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New Approaches for Integrated Multimodal Transport Systems

Editors:

Dhaval Desai

Nandan Dawda

Durham University

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NEW APPROACHES FOR INTEGRATED MULTIMODAL URBAN TRANSPORT SYSTEMS

EDITORS
DHAVAL DESAI AND NANDAN DAWDA

Observer Research Foundation
20 Rouse Avenue, Institutional Area
New Delhi, India 110002
contactus@orfonline.org
www.orfonline.org

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Introduction

Dhaval Desai and Nandan Dawda

Cities are paramount to India's sustained economic growth, with the urban population expected to reach 590 million by 2031 (1). This anticipated surge necessitates optimal, cost-efficient, and effective public transport systems for sustainable urban development.

Traditionally, Indian cities rely on bus-based systems (city buses and bus rapid transit systems), rail-based systems (metro rail, suburban rail, trams), and private shared mobility (paratransit or intermediate public transport systems). Against the current demand of 130,000 buses (estimated to increase to 220,000 by 2031), 127 Indian cities offer formal bus services with a fleet size of 46,000 buses. Of these, 36,000 buses are operational in 53 cities with a population of over 1 million (2). Wide variations exist even in these cities. For example, Bengaluru operates 53 buses per 100,000 people (the highest). In comparison, Lucknow has six buses per 100,000 people (the lowest), with all other cities falling within this spectrum (3). Of the 36,000 buses owned by the 127 cities, 82 percent are operational in megacities alone. Unorganised systems, including private bus services and/or intermediate public transport, fulfil the enormous unmet demand in other cities.

Metro rail systems are currently operational in 20 cities, with networks under construction in seven cities (4). Four cities are evaluating proposals for metro rail, and feasibility studies for Metro Lite are ongoing for 20 cities. Additionally, three others are exploring the feasibility of Metro Neo (5). While metro rail is increasingly considered a panacea for transport woes by several cities and towns across India, their ridership is not commensurate with the carriage capacities, with several operational metro systems far from achieving their projected ridership. Conversely, ridership data for bus-based transit systems consistently exhibit higher bus commuter volumes than metro ridership in most cities with operational metro rail. For example, in nine cities with operational metro rail, passengers use buses up to 20 times more than the metro services despite an enormous bus shortage.

Transport service optimisation through strategic planning and multimodal coordination can fulfil the diverse mobility needs of different cities and their populations. Addressing integration gaps at the institutional, operational, and informational levels, and enhancing physical and fare integration is vital to unlocking a more interconnected and user-friendly public transport experience across Indian cities.

The institutional arrangements of these urban public transport systems are often fragmented, lack a unified command structure and a cohesive decision-making authority, and have poor stakeholder involvement. Despite mandates from key national initiatives such as the National Urban Transport Policy (6), Jawaharlal Nehru National Urban Renewal Mission (7), Metro Rail Policy (8), and several other central programmes advocating the establishment of a unified metropolitan transport authority (UMTA) to oversee the diverse modes of transport, its implementation remains limited. Without sufficient legislative support and empowerment, concerns also persist regarding the efficacy of UMTAs where they exist.

These institutional shortcomings hinder the establishment of integrated multimodal transport systems, increasing travel times and costs. Major urban centres, including Delhi, Mumbai, Bengaluru, and Kolkata, lose an estimated US$22 billion annually to road congestion (9). Moreover, the institutional mechanism and its requirements differ based on a city's size and the complexity of public transport systems. Integration across public transport's different institutional, operational, informational, and fare aspects is necessary for efforts like the 'National Common Mobility Card' (10) to succeed.

This volume is divided into three sections encompassing the critical aspects of multimodal transport integration: Institutional and Governance Integration, Physical and Operational Integration, and Fare and Information Integration.

Essay contributors—including industry and government representatives, mobility service providers, researchers, and academics—identify the challenges and barriers, and recommend an actionable policy roadmap for urban India to transition toward integrated and sustainable multimodal transport systems.

Poonam Sabikhi, C. Sathiya Narayanan, and Akila S. set the tone for this series by evaluating the performance of the Chennai Unified Metropolitan Transport Authority (CUMTA), a pioneering body operationalised with a legislative sanction in 2022 to coordinate among various transport modes, improve physical and operational integration, and foster sustainable urban mobility. They emphasise the need for policy-level integration to address congestion, inefficiencies, and lack of intermodal connectivity. Drawing on international best practices from London (UK), Singapore, and South Korea, the essay advocates empowering CUMTA and similar authorities across India with financial autonomy, regulatory powers, advanced technology-driven data-sharing mechanisms, and institutional capacity.

