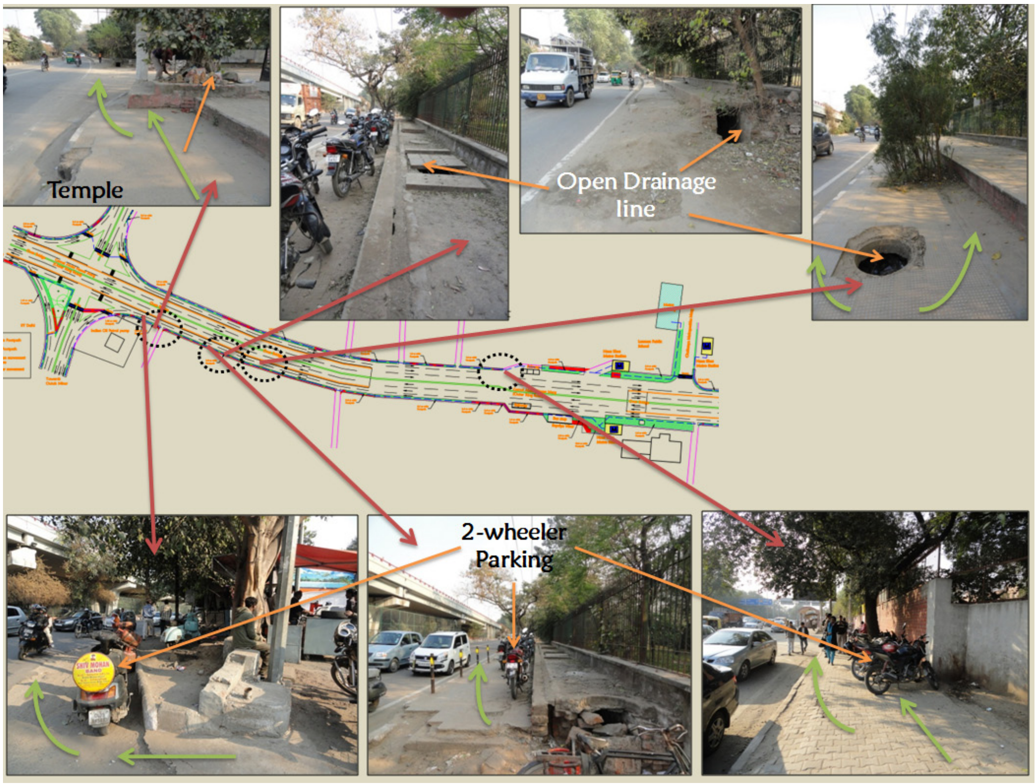

HAUZ KHAS METRO STATION
Green Park
2.0 m wide Footpath
5.0 m wide Footpath
3.5 m wide Footpath
Towards Munirka
Over Bridge
Gamal Abdel Nasser Marg (Outer Ring Road)
N
1.35 m wide Footpath
Key Plan
IIT Delhi
1.35 m wide Footpath
Indian Oil Petrol pump
2.00 m wide Footpath
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
Towards Qutub Minar
Hauz Khas Fly over Junction


HAUZ KHAS METRO STATION
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
Key Plan
N
1.5 m wide Footpath
Over Bridge
3.0 m wide Footpath
1.5 m wide Footpath
1.8 m wide Footpath
1.8 m wide Footpath
3.0 m wide Footpath
2.5 m wide Footpath
2.5 m wide Footpath
Road between Junction and Metro Station

