

Metro systems in India: *Case study DMRC*

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Metro systems in India

- Kolkata metro 18 km in 18 years, operational in 1986
- Delhi metro, first project report in 1969, operational in 2002
- 12th plan proposal: All 2 million plus cities should plan for corridors having 15,000phpd for 5 km continuous corridor, average trip length of motorised trips > 7 kms.

Operational Metro Projects

Metro Project	Length (Km)	Cost (Rs. Crore)
Delhi (Phase I and II)	190	29,700
Delhi Airport Express Link	23	5,600
Kolkata Metro	25	1,825

Under Construction Metro Projects

Metro Project	Length (Km)	Cost (Rs. Crore)
Mumbai (Phase I)	145	25,400
Hyderabad	71	16,400
Chennai	45	14,800
Jaipur	29	7,500
Navi Mumbai (Phase I)	21	1,984
Gurgaon	6	1,100
Bangalore (Phase I and II)	112	26,000

Planned Metro Projects

Metro Project	Length (Km)	Cost (Rs. Crore)
Pune	103	7,128 (Phase I- 31.5 Km)
Kanpur (Phase I)	66	NA
Chandigarh	64	15,000
Ahmedabad	44	11,000
Lucknow	40	6,000-10,000
Ludhiana	29	9,000
Kochi	25	6,000

Financing of Metros

Metro Project	GOI (%)	State Govt. (%)	JICA (%)	Others* (%)	Total (Rs. Billion)
Delhi Metro Phases I&II	18	18	53	10	297
Kolkata	100	0	0	0	18.3
Kolkata East-West Corridor	24	30	46	0	48.7
Bangalore	15	15	45	25	81.6
Chennai	20	20	59	0	148
Public-Private Partnerships (PPP)					
Delhi Airport Express Link	19	19	0	62	40
Mumbai Phase 1	9	22	28	41	254
Hyderabad	9	0	0	91	163.8
Gurgaon	0	0	0	100	11

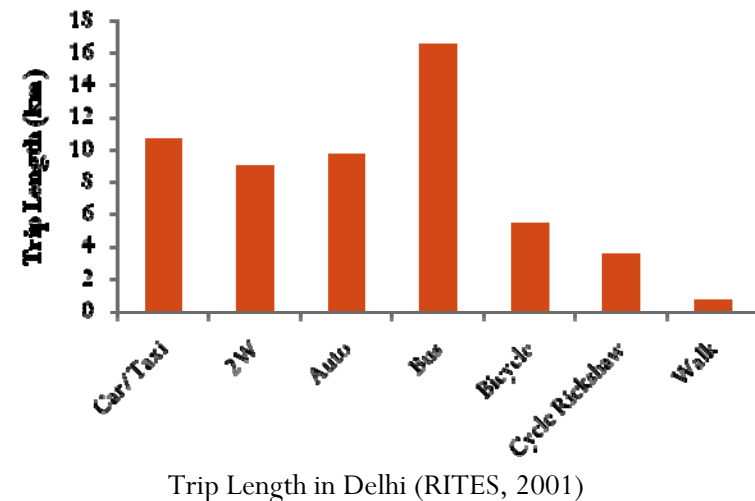
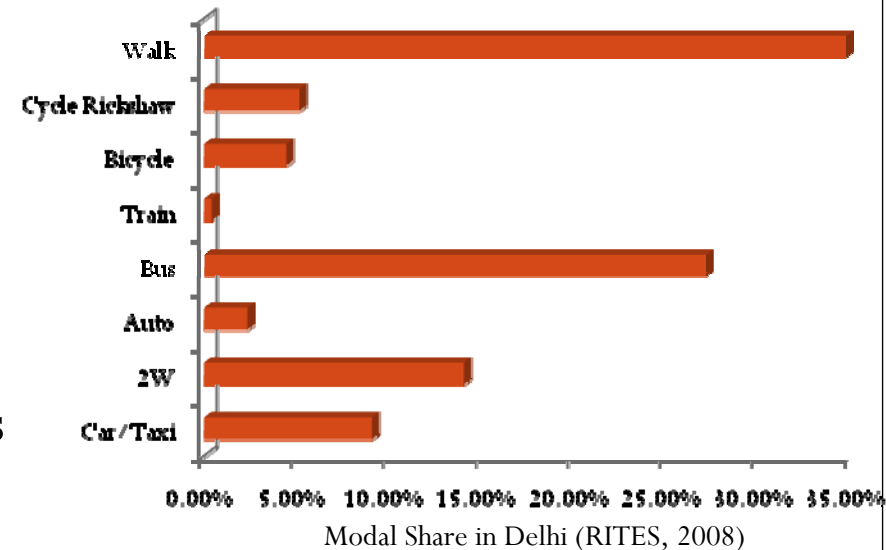
*Property development, Interest Free Subordinate Loans, grants etc.

