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A Comprehensive Report On Metro Rail Systems In India

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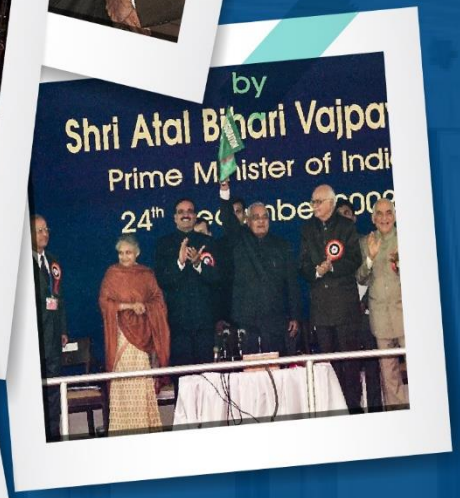
INDIA INFRAHUB



Contents

Metro Rail in India: Introduction

India has been rather late to adopt metro rail transit. While a committee set up by W. E. Crum in the Imperial Legislative Council at Shimla recommended the first metro line in Kolkata way back in 1919, the proposal was not undertaken due to lack of funds.

Post-independence, the metro project was reconceived by the then Chief Minister of West Bengal, Bidhan Chandra Roy, in 1950, but nothing concrete came of it. It was only after the Metropolitan Transport Project (MTP) was set up in 1969 to find alternative solutions to the traffic problems in Kolkata that concrete plans for metro projects started in India. The first metro was operationalised in Kolkata in 1984.

Although India got its first metro rail in 1984, progress since then has been slow. Delhi metro took off on December 25, 2002, a full eighteen years after the Kolkata metro becoming operational. Bengaluru (2011), Gurgaon (2013) and Mumbai (2014) got a new skeletal metro presence but growth remained anaemic for a long time.

Only in the last few years had the need been felt to expand the Indian metro network. Even then, there have been questions raised on why a $2,000 per year per capita income country needs metro transit. Urban planners often seem to stress road improvements and ‘walkability’ of cities and a metro rail is considered superfluous.

Metro rail technology, however, is nothing new. These urban mass rapid transit (MRT) systems have existed globally for several years. In fact, most countries around the world started constructing these networks when their per capita incomes were far below the current Indian levels.

A perspective of global metro evolution is helpful in contextualising the long adoption delay that metro has faced in India.

Brief Global History of Metro systems

A metro train is named "Metro" because it is most suitable for metropolitan cities with large populations. These systems generally operate at an average speed of 32-35 km/hr, and are characterised by their high capacity (50,000-75,000 passengers per hour, per direction) and high frequency of operation.

At the end of 2017, there were metros in 178 cities in 56 countries, carrying on average a total of 168 million passengers a day. The total route length is 13,903 km and there are 11,084 stations worldwide. The average line length of a metro route globally is 20 km and the average distance between stations is 1.25 km. Underground metros are most common, accounting for roughly 65 per cent of all stations in the world.

1. *Metro networks worldwide 2017:*

Region	Network (km)	Annual ridership (in billions)	No of Cities	No of Stations	No of Carriages
Asia-Pacific	*7,218	26.69	70	5,200	53,700
Europe	2,921	10.75	46	2,950	25,800
Latin America	943	5.92	19	780	9,000
Eurasia	813	4.70	16	540	8,100
North America	1,544	3.73	18	1,270	14,200
MENA	464	1.99	9	350	3,300
Total	**13,903**	**53.78**	**178**	**11,090**	**1,14,100**

Source: Statistics Brief of UITP, World Metro Figures 2018

*In the global context, India is set to increase its metro network from the existing operational 671 km to a planned 1,985 km (an increase of 1,315 km at an estimated investment of Rs.5,354billion)**.** This will take India's investment in metros from Rs.1,484 billion to Rs.6,838 billion.

The world over, metro constructions were initially hindered by various issues including lack of funds. For e.g., during the First World War, network construction was stopped for various metros. Some parts of the Berlin U-Bahn suffered damage caused by bombs and the whole network was shut down following the failure of the power supply system during the Second World War. Planned expansions of the Paris Metro were put on hold during the Second World War, which resulted in a number of stations being closed. Plans to build the Beijing metro system were first discussed in the early 1950s but preparations were halted in 1961 as a result of the Great Famine. The New York City Subway has suffered from a backlog of maintenance work since the 1970s when ridership fell as crime and vandalism increased.

We briefly discuss some of the key metro systems of the world.

The London Underground – The Tube

The London Underground, which opened in 1863, was the world's first underground railway system. More than 30,000 passengers tried out the Tube on the opening day and it was hailed by the Times as "the great engineering triumph of the day". It is the world's third longest metro system, spanning 402 km with 270 stations across its 11 lines. Only 45 per cent of the network actually runs underground, mainly in the city centre, with lines in the suburbs mostly running over-ground. It carries approximately 1.8 billion passengers every year.

Paris Métro

Paris Métro in France was opened in 1900. It was one of the first to use the term 'metro', which was abbreviated from the original operating company's name, 'Compagnie du chemin de fer métropolitain de Paris'. Paris Métro now carries approximately 1.5 billion passengers every year.

The New York City Subway

The New York City Subway, which opened in 1904, is one of the very few that offers a 24-hour service and has the highest number stations in the world (at 468). It carries 1.7 billion passengers every year.

The Buenos Aires Metro

Opened in 1913, the Buenos Aires metro is the oldest in Latin America. Wooden carriages were used for nearly 100 years until they were phased out in early 2013 and replaced by modern Chinese units.

The Tokyo Subway

The Tokyo subway opened in 1927. It has the world's largest underground railway station. It has introduced women-only carriages during the morning rush hours. Its subway manners guidebook advises passengers to set their mobile to silent mode and refrain from talking during the ride. It now carries 3.2billion passengers every year.

The Moscow Metro

Although Moscow's metro opened in 1935, the first plans to build a metro date back to the Tsarist era. Joseph Stalin was the first passenger and the driver had to practise driving a train with a Stalin dummy in it for several days before the actual trip. Moscow's Metro is famed for the grand designs of its stations, sometimes dubbed people's palaces.

The Beijing Metro System

Plans to build the Beijing metro system were first discussed in the early 1950s but preparations were halted in 1961 as a result of the Great Famine. When the subway plan was first discussed, the Chinese capital had a population of only three million. Beijing's subway is now one of the busiest in the world, carrying nearly 3.7 billion passengers every year.

Seoul Subway

Seoul's subway, which opened in the 1970s, provides 4G and wireless broadband coverage at all stations and on trains. The coaches are climate-controlled and automatically heat up in winter. Its cleanliness and ease of use has earned it the reputation of being one of the world's best systems.

2. *World's top 10 oldest Metros:*

SN	Name	Year Opened	Key Points
1	The London Underground –The Tube, England	1863	• World's first underground railway system • World's third longest metro system • Carries approximately 1.18 billion passengers every year
2	Budapest Metro, Hungary	May 1896	• Line 1 is listed as World Heritage Site by Unesco • M4 is the first automated metro route in Eastern Europe
3	Glasgow Metro, Scotland	Dec 1896	• Runs along an underground 10.5-km loop in the city and is one of the only metros in the world not to have been expanded beyond its original route • Carries approximately 13 million passengers every year.
4	Chicago 'L', Illinois, USA	1897	• The second busiest metro in the USA • Carries approximately 230 million passengers every year
5	Paris Métro, France	1900	• One of the first to use the term 'metro'

			• Carries approximately 1.5 billion passengers every year
6	MBTA subway, USA	1901	• Massachusetts Bay Transportation Authority Subway
7	Berlin U-Bahn, Germany	1902	• Approximately 80 per cent of the lines run underground • Carries approximately 553 million passengers every year
8	Athens Metro, Greece	Sep 1904	• A fourth line is expected to open in 2026, which will operate automatically without a driver present
9	The New York City Subway, USA	Oct 1904	• One of the very few that offer 24-hour service • Has the highest number of stations in the world (at 468) • Carries approximately 1.7 billion passengers every year
10	SEPTA Metro, Philadelphia, USA	1907	• South-eastern Pennsylvania Transportation Authority metro • Carries approximately 113 million passengers every year

Source: The Guardian: A short history of world metro systems, https://www.railway-technology.com/features/worlds-oldest-metro-systems/

3. World's top 10 busiest Metros, 2017:

SN	Metro	*Annual ridership (in billions)*
1	Tokyo, Japan	3.46
2	Moscow, Russia	2.37
3	Shanghai, China	2.04
4	Beijing, China	1.99
5	Seoul, South Korea	1.89
6	New York City, USA	1.81
7	**New Delhi, India**	**1.79**
8	Guanghzou, China	1.73
9	Mexico City, Mexico	1.68
10	Hong Kong, China	1.60

Source: Statistics Brief of UITP, World Metro Figures 2018

In comparison, with a network of 390 km, the Mumbai suburban railway operates 2,342 train trips and carries more than 7.5 million commuters daily, i.e., 2.64 billion passengers every year.

Why is Metro the right MRT option?

The transportation system occupies a central position in the fabric of a modern urbanised society. MRT is a type of high-capacity public transport generally found in urban areas. Unlike buses, rapid transit systems are electric railways that operate on an exclusive right-of-way, which cannot be accessed by pedestrians or other vehicles, and which is often grade-separated in underground tunnels or on elevated railways. The capital cost of construction is between 20 and 30 times that of a bus rapid transit system, depending on whether the metro

systems are underground or elevated. The metro rail system has proved to be the most efficient MRT system due to various reasons.

Key Benefits

The immediate and long-term benefits of metro rail are unmatched by any other type of transportation system. Some of these are discussed below.

Eco-friendly:
Metros are low on energy consumption. It helps reduce air and noise pollution, besides enabling saving of fuel; metros reduce the carbon footprint by controlling the emission of greenhouse gases and generate carbon credits.

Most economical:
Metros are very high-capacity passenger carriers. They have very high volumes of peak hour peak direction trips. As compared to other systems, they occupy less ground space. They consume very little energy per passenger, leading to lower cost to passengers without compromising on comfort and speed.

Reduced travel time:
A metro reduces journey time by 50 per cent. The short distance between stations makes it convenient for passengers to reach their destination easily. Many of the inconveniences associated with other modes of surface travel such as frequent traffic jams and the difficulty in finding parking spaces can be avoided as metros have exclusive right-of-way. Furthermore, the integration of metro with other supplementary modes of transport like buses, trams and taxi service saves time and money for the passenger.

Impact on Urbanisation

Improvement in standard of living
Metro rail system development improves the standard of living of a large segment of the urban population and acts as a catalyst for sustainable development across large urban swathes.

New suburban clusters
Improved road connectivity has a massive impact on real estate prices. Demand for houses in well-connected areas is always higher because they are more accessible, safer, healthier and cheaper to live in.

The deployment of a metro directly impacts real estate through an increase in land value, land use change and densification along the corridor. Experts believe land values are inversely related to the distance of land parcels from a metro station. The 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.

In a way, metro balances out real estate prices across the city as the reach and connectivity increases. Areas that were once barren stretches of land are now home to vast flourishing

market places and the scene of hectic commerce and business. The metro's connectivity with the outskirts of the city has a positive impact on property and land prices in these areas. For example, the Noida-Greater Noida metro with a route length of 30 km has increased the property prices in Noida and Greater Noida.

Population density along metro routes

Not only does Metro rail affect retail or commercial areas due to improved accessibility, even residential areas receive a dual demand driver – it generates jobs, which results in increased demand for homes, reduces commuting costs and increases conveniences. Naturally, it draws buyers to areas in close proximity to the rail.

To address the needs of urbanisation in these areas, the government usually addresses the specific needs of housing development by granting extra floor space index (FSI) along the corridor. This increased FSI will reflect in a rise in land prices along the metro corridor and automatically lead to increased population density near the station.

Displacement of people

On the negative side, 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 loss of access to regular employment and livelihood opportunities, in addition to education, health care, and other social necessities.

When to Build a Metro

Factors that make the metro imperative are the following:

- High peak hour peak direction traffic (PHPDT) in compact, high density city centres
- High vehicular strength and vehicular density in an area leading to heavy traffic congestion
- High passenger density on a movement route
- Fewer options to develop other modes of transport due to narrow roads, establishment of commercial complexes, etc.
- High demand forecast based on passengers' current spending for regular trips and their expectation while switching over to metro

Once the commercial viability is established based on the above, the project cost is estimated and funding options explored.

When Not to Build a Metro

Apart from the obvious issue of whether or not a metro would be financially viable, some other factors could also make it infeasible to build a metro system. These are briefly discussed below.

Land acquisition laws

Tenuous land acquisition laws can make it difficult to acquire land to build stations, car-sheds, etc. This is particularly true in the case of acquisition of land with religious structures

or that involves deforestation since an attempt to acquire such land can lead to public protests.

Funding institutions

It is imperative to find willing debt partners to fund a metro project along with the state and central governments. Public private partnerships are being encouraged to expand the metro network. The heavy investment and the long gestation period required to build a metro network make it difficult for these projects to be primarily funded by the private sector, as seen the world over.

Technical expertise

The availability of high-quality engineers and partners is a pre-requisite to conceptualise and operationalise the project.

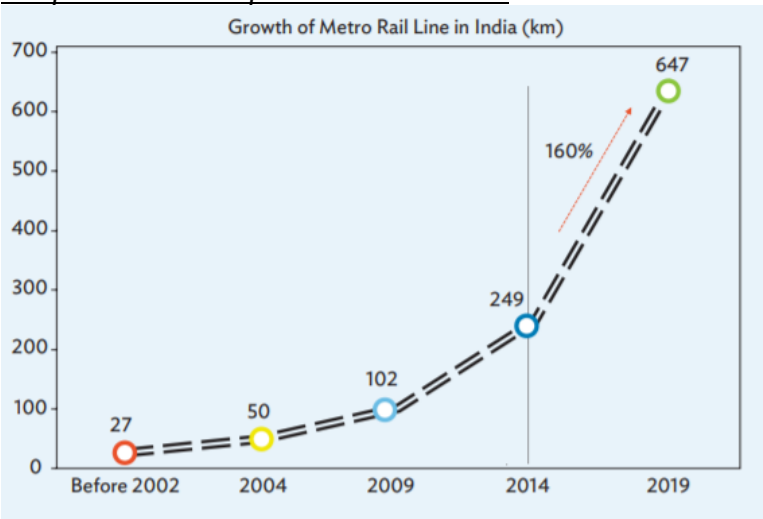
Stability of Government

Since the projects take several years to build and operationalise, a stable government helps infrastructure development as bureaucratic hassles are reduced.