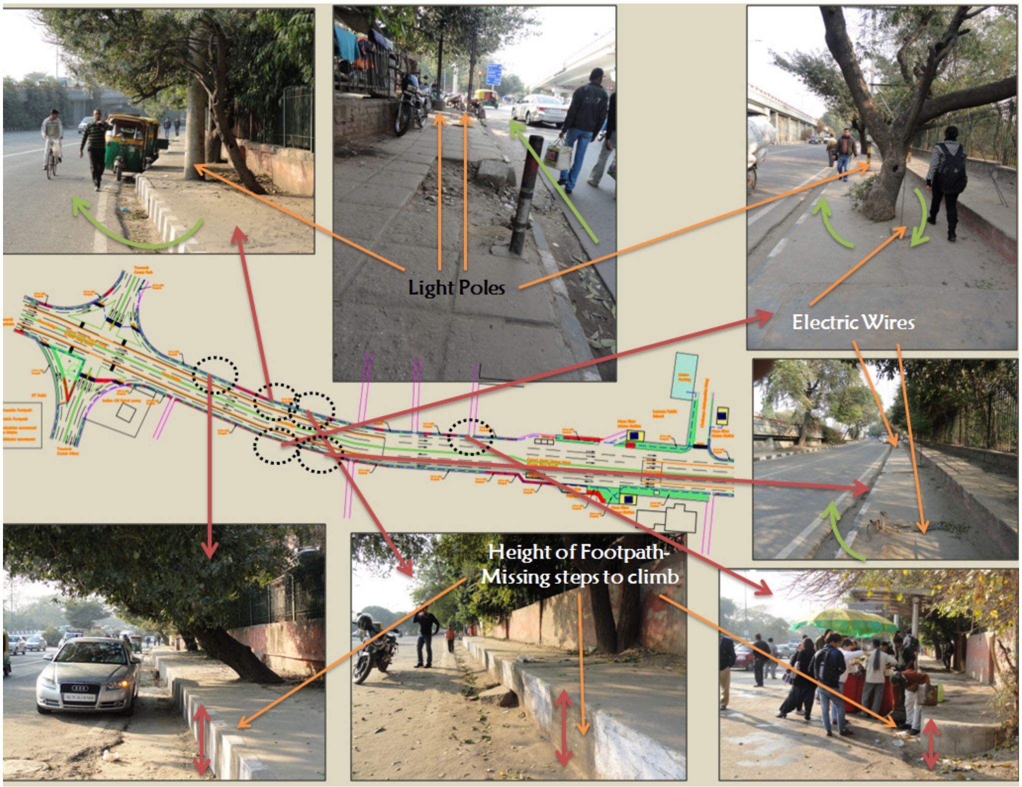

HAUZ KHAS METRO STATION
Key Plan
Metro Parking
Chaitanya Mahaprabhu Marg
Laxman Public School
Hauz Khas Metro Station
Hauz Khas Metro Station
4.0 m wide Footpath
Subway
5.0 m wide Footpath
Crossing
2.0 m wide Footpath
Gamal Abdel Nasser Marg (Outer Ring Road)
Over Bridge
Subway
1.3 m wide Footpath
Bus stop
Supriya Vihar
5.0 m wide Footpath
10.0 m wide Footpath
Hauz Khas Metro Station
4.0 m wide Footpath
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
N
At Metro Station



Trees on footpath
Key Plan
Photos showing the obstructions on footpath
Hawkers



Temple
Open Drainage line
2-wheeler Parking


Light Poles
Electric Wires
Height of Footpath-
Missing steps to climb


Lack of
Maintenance

Kashmere Gate Metro Station

DIRECTION : NORTH SIDE OF KASHMIRI GATE METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fare (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes	✓			1.0	Footpath surface is smooth and pedestrian friendly. Usable footpath -90% , Unusable footpath -10%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes	✓			1.0	Variable footpath widths from 1.5 m to 2.5 m. 7.0m to 10.0 m wide in front of metro station. Height of footpath varying from 0.15 to 0.30 m.
	3) Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights). Street lights are present on the edge of footpath.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					3.0 /4.0	Footpath facility on the north side of metro station is good.

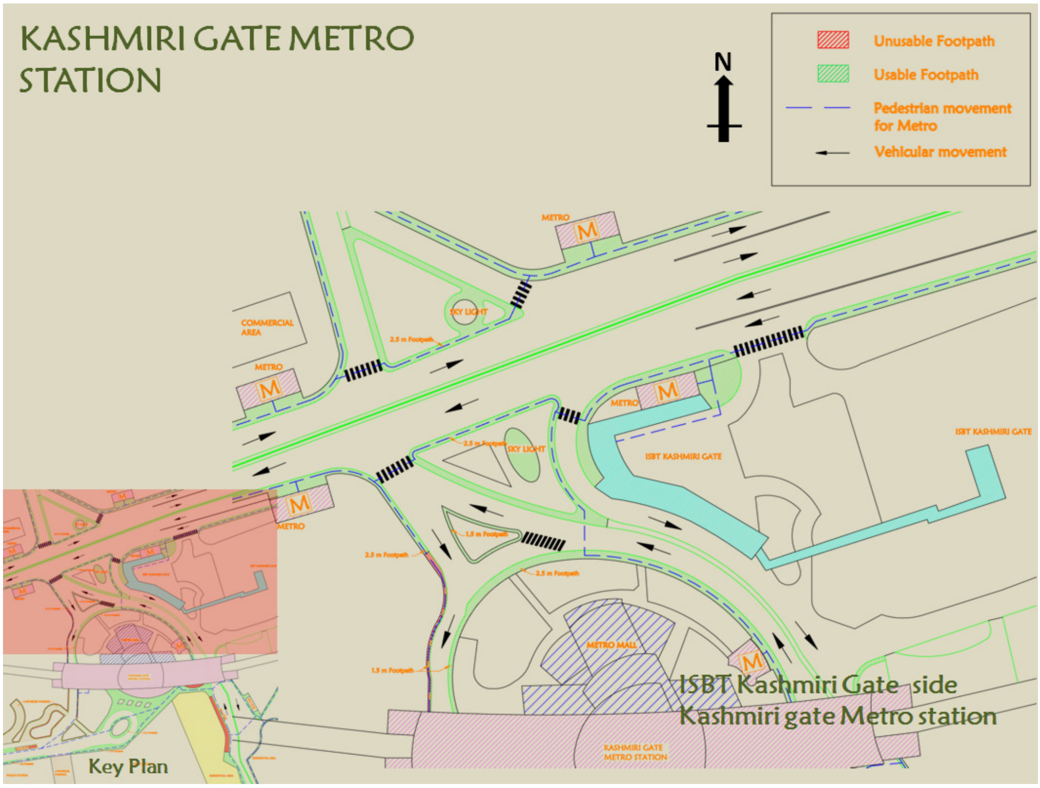
DIRECTION : SOUTH SIDE OF KASHMIRI GATE METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fare (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes		✓		0.5	Uneven, broken at some places, Rough textured. Usable footpath -70% , Unusable footpath -30%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes		✓		0.5	Variable widths from 1.0 m to 2.5 m. 7.0m to 10.0 m wide in front of metro station. Height of footpath varying from 0.10 to 0.20 m.
	3) Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights). Street lights are present on the edge of footpath.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					2.0 /4.0	Footpath facility on the south side of metro station is moderate.