Debt and Equity for PPP

DELHI METRO

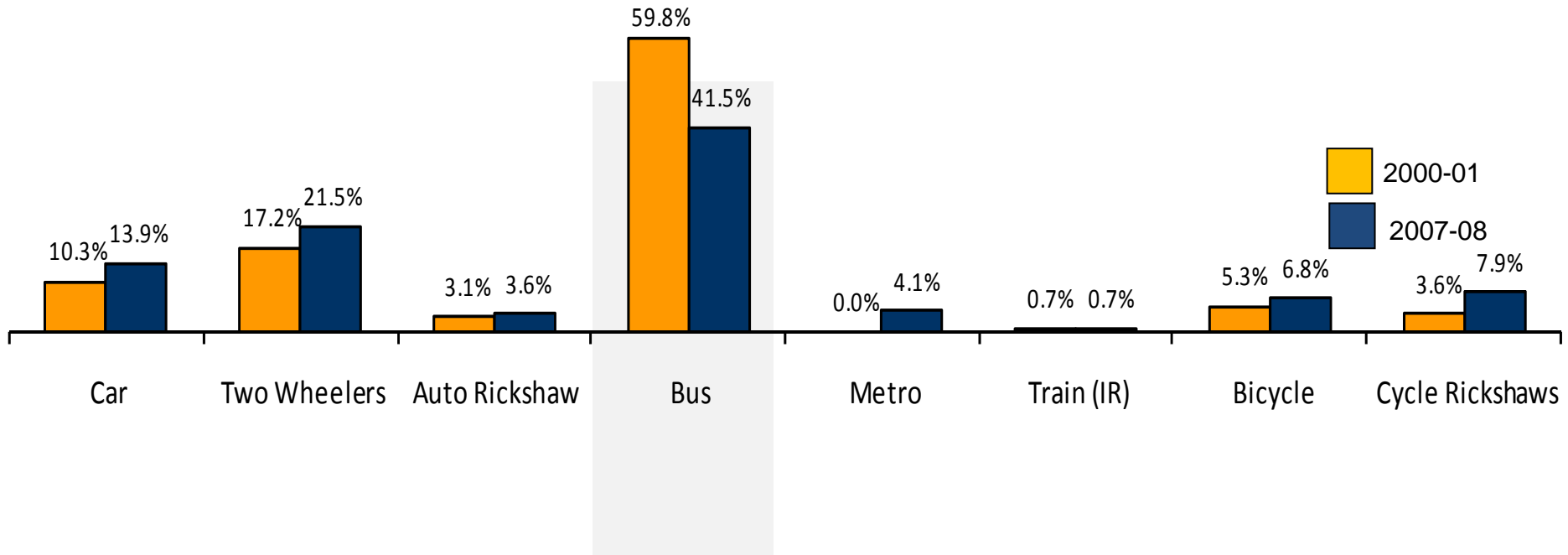
Delhi- An Introduction

- Mixed land use pattern
- Central Core areas are both commercial as well as densely residential
- People of the lower classes reside at the outskirts in resettlement colonies built by the government,
- Elite class are mostly concentrated in the peripheral zones,
- and middle-class areas are dispersed all over the city.