Implementation of Metro in Indian Context

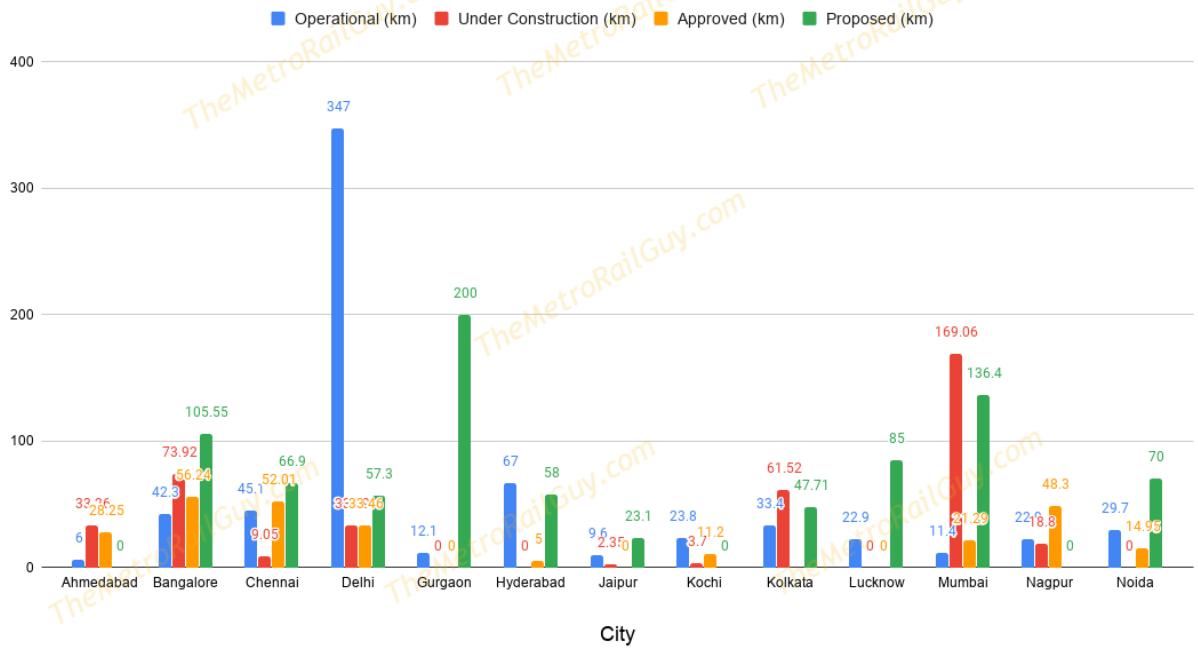
There are two key factors in the fructification of metro projects in India. One relates to how swiftly state and central governments provide hassle-free land for the development of metro rail. The other relates to how efficiently central and state governments raise capital to fund these projects.

Graph 1: Growth of Metro line in India



Source: MOHUA

Graph 2: Progress of metro system in Indian cities as of May 2020



Source: Metro rail guy

The Planning Commission had recommended in the Twelfth Five-Year Plan (2012-17) that all Indian cities with a population in excess of 2 million should start planning rail transit projects, and cities with a population in excess of 3 million should start constructing metro rail systems. As a general guideline, the Ministry of Urban Development, India (MoUD) has proposed the following criteria.

4. *Criteria for different modes of transport:*

Mode Choices	Peak Hour Peak Direction Traffic (PHPDT) on the proposed corridor	Population of the city/urban agglomeration	Average Trip Length
Metro Rail	>=20,000 by 2030	>=2 million as per 2001 census	More than 7-8 km
Light Rail Transit (LRT) primarily at grade	<20,000 by 2031	>1 million as per 2001 census	More than 7-8 km
Monorail *Monorail has almost the same cost of construction as elevated metro with less than half the carrying capacity and higher maintenance cost.*	<20,000 by 2031	>2 million as per 2001 census	
Bus Rapid Transit System	>4,000 and up to 20,000 in 2031 generally.	>1 million as per 2001 census	More than 5 km

Source: Background Paper for Mass Rapid Transportation Systems in India

Issue of elevated vs. underground corridor in a Metro rail project

While any decision on this aspect would depend on local conditions, including availability of land in the first place, in the metro rail project taken up so far, concerns over keeping

costs within manageable limits have resulted in a preference for elevated corridors. MRTS projects have a very long project life. Hence, cost calculations should ideally take into account the long-term opportunity cost of land as elevated structures are more land intensive. The cost of land used in the case of an elevated corridor should be compared with the cost of an underground corridor.

Indian Issues with Implementation

There are various factors that affect conversion of personal transport to metro.

Transport policies for private motorised vehicles

An increase in 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 of metro use, in particular. It has been observed that the metro will become attractive when roads are congested. So, irrespective of distance, people will switch over to metro to save time.

Average Trip Length

The average trip length is the distance between the starting and destination metro stations. While the metro can cater to long trips (10 km or more), transport policies should focus on improving non-motorised transport (NMT) to cater to shorter trips, which comprise more than 80 per cent of all trips in Delhi as well as in other Indian cities.

Trip Fare

The economically weaker section (EWS) in India are highly price sensitive and a rise in ticket price beyond a certain limit will result in a shift away from metro rail to buses and non-motorised transport.

Availability of non-motorised transport (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 great potential to increase access to metros and hence, metro ridership.

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 to a station. It includes walking down the stairs/escalators, waiting in a queue to buy a token (an estimated 55 to 60 per cent of passengers use smart cards), waiting to be frisked by security forces leading to long queues followed by baggage checks using scanner machines. Following this, passengers proceed to the gates, which open after 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 passenger boards the bus, overlapping with in-vehicle time, and there are no security checks at bus stops.

Accessing metro stations contributes to a significant proportion of the disutility (or inconvenience) of a trip by metro. There are several reasons for this. First, the access and egress parts of a metro trip involve the most physical effort. Second, unlike bus networks, which have a much higher coverage and smaller catchment area for each bus stop, metro

stations have much larger catchment areas. Consequently, there is a large portion of the city's population for whom access and egress distances are longer than a comfortable walking distance of 500 to 700 metres. Third, as access and egress trips become longer, individuals have to interact with more elements of road infrastructure, such as footpaths and pedestrian crossings.

Access and egress design, hence, are very critical in designing metro systems in India and should be part of the initial planning. Security considerations are non-negotiable but use of technology can make the overall travelling experience friendlier and help in reducing time spent in the security process.

Poor pedestrian infrastructure

Pedestrian infrastructure has important implications 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 pedestrian infrastructure is poorly designed or absent along roads providing access to metro stations. 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, construction material and discontinuity due to driveways, and encroachment of footpaths. The discontinuity is made worse with elevated footpaths that have no ramps. There is a consistent pattern of poor lighting for pedestrians along footpaths; adequate lighting is only available near the entry gates of metro stations.

For a metro system to be successful, pedestrian infrastructure should be improved and designed, keeping in mind the needs of metro access.

Last mile access

E-scooters, e-rickshaws and feeder buses must be available as an important feeder mode for metro users for last-mile connectivity. Parking for these vehicles near metro stations is also required to facilitate the use of these vehicles for access and egress trips to metros.

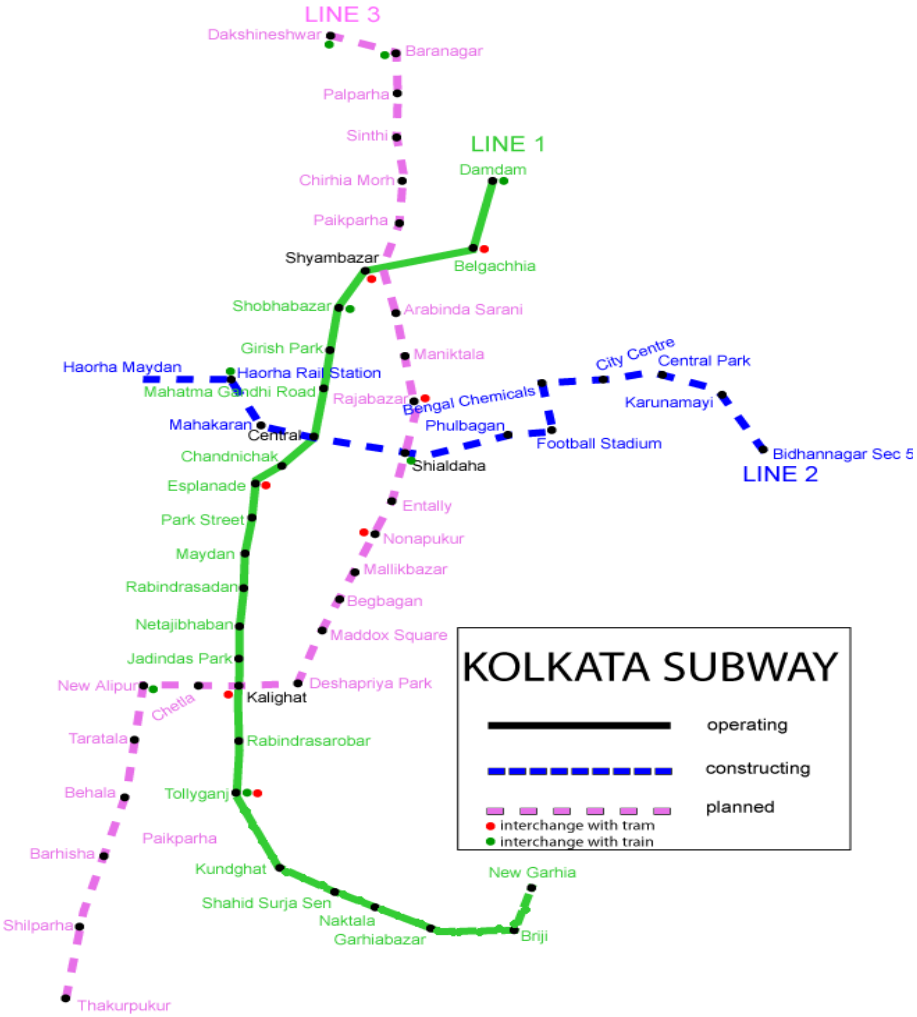
Metro in India: Spotlight Kolkata

The Kolkata Metro is the oldest rapid transit system in India. It was initially planned in the 1920s. In 1949-50, the government conceived the idea of building an underground railway for Kolkata. But metro construction started only in the 1970s. The first elevated stretch of the north-south corridor, from Bhawanipore (now Netaji Bhawan) to Esplanade, opened in 1984. It was later extended to run from Dum Dum to Tollygunge, and later, on to Noapara in the north and New Garia (named Kavi Subhash) in the south.

Spread over 1750 sq km with a population of approximately 15 million, Kolkata is one of the most populous urban areas in the world. Kolkata is the main business, commercial and financial hub of eastern and the north-eastern India. Only 6 per cent of the city consists of roads as against more than 20 per cent for other comparable metro cities in India. With a vehicle population estimated at around 1.6 million and 23.50 million transit trips a day in 2011, the city is bursting at its seams. There is very little scope to increase the road area in the city; the vehicle population is expected to reach 3 million while transit trips are expected to number 32 million per day in 2025. It was realised early on that only road transport would not be adequate to meet the

growing transport needs of the population and a rail-based system for mass rapid transport would be the most viable option to address this need.

Figure 1: Kolkata subway network map



Source: mapa-metro.com

Kolkata currently has two operational lines – a 27-km line from Noapara to Kavi Subhash and a 6-km line from Salt Lake Sector V to Salt Lake Stadium, a total of 33 km. Four other lines have been planned, totalling an additional 129 km. Kolkata Metro is the fifth-longest operational metro network in India after the Delhi Metro (351 km), Hyderabad Metro (69 km), Chennai Metro (45 km) and Namma/Bangalore Metro (42 km). The Kolkata metro system has a mix of underground, at-grade and elevated stations using both broad-gauge and standard-gauge tracks. Trains operate between 5.45a.m. and 9.55 p.m.

Figure 2: Kolkata metro

Source: Metro rail guy

The Kolkata Metro is the only metro system in the country operated by the Indian Railways. In most other cities in India, metros are operated by a corporation set up as a partnership between the central and state government.

5. *Kolkata Metro Network:*

Line	Description	Route length (km)	Total Stations
Line 1 (North South Corridor)	Noapara-Kavi Subhas Nagar	27	24 (at grade 2, elevated 7, underground 15)
Line 2 (East West Corridor)	JBS-Falaknuma (via MG Bus Station)	17	12 (elevated 6, underground 6)
Line 3	Joka-Esplanade	17	14 (elevated 9, underground 5)
Line 4	Noapara-Barasat	16	10 (elevated 5, underground 5)
Line 5	Baranagar-Barrackpore	12	11 (all elevated)
Line 6 (Airport Metro)	Kavi Subhas-Biman Bandar	30	24 (at grade 1, elevated 22, underground 1)

Source:https://www.urbantransportnews.com/page/metro-rail-projects-in-india

Hardships

Since the Kolkata metro was India's first metro and was completely indigenous, a traditional cut and cover method and driven shield tunnelling was chosen. The Kolkata metro was more of a trial-and-error affair, in contrast to the Delhi metro, which saw the involvement of numerous international consultants. As a result, it took nearly 23 years to construct the initial 17-km underground railway.

In the early days, the project was led by the Union Railway Minister from West Bengal, A. B. A. Ghani Khan Choudhury, often against the prevailing socio-political stance of his contemporaries in the West Bengal government. From the start of construction, the project had to contend with several problems including insufficient funds (until 1977-1978), the need to shift underground utilities, court injunctions, and an irregular supply of vital materials.

The main problem the railways faced was land issues. Railway lines, especially underground lines, cannot run in a zig-zag manner. They have to be straight lines. There were temples along the route that needed to be removed even though the network was being constructed underground due to the traditional cut and cover method used. The railways had to take time to resolve issues through negotiation and compensation. It was only then that the railways thought of bringing in legislation to ensure acquisition of land for a public project.