Often ignored in mobility planning, adequate parking facilities are pivotal for efficient, multimodal public transport systems in bustling metropolises like Mumbai. Prachi Merchant and Dhaval Desai's essay underscores the significance of integrating parking facilities into Mumbai's multimodal transport strategy. It highlights global best practices and discusses challenges, including disjointed institutional responsibilities, limited land availability, and ad hoc parking policies, which exacerbate congestion and impede seamless transit in cities of the Global South. The essay advocates urban mobility strategies to have parking an essential component through smart technology, integrated planning, and participatory governance, enabling sustainable urban mobility and reduced emissions.

Next, Roshan Toshniwal delves into the challenges faced by Indian cities due to fragmented transport governance and the limited effectiveness of UMTAs. He recommends learning from global best practices, like Transport for London and the Seoul Transport Operation and Information Service, and harnessing advanced digital tools and data-sharing mechanisms to empower UMTAs. By transforming UMTAs into robust, data-driven authorities, Indian cities can foster multimodal integration, mitigate congestion, and pave the way for sustainable and efficient urban mobility solutions, he argues.

Damodar Pujari and Dhaval Desai highlight how micromobility provided by small, lightweight vehicles like bicycles and e-scooters can address urban mobility challenges in India by providing first- and last-mile connectivity. It presents case studies from cities like Copenhagen (Denmark), Barcelona (Spain), and London (UK), for mainstreaming micromobility in transport plans to ease urban congestion and reduce environmental impacts. It recommends targeted investments, policy focus, and infrastructure development to integrate micromobility into urban transport systems.

The next section on physical and operational integration begins with Nandan Dawda and Firsat Mulla's essay, which explores the critical role of informal public transport (IPT) systems, particularly autorickshaws, in urban India's mobility landscape. Though they fill the gaps in formal public transport systems, IPT operations face challenges such as poor regulation, operational inefficiencies, and exploitation by aggregator platforms. The essay examines the Ola, Uber, Namma Yatri and InDrive models in India and global best practices, such as Rwanda's reforms and Senegal's financial mechanisms, that successfully formalised and improved IPT systems. Finally, it advocates for multimodal integration through mobility-as-a-service (MaaS) platforms to enhance urban mobility comprehensively.

Drawing on global best practices from cities like Tokyo (Japan), London, and Singapore, the following essay by Samir Sharma emphasises the critical role of seamless physical and operational coordination among diverse transit modes to reduce travel times and improve commuter convenience. It highlights the Regional rapid transit system in India's National Capital Region as a model of integration, featuring interoperable corridors, multimodal transit complexes, and real-time operational data, and how it aims to improve connectivity between urban and regional networks, promote sustainability, and expand public transport usage. It urges strategic planning, stakeholder coordination, and technology adoption to create efficient and sustainable urban mobility frameworks.

In their essay, Mitali Nikore and Brinda Juneja identify the gaps in India's urban transport systems that hinder the ease of access and safe mobility of women, girls, and other marginalised groups. With women comprising the majority of public transport users in Indian cities, the authors suggest ways to overcome systemic barriers like affordability, accessibility, and inclusivity in design. Drawing on global best practices and case studies, they propose a four-pillar strategy to reimagine urban mobility, provide safer commutes and equitable opportunities, and foster inclusive urban growth.

Next, Himani Jain and Krishna Khanna explore using smartphone GPS data to enhance public transport systems in Delhi. They leverage aggregated GPS data to analyse travel patterns and identify gaps in bus services to optimise accessibility, service reliability, and multimodal integration. They combine this data with generalised transit feed specification data to assess public transport demand, mainly focusing on underserved areas and peak-hour gaps. Acknowledging smartphone GPS datasets' social and demographic limitations, the study highlights how their evaluation can aid infrastructure improvements and service optimisation. The authors urge mainstreaming this approach for cost-effective, real-time data sharing for better planning and multimodal coordination in the public transport sector.

The final section on fare and information integration begins with an essay by Nandan Dawda that highlights the role of trip planners in achieving an integrated and sustainable multimodal transport system. Analysing trip planners in 25 global cities—20 Indian and five international (London, Singapore, Hong Kong, Paris, and New York)—the essay develops an evaluation framework to assess the trip planners' performance across six components: (i) features, (ii) status updates, (iii) maps, (iv) fare integration, (v) help and contact, and (vi) other useful commuter information. Inferences from the framework indicate why India must adopt a standardised framework, incorporating real-time data, and enhancing user-centric features to improve urban mobility solutions in Indian cities.