Declining Share of Public Transport, especially Bus Transport

Modal Split - % of Person Trips (excluding walk trips) in Delhi*
(Figures in Percent)

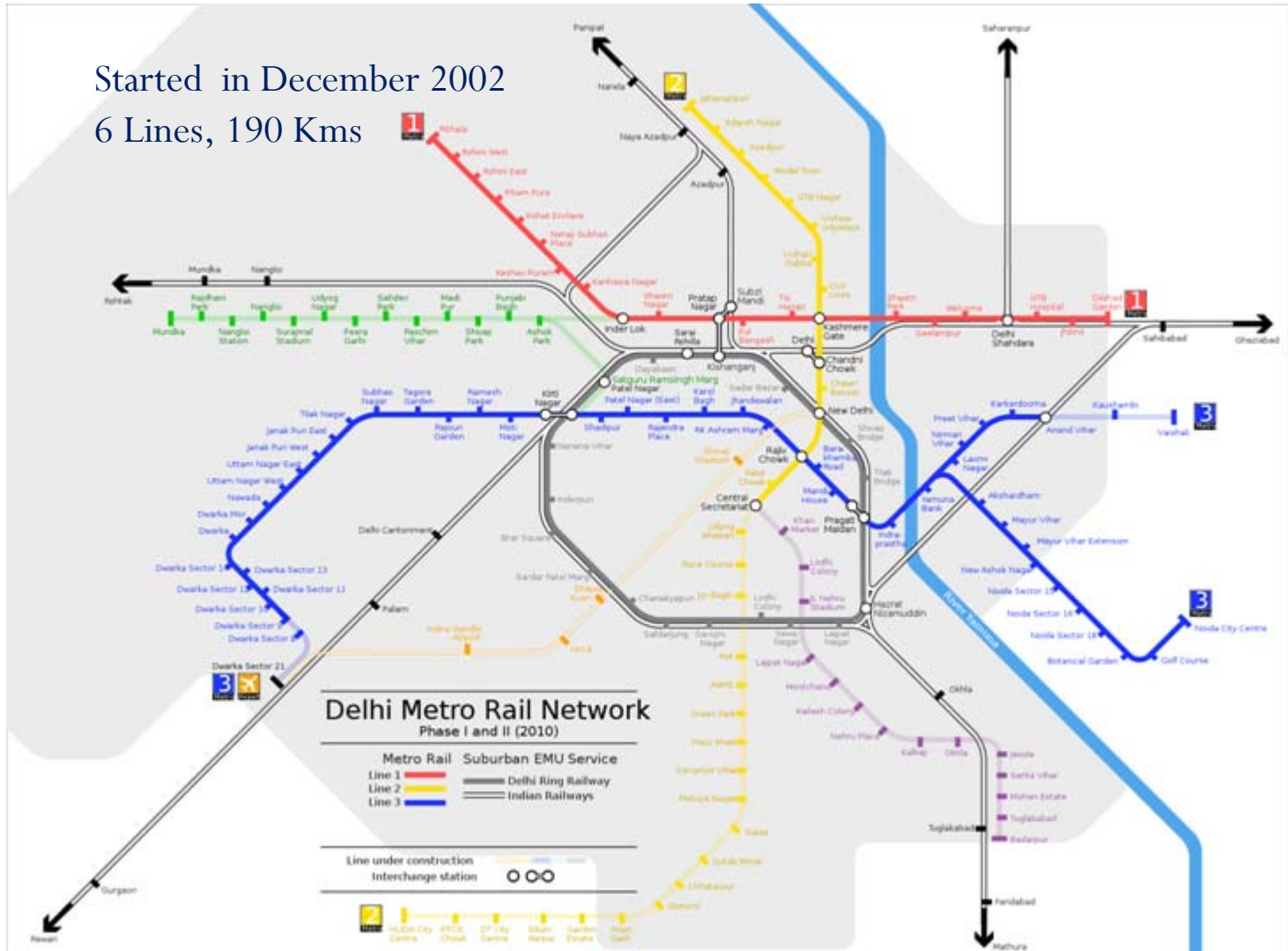


Source: Delhi Traffic and Forecast Study (2008) commissioned by DIMTS to RITES

Delhi Metro Network

Started in December 2002

6 Lines, 190 Kms



Projected vs. Actual Ridership

Year	Actual Passengers per day	Projected Passengers per day	Actual as % of 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%