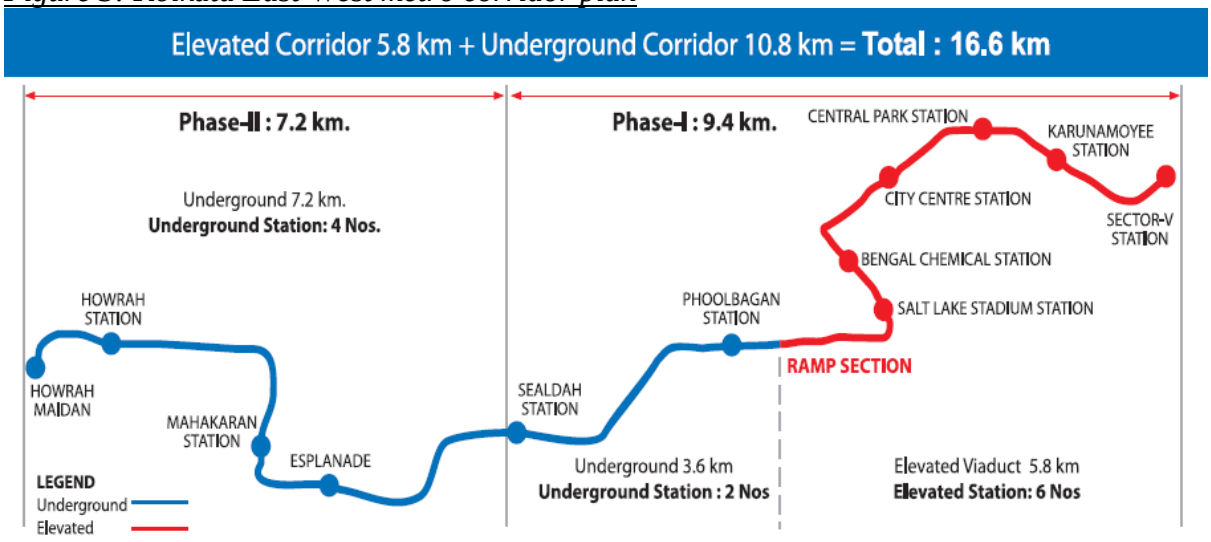
The East-West corridor

The East-West corridor metro line (17 km) is the second metro corridor to connect Kolkata with Howrah by an underwater metro line below the Hooghly River. It is scheduled to be completed in December, 2021. The project cost for this 17-km line is estimated at Rs.8,574 crore, funded by the central government (12 per cent), Indian Railways (40 per cent) and a loan from the Japan International Co-operation Agency (JICA) (48 per cent). The average cost is Rs.518 crore/km.

Unfortunately, the East-West corridor is one of the slowest metro projects in the world. The East-West Metro project across the Hooghly was conceptualised by the British in 1921, at the same time as the river Thames was being tunnelled in London. However, it was shelved because of a paucity of funds. Almost 100 years later, it is yet to become fully operational.

The East-West Metro was revived and sanctioned in 2008 at an initial estimated project cost of Rs.4,754 crore. The foundation stone was laid in 2009. Since then, the project has missed six deadlines — 2012, 2015, 2016, 2017, 2019, and 2020. Repeated delays have resulted in a 100 per cent cost escalation. In 2012, the estimated cost was Rs.4,874 crore, but the Kolkata Metro Rail Corporation (KMRC) estimates that it has risen to Rs.8,574 crore now.

Figure 3: Kolkata East-West metro corridor plan



Source: Kolkata Metro Rail Corporation

By the end of 2012, the East-West Metro started facing issues related to land acquisition and slum relocation. The railways never had any intention of taking up the project, but it did when Mamata Banerjee became the railway minister. In all cities, metro projects are executed by the urban development ministry. But Banerjee transferred the project from the urban development ministry to the railways.

Figure 4: East west corridor underground tunnel

Source: Kolkata metro rail corporation

Politics has not been the only issue facing the railways in building the East-West Metro. The biggest setback has been technical – while tunnelling, water started gushing from the river at Strand Road, which runs along the river on the east bank (Kolkata side). Engineers have now secured the tunnel with 35 metres of concretisation inside and barricaded the water source at Strand Road. But things went wrong once again in September 2019, when the imported Tunnel Boring Machine (TBM) hit an aquifer under B.B. Ganguly Street at Bowbazar while carving out space for a tunnel towards Sealdah. Water gushed out and several houses collapsed. Since then, the TBM has been stuck inside the tunnel and the KMRC has been unable to take it out, despite the Calcutta High Court directing the agency to resume work. There is no way to retrieve the machine except to dismantle the machine.

The East-West Metro project is insured for around Rs.1,200 crore, and a major part of this will go towards covering the losses caused by the TBM hitting the aquifer. The railways had to compensate the displaced families and build new furnished houses for them.

Fare

The fares are the cheapest in the country ranging from Rs.5 to Rs.25. Kolkata Metro, which suffered a loss of Rs.350 crore in FY19 (April 2019-March 2019), remains the cheapest form of public transport in Kolkata. A bus ride in the city is more expensive than an underground commute in air-conditioned comfort. The minimum fare for non-AC buses is Rs.7 for a 4-km ride. Kolkata Metro authorities have been trying for long to increase fares but successive railway ministers have refrained from approving a hike, leaving Kolkata's transport lifeline struggling to maintain its services. The metro fares were revised recently after six years in December 2019. Kolkata Metro ferries approximately 700,000 passengers every day (256 million annually). Around 40 and 44 per cent of passengers travel a distance of between 8 and 10 km. Only 1.5 per cent go beyond 20 km.

6. Daily fare for Kolkata Metro, North–South corridor

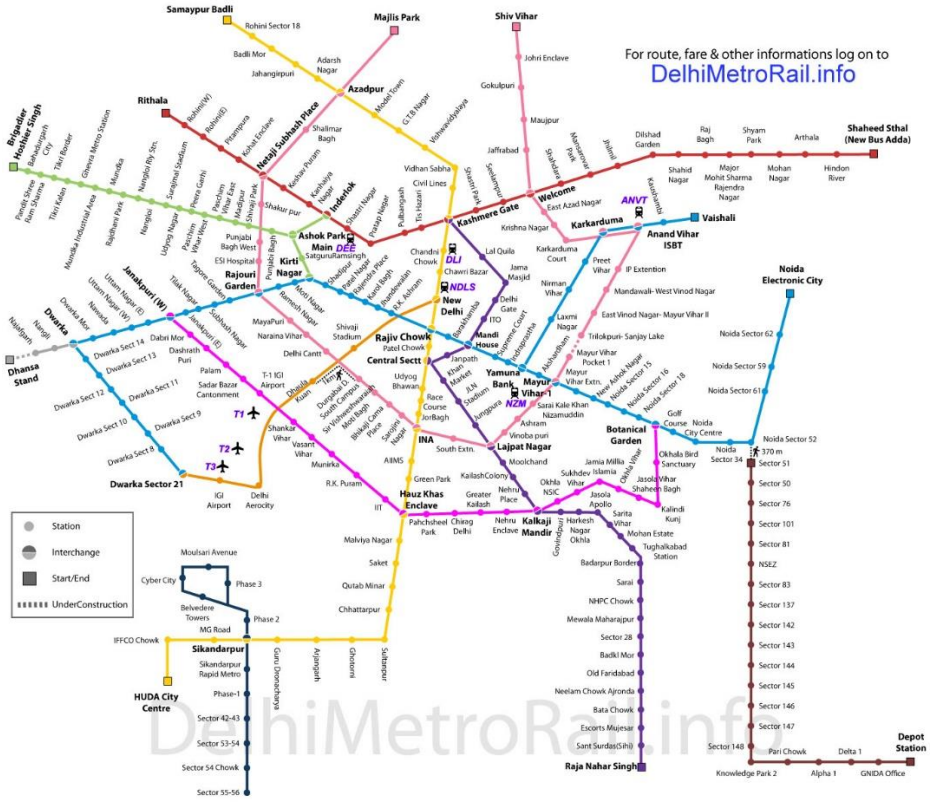
Km	New fare (Rs.)	Old fare (Rs.)
0-2	5	5
>2-5	10	5
>5-10	15	10
>10-20	20	15
>20	25	20

Source: https://mtp.indianrailways.gov.in/; TNN article

Metro in India: Spotlight Delhi

The Delhi Metro, with an operational network of 351 km, is undoubtedly India's most efficient suburban rail system, connecting areas at different ends of the national capital region (NCR). As of 2017, Delhi metro was the seventh busiest metro in the world with an annual ridership of 1.79 billion. The Delhi metro network is projected to increase to 470 km in the next five to seven years. The average capital cost is projected to increase from Rs.200 crore per km for Phases 1, 2 and 3 to Rs.403 crore per km in phase 4. Going ahead, the system could be bigger than the London Underground and is expected to carry 6 million passengers daily.

Figure 5: Delhi Metro Network map



Source: Delhi Metro Rail

Delhi Metro commenced operations in 2002 and is regarded a financial and technical success. Upon its inauguration, the metro system was so well received that on the first day of operations, about 1.2 million passengers used the metro rail system, which was six times the designed capacity. The modern, air-conditioned trains, contactless tokens instead of the paper tickets used in buses, escalators at stations, clean platforms, and convenient passenger information

system provided great relief to daily commuters. It has grown to over 350 km in just 18 years and is continuously expanding.

7. Delhi Metro Network:

Line	Description	Route length (km)	Total Stations
Phase 1, 2, 3			
1 Red Line	Shahid Sthal-Rithala	35	29
2 Yellow Line	SamaypurBadli-HUDA City Centre	49	37
3 Blue Line	Dwarka Sec 21-Noida Electronic City	57	50
4 Blue Line	Yamuna Bank-Vaishali	9	8
5 Green Line	Inderlok-Brigadier Hoshiyar Singh	30	23
6 Violet Line	Kashmere Gate-Raja Nahar Singh	47	34
7 Pink Line	Majlis Park-Shiv Vihar	58	29
8 Magenta Line	Botanical Garden-Janakpuri West	37	25
9 Grey Line	Dwarka-Najafgarh	4	3
10 Airport Line	New Delhi-Dwarka Sec 21	23	6
3 Blue Line Extn.	Vaishali-Mohan Nagar	6	3
3 Blue Line Extn.	Noida Electronic City-Sahibabad	6	5
Phase 4			
7 Pink Line Extn	Maujpur-Mukundpur	13	6
8 Magenta Line Extn	RK Ashram-Janakpuri West	30	25
11	Delhi Aerocity-Tughlakabad	21	15
12	Inderlok-Indraprastha	13	10
13	Lajpat Nagar-Saket G Block	8	7

Source:https://www.urbantransportnews.com/page/metro-rail-projects-in-india

Funding

The Japan International Co-operation Agency (JICA) has been the biggest contributor in the financing of the Delhi Metro, followed by the central and state governments (both having equal contribution). The Delhi Metro project is funded by debt from JICA to the extent of 50 to 60 per cent and the balance is funded in the ratio of 50:50 by the central and state governments. JICA charges an interest rate in the range of one to two per cent. For instance, for Phase I of the Delhi metro, JICA sanctioned the loan at an annual interest rate of 1.2% with a repayment period of 30 years and a moratorium .period of 10 years.

8. Delhi Metro outlay

City (State)	Total Network (km)	Total cost (Rs. crore)	*Rs. crore per km*	GoI (% share)	State Government (% share)	Loan from JICA (% share)
Phase 1	65	10,571	*163*	*20%*	*20%*	*60%*
Phase 2	125	18,783	*150*	*23%*	*23%*	*55%*
Phase 3	161	41,079	*255*	*26%*	*26%*	*49%*
Total existing	**351**	**70,433**	*201*			
Phase 4	62	25,000	*403*	*19%*	*30%*	*52%*
Phase 4 extension	57	22,971	*403*			

Grand Total	**470**	**1,18,404**	*252*			

Source: http://www.delhimetrorail.com/funding.aspx; https://www.businesstoday.in/current/economy-politics/delhi-metro-phase-iv-centre-to-share-50-land-cost-with-delhi-govt/story/391910.html

Lessons from DMRC Success

The Delhi Metro Rail Corporation Ltd. (DMRC) was registered in May 1995 as a joint venture between the Ministry of Urban Affairs and the Government of the National Capital Territory of Delhi (GNCTD) to implement and operate the metro project,. DMRC has gained reputation in its role as a metro system developer and is actively consulting on many national and international metro system development projects. The success story of DMRC has been published in various international newspapers. It has been termed the *World's Best Practice* (The Sydney Morning Herald, Australia dated April 2 2013).

Figure 6: Delhi metro

Source: Business Insider

While the Delhi metro has been hugely successful, registering an operational profit in its first year of operation, the Delhi metro cannot be seen as an ideal model for all cities in India. Metro projects are capital intensive and are effective only in specific contexts. Urban planners should not adopt a "one size fits all" approach; instead, they should design and plan transportation systems according to the requirements of different regions. Transportation planning must be decentralised (to the district level) to adequately consider, incorporate and be accountable to local needs and practices, especially of the marginalised.

There are various factors that contributed to the success of the Delhi metro rail system.

Exemplary leadership

The deadlines and investments for the project were realistic and the project was implemented on schedule and within the budget allocated. DMRC had an exemplary leadership team headed by E. Sreedharan, who was given the sobriquet of Metro Man by the media for the successful completion of the Delhi Metro. He ensured that contractors delivered work on time and as per budget. Most of the contracts were divided among various companies so that timely delivery of work could be ensured. His stint at the Delhi Metro has been considered so successful and crucial to India that he was awarded the Padma Shri by the Government of India in 2001, was named one of Asia's Heroes by Time magazine in 2003, was awarded the Chevalier de la Légion d'honneur in 2005 by the French government and the Padma Vibhushan in 2008. After 16 years of service with the Delhi Metro, Sreedharan retired from service on December 31, 2011. He was succeeded by Mr Mangu Singh.

Technical expertise

Unlike Kolkata's first metro, which was completely indigenous and largely a trial and error effort, DMRC employed several international experts.

High passenger satisfaction

Currently, DMRC ensures that 99.97 per cent of trains arrive within one minute of the scheduled time. Even during peak hours, the trains do not break down. There have been no accidents on the metro system. Passenger satisfaction is high and discipline is ensured to keep the metro clean.