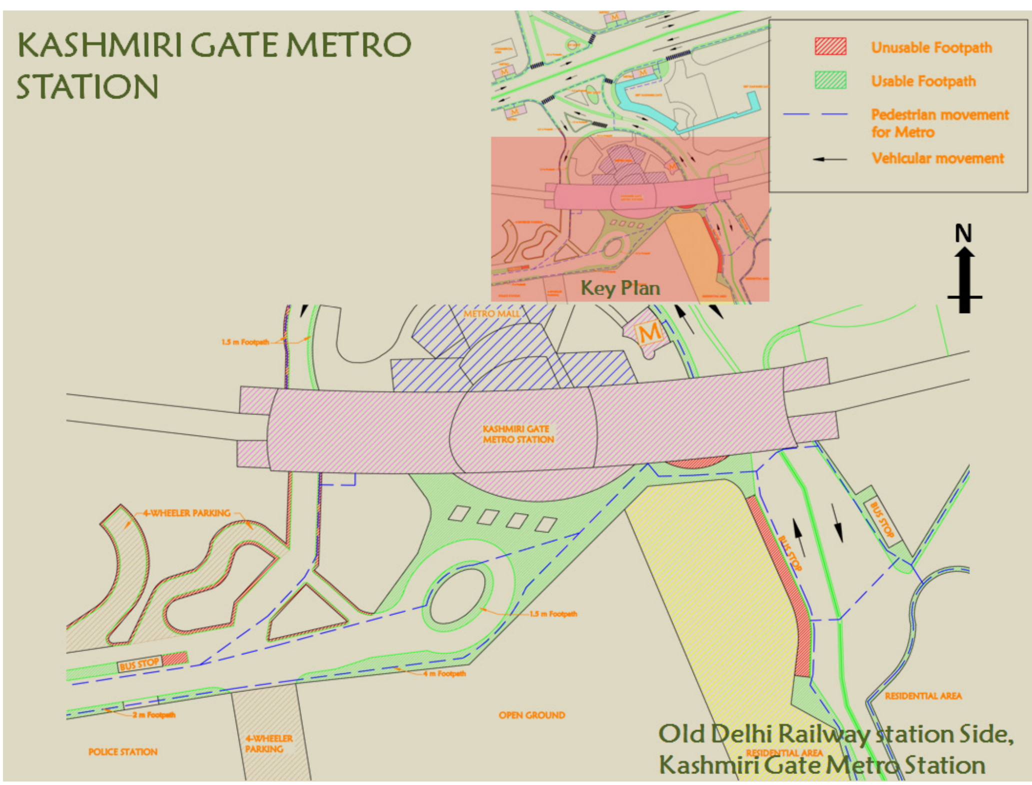
BETWEEN KASHMIRI GATE JUNCTION AND METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fare (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	1) Kashmiri gate Junction to metro station						
	Geometric standard (Width of subway should be between 1.0 m to 1.5m)	Yes	✓			1.0	**SUBWAY**, Standard metro subway with 4 gates on all the four side of junction is present. Width of the subway is 10.0m, Escalators are present on both side of subway.
	Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility present inside subway.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0	Escalators are present on both side of subway which helps disable friendly people to climb the subway easily.
	Overall					2.0/3.0	Pedestrian crossing quality between Kashmiri gate junction and metro station is very good.

AT KASHMIRI GATE JUNCTION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fare (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	1) Kashmiri gate Junction (at-grade crossing)						
	Geometric standard (Width of zebra crossing should be between 3.0 m to 5.0 m)	Yes	✓			1.0	**Zebra marking** (3m wide) is in Good condition on both side. Total zebra marking length is 90 m.
	Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights). Street lights are present on the edge of footpath.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath on the both sides of zebra crossing.
	Overall					2.0/3.0	Pedestrian crossing quality at kashmiri gate junction is moderate.

BETWEEN ISBT AND KASHMIRI GATE METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fare (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	2) Between ISBT and Kashmiri gate metro station						
	Geometric standard (Width of zebra crossing should be between 3.0 m to 5.0 m)	No				0.0	**Zebra marking** is absent on the road to cross the road. Jaywalking is happening on this stretch.
	Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights). Street lights are present on the edge of footpath.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath on the both sides of zebra crossing.
	Overall					1.0/3.0	Pedestrian crossing quality between ISBT and kashmiri gate metro station is poor.

AT SOUTH SIDE OF KASHMIRI GATE METRO STATION							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fare (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	3) Near Metro station						
	Geometric standard (Width of subway should be between 1.0 m to 1.5m)	No				0.0	Pedestrian crossing is at-grade but zebra crossing marking is absent on road.
	Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights along the footpath). Street lights are present on the edge of footpath.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					1.0/3.0	Pedestrian crossing quality at southern side of metro station is poor.


KASHMIRI GATE METRO STATION
N
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
METRO
COMMERCIAL AREA
SKY LIGHT
ISBT KASHMIRI GATE
METRO MALL
KASHMIRI GATE METRO STATION
Key Plan
ISBT Kashmiri Gate side
Kashmiri gate Metro station


KASHMIRI GATE METRO STATION
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
N
Key Plan
METRO MALL
KASHMIRI GATE METRO STATION
4-WHEELER PARKING
BUS STOP
OPEN GROUND
POLICE STATION
RESIDENTIAL AREA
Old Delhi Railway station Side,
Kashmiri Gate Metro Station


COMMERCIAL AREA
METRO
SKY LIGHT
ISBT KASHMIRI GATE
METRO MALL
KASHMIRI GATE METRO STATION


KASHMIRI GATE METRO STATION
4-WHEELER PARKING
BUS STOP
1.5 m Footpath
4 m Footpath
4-WHEELER PARKING
RESIDENTIAL AREA

New Delhi Railway Station

DIRECTION : BETWEEN NEW DELHI RAILWAY STATION AND NEW DELHI METRO STATION (GATE NO. 1)							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes	✓			1.0	Footpath surface is smooth and pedestrian friendly. Usable footpath -90% , Unusable footpath -10%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes	✓			1.0	Variable footpath widths from 1.6 m to 1.8 m. 10.0 m wide along the railway station. 3.2 m wide footpath in front of metro gate. Height of footpath varying from 0.15 to 0.20 m.
	3) Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights). Halogen Street lights are present on the edge of footpath.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					3.0 /4.0	Footpath facility between railway station and metro station is good.