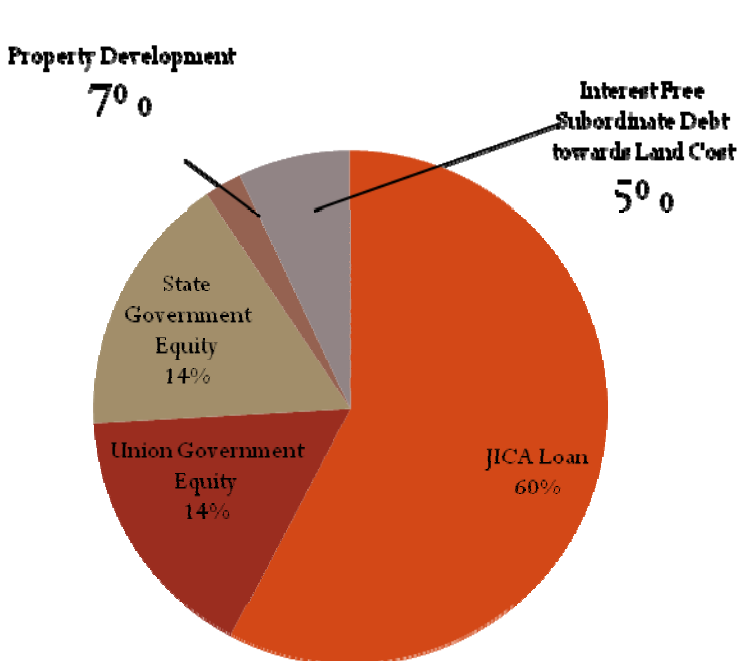
Source: CDM report on Delhi Metro, UNFCCC website

**Actual Ridership < one-fourth of the Projected
Ridership**

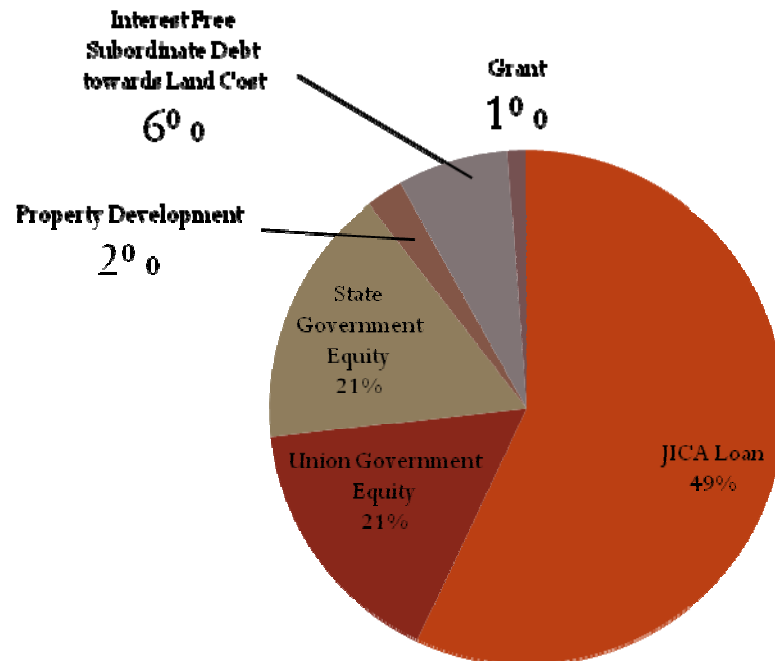
Does this mean Delhi Metro achieves only “one-fourth” of the benefits mentioned in DPR?- Emissions, Travel Time, Accident