Ridership

Delhi Metro has seen consistent growth in ridership since the commencement of operations in 2002. The increase in ridership can be attributed to the high quality of service and accessibility due to network expansion. In five years (FY 2012-FY 2017), there was a cumulative growth in ridership of about 43 per cent, from 703 million to 1 billion.

Key learning – Fare must be kept affordable:

Delhi metro fares were hiked by up to 100 per cent across distance slabs in May 2017 after eight years. It resulted in the loss of 300,000 passengers per day. Still, Delhi metro fares are more affordable than say Lucknow or Chennai. While Delhi metro charges Rs.60 for a distance greater than 32 km, Lucknow metro charges Rs.60 for any distance greater than 21 km (18 stations) and Chennai metro charges Rs.60 for any distance greater than 10 km.

9. Daily fare for Delhi metro:

Km	Rs.
0-2	10
2-5	20
5-12	30
12-21	40
21-32	50
>32	60

Source: https://themetrorailguy.com/

Revenue Generation – various sources:

Let us discuss the revenue stream of the Delhi metro. During FY19 (April 2018-March 2019), the total revenue generated was Rs.6,461 crore as against Rs.6,211 crore in the previous year. The operating profit was 30 per cent at Rs.1,963 crore in FY19. However, PAT was negative with a loss of Rs.464 crore in FY19. The DMRC has various sources of revenue.

Traffic Operations (58 per cent of total revenue)
This includes income from train operations, feeder bus earnings and rental income from kiosks, parking, shops, restaurants and advertisements. Traffic earnings account for roughly 80 per cent within this stream of revenue. In FY19, revenue from traffic operations stood at Rs.3,582 crore, recording an increase of 18 per cent over the previous year. The operating profit under this stream was 29 per cent at Rs.1,024 crore in FY19. In FY20, DMRC earned Rs.462 crore from rentals and another Rs.97 crore from leases as against Rs.3,122 crore from passenger fares.

External Project Works (31 per cent of total revenue)
This includes income from works carried out in other metro projects. During FY19, DMRC executed external project works of Rs.1,980 crore as against works worth Rs.2,331 crore in the previous year.

Real Estate
This includes income from sale of land and leases. In FY19, the real estate earnings were Rs.97 crore as against Rs.92 crore in the previous year.

Consultancy
This includes income from consultancy services to other metro systems in India and abroad. In FY19, consultancy earnings were Rs.34 crore as against Rs.33 crore in the previous year.

Others
This includes deferred government grants, income from the sale of carbon credits, sale of tender documents, etc.

Eco-friendly
Delhi metro is an asset to Delhi's environment, offsetting carbon emissions to the tune of 36.2 lakh tonnes over the past 10 years.

How has DMRC handled felling of trees?
The DMRC has pulled off the Delhi metro project with careful planning that addressed deforestation. DMRC made a conscious effort to minimise environmental damage. For example, a depot at Khyber Pass was built at a landfill site to avoid tree-felling. This required the DMRC to remove all the garbage from the site and laying it with good earth for the tracks to be laid.

DMRC planted over 5 lakh saplings to compensate for the 43,727 trees cut for the three phases of the network. The trees planted have sucked up 1.02 lakh tonnes of carbon dioxide over the past 10 years and given out 1.07 lakh tonnes of oxygen. Another 35 lakh tonnes of carbon emissions were offset through the use of clean alternatives like solar power and reducing commuters' reliance on fossil fuels. All the stations being built under Phase 3 were designed as "green buildings" with specific provisions for the conservation of energy.

Current Metro Plans in India

India is set to increase its metro network from an existing operational 671 km to a planned 1,985 km (increase by 1,315 km at an estimated investment of Rs.5,354 billion), over the next five to seven years**.** This will take India's investment in metros from Rs.1,484 billion to Rs.6,838 billion. The average cost of building a metro has increased from an average of Rs.230 crore per km to Rs.407 crore per km. The cost depends largely on whether the metro is built underground (higher) or at ground level. The other factor that influences the cost is the timeliness of implementation. Cost escalations are imminent whenever the projects are delayed due to design or implementation issues.

Figure 7: Indian cities with and planned metros of 2018

Source: Maps of India

Of the total projected increase in the metro network by 1,315 km, approximately 579 km (at an estimated investment of Rs.2,175 crore) is expected to be completed in the medium term in the next two to three years while the remaining route length of 736 km (at an estimated investment Rs.3,179 crore) is expected to be completed over the next five to seven years.

The metro system currently operational (671 km) in India include the Kolkata Metro in West Bengal (oldest metro in India), Delhi Metro (longest metro in India) and Noida Metro in NCR, Hyderabad Metro in Telangana, Bengaluru/Namma Metro in Karnataka, Chennai Metro in Tamil Nadu, Kochi Metro in Kerala, Mumbai Metro and Nagpur Metro in Maharashtra, Ahmedabad Metro in Gujarat, Jaipur Metro in Rajasthan and Lucknow Metro in Uttar Pradesh.

Similar metros have been planned and/or are under construction in new cities, totalling a route length of 363 km (at an outlay of Rs.1,331 billion**).** These are the Pune Metro, Navi Mumbai Metro and Thane Metro in Maharashtra, Surat Metro in Gujarat, Kanpur Metro and Agra Metro in Uttar Pradesh, Indore and Bhopal Metro in Madhya Pradesh, Patna Metro in Bihar and Dehradun-Haridwar-Rishikesh metro in Uttarakhand.

Expansion projects have also been planned and/or are under construction in existing metro cities. These involve a route length of 951 km (at an estimated cost of Rs.4,024 billion**).** These include the Delhi Metro and Noida Metro in NCR, Kolkata Metro in West Bengal, Mumbai Metro and Nagpur Metro in Maharashtra, Ahmedabad Metro in Gujarat, Jaipur Metro in Rajasthan, Lucknow Metro in Uttar Pradesh, Hyderabad Metro in Telangana, Chennai Metro in Tamil Nadu and Bengaluru Metro in Karnataka.

City Review

Kolkata metro, with an operational network of 33 km, is the oldest metro in India, having been operationalised in 1984. It took nearly 23 years to completely construct the initial 17-km underground railway in Kolkata as it was completely indigenous. In 1999-2000, the expansion of the North-South corridor was undertaken, which was largely operationalised in 2009-10.

Delhi metro, with an operational network of 351 km, is undoubtedly India's most efficient and successful metro rail system. Phase 1 consisting of 65 km was operationalised in various stages starting 2002 till 2006.

Both Delhi and Kolkata metro, which have been running for almost two decades, have provided several pre-construction as well as operational lessons that have helped in the development of other metros in India.

10. City-wise list of Metro rail network:

City (State)	**Operational**			**Under Construction**		**Proposed Expansion**		**Total (km)**	**Total (Rs. cr)**
	Network (km)	Start Date	Cost (Rs. cr)	Network (km)	Cost (Rs. cr)	Network (km)	Cost (Rs. cr)		
Delhi Metro, NCR	351	24-Dec-02	70,433	62	25,000	57	22,971	**470**	**1,18,404**
Cost per km			*201*		*403*		*403*		
Noida Metro, NCR	30	25-Jan-19	5,503	15	2,682			**45**	**8,185**
Cost per km			*185*		*179*				
Hyderabad Metro, Telangana	69	29-Nov-17	18,069	3	809			**72**	**18,878**
Cost per km			*261*		*261*				
Chennai Metro, Tamil Nadu	45	29-Jun-15	11,667	9	2,333	119	69,180	**173**	**83,180**
Cost per km			*259*		*259*		*581*		
Bangalore Metro, Karnataka	42	20-Oct-11	11,609	72	32,000			**114**	**43,609**
Cost per km			*274*		*444*				

Kochi Metro, Kerala	24	17-Jun-17	4826	2	356			**26**	**5,182**
Cost per km			*203*		*178*				
Kolkata Metro, West Bengal	33	24-Oct-84	*1,651*	17	8,574	112	58,249	**162**	**68,474**
Cost per km			*50*		*518*		*518*		
Mumbai Metro, Maharashtra	11	08-Jun-14	4,324	180	85,183	146	55,004	**337**	**1,44,511**
Cost per km			*379*		*473*		*378*		
Navi Mumbai Metro, Maharashtra				11	3,063	16	5,840	**27**	**8,903**
Cost per km					*278*		*355*		
Thane Metro, Maharashtra						29	13,095	**29**	**13,095**
Cost per km							*452*		
Nagpur Metro, Maharashtra	25	07-Mar-19	5,567	14	3,113	48	11,239	**86**	**19,919**
Cost per km			*227*		*227*		*233*		
Pune Metro, Maharashtra				40	11,420			**40**	**11,420**
Cost per km					*286*				
Ahmedabad Metro, Gujarat	7	04-Mar-19	1,749	34	9,024	28	5,523	**68**	**16,296**
Cost per km			*269*		*269*		*196*		
Surat Metro, Gujarat						40	12,114	**40**	**12,114**
Cost per km							*300*		
Jaipur Metro, Rajasthan	12	03-Jun-15	6,149			23	6,583	**35**	**12,732**
Cost per km			*517*				*286*		
Lucknow Metro, UP	23	05-Sep-17	6,880			11	4,538	**34**	**11,418**
Cost per km			*300*				*413*		
Kanpur Metro, UP				32	11,076			**32**	**11,076**
Cost per km					*342*				
Agra Metro, UP				29	8,379			**29**	**8,379**
Cost per km					*285*				
Indore Metro, MP				32	7,500			**32**	**7,500**
Cost per km					*238*				
Bhopal Metro, MP				28	6,941			**28**	**6,941**
Cost per km					*248*				
Patna Metro, Bihar						32	13,476	**32**	**13,476**
Cost per km							*420*		
Dehradun-Haridwar-Rishikesh metro, Uttarakhand						73	*40,150*	**73**	**40,150**
Cost per km							*550*		
Total	**671**		**1,48,427**	**579**	**2,17,453**	**735**	**3,17,962**	**1,985**	**6,83,842**

Cost per km			*230*		*375*		*432*		*349*

Key Notes:

1) *Compiled from various sources including various metro websites, newspaper articles/ reports including https://www.urbantransportnews.com/page/metro-rail-projects-in-india, the metrorailguy.com*
2) *This is an indicative list of projects that have been widely reported and that we consider most likely to fructify. We have tried to take into account the most probable proposed/ planned metro networks.*
3) *While in the last thirty years, India has added 20-25 km per annum of metro rail network, we are now projecting expansion of 175-200 km per annum over the next seven years.*
4) *In addition to the above projects, there are network expansion plans at a very preliminary stage, totalling approximately 1,300 km as follows.*
   New metro plans in new cities totalling to approximately 450 km namely Coimbatore Metro, Tamil Nadu 136 km, Vijayawada Metro, Andhra Pradesh 66 km, Trivandrum, Kerala 22 km, Kozhikode Metro, Kerala 13 km, Prayagraj Metro, Uttar Pradesh 42 km, Varanasi Metro, Uttar Pradesh 29 km, Gorakhpur Metro, Uttar Pradesh 27 km, Guwahati Metro, Assam 61 km, Jammu Metro, J&K UT 44 km, Srinagar Metro, J&K UT 25 km.
   Additional expansion plans in existing cities totalling approximately 850 km, namely, Noida Metro, Uttar Pradesh 70 km, Hyderabad Metro, Telangana 58 km, Bangalore Metro, Karnataka 162 km, Kochi Metro, Kerala 12 km, Navi Mumbai Metro, Maharashtra 79 km, Pune Metro, Maharashtra 41 km, Lucknow Metro, Uttar Pradesh 74 km, Indore Metro, Madhya Pradesh 57 km, Bhopal Metro, Madhya Pradesh 77 km, Gurgaon Metro, Haryana 200 km, Meerut Metro 35 km.
5) *We have used calculated estimates for route length and project cost, based on various updated news reports as the project costs keep getting revised.*
6) *For the operational Kolkata network, cost per km is assumed at Rs.50 crore flat in the absence of any information. This has been excluded from calculating the cost per km as it is an outlier.*
7) *For Delhi network's planned expansion of 57 km beyond the approved 62 km, we have assumed the same cost per km as for 62 km.*

Key Players – Financing Metro Projects

Japan International Co-operation Agency:

Japan International Co-operation Agency (JICA) is the key funding agency. It has provided loans of more than Rs.1,000 billion across metro projects in India.

JICA has been providing easy credit terms. For instance, for the Nagpur metro expansion, JICA funding may come via a loan for 30 years at an interest rate as low as 0.3 per cent per annum with a moratorium on loan repayment of 10 years. Comparatively, the rate of interest charged by Kfw, a German funding agency, is 1.6% plus 6-monthly Euribor while the French AFD is ready to provide loan at 0.6% plus 6-monthly Euribor. Both have a moratorium period of 5 years. However, while JICA loan appears to be most attractive on paper, it comes with the rider that the implementing agency buys only Japanese equipment. Typically, this equipment tends to be costlier than that provided by non-Japanese players.

However, several projects consider JICA a funding agency because they have allowed government to appoint contractors, who will manufacture rakes in India, under the 'Make in India' initiative.

Other multilateral funding agencies:
Asian Infrastructure Investment Bank (AIIB), Asian Development Bank (ADB), Agence Francaise de Developpement (AFD), European Investment Bank (EIB), New Development Bank (NDB), and Kfw, the German government's development bank, have also provided loans for Indian metro projects.