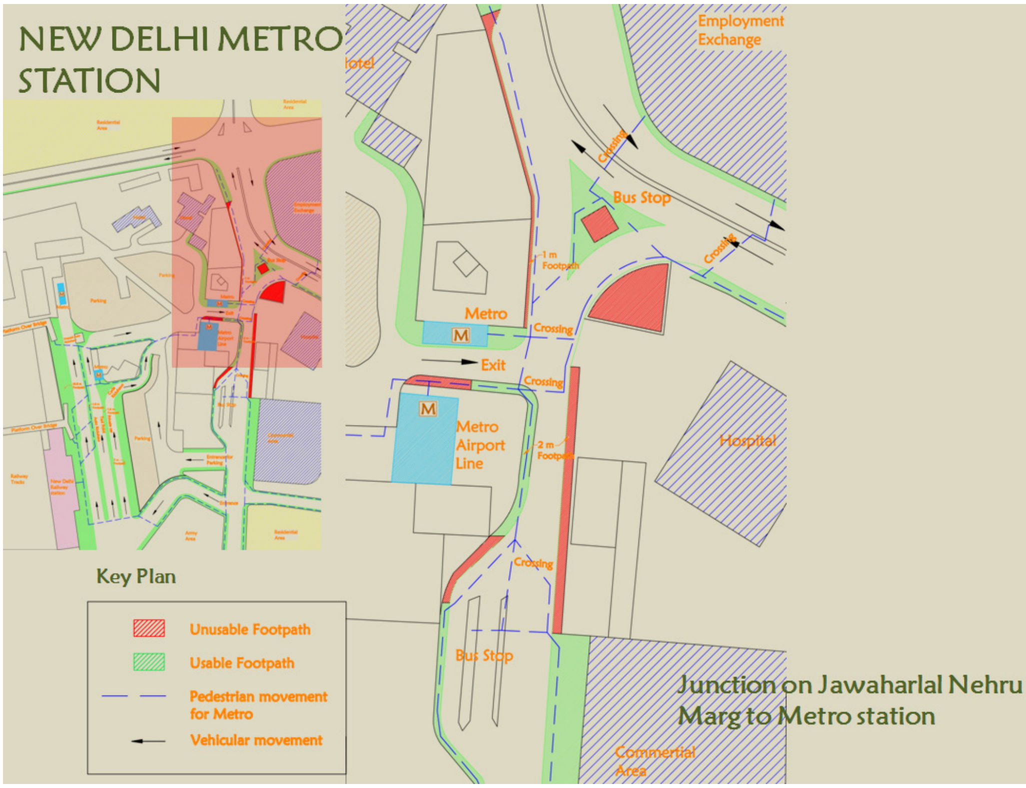
DIRECTION :BETWEEN NEW DELHI METRO STATION AND AIRPORT METRO LINE (GATE NO.2)							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes	✓			1.0	Footpath surface is smooth and very pedestrian friendly. Usable footpath -90% , Unusable footpath -10%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes		✓		0.5	Variable widths from 1.2 m to 2.0 m. 2.5m to wide footpath in front of metro station. Height of footpath varying from 0.15 to 0.20 m.
	3) Lighting (Street lights especially for pedestrians)	Yes		✓		0.5	Moderate lighting facility between metro station and airport line. Street lights are present near Airport line station only and not at metro station gate.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					2.0 /4.0	Footpath facility between airport line and metro station is moderate.

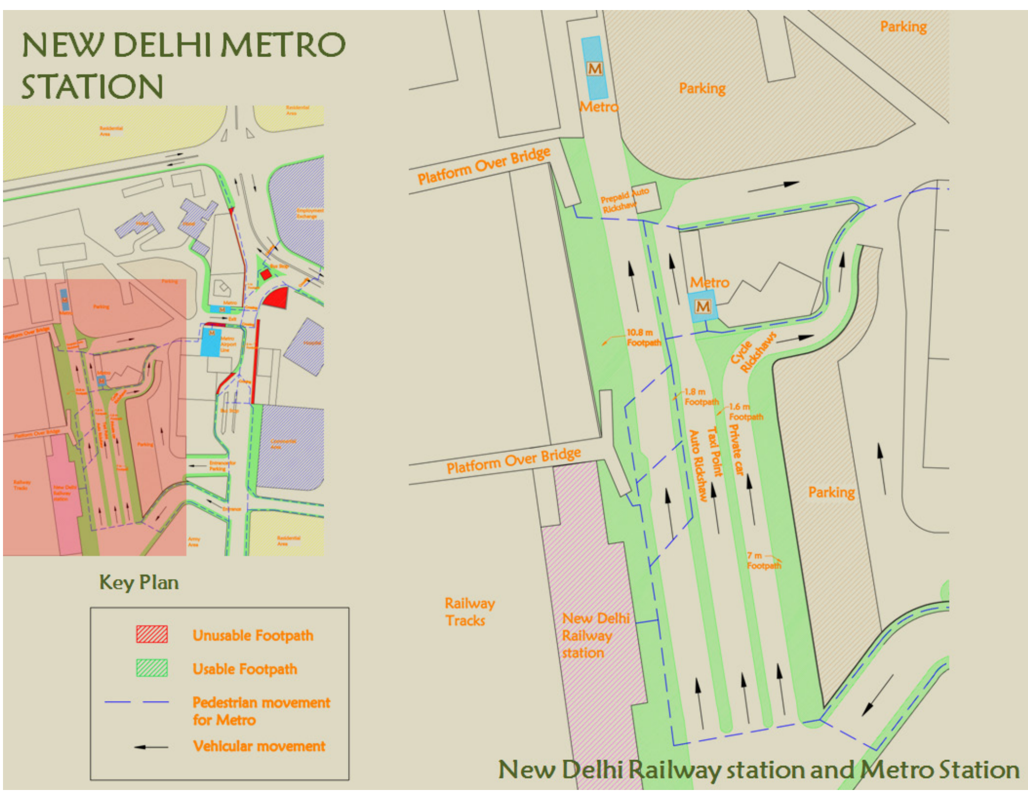
DIRECTION :BETWEEN NEW DELHI RAILWAY STATION AND BUS STOP							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
1.	**Footpath**						
	1) Pavement (Paver blocks)	Yes	✓			1.0	Footpath surface is smooth and very pedestrian friendly. Usable footpath -90% , Unusable footpath -10%
	2) Geometric standard (Sizes of footpath) (Standard sizes for footpath - 1.5 m width and 0.15 m height)	Yes			✓	0.2	Variable widths from 1.0 m to 1.5 m. Height of footpath varying from 0.15 to 0.30 m.
	3) Lighting (Street lights especially for pedestrians)	Yes		✓		0.5	Sufficient lighting facility (i.e. street lights). Street lights are present on the edge of footpath.
	4) Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					1.7 /4.0	Footpath facility between bus stop and metro station is moderate.