Financing- Delhi Metro ; ~ 30000cr/186 km

- Central and State Govt. Equity
- Japan International Cooperation Agency (JICA) – 1.2 % interest rate, repayment period of 30 years
- Property Development
- Interest Free Subordinate Loan by Centre and State Govt. for land acquisition
- Govt. Grant



Phase I (Total Rs. 10571cr)



Phase II (Total Rs 19131cr)

JICA Loans

- Loan has been accompanied by a series of general contracts going to Japanese firms
- In May 1998- DMRC appointed Japan's Pacific Consultants International (PCI) as general consultant
- The general consultant's role is vital
- It chooses the firm which will finally execute the project

DMRC Tax regime

DMRC pays:

- Wealth Tax
- Fringe Benefit Tax

Exempted from:

- Property Tax
- Sales Tax
- Works' contract Tax
- Income Tax
- Capital Gains Tax
- Customs
- Excise

Comparison with DTC

Delhi Transport Corporation Pays :	Delhi Metro Rail Corporation Pays:
1. Taxes on acquisition of immovable property: <ul style="list-style-type: none"> a. Tax on acquisition of land (State)? b. Property Tax (Municipal Body) 	<ul style="list-style-type: none"> 1. Wealth Tax 2. Fringe Benefit Tax (abolished in 2009)
2. Taxes on acquisition of buses: <ul style="list-style-type: none"> a. VAT (State Govt.) b. Central Excise (Centre) c. Customs Duty in case of Imports (Centre) d. Octroi (Municipal body) e. Entry tax (State) 3. Taxes related to operations: <ul style="list-style-type: none"> a. Excise Duty on consumables (Centre) b. VAT on consumables (State) c. Excise and VAT on spare parts 4. Tax on use of vehicles for transporting passengers: <ul style="list-style-type: none"> a. Motor Vehicle Tax (State Govt.) 5. Advertisement Tax (City)	<p>DMRC is “exempted” from the following taxes:</p> <ul style="list-style-type: none"> 1. Property Tax 2. Sales Tax 3. Works’ contract Tax 4. Income Tax 5. Capital Gains Tax 6. Customs 7. Excise

Other Concessions to DMRC

- Interest free subordinate loans from:
 - GOI, GNCTD, HUDA, NOIDA
- Concessional loans from Japan International Cooperation Agency (JICA)
- Exchange rate risk is borne by Government
- No dividend is paid on GOI share of equity till the senior debt is repaid fully by the twentieth year
- Electricity at cost to serve basis (300P/kVAh)*

*NDPL Order (FY 2007-08)

REVENUE

Revenue Streams

- Traffic Operations (Fare box, Feeder Bus, Rental)
- Consultancy
- Real Estate
- External Project Works
- Others: Deferred Govt. Grant, Income from sale of carbon credit, Interest from bank, sale of tender documents, etc.

DMRC Revenue

Income Source	2006-07 (Rs. Crore)	% Total Income	2007-08 (Rs. Crore)	% Total Income	2008-09 (Rs. Crore)	% Total Income	2009-10 (Rs. Crore)	% Total Income
Traffic Operations	223	41%	317	63%	393	54%	527	71%
Consultancy			13	3%	28	4%	32	4%
Real Estate	252	46%	120	24%	245	34%	29	4%
Ext. Project Works	-	-	-	-	-	-	83	11%
Others			54	11%	58	8%	65	9%
Total Income	543	100%	504	100%	723	100%	739	100%

- Real Estate contributed more than one-third till 2009
- Till 2009, upfront income from Real Estate- when vacant land is given
- Traffic Operation income is increasing over the years

Revenue Breakdown: Traffic Operations

	2007-08 (Rs. Crore)	% Total	2008-09 (Rs. Crore)	% Total	2009-10 (Rs. Crore)	% Total
Traffic Earnings	246	78%	298	76%	413	78%
Feeder Bus Earning	0.43	0.1%	2.65	0.7%	2.67	0.5%
Rental	70	22%	92	23%	111	21%
Total Traffic Operations	317	100%	393	100%	527	100%

Source: Delhi Metro Annual Reports

Rental from Real Estate- How is this included in “Traffic” Operations?