11. City-wise list of Metro Funding:

City (State)	Total Network (km)	Total cost (Rs. crore)	GoI (% share)	State Government (% share)	Others (% share)	
Delhi Metro, NCR, Phase 1	65	10,571	*20%*	*20%*	*60%*	JICA
Delhi Metro, NCR, Phase 2	125	18,783	*23%*	*23%*	*55%*	JICA
Delhi Metro, NCR, Phase 3	161	41,079	*26%*	*26%*	*49%*	JICA
Delhi Metro, NCR, Phase 4	62	25,000	*19%*	*30%*	*52%*	JICA
Noida Metro, NCR, Existing	30	5,503	*50%*	*50%*		
Noida Metro, NCR, Aqua line	15	2,682	*20%*	*80%*		
Hyderabad Metro, Telangana	72	18,800	*10%*		*90%*	PPP, L&T Metro Rail Hyderabad
Chennai Metro, TN, Phase 1	54	14,000	*20%*	*21%*	*59%*	JICA
Chennai Metro, TN, Phase 2	119	69,180	*16%*	*36%*	*48%*	29% JICA, 3% AIIB, 16% ADB and others to be tied up
Bangalore Metro, Karnataka, Phase 1	42	13,180	*31%*	*31%*	*38%*	24% JICA, 7% AFD, 3% HUDCO, 4% to be tied
Bangalore Metro, Karnataka, Phase 2	72	32,000	*31%*	*31%*	*38%*	7% AIIB, 13% EIB, 17% to be tied up
Kochi Metro, Kerala	26	5,182	*19%*	*39%*	*42%*	JICA
Kolkata Metro, West Bengal East-West Corridor	17	8,574	*12%*		*88%*	48% JICA,40% Indian Railways
Mumbai Metro, Maharashtra	11	4,324		*15%*	*85%*	PPP with 8% Reliance Infra, 1% Transdev France, 77% consortium of Indian

						Banks led by Syndicate Bank
Mumbai Metro, Maharashtra Line 2A, 2B, 7	58	23,604	*31%*	*31%*	*38%*	29% ADB, 8% NDB
Mumbai Metro, Maharashtra, Line 3	34	23,135	*21%*	*21%*	*57%*	JICA
Navi Mumbai Metro, Maharashtra Line 1, 2, 3	27	8,903		*100%*		
Nagpur Metro, Maharashtra, Phase 1	38	8,680	*20%*	*28%*	*52%*	43% Kfw, 9% AFD
Nagpur Metro, Maharashtra Phase 2	48	11,239	*23%*	*23%*	*53%*	Foreign Loans - Kfw, JICA, AFD being considered
Pune Metro, Maharashtra	40	11,420	*20%*	*20%*	*59%*	42% EIB, 17% AFD
Ahmedabad Metro, Gujarat Phase 1	40	10,773	*18%*	*25%*	*56%*	JICA
Ahmedabad Metro, Gujarat Phase 2	28	5,523	*20%*	*20%*	*60%*	JICA
Surat Metro, Gujarat	40	12,114	*20%*	*20%*	*60%*	17% AFD, 43% to be tied up
Jaipur Metro, Rajasthan, Phase 1	12	6,149		*84%*	*16%*	ADB
Jaipur Metro, Rajasthan, Phase 2	23	6,583	*50%*	*50%*		
Lucknow Metro, UP, Phase 1A	23	6,880	*25%*	*25%*	*51%*	EIB
Kanpur Metro, UP	32	11,076	*28%*	*28%*	*43%*	EIB
Indore Metro, MP	32	7,500	*20%*	*20%*	*60%*	23% NDB, 37% to be tied up
Bhopal Metro, MP	28	6,941	*25%*	*25%*	*51%*	EIB
Patna Metro, Bihar	32	13,476	*20%*	*20%*	*60%*	PPP, debts from FIs

Key Notes:

1. *Compiled from various sources including various metro websites, newspaper articles/ reports including https://www.urbantransportnews.com/page/metro-rail-projects-in-india*
2. *This is an indicative list of funding plans/tie-up projects that have been widely reported and that we consider most likely to fructify. The estimates include cost overruns, if any.*
3. *We have clubbed debt and equity from the government under the relevant heads. Furthermore, we have clubbed any state-owned agency funding under state funding for ease of comparison.*

Public Private Partnership (PPP)

Some metro projects have been implemented in partnership with the private sector like the Hyderabad metro (L&T), Mumbai metro (Reliance Infrastructure), etc. Notably, the Gurgaon rapid metro was entirely 100 per cent owned by IL&FS before being taken over by the DMRC in October 2019.

Hyderabad Metro, built on a public-private-partnership mode, has been in serious financial trouble – had it not been owned by cash-rich L&T, it would have collapsed by now. The Hyderabad metro took a loan of Rs.12,000 crore from a consortium of banks led by the State Bank of India. The interest component itself is reported to be about Rs.1,300 crore per annum.

NVS Reddy, MD of Hyderabad Metro Rail Ltd, has listed the following measures that need to be taken immediately for private players to build metros in India:

- Longer term loans, at least for 20 years against the usual tenure of nine to ten years for private players
- At least two to three percentage point reduction in interest rate from 11 per cent
- Liberal grant of loans by banks and financial institutions
- Initial hand-holding by the government with viability gap funding being increased from the present 40 per cent of the project cost, which is insufficient, to 60 per cent
- Better facilitation from government departments during the construction phase

A case in point – Mumbai Metro line 1:

Mumbai Metro One (MMOPL) is a special purpose vehicle (SPV) incorporated to implement the currently operational line 1, the Versova-Andheri-Ghatkopar Corridor metro project of 11 km. Reliance Infrastructure holds 69 per cent of the equity share capital of MMOPL while Mumbai Metropolitan Region Development Authority (MMRDA) holds 26 per cent. The remaining 5 per cent is held by Transdev (formerly Veolia Transport, France). This is a PPP.

Despite investing Rs.133 crore and providing viability funding gap of Rs.500 crore, the Maharashtra government owns only a 26 per cent stake in the Mumbai Metro. Against this, Reliance Infrastructure has invested only Rs.353 crore for a 69 per cent stake and Transdev has put in Rs.26 crore for a 5 per cent stake.

Mumbai Metro Line 1 is the first metro to be financed by Indian banks. The project has been financed by a consortium of banks led by Syndicate Bank. Syndicate Bank had undercut other lenders to edge itself into the consortium for Reliance Infrastructure's Mumbai Metro project and head it. The other banks in the consortium are Indian Bank, State Bank of Hyderabad, Bank of Maharashtra, IDBI Bank and India Infrastructure Finance Company (UK). Notably, Syndicate Bank's Rs.1,928 crore exposure is understood to have been classified as a non-performing asset (NPA) in 2018 and it is currently assessing a restructuring proposal.

Recently, Reliance Infrastructure-led MMOPL approached the Maharashtra government, to sell its stake in the company. Metro-1 was shut at the onset of the Covid-19 pandemic, which added to the losses it suffered prior to the lockdown.

Loss-making since it became operational in June 2014, MMOPL had planned to increase fares, but those plans faced roadblocks. In 2019, the second fare fixation committee rejected

MMOPL's proposal to increase fares and asked the company to re-examine innovative non-fare revenue avenues. MMOPL is also in the middle of arbitration against MMRDA over cost escalation during the construction of Metro-1. While MMOPL claims it cost upwards of Rs.4,000 crore to build Metro-1, MMRDA claims the cost is Rs.2,356 crore as per the original contract.

Figure 8: Western express highway excavated for Mumbai metro layout

Source: DNA India

Implementation Challenges due to Political Reasons

There have been implementation delays for political reasons too. The Mumbai Metro Line 3 (Colaba-Bandra-SEEPZ) is a case in point.

The 33.5-km underground Metro Line 3 passes through Aarey Colony and its car-shed was supposed to come up in this forested area. Implementation agencies had followed the template from Delhi, focusing on extensive compensatory afforestation. In 2019, with the due judicial process being complete, about 2,700 trees were cut in the Aarey Colony to make way for the metro car-shed.

However, there were huge protests against the felling of 2,700 trees in Aarey Colony for the car-shed. When the government in Maharashtra changed in November 2019, the new government decided to use executive powers to review the issue, which had become a key point of political contention in the state assembly election held in October 2019.

Figure 9: Save Aarey protests, October, 2019.

Source: Metro rail news

In December 2019, Chief Minister Uddhav Thackeray formed a committee of IAS officers to review the site for car-shed. In January 2020, the committee had given its consent for Aarey colony for the Metro car-shed. However, in August 2020, Chief Minister Uddhav Thackeray asked Mumbai Metro and Mumbai Metro Rail Corporation Ltd (MMRCL) officials to examine whether the proposed metro car-shed in Aarey Colony can be shifted to Kanjurmarg or Pahadi-Goregaon.

MMRCL officials have conveyed that if they start work on the Aarey land parcel, the project would be completed by 2022. However, if they are given an alternate site, work will have to begin from scratch and it will take an additional three or more years, i.e., 2025 and beyond to complete the project. Notably, 80 per cent of tunnelling and civil work for the first phase of the metro has been completed. However, even if the full civil works are completed, it will be infructuous without the car-shed.

The frequent delays in Metro Line 3, including the 10-month stay on the construction work on the car-shed in Aarey in 2019 have already led to the project cost spiralling by nearly Rs.9,000 crore, from Rs.23,136 crore in 2011 to Rs.32,000 crore. The delay in the construction of the car-shed and the need to find a new location for it could add an additional financial burden of Rs.2,000 crore to Rs.3,000 crore on the project.

Governance Structure Challenges

While most lines are owned by the central and state governments with debt from FFIs, some others have part private sector ownership. The Delhi Airport Express Line is a good example. Called the Orange line, this line is 23-km long – 16 km is underground and 7 km elevated. It

was implemented on a public private partnership (PPP) basis through a special purpose vehicle (SPV) – the Delhi Airport Metro Express Private Limited (DAMEPL). The shareholders of DAMEPL were Reliance Infrastructure Limited and a Spanish company.

The civil works were carried out by the DMRC, while the system installations as well as the rolling stock was supplied, installed and operated by DAMEPL, which also developed, operated and maintained the line. DAMEPL was to operate the line for 30 years under a revenue sharing model. It was to pay DMRC a fixed concession fee of USD10.2 million and a share of gross revenue – 1 per cent for the first five years, 2 per cent from the fifth to the tenth year, 3 per cent from the eleventh to the fifteenth year and 5 per cent thereafter.

The Airport Express Line was opened in February 2011. Service was suspended from July 2012 to January 2013 due to technical problems. After reopening, the speed was cut to only 50 km/hr, extending the journey time from the airport to New Delhi Station to over 40 minutes. On June 27 2013, Reliance Infrastructure Ltd. announced that they would be unable to operate the line beyond June 30 2013. Following this, DMRC took over the operations of the Airport Express line from July 1 2013, with an operations and maintenance team of 100 officials to handle the line. DMRC restored speed on the line to 80 km/hr in mid-2014. In January 2015, DMRC reported that the Airport Metro has recorded about 30 per cent rise in its ridership following a fare reduction of up to 40 per cent in July 2014.

Other Considerations

Inter-Government Co-operation

Urban transport is a state subject. In most cities in India, metros are operated by a corporation in partnership between the central and state government. Inter-government co-operation is imperative. The Kolkata Metro is the only system in the country operated by the Indian Railways since Mamta Banerjee pulled out of the project.

While the new Metro Rail Policy has stipulated that metro rail projects should be taken under the Metro Act, which is a Central Act, there are many important arguments in favour of giving states a major role. The issue. Therefore, needs to be re-visited.

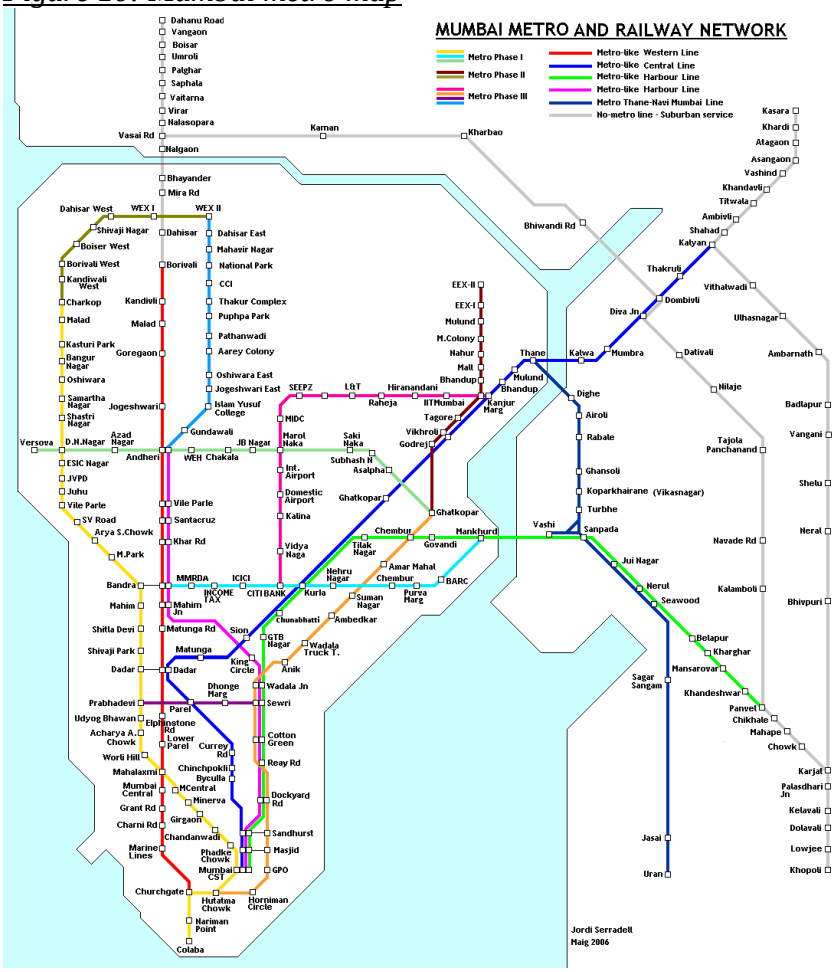
Impact of Covid-19

As social distancing protocols and work from home continue, metros are unlikely to see traffic anywhere close to the pre-Covid-19 days. Thus, the viability of the metro rail projects across India and their ability to stick to debt repayment schedules has been called into question. For e.g., for five months during the pandemic from April 2020 to August 2020, the Delhi Metro Rail Corporation (DMRC) has been losing Rs.9.3 crore every day. Since the lockdown, the DMRC has regularly been paying salaries to its employees, and has also repaid Rs.79 crore towards the interest component of its loan from JICA. However, DMRC is yet to repay the balance of loan instalment for FY 2020 – Rs.1,163 crore.

Under Construction Metros in India: Spotlight Mumbai – A Suburban Rail Comparison

India's suburban rail carries a significant number of passengers, especially in cities like Mumbai and Kolkata. Its role will continue to be relevant. From the railways point of view, the foremost concern is the operational loss suffered in these services.