BETWEEN NEW DELHI RAILWAY STATION AND NEW DELHI METRO STATION (GATE NO. 1)							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	Geometric standard (Width of zebra crossing should be between 3.0 m to 5.0 m)	No				0.0	**Zebra marking** is absent on the road to cross the road. Jaywalking is happening on this stretch. Dedicated footpath is absent, pedestrians should cross the motorized vehicle lanes to reach metro station.
	Lighting (Street lights especially for pedestrians)	Yes	✓			1.0	Sufficient lighting facility (i.e. street lights). Halogen Street lights are present on the edge of footpath.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					1.0/3.0	Pedestrian crossing quality between Railway station and metro station is poor.

BETWEEN NEW DELHI METRO STATION AND AIRPORT METRO LINE (GATE NO.2)							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	Geometric standard (Width of zebra crossing should be between 3.0 m to 5.0 m)	No				0.0	**Zebra marking** is absent on the road to cross the road. Jaywalking is happening on this stretch.
	Lighting (Street lights especially for pedestrians)	Yes		✓		0.5	Moderate lighting facility between metro station and airport line. Street lights are present near Airport line station only and not at metro station gate.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					0.5/3.0	Pedestrian crossing quality between Airport line and metro station is poor.

BETWEEN NEW DELHI RAILWAY STATION AND BUS STOP							
No.	Indicators	(A) Present (1 pt)	(B) Quality				Remark
			Good (above 80%) (1 pt)	Fair (40% to 80%) (0.5 pt)	Poor (below 40% (0.2 pt)	Total (A) X (B)	
2.	**Pedestrian crossing**						
	Geometric standard (Width of zebra crossing should be between 3.0 m to 5.0 m)	No				0.0	**Zebra marking** is absent on the road to cross the road. Jaywalking is happening on this stretch.
	Lighting (Street lights especially for pedestrians)	Yes		✓		0.5	Sufficient lighting facility (i.e. street lights). Street lights are present on the edge of footpath.
	Barrier free (Ramps and other facilities according to barrier free design standards)	No				0.0	Ramps are missing to climb the footpath.
	Overall					0.5/3.0	Pedestrian crossing quality between Railway station and bus stop is poor.


NEW DELHI METRO STATION
Key Plan
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
Employment Exchange
Hotel
Bus Stop
Crossing
1 m Footpath
Metro
Exit
Metro Airport Line
2 m Footpath
Hospital
Bus Stop
Commercial Area
Junction on Jawaharlal Nehru Marg to Metro station


NEW DELHI METRO STATION
Key Plan
Unusable Footpath
Usable Footpath
Pedestrian movement for Metro
Vehicular movement
Parking
Metro
Platform Over Bridge
Prepaid Auto Rickshaw
Metro
10.8 m Footpath
1.8 m Footpath
1.6 m Footpath
Cycle Rickshaws
Auto Rickshaw
Taxi Point
Private car
7 m Footpath
Platform Over Bridge
Railway Tracks
New Delhi Railway station
New Delhi Railway station and Metro Station


Parking
Parking
Metro
Platform Over Bridge
Metro
Platform Over Bridge
Parking
Railway Tracks
New Delhi Railway station
Key Plan
Railway station
Metro station
10 m


Employment Exchange
Bus Stop
Metro
Exit
Metro Airport Line
Hospital
Key Plan
Airport line
Metro station

Annexure 3

Rail Transportation (Delhi Metro)

Assumptions & Calculations

1) Average life span (metro): 40 years/vehicle

2) Kilometric performance per vehicle (over total life span): 5,627,933 km

3) Average load:
    a) Off peak capacity (seating only, GVW 196 tonne): 221 pax
    b) Peak capacity (seating & standing, GVW 258 tonne): 1,262 pax
    c) Average capacity (average of off peak & peak, GVW 227 tonne): 742 pax

4) Transport performance per vehicle (over total life span):
    a) Off peak capacity: 1,243,773,184 pkm/vehicle (1,244 million pkm/vehicle)
    b) Peak capacity: 7,102,451,397 pkm/vehicle (7,102 million pkm/vehicle)
    c) Average capacity: 4,173,112,291 pkm/vehicle (4,173 million pkm/vehicle)

5) Vehicle kilometre per day performance: 69,000 metro km/day

6) Specific consumption transport performance:
    a) Off peak capacity: 0.0505 kwh/pkm
    b) Peak capacity: 0.0117 kwh/pkm
    c) Average capacity: 0.0175 kwh/pkm

7) Demand factor for passenger transport vehicle fleet (metro):
    a) Off peak capacity: 8.04×10^{-10} train/pkm
    b) Peak capacity: 1.41×10^{-10} train/pkm
    c) Average capacity: 2.40×10^{-10} train/pkm

8) Demand factor for total metro rail network:

A) Demand factor for rail construction & disposal:

i)	Off peak capacity:	3.47×10^{-5} (m*y)/pkm
ii)	Peak capacity:	6.07×10^{-6} (m*y)/pkm
iii)	Average capacity:	1.03×10^{-5} (m*y)/pkm