Removing the Rental portion from Traffic Operations, reduces the proportion of Traffic Operations in the Total Income to 56% (2009-10), 42% (2008-09) and 49% (2007-08) from 71%, 54% and 63% respectively.

Expenditure

	Operational Expenditure (Rs. Crore)	Ridership per Day	Expenditure per Passenger (Rs.)	Expenditure per Passenger-Km (Rs.)
2008	200	767,662	7.1	0.42
2009	228	889,094	7.0	0.41
2010	290	1,500,000	5.3	0.31

	Total Cost (Rs. Crore)	Ridership per Day	Cost per Passenger per day (Rs.)	Cost per Passenger-Km (Rs.)
2008	558	767,662	19.9	1.17
2009	694	889,094	21.4	1.25
2010	942	1,500,000	17.2	1.01

Assuming an average trip length of 17 km

Electricity (fuel)Consumption- Delhi Metro

- Running of Trains
- Air-conditioning of underground stations
- Lighting of Stations
- Lifts, and escalators

Electricity constitutes 25 percent of Operating Cost

Without Subsidy will be even higher

Need to take in to account CO₂ emissions and fly ash pollution per KWh of Electricity

Emissions due to Electricity

- In India- 75% of the total power comes from coal-based thermal power plants
- Thermal Power Plants emits: CO₂, SO₂, NO₂ and Fly ash(Particulate Matter)
- Coal Used in India has higher ash content
- Only 3% of the fly ash is consumed
- CDM Report by UNFCCC estimates CO₂ emissions/passenger-km as 21g for metro (electricity only for trains) and 25g for buses
- CDM Report assumes a transmission loss of 3.9%

Carbon Emissions- Delhi Metro

- Electricity Emission Factor= 840 gCO₂/kWh
- Transmission Losses= 30%
- For 490 million units of Electricity consumption per year of DMRC in 2011

$$\text{CO}_2 \text{ emissions per passenger per day (gm)} = \frac{490,000,000 \times (1 + 0.3) \times 840}{1,600,000 \times 365} \sim 900$$

- For an average passenger trip length of 17 Km-
CO₂ emissions/passenger-km= 53g

Electricity consumption includes train, air-conditioning of stations etc.

Fare Hike

- March 2004: Min fare from Rs. 4 to 6 (30-50 % increase in fare structure)
- December 2005: Max fare from 14 to 22
- Nov 2009: Min- 6 to 8 and Max- 22 to 30 (average increase of 36 percent in every slab)

Delhi Metro Started in December 2002

IMPACTS

Users vs non users

Households in the vicinity of Delhi Metro Line

- Bus route availability and frequency reduced after the metro for the community
- Bus unavailability to destination increased from 5% to 37% households
- 87% of the respondents had never used the metro

Accessibility of the low-income households in the vicinity of the metro line reduced after the Metro

Households Relocated due to Delhi Metro

- The bus route availability and frequency has reduced after relocation: average frequency reducing from 5 min to 63 min (13 times)
- 99 % of the households did not have availability/need of using RTVs for access before relocation, but all households use RTV to travel after relocation
- After relocation, cycle rickshaws are available to 28% of the households compared to 93% before relocation
- The daily travel distance after relocation increased from 4.4 Km to 15.4 Km on an average

Accessibility of the low-income households relocated due to Metro also reduced

Projected vs. Actual Ridership

50 % of the network under:

- Line-2 (Jahangirpuri – HUDA City Centre)
- Line-3 (Dwarka Sector 9 to NOIDA City Centre)
- Line-4 (Yamuna Bank to Anand Vihar)

accounts for 75% of the total ridership

“The fact that transport modeling for ridership was not carried out accurately by RITES, was accepted by the company (DMRC) as well as the MoUD before the Empowered Group of Secretaries in 2005”- CAG report, 2008