Figure 10: Mumbai metro map



Source: MMRCL

Unlike Delhi, which had no suburban rail services before the metro was introduced, Mumbai already has a well-established suburban train network. With a network of 390 km, the Mumbai suburban railway operates 2,342 train trips and carries more than 7.5 million commuters daily, i.e., 2.64 billion passengers every year. The Mumbai metro network is set to expand from the existing 11 km to a planned 337 km.

Fare

Mumbai metro has a unique adoption problem – the suburban rail system in the city is quite well developed and cheap. While the suburban rail system is inadequate in terms of both capacity and coverage, it is still more affordable when a similar routing option is available.

Passengers who do not travel daily could switch to the metro as can be seen from the price points. For e.g., a passenger who travels 10 km would end up spending Rs 20 in the metro, Rs.70 in a first class suburban train and Rs.10 in a second class suburban train.

It is probable that daily first-class passengers will switch from suburban trains to the metro if they are willing to pay a higher price for a more comfortable travel. Students and office goers normally take the monthly pass for the suburban services, which is very moderately priced even for first class. For e.g., an office goer, who travels 10 km to and fro, would spend Rs 40 in the metro while he would be spending only Rs.22 if he carries a first-class monthly season pass for the suburban train, and would only be spending Rs.6 if he carries a second-class monthly season pass for the suburban train.

Metro fares are far too high compared to the second-class local train fare and the lower middle class, who travel second class, may find it difficult to switch to the metro. If we assume that 15 per cent of the passengers switch over from local trains, that would give an annual ridership of 396 million on the metro.

12. Daily fare – a comparison:

Mumbai metro		**Mumbai Suburban**							**Mumbai Monorail**	
			1st class (Rs.)			**2nd class (Rs.)**				
km	Rs	Station	Daily fare	*Based on monthly pass rate	*Based on yearly pass rate	Daily fare	*Based on monthly pass rate	*Based on yearly pass rate	Slab	Rs.
0-3	10	Churchgate to Mumbai Central (4.5 km)	50	15	26	5	5	6	Slab 1	10
3-12	20	Churchgate to Dadar (10 km)	70	22	28	10	6	7	Slab 2	20
12-18	30	Churchgate to Bandra (15 km)	70	22	28	10	6	7	Slab 3	30
18-24	40	Churchgate to Andheri (22 km)	105	30	54	10	10	14	Slab 4	40
24-30	50	Churchgate to Virar (60)	165	53	80	20	14	20		
30-36	60	Churchgate to Dahanu (124 km)	245	90	158	35	23	45		
36-42	70									
>42	80									

Source: Compiled from various sources including
https://www.mumbai77.com/city/3653/travel/local-train-seasonal-pass-fares/
**Assuming 22 travel days for the season pass, a passenger can travel to and fro at this price*

Convenient and comfortable

Today, Mumbai's suburban trains are overcrowded, each carrying on average 5,000 passengers against their designed capacity of 1,750 passengers. Since the entire train will be air-conditioned in the metro, commuters will be saved from noise/dust pollution and will be able travel in greater comfort at an affordable cost.

Security

The Central Railway has issued circulars advising tourists not to travel in Mumbai's suburban trains from 7 a.m. to 11 a.m. and 5 p.m. to 10 p.m. during weekdays because of overcrowding. On average, approximately 2,000 people die annually due to trespassing on the railway tracks and falling off suburban trains in Mumbai.

Figure 11: Comparison of commute in Mumbai suburban train and Mumbai metro

Source: Financial Express (left), Reliance Mumbai Metro (right)

The provision of escalators/elevators, secured platforms, closed doors of train services and CCTV cover ensure greater safety and comfort level for senior citizens, ladies, patients, etc., in the metro. There will be entry from either side of roads, making it unnecessary for people to use foot overbridges or cross roads. Platform screen doors will ensure the safety of passengers and eliminate chances of accidents while alighting/boarding.

Connecting 'Unconnected' Areas:

For example, Mumbai Metro 3 (MML-3) will run along the Colaba-Bandra-SEEPZ corridor connecting Mumbai's key financial hubs such as Nariman Point, Bandra-Kurla-Complex, Fort, Worli, Lower Parel, Goregaon, etc. The metro will provide for the first time connectivity to the airport, Nariman Point, Cuffe Parade, Kalbadevi, Worli, BKC, Airport, SEEPZ and MIDC. Besides, two important heritage stations of Mumbai, i.e., Chhatrapati Shivaji Terminus (CSTM) and Churchgate will also be connected through the MML-3 alignment. MML-3 project will bring Colaba back on the rail map after 85 years. Besides, due to its unique routing, almost like bus stops, metros can leave people closer to their destination as compared to suburban trains. For example, MML-3 has shorter stops at Worli, Siddhivinayak, Dadar, Sitladevi, etc., and its routing and stops are similar to that for buses.

Inter-change facilities:

The attractiveness of a typical metro rail project gets greatly reduced on longer stretches as the train must stop at a large number of stations. For such mobility, the approach has been to integrate rapid regional transport services to city-based slow moving metro rails. For smaller stretches, speed of movement is not a critical factor as the actual ride on the train is just a part of the overall trip time, the other part being the approach to the terminal and the time taken at stations. However, for a longer regional transport system, speed as well as a fewer number of stops are critical to making them attractive. Cities in developed nations, especially with relatively large populations like Paris and Amsterdam, have a network of metro rail (having many stoppages) interspersed with fast moving regional rail while ensuring inter-modal integration. A major implication for large metropolitan cities in India, therefore, is the need to develop integrated transport systems.

For example, MML-3 will facilitate the change-over to existing suburban trains at Churchgate, CSTM, Mumbai Central and Mahalakshmi. The existing suburban train facility will be complementary to the MML-3 and will help take train services closer to city areas that are not connected by the suburban rail network. Thus, the metro systems could supplement suburban train services in Mumbai.

Decongestion of roads and reduction in travel time:
The Mumbai metro is likely to reduce congestion on the city's roads. The present travel time of 100 minutes from Cuffe Parade to the Airport will be reduced to 50 minutes due to MML-3.

Last Mile connectivity:
Since access to stations is sometimes difficult, efforts are being made to improve last mile connectivity by piloting electric vehicles and non-motorised transport at select stations.

13. Mumbai Metro Network:

Line	Description	Route length (km)	Total Stations	Status/ Deadline
1	Versova-Ghatkopar	11	12	Operational
2A	Dahisar-DN Nagar	19	16	2020
2B	DN Nagar-Mandale	24	22	2022
3	Cuffe Parade-Aarey Depot (Colaba-Bandra-SEEPZ)	34	27	2022-2025
4	Wadala-Kasarwadavali	32	32	2022
4A	Kasarwadavali-Gaimukh	3	2	2022
5	Thane-Bhiwandi-Kalyan	25	17	2024
6	Samarthnagar-Vikhroli	15	13	2022
7	Dahisar (E)-Andheri (E)	17	13	2020
7A	Andheri (E)-Chhatrapati Shivaji International Airport (CSIA)	2	2	2024
8	CSIA-NMIA (Navi Mumbai International Airport)	35	To be declared (TBD)	2026
9	Dahisar (E)-Mira Bhayandar	11	9	2024
10	Gaimukh-Shivaji Chowk	9	4	2024
11	Wadala-CSMT	13	10	2026
12	Kalyan-Taloja	21	17	2024
13	Shivaki Chowk-Virar	23	TBD	2026
14	Kanjurmarg-Badlapur	45	TBD	2026

Source:https://www.urbantransportnews.com/page/metro-rail-projects-in-india

Technical details

Rolling Stock:
Rolling stock is an important component of total cost, roughly 20 per cent. Let us continue with the DMRC discussion. As at the end of FY19, DMRC had a total of 2,206 coaches (1,296 broad gauge and 910 standard gauge) until phase 3, i.e., for a network of 351 km, with roughly 6 to 8 coaches for every km.

Communication Based Train Control (CBTC) System

A research project, led by DMRC, has been initiated to develop an indigenous CBTC system. It is expected that an automatic train supervision (ATS) system, developed as part of the project, will be available for use in Phase 4.The indigenously developed CBTC will help reduce cost of the signalling system.

Train Control Management System
Rolling stock is provided with a micro-processor based Train Control Management System (TCMS), which monitors the health of the train system.

Several sensing devices, viz., thermal sensors to measure the temperature of cables, heat and smoke detectors, axle box temperature detection system, battery control and monitoring unit, etc., have been fitted to the rolling stock to monitor other equipment.

Monitoring
DMRC is undertaking various monitoring measures such as installation of a track-side wheel profile monitoring system to measure critical parameters on the run, installation of track health monitoring system and overhead equipment health monitoring system in its new stock, and Internet of Things (IOT) based applications for monitoring other assets like lifts, escalators, etc.

Security
Platform Screen Doors (PSD) have been installed to ensure commuter safety and better crowd management. Commuters are also provided Delhi Metro related updates and information via social media.

Fare Collection
DMRC has added automatic fare collection gates (AFC), token vending machines and point of sale machines. Gradually, all metro stations in the country will have AFC gates as well as single-use tokens, smart cards and NCMC cards.

National Common Mobility Card (NCMC) – One Nation One Card
The NCMC is an indigenously made product, and is a part of the Make in India project. The transport card enables the user to pay for travel, toll duties, retail shopping and cash withdrawals. This eco-system, consisting of NCMC and Automatic Fare Collection (AFC) Gate with suitable readers, is under extensive trial since 2019. DMRC has been helping C-DAC and Bharat Electronics Ltd. in developing the AFC system.

5D Building Information Modelling (BIM) technology:
BIM enables visualisation of the exact structure of a building before it is built. It can be a metro station and the adjacent area, tracks, etc. Many international metro projects, including the Crossrail project in London, subway extension in New York City and Dubai Metro, use this platform. This technology has been acquired by Maharashtra Metro Rail Corporation Limited.

Financial Models in Implementing Metro

Since metro systems are capital-intensive projects, the financial sustainability of these systems is an important issue to be explored. Globally, in case of public utilities, there are hardly any examples of cost being fully recovered. It remains a big challenge.

Fare

While high per capita disposable income in developed nations have allowed many of these projects to improve the financial viability of metros even with low ridership, many cities have subsidised metro tickets and mere revenue realisation has not been the goal of such city governments. The fare also has to be kept affordable to increase the modal share of public transport.

In India, fare pricing has to face the twin challenges of ensuring the financial viability of metro projects and its affordability for the economically weaker sections of the population. A rise in ticket price beyond a certain limit would result in shifting ridership away from metro rail to buses and other modes of transport. For instance, metro fares in Delhi were hiked by up to 100 per cent across different distance slabs in May 2017 after eight years, resulting in the loss of 300,000 passengers per day.

Kolkata metro fares are the cheapest across the country. Metro fares in Lucknow are high (even higher than the fares of the Delhi Metro), suggesting that the metro was designed keeping in mind the city's middle class. While the Delhi metro charges Rs.60 for a distance greater than 32 km, the Lucknow metro charges Rs.60 for any distance greater than 21 km (18 stations). For example, for the same fare, a rider can travel a distance of about 38 km in Delhi and a distance of about 23 km in Lucknow. Moreover, the Delhi metro gives discounts on Sundays and national holidays. Fares in Chennai too are quite high compared to Delhi.

14. Metro fare- a city-wise comparison:

Delhi metro		**Mumbai Metro**		**Kolkata Metro**		**Jaipur Metro**		**Lucknow Metro**		**Chennai Metro**		**Kochi Metro**	
Distance travelled (km)	Rs.	Distance travelled (km)	Rs.	Distance travelled (km)	Rs.	station	Rs.	Station	Rs.	Distance travelled (km)	Rs.	Fare	Rs.
0-2	10	0-3	10	0-2	5	0-2	6-11	1	10	0-3 stations	10	Min	10
2-5	20	3-12	20	>2-5	10	3-5	11-17	2	15	Up to 10 km	40	Max (18 km)	50
5-12	30	12-18	30	>5-10	15	6-8	17-23	3-6	20	Up to 21 km	60		
12-21	40	18-24	40	>10-20	20			7-9	30				
21-32	50	24-30	50	>20	25			10-13	40				
>32	60	30-36	60					14-17	50				
		36-42	70					>18	60				
		>42	80										

Source: various metro websites

Ridership:
The actual ridership on the Delhi Metro is, at most, one-fourth the projected ridership, leading to an overestimation of the benefits (and unfair justification) of the metro system in the DPRs during the planning phase. This has been found to be true of most metro projections worldwide. Future planning of metros in other cities should address this issue and travel demand models should be improved to provide a realistic projection of demand and, hence, the benefits of metro systems.

A comparison of ridership across cities shows that Kolkata with the cheapest fares has a higher ridership per km per day compared to Delhi. Delhi fares are much lower than in Chennai and Lucknow. However, despite its high ridership, Kolkata has recorded huge losses. This goes to show that non-farebox revenue is critical for the survival of metros.

15. Ridership – a city wise comparison

City (State)	Network (km)	Annual ridership (million)	Ridership per km per day
Delhi Metro, NCR	351	1,790	*13,972*
Hyderabad Metro, Telangana	69	173	*6,884*
Chennai Metro, Tamil Nadu	45	42	*2,556*
Bangalore Metro, Karnataka	42	164	*10,714*
Kolkata Metro, West Bengal	33	256	*21,254*
Noida Metro, NCR	30	5	*500*
Nagpur Metro, Maharashtra	25	4	*400*
Kochi Metro, Kerala	24	17	*1,941*
Lucknow Metro, UP	23	22	*2,609*
Gurgaon Rapid Metro, NCR (LTR)	12	18	*4,167*
Jaipur Metro, Rajasthan	12	7	*1,592*
Mumbai Metro, Maharashtra	11	138	*34,435*
Ahmedabad Metro, Gujarat	7	0.4	*164*

Source: various metro websites

Regulation of price and issue of technical price versus actual price
If fare fixation is outside the purview of the contract, which is currently the case, it significantly adds to the uncertainty around the project. The extant legal provision in the acts governing metro rail in India provides for a fare fixation committee. One way to create an enabling framework to attract private investment is to determine a technical fare with a formula-based escalation. If the contract can provide that any variance between actual and technical fare is to be compensated by the respective parties, much of the fare fixation problem can be sorted out. Besides, revision of prices should take place at regular intervals in line with inflation.