B) Demand factor for rail maintenance:

iv)	Off peak capacity:	3.47×10^{-5} (m*y)/pkm
v)	Peak capacity:	6.07×10^{-6} (m*y)/pkm
vi)	Average capacity:	1.03×10^{-5} (m*y)/pkm

SOURCE

1) Assumptions 10 years more than New York Metro declaration
2) Own calculations
3) Own counting & calculations
4) Own calculation (221*5,627,933)
5) Own calculations
6) Own calculations & Energy Conservation Policy Report of the DMRC dated 17-10-2008
7) Own calculations
8) Own calculations

Road Transportation (CNG Bus)

Assumptions & Calculations

9) Average life span (CNG bus): 12 years/vehicle

10) Kilometric performance per vehicle (over total life span): 750,000 km

11) Average load:

d) Off peak capacity (seating only, GVW 13 tonne): 36 pax

e) Peak capacity (seating & standing, GVW 17 tonne): 108 pax

f) Average capacity (average of off peak & peak, GVW 15 tonne): 72 pax

12) Transport performance per vehicle (over total life span):

d) Off peak capacity: 27,000,000 pkm/vehicle (27 million pkm/vehicle)

e) Peak capacity: 81,000,000 pkm/vehicle (81 million pkm/vehicle)

f) Average capacity: 54,000,000 pkm/vehicle (54 million pkm/vehicle)

13) Vehicle kilometre/day performance:

a) Car + taxi: 19.396 million vkm/day

b) Two-wheelers: 22.505 million vkm/day

c) Three-wheelers: 4.78 million vkm/day

d) Goods vehicle: 1.508 million vkm/day

e) Buses: 1.826 million vkm/day

14) Specific consumption transport performance: 0.28571 kg/vkm

15) Demand factor for passenger transport vehicle fleet:

d) Off peak capacity: 3.7×10^{-8} bus/pkm

e) Peak capacity: 1.23×10^{-8} bus/pkm

f) Average capacity: 1.85×10^{-8} bus/pkm

16) Demand factor for total road network:

C) Demand factor for road construction & disposal:

vii) Off peak capacity: 4.32×10^{-4} (m*y)/pkm

viii) Peak capacity: 1.75×10^{-4} (m*y)/pkm

ix) Average capacity: 2.4×10^{-4} (m*y)/pkm

D) Demand factor for road maintenance:

x) Off peak capacity: 5.68×10^{-5} (m*y)/pkm

xi) Peak capacity: 1.89×10^{-5} (m*y)/pkm

xii) Average capacity: 2.84×10^{-5} (m*y)/pkm

Source

9) Delhi transport corporation Global RFP number: CGM/SBU/846/2008

10) Delhi transport corporation Global RFP number: CGM/SBU/846/2008

11) Own counting & calculations

12) Own calculation (36*750,000)

13) RITES primary survey 2007-2008

14) TATA workshop at DTC Depot Vasant Vihar (CNG consumption @ 3.5 km/kg of CNG)

15) Own calculations

16) Own calculations

Annexure 4

1. Bangalore Metro

The Bangalore Metro project, popularly known as "Namma Metro", is being implemented by the Bangalore Metro Rail Corporation Limited (BMRCL) – a joint venture of the Government of India and the Government of Karnataka. The BMRCL is a Special Purpose Vehicle entrusted with the responsibility of implementing the Bangalore Metro Rail Project. The Bangalore Metro project was undertaken in 2007. The DMRC prepared the DPR for Phase I of the project. The initial 7.5 km long reach of the Bangalore Metro started its operation in October 2011.

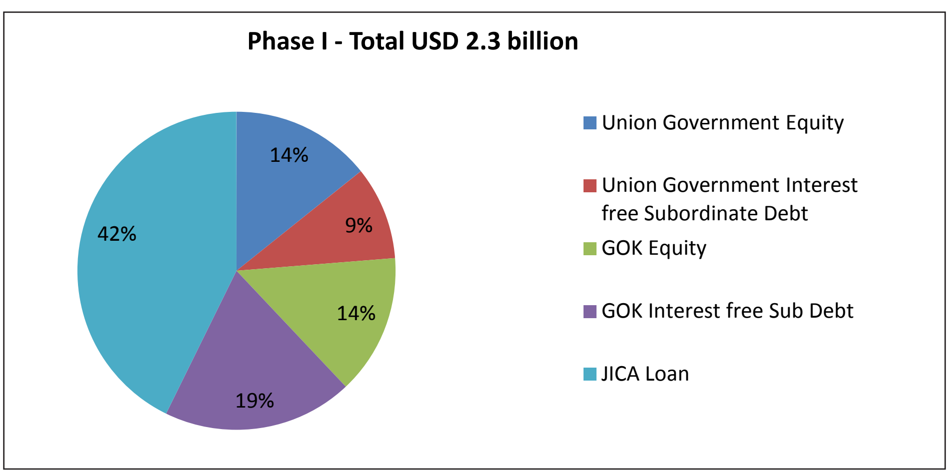
1.1 Coverage

The Bangalore Metro project is to be developed in two phases. As per BMRCL plans, the total length of Phases I and II will have covered ~112 km by 2014. The Phase I network of the Namma Metro consists of two corridors – East-West and North-South. The East-West corridor is 18.1 km long, and starts from Baiyappanahalli in the East and ends at Mysore Road terminal in the West. The North-South corridor is 24.2 km long, from Nagasandra in the North to Puttenahalli in the South (see Bangalore Metro website). The East-West corridor is named the Purple Line and the North-South corridor is the Green Line. The two corridors intersect at Kempegowda station, which is a two level interchange station. Of the total length under Phase I, 8.82 km is underground and the rest is elevated. Phase II of the project will cover 70 km of the network, and will include a new rail line connecting Nagavara through Shivajinagar and Cantonment Railway Stations.