Passengers Per Kilometer Per Day

Year	Length (Km)	Passengers per Km per Day (Actual)	Passengers per Km per Day (Projected)
2006	33	14900	75700
2007	65	9550	42400
2008	68	11300	44800
2009	76	11600	44000
2010	186	9900	-

- An average of 11,000 passengers per Km of the Metro network
- With Phase III in 2016- total network length ~300 Km
- **Average ridership per day in 2016 = 3,300,000 => Projected Ridership in 2008 with one-fourth (68 Km) of the network length**

Low-Ridership

- Despite low ridership- congestion on the Metro during peak hours
- Congestion was attributable to various factors like-
 - ✓ lower number of passenger cars,
 - ✓ Suboptimal speed over the rail network,
 - ✓ lower frequency of trains, and
 - ✓ absence of differential fares during peak hours

Travel Characteristics- Metro Users*

- 48% own two-wheelers and 26 % own cars
- Prior mode: Before metro 69% used PT, 2% used para-transit and 29% used private vehicles
- Average daily travel distance for metro users is 36 Km- only 3.2 percent travel up to 10 km
- Average daily cost of travel -Rs 33

* From a survey of 221 metro users at 18 metro stations (Red Line) in 2004

Delhi Metro Demand Estimation

- Model developed in TRIPP, IIT Delhi*:
 - Estimates 21 percent of the ridership projected by DMRC for year 2021 – *close to current ridership pattern*
 - In 2021, Delhi metro would be able to carry 36% trips (maximum) of the total trips made by public transport
 - 64% of public transport trips will be on the bus.
- Model included the effect of:
 - the access and egress trips in terms of distance, time and cost
 - Ratio of access-egress distance and main-haul trip distance-> **an important factor**

* Advani, M. (2010), Demand estimation for public transport systems - Case Study of Delhi, IIT Delhi, unpublished thesis

Delhi Metro Demand Estimation

- Study highlighted the importance of cycle-rickshaws as a feeder mode for metro
- 27% to 38% metro trips are dependent on rickshaws
- Policy of Delhi government of restricting rickshaws in several parts of the city
-> will adversely affected metro ridership.

On going Work

- Rebound effect/induced trips
- Modal shifts
- Safety(access/ egress trips, along the corridor)
- CO2 emission based on Life –Cycle Analysis
- Expected financing from GOI
- Comparison with road based systems