Non-fare box revenue
The farebox contributes less than 50 per cent of the total revenue of the Delhi Metro. Globally, metros get 30 to 40 per cent of their income from non-railway operations. The non-fare box revenue becomes critical to ensuring financial viability. To make metro projects across cities financially viable, metro rail companies are looking to explore alternative revenue streams to increase their non-fare box revenue. This has significant implications for the sustainability of metro systems. One major source of alternative revenue is redevelopment of real estate around metro stations and other facilities. This could sometimes lead to problems, because unlike bus systems, the development of metro systems could lead to a permanent change in the city's

structure and consequently, attract opposition from those who are adversely affected by such changes.

Environmental cost

The social benefit of metro projects has dictated that the objective remains to shift away from personalised transport. The returns from metro projects have to be assessed taking into account environmental costs, equity costs and so on. For example, the Shanghai metro charges 3 and 4 yuan for journeys up to 16 km, effectively encouraging all income segments to board. The costs that are saved are in terms of people opting for public transport instead of taxis, bus, etc. This reduces the carbon footprint of the city and improves air quality.

Financing Structure

Metro systems are natural monopolies and hence are regulated. The central government now requires a higher than before commitment from states and public-private partnership (PPP) in terms of land clearances and funding obligations. They offer viability gap funding of up to 40 per cent in PPP projects to attract private players. The metro rail policy stipulates a shift from a financial internal rate of return (IRR) of 8 per cent to an economic IRR of 14 per cent in line with global best practices. The policy aims to encourage private investment across a range of metro operations through the PPP route.

Private investment and other innovative forms of financing have to be explored to meet the huge investment requirement for metro schemes. Nowhere in the world has the PPP construction and maintenance model in metro rail completely succeeded as yet. The track record of Reliance Infra with Delhi's airport line or Mumbai Metro does not inspire confidence. There is general consensus that international experience does not encourage much optimism in the use of private finance as a dominant source of funding for these projects. As has been observed, the failure of many franchises suggested the prevalence of the "winner's curse" syndrome, as bidders overreach themselves to win contracts. Unrealistic bids may occur because of the excessive optimism of bidders.

Provisions for unforeseen circumstances

Due to the long gestation period of metro projects, international experience indicates that renegotiation is problematical even though the pressure to renegotiate arises from unforeseen changes in circumstances. First, any renegotiation will tend to undermine the integrity of the contract process and is open to challenge in courts. Second, allowing relief under adverse circumstances may act as a disincentive to control costs.

An alternative approach is to make broad provisions regarding many of these circumstances in the concession agreement itself, say, for instance, providing a clause pertaining to change in law where the authority has to insulate the concessionaire against the adverse effect of any abrupt change in law. To prevent windfall gains accruing to the concessionaire, the approach has been to insert a clause pertaining to value share in case a project's revenue exceeds a threshold level. Yet another approach applied internationally is to vary the concession period (Malaysia) if it is not expedient to raise user charges or if the commercial returns on the project is less than a threshold level.

Commercial Viability

Since metros are treated as social infrastructure, fare is typically regulated and thus, fare revenue by itself can never help metro projects to break even. This has been the global trend in

all cities with metros. Affordability is a big issue. While most Indian metros are reasonably priced given their service quality, in absolute terms, they are still unaffordable for the economically weaker sections of society.

Unrestricted monetisation of commercial revenue streams is key to the operating viability of any metro network. Furthermore, congestion charges and increasing parking costs must be levied to discourage private vehicles and to increase metro ridership and farebox revenues.

One of the profitable metros is the Hong Kong Metro, which reported an operating profit of 36 per cent in 2018, amounting to approximately USD1.5 billion in 2018, thanks to its monetisation from station commercials and property rentals.

Even as India makes heavy investment to develop metro networks across the country, most metro networks face heavy losses. In FY19, Bengaluru, Chennai, Hyderabad, Gurgaon and Kochi Metros faced losses, with Chennai Metro alone facing net losses amounting to Rs.714 crore on a total income of Rs.183 crore. Bengaluru, earned revenue of Rs.536 crore, but faced net losses amounting to Rs.498 crore. However, for Bengaluru and Chennai, while the revenue figures correspond to the operational line, the cost figures correspond to all lines, even those under construction. Bengaluru Metro lost a major chunk of non-fare revenue as the city municipal corporation banned outdoor advertising in 2018 owing to the menace of illegal hoardings. In Chennai and Hyderabad, only a small stretch of the metro line is operational, leading to restricted ridership vis-à-vis potential. Mumbai, which has only one operational line (11.2 km line (connecting the suburbs of Versova and Ghatkopar) also faced a net loss of Rs.236 crore on a revenue of Rs.322 crore. Jaipur metro has recorded an operational loss of Rs.26 crore in 2019-20.

In comparison, Delhi metro earned a total revenue of Rs.6,461 crore with an operating profit of 30 per cent (Rs.1,963 crore) and a net loss of 7 per cent (Rs.464 crore) in FY19.

The key reasons for the metros recording losses include lower than expected ridership due to poor last-mile connectivity, delay in commissioning of under-construction lines which would feed ridership to already operational lines, and sub-optimal monetisation of non-fare revenue options such as commercial space leasing, advertisement space leasing, property development, land monetisation, etc., due to various constraints, including regulatory and contractual restrictions.

Monetising the Metro

A key consideration for all under-construction metro systems is to look at the monetisation aspect early on. Sources of monetisation have to be explored actively to ensure financial viability. This is especially important for metros in smaller cities, where the fare adjustment capacity of the state governments may not be very high. Metro users may not pay hefty sums for travel, and may perceive the metro as a luxury.

Digital advertising

Many metros are exploring ways to introduce advanced advertising across their transit networks, illuminating formerly dark tunnels and sterile stations with targeted advertising through digital screens. This can generate significant additional revenue.

Private station labelling

Metro rail companies are exploring the possibility of tying up with realtors, hoteliers and IT companies to monetise their space. For example, Bangalore Metro Rail Corporation (BMRCL) has signed an MoU with computer hardware major Intel, under which "naming rights" of stations would be provided along with 3,000 square feet of commercial space and 1,000 square feet of advertising space. BMRCL is expected to get Rs.100 crore from this arrangement.

Property Development

In an effort to increase revenue, some metro rail companies (for example, Chennai Metro Rail Limited (CMRL) and BMRCL) construct buildings on land owned by it in the vicinity of some of its stations and earn lease rental income from it. They hand over the property development to real estate companies.

Global best practices – Integration of land use pattern and metro

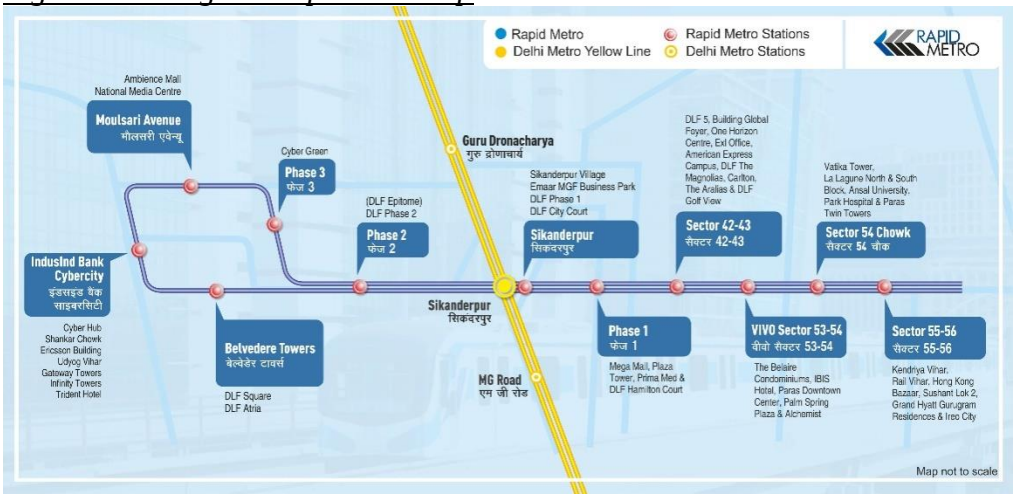
The Indian government is yet to realise the full land value capture of land owned by it. Indeed, there are parcels of government land located in prime locations that are either unutilised or underutilised. Changing the land use pattern and commercially exploiting these lands can generate significant revenue for government for infrastructure.

Singapore offers perhaps the best example of raising the ridership of metro with its attendant benefit through strategic densification along corridors of metro rail projects. The policy instrument here is the variation of the floor area ratio (FAR), which, in simple words, means the extent of construction allowed on a given plot. Attempts to raise the FAR along metro corridors have been limited so far. There are indeed difficult challenges: legacy issues, lack of appropriate institutional arrangements to effect such change and infrastructural deficiencies in cities. Instead of effectively using FAR variation to strategically densify cities as well as create a sense of space, most state governments/urban local bodies have imposed restrictions on FAR. It is readily admitted that using plot-by-plot variation of FAR as a planning instrument in Indian cities is easier said than done as it requires a paradigm shift in Indian planning. Singapore has integrated land use pattern with efficient transport by setting up the Land Transport Authority.

- **A case in point – the troubled Gurgaon Rapid Rail (Light Rail Transit)**

  DMRC took charge of operations of the privately-run Rapid Metro in Gurugram in October 2019, which had served a closure notice to the Haryana government citing an acute cash crunch and consequent inability to run operations.

Figure 12: Gurgaon Rapid Rail map



Source: Rapid Metro

The Gurgaon rapid metro, a one of its kind system, was fully privately owned by IL&FS. The concessionaire companies are currently insolvent and bankrupt. The Economic Offences Wing, Delhi, has filed an FIR against IL&FS, IL&FS Transportation and others for siphoning funds to the tune of Rs.154 crore. The entire outstanding equity to the extent of Rs.3,770 crore will need to be written off. This public loss does not include the cost of land for right of way and depots, which were given away almost free to the concessionaire companies.

The Gurgaon Rapid Metro earned more from advertisements than passenger traffic. About 60 per cent of the revenues came from advertisements, while the share of traffic revenues was only 39 per cent. High costs, low ridership (12 million annually) and poor location ensured the failure of the Gurgaon Rapid Metro. By taking it to the higher income stretch of Golf Course Road, Rapid Metro actually did a disservice to the operation since the residents there do not require public transport. However, prices and rentals of properties along the metro corridor surged by 10 to 15 per cent.

Figure 13: Advertisement in Gurgaon Rapid metro

Source: Media ant and Rapid metro

While advertisement rights, which is permitted under the provisions of the Metro Act, were accorded under their respective concession agreements signed much earlier in December 2009 and January 2013, subsequent by-laws sought to withdraw many of the advertising rights. There was a substantial withdrawal of advertisement rights due to multiple rounds

of modifications to the bye-laws by the Urban Local Bodies Department, framed between September 2016 and May 2018. The amendments imposed a ban on advertisements

- On metro pillars, a prolific source of revenue generation
- In areas facing the direction of traffic on public roads at metro stations etc.

Furthermore, the authority did not approve property development rights, as permitted under the Metro Act, on all land including depot and stations available with Rapid Metro Gurgaon Ltd (RMGL). Around 2 million square feet of commercial development on the land already available for depots with permissible FAR's (floor area ratio) under TOD (transit-oriented development) policy was not allowed to take shape.

Overall, fare revenues were hugely affected by

- Non-allocation of land for parking at stations
- Absence of feeder/evacuation services from metro stations, a state subject
- Extensive diversion of traffic through alternate forms of transport in the absence of an appropriate regulatory/policy framework
- Lack of streamlining of routes for alternate modes
- Overall lack of integration with a comprehensive mobility plan for Gurugram

Incidentally, all these features are necessary and are recognised by the metro policy announced by the Government of India in August 2017.

An Alternative for Tier 2/3 Cities – Light-rail Transit (LRT/Metrolite)

Light-rail transit (LRT) is a medium capacity mode of mass rapid transport that falls between heavy capacity metro rail and low capacity bus services. To boost the public transportation system in tier 2 and tier 3 cities, where ridership would be lower than in metros, the central government is planning to bring in LRT. Metrolite could become a dedicated rapid rail in cities and towns with tracks on surface (like railways) instead of elevated or underground stretches as is the case with metro rail corridors. The cost of metrolite is less than half that of the metro, making them financially viable.

16. LRT Projects:

City (State)	Operational			Proposed Expansion		Total (km)	Total (Rs. cr)
	Network (km)	Start Date	Cost (Rs. cr)	Network (km)	Cost (Rs. cr)		
Gurgaon Rapid Metro, NCR	12	14-Nov-13	1,088			**12**	**1,088**
Cost per km			*93*				
Delhi Metrolite, NCR				41	5,587	**41**	**5,587**
Cost per km					*136*		
*Mumbai Monorail, Maharashtra	20	02-Feb-14	3,000			**20**	**3,000**

Cost per km			*154*				
Nashik Metro Neo, Maharashtra				32	2,100	**32**	**2,100**
Cost per km					*66*		
Nagpur Broad Gauge metro, Maharashtra				267	418	**267**	**418**
Cost per km					*2*		
Dholera Metro, Gujarat				100	7,000	**100**	**7,000**
Cost per km					*70*		
Visakhapatnam Metro				80	8,300	**80**	**8,300**
Cost per km					*104*		

Key Notes:

1) *Compiled from various sources including various metro websites, newspaper articles/reports, including https://www.urbantransportnews.com/page/metro-rail-projects-in-india*
2) *This is an indicative list of projects that have been widely reported and that we consider most likely to fructify. We have tried to take into account the most probable proposed/planned metro networks.*
3) *We have used calculated estimates for route length and project cost, based on various updated news reports as the project costs keep getting revised.*
4) **Mumbai Monorail (for comparison only- not LRT)*

Mumbai Monorail:

At almost 20 km, Mumbai monorail is the third largest route in the world after China with 98 km and Japan with 28 km. Unfortunately, the Mumbai monorail is a failure. The monorail fare is expensive for the EWS in Mumbai. The monorail on its route was barely integrated with other modes of transport. Its stations are neither properly connected to suburban train stations nor are there frequent buses nearby to take passengers to their destinations. Monorail services have been disrupted several times due to issues such as power outages and technical glitches, with passengers stranded on the elevated trains on a few occasions. The frequency too is poor, both due to low ridership (4 million annually) as well as ill-maintained rakes. The MMRDA currently incurs a loss of Rs.3 lakh a day due to the monorail.