1.2 Funding Pattern

The revised cost of Phase I is USD 2.32 billion (previously USD 1.6 billion), and it is being financed on a debt-equity ratio of 70:30. The debt component is USD 660 million as subordinate debt, and USD 860 million as senior-term debt. The equity component of USD 660 million has been shared equally between the Union and State Governments (IIR, 2011; Bangalore Metro Website). Phase II of the Bangalore Metro project will cost USD 2.9 billion. The State Government will bear USD 1.3 billion of the cost, while the balance will be covered by the Union Government (http://bmrc.co.in/ProjectHighlights.htm).

Figure 17. Funding pattern of Bangalore Metro – Phase I



2. Chennai Metro

The Chennai Metro project was approved by the Ministry of Urban Development (MoUD) in January 2009. The Government of Tamil Nadu created a Special Purpose Vehicle for implementing the Chennai Metro Rail Project. This SPV, named "Chennai Metro Rail Limited", was incorporated in December 2007 under the Companies Act, and is a joint venture of the Government of India and the Government of Tamil Nadu – with equal equity holdings (Chennai metro website).

2.1 Coverage

A Detailed Project Report (DPR) relating to the Chennai Metro Rail Project was prepared and submitted by the DMRC. The DPR envisages the creation of two initial corridors under the proposed Phase I of the Chennai Metro Rail Project, as shown below.

Corridor	Length (km)
Washermanpet to Airport	23.1
Chennai Central to St. Thomas Mount	22.0
Total	45.1

The portions of Corridor-1 with a length of 14.3 km, from Washermanpet to Saidapet, and Corridor-2 with a length of 9.7 km, from Chennai Central to Anna Nagar 2nd Avenue, will be underground, while the remainder will be elevated. The alignment and stations noted above are tentative and subject to change during detailed design and execution.

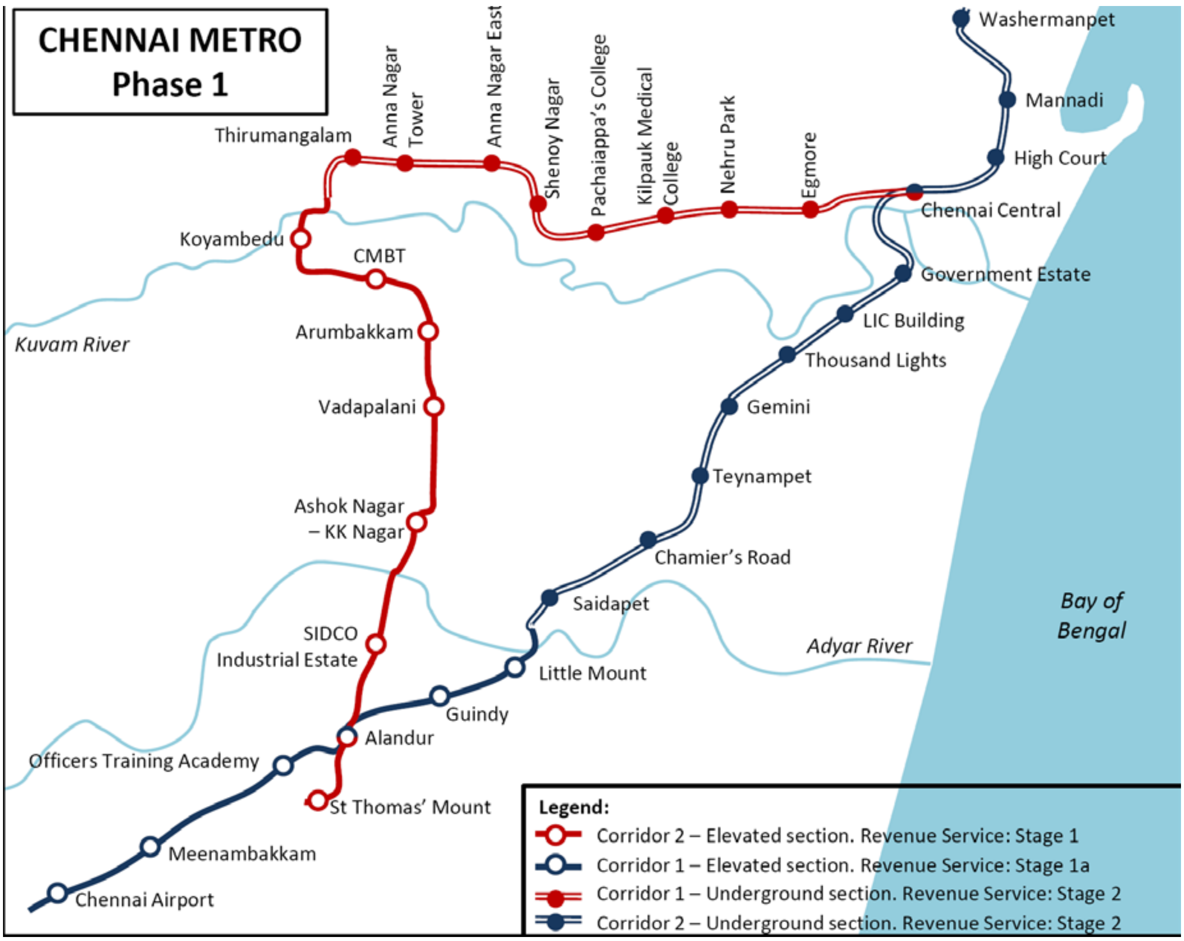
Tentatively, Phase I of the project is programmed for completion in the 2014–2015 financial year. The physical works are in progress.

2.2 Funding Pattern

The estimated base cost of this project is about USD 2.8 billion, of which the Central and State Governments, together, are expected to contribute approximately 41%. The balance will be met by a loan granted by the Japan International Cooperation Agency (JICA). In November 2008, JICA agreed to finance the project, and the loan agreement between the Governments of India and Japan were signed in Tokyo.

The Chennai Metro Rail Limited (CMRL) has appointed the DMRC as the Prime Consultant (PC) for Phase I of the project. The Prime Consultant will assist the CMRL, in an advisory role, in the execution of the project.