Mohit Kalawatia and Balaje Rajeraman highlight the challenges to multimodal transportation integration, such as data standardisation, interoperability, and stakeholder coordination, and emphasise the role of technology, shared mobility, and MaaS platforms. They recommend the universal adoption of India's Open Network Digital Commerce to accelerate the transition of India's cities to an integrated transportation system that provides seamless scheduling, a single-window ticketing system across modes and real-time information sharing among transport service providers, making public transport attractive, accessible, and equitable for all classes of commuters.

Partha Mukhopadhyay and Gurkirat Singh Juneja's essay emphasises fare and information integration across transport modes as critical enablers of the imperative shift from private to public transport in India to address climate concerns and accommodate rapid urbanisation. By studying informal transit modes like autorickshaws alongside formal systems, the authors highlight the need for these to be included in an integrated framework. The essay evaluates how various best practices of fare integration, including fare unification, digital ticketing, and frequency optimisation, offer lessons for India.

In the final essay, Aditya Rane highlights how disparate fare policies between buses and metro systems undermine the affordability and accessibility of multimodal travel, particularly for vulnerable commuters. Drawing on examples from cities like Pune and Mumbai and global cases like Singapore, his essay emphasises streamlining fare policies, implementing universal travel passes, and extending welfare schemes across modes. It recommends empowering UMTA with the power to regulate fares, adopting unified payment systems like the National Common Mobility Card, and promoting inclusive policies to ensure increased ridership, financial sustainability and equitable access to public transport.

A well-integrated multimodal transport system needs robust interagency collaboration, innovative technologies, and a user-centric approach. With focused efforts, India can achieve sustainable and equitable urban mobility for its rapidly growing cities and set a benchmark for several other cities in the Global South. Rapid urbanisation and an expanding technology base can catalyse an efficient and inclusive urban mobility ecosystem in India. However, it must simultaneously address issues of fragmented governance, infrastructural bottlenecks, and diverse socioeconomic needs.

Dhaval Desai *is a Senior Fellow and Vice President at ORF Mumbai.*

Nandan Dawda *is a Fellow with ORF's Urban Studies Programme.*

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Ensuring Coordinated Transport: Innovations in Institutional Integration for Multimodal Transport Systems

Towards Integrated Multimodal Transportation Systems in India

Poonam Sabikhi, C. Sathiya Narayanan, and Akila S.

Multimodal transport solutions are vital for socioeconomic development and access to employment, education, healthcare, and other essential services. Rapid growth in population, vehicle ownership, and economic activities have placed enormous pressure on the transport system, leading to traffic congestion, air pollution, and inadequate public transport infrastructure. For example, the 2023 TomTom Traffic Index ranked Indian cities Bengaluru and Pune among the world's most congested (1). Notably, this scenario is not limited to cities in the Global South—the index ranks London (UK), Toronto (Canada), Dublin (Ireland), and Milan (Italy) as the world's most congested cities, with an average traffic speed of 16 km/hour (2).

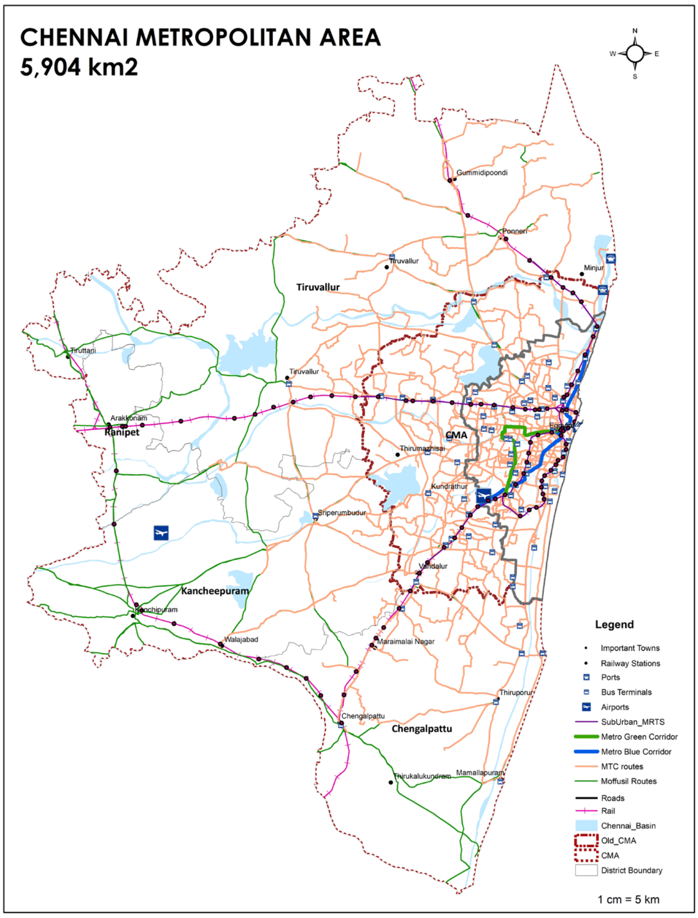
The increasing inadequacy of traditional approaches to managing urban transport calls for enhanced policy-level integration and a robust institutional framework for a sustainable multimodal mobility network.