Make in India Opportunity

The projected investment of Rs.5,354 billion (1,315 km planned) in metros over the next say, two to eight years, presents a huge opportunity for employment generation during and after construction. In line with the "Make in India" initiative of the Government of India, the tender conditions for procurement and execution of metro works over the years have increasingly focussed on indigenisation so that more and more Indian firms can be roped in to manufacture, supply and execute the projects. It boosts local manufacturing, capital investment and generation of employment opportunities in India. Broadly, the construction of metro rail projects can generate opportunities in the following ways.

Rolling Stock (Trains and Coaches, Locomotives, Wagons)

The Indian metro rail industry has come a long way in the last 15 to 20 years from being an importer of metro coaches to becoming an exporter of coaches. The country had imported CBUs (completely built units) from Germany and South Korea at the launch of DMRC.

Currently, out of 2,206 coaches (351 km till phase 3) procured by DMRC until the end of Phase 3, 88 per cent have been manufactured in India. The capital costs of metro coaches in India are substantially lower than in the rest of the world. The cost of a coach is around Rs,9 to Rs.10 crore in India, which is roughly 45 to 50 per cent cheaper than imported coaches. Assuming an estimate of six to seven coaches per km, the investment opportunity in rolling stock alone for 1,315 km is roughly Rs.1,000 billion.

Seventy-five per cent of the rolling stock procured for use on Indian metro systems are required to be manufactured in India either through tie-ups or through a wholly-owned subsidiary. These conditions pushed international manufacturers to setup green field manufacturing plants in India under the union government's Make in India programme. Bharat Earth Movers Ltd, a central PSU, has made considerable investment to upgrade facilities for the manufacture of metro rolling stock at their plant in Bangalore. Alstom has a manufacturing facility at Sricity, Andhra Pradesh, for rolling stock and other components. It has also exported for the Sydney Metro. Bombardier Transportation has a rolling stock manufacturing plant at Savli, Gujarat. Companies like Bombardier, Alstom, Kawasaki and Mitsubishi are among the companies considered to be technology leaders in the field.

17. <u>An indicative list of rolling stock suppliers</u>

Name of the company	Facility at	Rolling Stock
Bharat Earth Movers Ltd. (BEML) as part of a consortium with Hyundai, Mitsubishi, Rotem	Bengaluru, Karnataka (since 2015)	Delhi Metro – 200 coaches Hyderabad Metro – 171 coaches Namma Metro – 150 coaches Kolkata Metro – 84 coaches Jaipur Metro – 40 coaches Mumbai Metro – 378 coaches (Rs.3,015 crore)
Bombardier Transportation	Savli, Gujarat (since 2008)	Delhi Metro – 614 coaches Export of semi-finished bogies to Australia Kanpur Metro, Agra Metro
Alstom	Sri City, Andhra Pradesh (since 2010)	Chennai Metro – 168 coaches Lucknow Metro – 80 coaches Kochi Metro – 75 coaches Mumbai Metro line 3 – 248 coaches (Euro 315 million/ Rs.2,678 crore)
Integral Coach Factory	Chennai, Tamil Nadu	Kolkata Metro – 456 coaches
Titagarh Firema	Nagpur	Pune Metro -102 coaches
Modern Coach Factory	Rae Bareli, Uttar Pradesh	Kolkata Metro, Nagpur Metro
Texmaco Rail & Engineering	Kolkata	Mumbai Metro- 12 rakes, Rs.152 crore

Source: Compiled from various newspaper articles

Systems (Signalling, Communication Systems)

Communication based train control (CBTC) is a railway signalling system that makes use of telecommunications between the train and track equipment for traffic management and infrastructure control. By means of the CBTC system, the exact position of a train is known more accurately than with traditional signalling systems. This results in greater safety and more efficient management of railway traffic. Metros are able to improve headways while maintaining and improving safety.

CBTC also integrates with 'CATC' (continuous automatic train control system), which includes CBTC, ATP (automatic train protection), ATO (automatic train operation) and ATS (automatic train supervision) sub-systems using radio communication between the track side and train. The estimated value of the CTBC signalling opportunity is in the range of Rs.150 to Rs.200 billion.

Alstom

Alstom is a key player in signalling. Over 25 per cent of the world's radio CBTC systems are operated with Alstom's Urbalis solutions. In India, Alstom has pioneered the introduction of CBTC by deploying Urbalis in the Kochi and Lucknow Metros. Alstom is executing 35 to 40 per cent of signalling for all Indian metro projects. In FY18, all CBTC projects in India were awarded to Alstom. It has various contracts in signalling in India, namely the Mumbai metro line 2A/2B/7covering a length of 58 km and Pune metro covering a length of 32 km (Rs.700 crore), Mumbai metro line 3 Euro 100 million (Rs.850 crore), Bangalore metro phase 1 covering a length of 42 km, Lucknow metro, Kochi metro, etc.

Most of the manufacture of signalling systems takes place in Bangalore, even for exports. The scope of the signalling contract could vary. For Mumbai metro line 3, the scope of the contract includes unmanned train operation (UTO), computer-based interlocking and centralised train supervision, platform screen doors, and electrical and mechanical supervisory control and data acquisition system.

The other players are Nippon Signal (Delhi metro), Thales (Hyderabad metro), Bombardier (Delhi metro, Agra metro, Kanpur metro) and Siemens. There are suppliers who supply the complete rolling stock including propulsion system.

A research project, led by DMRC, has been initiated to develop an indigenous CBTC system. It is expected that the automatic train supervision (ATS) system developed as part of the project will be available for use in Phase 4. Further, the indigenously developed CBTC will help reduce the cost of the signalling system.

Construction and Civil Works (Tunnels, Bridges and Stations)

There are various players in this segment across metros. The labour is mostly indigenous.

18. An indicative list of construction and civil work contractors

KEC International Ltd	Delhi Metro Phase 4	Rs.955 crore
Dilip Buildcon Ltd., Bhopal	Delhi Metro Phase 4	Rs.825 crore

	Bhopal metro and Indore metro	Rs.476 crore
Hindustan Construction Company (HCC) in a joint venture (JV) with Vensar Constructions Company (VCCL)	Delhi Metro Phase 4	Rs.489 crore
Quality Buildcon Pvt. Ltd	Delhi Metro Phase 4	Rs.18 crore
L&T Ltd	Mumbai Metro line 2B /line 4	Rs.1,200 –1,400 crore
Reliance Infrastructure in JV with Italy-based Rizzani de Eccher S.p.A	Mumbai Metro line 2B /line 4	Rs.1,200 –1,400 crore
NCC Infra	Mumbai Metro line 2B /line 4	NA
Simplex Infrastructures	Mumbai Metro line 2B /line 4	NA
JMC Projects	Mumbai Metro line 2B /line 4	NA
J Kumar Infraprojects	Mumbai Metro line 2B /line 4	NA
TPL-CHEC (JV between Tata Projects and China Harbour Engineering Company)	Mumbai Metro line 4	Rs.675 crore
Afcons Infra, Shapoorji Pallonji group	Mumbai Metro	NA
ITD Cementation India Ltd	Kolkata Metro	Rs.1,200 crore
IL&FS Engineering	Kolkata Metro	Rs.300 crore

Source: Compiled from various newspaper articles

Last Mile Connectivity

The viability of a trunk infrastructure is critically dependent on last mile connectivity. As pressure for maintaining higher ridership of metro will increase, there is a significant investment opportunity in developing last mile connectivity to this trunk infrastructure.

Similarly, smart cards and the creation and integration of data bases of different modes would also generate avenues for private investment. Texmaco Rail & Engineering has been awarded an order worth Rs.110 crore for the design, manufacture, supply, installation, testing and commissioning of the automatic fare collection system (AFC) for the Mumbai Metro.

Electrification Opportunity along with Renewable Use

The metro is a system that runs mainly on electricity. Electricity is needed for both traction (running of trains) and non-traction purposes such as lifts and escalators, air-conditioning of underground stations, lighting of stations, etc. Electricity contributes roughly 30 per cent of the total operating cost of the Delhi Metro. The power requirements of a metro system are determined by the peak-hour demand for power for traction and auxiliary applications. Electrification opportunities will exist even before the metro starts running. When metro train starts operating, there will be opportunities to supply electricity for traction and non-traction purposes. Broadly, there is an estimated electrification opportunity of roughly Rs.250 billion (1,315 km) at an electrification rate of Rs.18.5 crore per km.

For instance, Alstom has a contract worth Euro 71 million (Rs.604 crore) to provide power supply and traction electrification for the 33-km extension to the Bangalore Metro under Phase II. The scope of the contract includes engineering, supply, installation, testing and

commissioning of 750V DC third-rail electrification, the construction of 30 33kV/415V auxiliary substations, 26 33kV/750V DC traction substations and a 33kV cable distribution network along the viaduct. Alstom will work on integrating this new infrastructure with the existing system on the Phase I lines, including the augmentation of the SCADA system. Alstom also has a contract worth Euro15 million (Rs.128 crore) for the electrification of 28 km in the Pune metro.

Power interruption

Incidences of any power interruption, apart from affecting the running of trains, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to the travelling public. Lack of illumination at stations, non-visibility of appropriate signage, and disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level is low on account of stress. The effect on signal and communication may affect train operations and passenger safety. Therefore, reliable and continuous power supply is mandatory for efficient metro operations. To ensure reliability of power supply, it is essential that both the source of supply and connected transmission and distribution networks are reliable and have adequate redundancy built in.

Solar energy

The development of metros also offers opportunities to companies in the renewable energy sector. Recently, Bharat Heavy Electricals Limited (BHEL) successfully commissioned a 1.7 MW Solar PV Plant at Bina in Madhya Pradesh for the Indian Railways. The plant will directly feed power to traction systems of the Indian Railways. The project is a landmark achievement in the history of solar power as this is the first time that solar power is being directly used for traction applications. With this, BHEL has achieved direct injection of a single-phase 25 kV power to a traction substation of the Indian Railways. The project has been installed and commissioned by BHEL in just four and a half months from the date of joint land survey with Indian Railways. This development marks a major step of merging the advantages of renewable energy in the railway sector in an unprecedented way.

With this successful demonstration by BHEL, Indian Railways' objective of turning its huge land bank into captive PV power plants for supporting the railway traction grid without the support of utilities and the Railways' 'Go Green' initiative by 2030 will become a reality.

Conclusion

In a bid to ensure more convenient, eco-friendly transportation and improve the quality of life of people in metropolitan cities, India is all set to expand its metro rail network to approximately 2,000 km over the next seven years. While in the last thirty years, India has added 20-25 km per annum of metro rail network, we are now projecting an expansion of 175-200 km per annum over the next seven years. The projected investment of more than Rs.5,000 billion presents a huge Make in India opportunity that could generate employment across various sectors including manufacturing of trains and coaches, signalling systems, civil construction, electrification and renewable energy.

Metro projects have been largely funded by central and state government investment in equal proportion aggregating to 40 to 50 per cent and by debt from multilateral international funding agencies. Although private participation has been explored in these projects, it has not been very successful so far. The Kolkata and Delhi metros that have been running successfully for close to two decades have provided valuable lessons in undertaking metro expansion across

various cities. Key issues include land acquisition, particularly around religious structures, deforestation, funding of long gestation, capital-intensive projects as well as displacement of people, not to mention the technical challenges. Better last mile connectivity, pedestrian infrastructure and non-motorised transport infrastructure can help increase metro ridership. The deployment of a metro directly impacts real estate through increase in land value and densification along the corridor.

In India, fare pricing has to face the twin challenges of ensuring the financial viability of metro projects and affordability by the economically weaker sections of the population. Since metros are treated as social infrastructure, fare is typically regulated and thus, the fare by itself can never help achieve break even for metro projects. In line with global practices, unrestricted monetisation of commercial revenue streams by way of increase in non-fare box revenue through advertisements, real estate development around metro rail, etc., is the key to the operational viability of metro projects.

Since metro systems are highly capital-intensive, financial sustainability has been an issue. If the project takes too long to construct, it becomes unviable. There should be a social cost-benefit analysis and not just a financial one. We should look at the reduction in carbon footprint, improvement in air quality and reduction in travel time. An efficient metro rail system will benefit everyone including road travellers as it would decongest the city. A metro system cannot be judged merely from a return on investment perspective.

As the second most populated country in the world, India needs to ensure successful and timely completion, implementation and sustainability of its metro rail systems across various cities. This would improve the productivity of millions of Indians and take India closer to progress.

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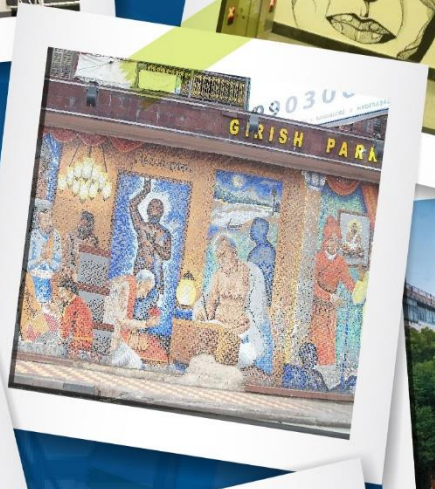

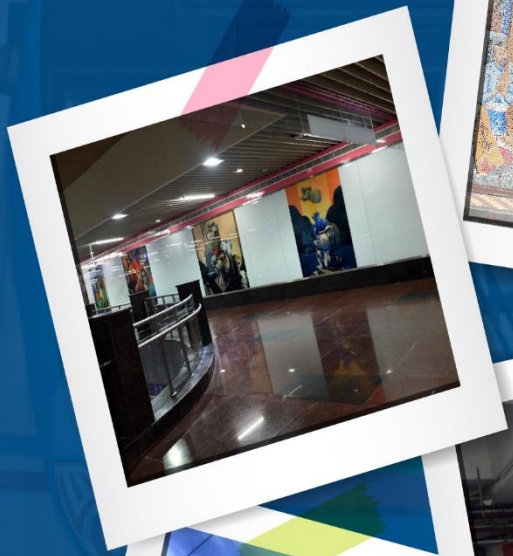

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