Issues

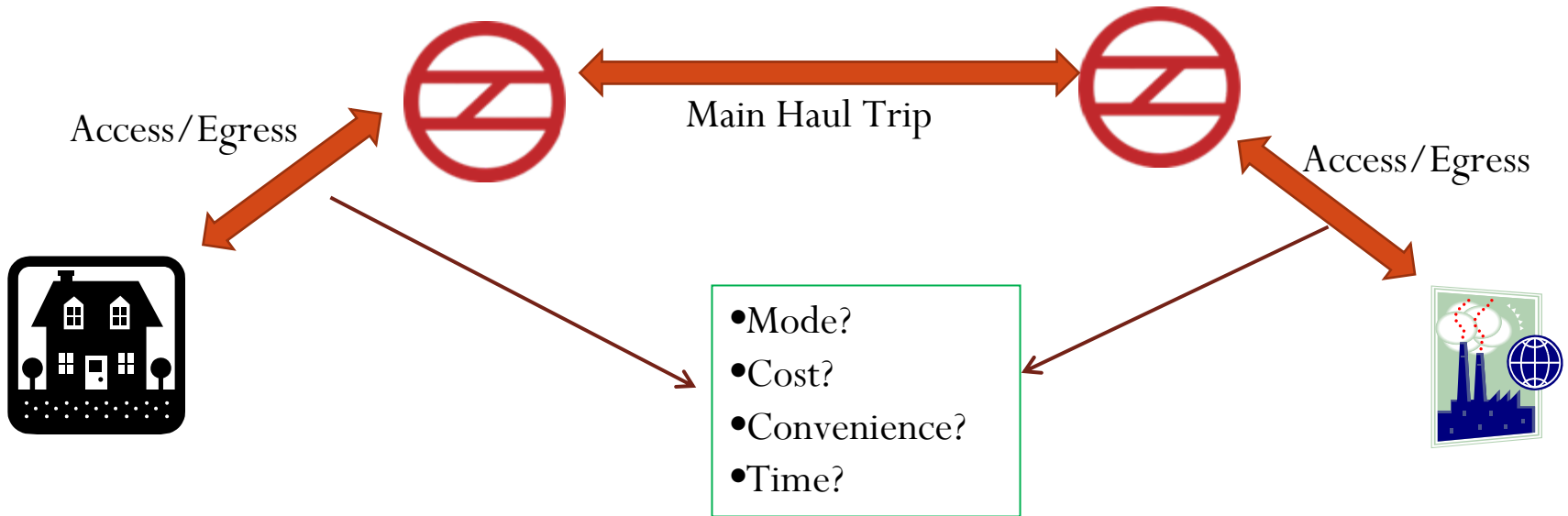
- High Capital/Operational and Maintenance Cost: Supported by Govt. Subsidies
- Induced Trips:
 - Auto trips required to access Metro stations
 - Trips on Metro due to availability of a faster mode (wouldn't be there otherwise)
 - Trips on roads when some auto trips are shifted to Metro
 - Trips by non-metro users due to availability of metro parking lots

Induced Trips “are likely” to nullify the emission and accident reductions due to trips by metro

Issues

- Displacement of Households/ shops
- Permanent Structure (elevated metro) changes the city's look forever
- Influence Zone: Few corridors, coverage area is less, can't be changed according to demand
- Access- Egress Inconvenience:
 - Cost of travel: cycle-rickshaw/auto/bus/car/2W
 - Waiting time: for feeder bus
 - No concessional schemes for students or other categories (only 10 percent discount on smart card)

Access- Main Haul - Egress

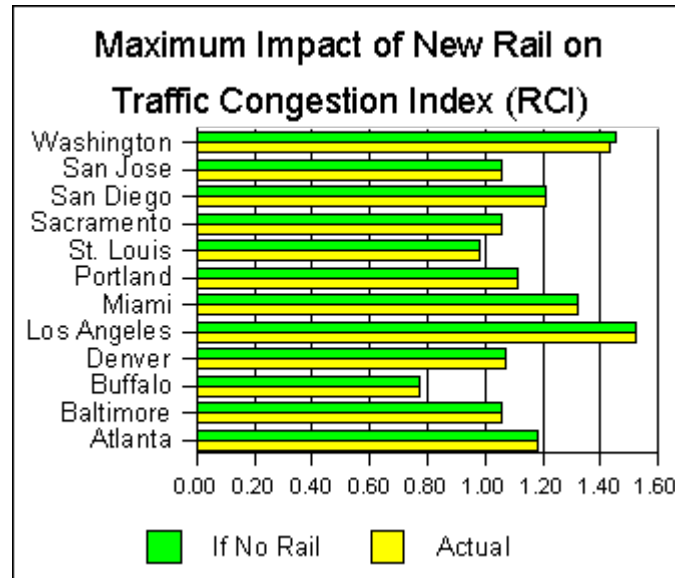


How are these different for bus and metro?

Experience around the world

- By 1999-2000 Kolkata Metro had a ridership of less than 10% of projected
- US DOT Study of ten rail projects in US: On an average actual ridership was 65 percent lower than forecast
- TRR Laboratory, UK study of 9 metro systems in developing as well as industrialized nations: Forecast was over 100 percent above the actual ridership
- Aalborg University, Denmark study of 27 rail projects: For two-thirds of projects, forecasts are overestimated by more than two-thirds

Experience around the world



TTI Study: In no case has new rail service been shown to have a noticeable impact on highway congestion or air quality