This essay focuses on Chennai, the capital of India's Tamil Nadu state. Its experiences can guide other Indian cities in establishing integrated multimodal transport systems.

Chennai Metropolitan Area: Urban Transport Landscape

The Chennai Metropolitan Area (CMA), with a population of approximately 14 million, faces significant urban mobility challenges. The CMA (5,904 sq. km) spans five districts, including Chennai City and parts of Kanchipuram, Chengalpet, Tiruvallur, and Ranipet. Chennai, a port city, has a radial-ring road network and a rail-based system. Its mobility framework involves various agencies and government bodies responsible for transport planning, infrastructure development, and traffic management. The Metropolitan Transport Corporation operates bus services, while Chennai Metro Rail Limited manages a 54 km metro network, with another 118 km under construction. The Southern Railways operates suburban and mass rapid transit system trains, and various local and regional agencies, including the police and urban local bodies, are involved in infrastructure development, traffic management, and public transport

Figure 1: Map of Chennai Metropolitan Area's Public Transport System



Source: Chennai Unified Metropolitan Transport Authority (4).

regulation (3). The focus of these agencies is confined to their respective jurisdictions, resulting in limited multimodal coordination and integration. Such fragmentation of responsibilities has led to inefficiencies, duplication, and lack of accountability, calling for integrated transport planning across the physical, network planning, operational and institutional levels.

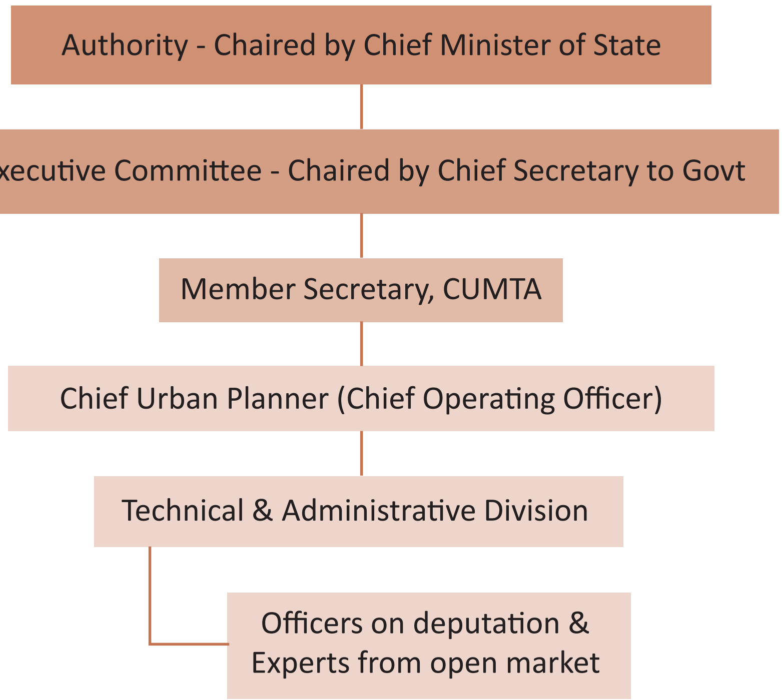
Despite diverse public transportation modes and intermediate paratransit catering to 28 percent of total trips, Chennai suffers from high congestion, longer trips, and long commute duration. The high dependency on private transport modes by 46.8 percent of daily commuters has also contributed to the city's deteriorating air quality (5). Economic growth and changing social preferences for private vehicle ownership explain the high preference for private transport modes. For the rest of the commuters who rely on public transport, the lack of intermodal connectivity hampers a seamless travel experience, forcing them to spend time and resources transferring between modes. Adequate multimodal transportation to provide a seamless and integrated travel experience thus requires integrated operations through a robust institutional mechanism, which remains limited in the CMA.