Figure 18. Chennai Metro Network under Phase I



3. Hyderabad Metro

The Hyderabad Metro is a public-private partnership (PPP) project, and will be implemented through a special purpose vehicle – "L&T Metro Rail (Hyderabad) Limited". The project is estimated to cost USD 2.8 billion, and will be executed on a design, build, finance, operate and transfer (DBFOT) basis. The Government of India (GoI) only has a minority stake in the project, contributing 10% of the total project cost as viability gap funding. The State Government will contribute another ~USD 400 million towards land acquisition, R&R package, shifting of utilities, etc. This funding does not count as part of the project cost, as per VGF guidelines of GoI (Hyderabad Metro Website). It is scheduled to be completed within a span of 5 years from the appointed date. The concession period for the project is 35 years, with an entitlement of an additional 25 years. The length of the proposed rail project is 72 km, and the expected number of commuters by 2015 will likely be 1.5 million. The project is expected to serve three high-density corridors. The collaboration will be to integrate the Metro Rail with other public transport systems in Hyderabad, such as Multi-modal Transport system (MMTS).

4. Mumbai Metro – Phase I

The first line of Phase I of the Mumbai Metro project (Versova-Ghatkopar Corridor) is also a PPP project, being implemented by a RInfra-led consortium (a private infrastructure company). For the implementation of this project, a special purpose vehicle – Mumbai Metro One Private Limited (MMOPL) – has been incorporated. The PPP project entails design, financing, construction, operation and maintenance of about 12 km of elevated metro, with 12 stations en route. The metro will provide the much-needed East to West connectivity, and will carry an estimated 600,000 commuters per day[13]. A trial run of this line was conducted in May 2013, in advance of its start of operation by October 2013.

This line of the Mumbai Metro is being constructed at a cost of USD 470 million. RInfra holds 69% of the equity share capital of MMOPL, while the Mumbai Metropolitan Region Development Authority (MMRDA) holds 26%, and Veolia Transport RATP Asia holds the remaining 5%. The MMRDA is an apex body appointed by the Government of Maharashtra State for the planning and co-ordinating of development activities in the Mumbai Metropolitan Region – comprising of Mumbai and its satellite towns. Veolia Transport RATP Asia is a private company and a joint venture between RATP Dev and Veolia Transport[14].

5. Other Metro Projects

The following section provides a glimpse of upcoming metro projects in other Indian cities, which are either in the planning stage or under construction. These include: Ahmedabad in Gujarat, Bhopal and Indore in Madhya Pradesh, Chandigarh, Ludhiana in Punjab, Jaipur in Rajasthan, Kochi in Kerala and Pune and Mumbai in Maharashtra and Hyderabad in Andhra Pradesh. Table 17 lists the projects under construction, their corresponding planned length, and the estimates of their costs. Table 18 lists all the metro projects in the planning stage.

Table 17. Under construction metro projects (Source: IIR, 2011)

Metro Project	Length (km)	Cost (USD Billions)
Jaipur	29	1.5
Navi Mumbai (Phase I)	21	0.4
Gurgaon	6	0.2

Table 18. Under planning metro projects (Source: IIR, 2011)

Metro Project	Length (km)	Cost (USD Billions)
Pune	103	1.4 (Phase I – 31.5 km)
Kanpur (Phase I)	66	NA
Chandigarh	64	3.0
Ahmedabad	44	2.2
Lucknow	40	1.2–2.0
Ludhiana	29	1.8

13 http://www.mumbaimetroone.com
14 http://www.mumbaimetroone.com

Metro rail projects entail large investments and have long gestation periods. Worldwide, most metro rail projects are not financially viable on their own and have the required public funding support. In India, most projects have either been developed entirely by the government, or in part through the PPP mode, in recent years. Table 19 lists the various metro rail projects and their funding pattern from the different sources. While the Kolkata Metro was fully funded by the Federal Government of India, the Delhi Metro included equal shares from Federal and State Governments, and the remainder from loan and property development. A similar model was followed by the Bangalore Metro and the Chennai Metro. The four metro projects with a PPP model are: Delhi Airport Link, Mumbai, Hyderabad and Gurgaon. Gurgaon is India's first metro system to be privately built and operated – with 100% private funding.

Table 19. Financing pattern of metro projects in India (Source: IIR, 2011)

Metro Project	GOI (%)	State Govt. (%)	JICA (%)	Others* (%)	Total (USD Billion)
Delhi Metro Phases I & II	18	18	53	10	5.9
Kolkata	100	0	0	0	0.4
Kolkata East-West Corridor	24	30	46	0	0.9
Bangalore	15	15	45	25	1.6
Chennai	20	20	59	0	2.96
Public-Private Partnerships (PPP)					
Delhi Airport Express Link	19	19	0	62	0.8
Mumbai Phase I	9	22	28	41	5.1
Hyderabad	9	0	0	91	3.3
Gurgaon	0	0	0	100	0.22

Information about the project:

UNEP Transport Unit in Kenya, UNEP Risø Centre in Denmark and partners in India have embarked on a new initiative to support a low carbon transport pathway in India. The three-year 2.49 million Euro project is funded under the International Climate Initiative of the German Government, and is designed in line with India's National Action Plan on Climate Change (NAPCC). This project aims to address transportation growth, development agenda and climate change issues in an integrated manner by catalyzing the development of a Transport Action Plan at national level and Low Carbon Mobility plans at cities level.

Key local partners include the Indian Institute of Management, Ahmedabad, the Indian Institute of Technology, Delhi and CEPT University, Ahmedabad. The cooperation between the Government of India, Indian institutions, UNEP, and the Government of Germany will assist in the development of a low carbon transport system and showcase best practices within India, and for other developing countries.

Homepage : www.unep.org/transport/lowcarbon

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DTU