Role of the Chennai Unified Metropolitan Transport Authority

India's National Urban Transport Policy 2006 (6) recommended the establishment of a Unified Metropolitan Transport Authority (UMTA) in cities with more than a million population. Until recently, no centralised agency/authority was responsible for promoting multimodal integration involving all relevant stakeholders within the CMA. The Chennai Unified Metropolitan Transport Authority (CUMTA) was established in 2010 through a legislative act to oversee, coordinate, promote, and monitor various traffic and transportation measures, including public mass transport systems and their operations (7). The Tamil Nadu government operationalised CUMTA in 2022 (8). It is the only authority in India with an operations document backed by a government order clearly defining CUMTA's staffing structure and its broad role and responsibilities. CUMTA focuses on integrating all public mass passenger transport modes, including routing and scheduling, operating feeder services, and providing standard ticketing options to facilitate seamless commuting.

CUMTA has a two-tiered structure, with the authority supported by an executive committee. The committee is responsible for the decisions related to implementation and operations, whereas the authority is responsible for critical policy decisions regarding urban transport in the CMA. As displayed in Figure 1, CUMTA's effectiveness is mainly due to its empowered organisational structure and the composition of its executive committee.

Figure 2: CUMTA's Empowered Institutional Set-Up and Organisational Structure



Source: Compiled by the authors (9).

CUMTA's authority and executive structure include the participation of all the departments working in the region's urban mobility domain to integrate the following diverse functions of urban transport planning and management:

- Strategic Planning: Develop long-term transport strategies and policies
- Project Preparation and Approval: Oversee the development and approval of transport projects
- Project Implementation: Manage the execution of transport projects
- Operations and Management: Ensure the efficient operation of transport systems
- Regulation: Establish and enforce rules for transport services
- Funding: Manage and allocate financial resources for transport projects
- Research, Studies, and Awareness: Conduct research, analyse data, and promote public awareness

Key Functions

CUMTA is crucial to addressing the gaps in the CMA's urban transport system. CUMTA is preparing comprehensive mobility and city logistic plans to develop strategies to integrate all modes of transport and align with the CMA's broader urban development goals. Beyond physical integration, CUMTA is focusing on creating an integrated ticketing app that will allow users to use different modes of public transport seamlessly. It is also in the planning stage of building a unified data platform to facilitate better coordination among stakeholders to plan transport services and improve service delivery.

To develop robust institutional mechanisms to facilitate coordination and address operational and implementation challenges collectively, CUMTA has established various subcommittees/committees, such as those on multimodal integration, road safety and non-motorised transport, digital Chennai, urban mobility resilience, and city logistics coordination.

With representation from all relevant stakeholders, CUMTA has made significant advancements in the last two years in solving complex issues related to multimodal integration, especially in improving physical and operational integration across the transport network and various modes.

Empowering CUMTA

Establishing CUMTA as a central coordinating body through a legislative Act is a welcome first step toward addressing the institutional challenges. However, challenges persist, and it is necessary to further empower CUMTA and its subcommittees for effective decision-making, better coordination, and for formulating and enforcing regulations and standards across all transport modes. The following measures can be considered to strengthen CUMTA:

- It must be given the necessary powers and mandate to carry out its crucial functions in formulating urban transport policy and developing regional mobility plans.

- It must play an overarching role in collecting and managing data from various transport authorities, providing crucial inputs for integrating transport services and minimising overlaps.

- It must have statutory backing and the desired level of expertise to function independently of other agencies.

- It must be empowered to fund and manage all aspects of urban transport, including comprehensive, multi-year business plans, funding outlays and the need for borrowings.
- It must be given financial autonomy. Having only a regulatory mandate without comprehensive financial autonomy will confine its effectiveness to being a coordinating and monitoring agency.

Learnings from Global UMTA Examples

While CUMTA has set an example for other Indian cities, incorporating learnings from the global metropolitan transport governance in London (UK), Singapore, and South Korea can also be helpful. Table 1 presents a comprehensive review of Transport for London, Singapore's Land Transport Authority, and South Korea's Metropolitan Transport Commission across several parameters.

Table 1: Review of UMTAs in London, Singapore, and South Korea

Organisation	Key Roles & Responsibilities	Institutional Arrangement	Funding Responsibilities
Transport for London (TfL)	• Implement London transport strategy • Manage transport services: operate Underground, manage suburban rail, light rail, and trams; manage buses and roads; promote cycling and walking • Administer the London congestion charge	• A statutory authority reporting to the Greater London Authority and the Mayor of Greater London • TfL is organised into three main directorates, each responsible for a mode of transport: London Underground, London Rail, Surface Transport	• All funding for various transport projects in London is routed through TfL • TfL is financed by revenue from ticket sales, government grants, and loans borrowed from multiple institutions • Its financial powers have been strengthened through amendments to the TfL Acts of 2008 and 2016, which gave further powers to, among others, acquire land, fix and recover road user charges, and street management

Organisation	Key Roles & Responsibilities	Institutional Arrangement	Funding Responsibilities
Land Transport Authority (LTA), Singapore	• Formulate land transport policies • Plan the central bus network • Plan, design, construct, manage, and maintain road infrastructure and rail transport • Plan, design and develop active mobility (walking/ cycling) • Regulate transport services • Regulate private transport ownership and usage	• A statutory authority reporting to the minister of transport • Services are broadly divided into two departments: infrastructure and development; and policy planning and corporate services	• LTA owns all operating assets and controls investment decisions • LTA conducts the planning and feasibility of all urban transport projects and seeks budget approval from the finance ministry
Metropolitan Transport Commission (MTC), South Korea	• Develop metropolitan transport plans to construct and improve transport facilities systematically • Manage the operation of metropolitan transport improvement measures • Establish plans to manage traffic issues related to large-scale development projects, including new towns. • Manage bus route adjustments, bus licensing, and bus companies	• MTC is headed by a chairperson (vice-minister level) • The office manages the policy division, bus division, road division, and economy (fare) division	• It is responsible for funding and the coordination of transit plans • It oversees matters related to finance and planning

Source: Compiled by the authors from CUMTA's international knowledge-sharing sessions.

Streamlining UMTAs Across Indian Cities

Evaluating the pros and cons of CUMTA and learning from Singapore, London, and South Korea can help UMTAs in Indian cities achieve robust institutional and governance integration (10):

- UMTAs must be empowered with financial powers to review and allocate funding for urban transport projects and ensure sustained funding and phasing of urban transport projects.
- They should be responsible for developing and implementing guidelines for integrating different transport modes, with regulatory powers to oversee and coordinate schedules, fares and routes across all public transport modes.
- They should be backed by robust operating procedures and time-bound action plans.
- UMTAs must develop a unified data platform and data-sharing mechanisms to enable real-time communication and data-driven decision-making, improve traffic management, and prepare public transport schedules.
- UMTA subcommittees must be empowered with powers and responsibilities-sharing for all relevant transport projects and initiatives.
- Beyond physical integration, UMTAs must focus on operational aspects such as route rationalisation, timetable coordination, and fare integration.
- UMTAs must be mandated to identify and address gaps in multimodal integration, direct relevant stakeholders to conduct periodic audits, and make recommendations based on the findings.
- The government must invest in capacity-building and training for planners, policymakers, and operators, and emphasise the importance of UMTAs in coordinated planning and integration.
- UMTAs must be given a clear mandate to establish performance metrics and regularly monitor the performance of urban transport systems.

Conclusion

CUMTA marks a significant step towards addressing the long-standing fragmentation in Chennai's transportation planning and management. However, its further empowerment, particularly in financial autonomy, regulatory powers, and data-sharing mechanisms, will be crucial in overcoming operational challenges. Learnings from international examples, such as London, Singapore, and South Korea, offer valuable insights into how similar UMTAs in India can function effectively.

The integration of institutional and governance frameworks is essential for the success of a seamless multimodal transportation system in urban regions. To fully realise the benefits of multimodal transport systems, UMTAs across Indian cities must be adequately empowered and resourced through statutory backing, and must expand their focus from physical integration to operational and information and fare integration. This includes making independent decisions, fostering inter-agency coordination, and ensuring data-driven planning and implementation. By doing so, cities can provide more sustainable, efficient, and accessible urban mobility, ultimately enhancing the quality of life for their residents.

Poonam Sabikhi *is a Senior Transport Specialist at the Chennai Unified Metropolitan Transport Authority.*

C. Sathiya Narayanan *is an Assistant Executive Engineer at the Chennai Unified Metropolitan Transport Authority.*

Akila S*. is an Environmental Specialist at the Chennai Unified Metropolitan Transport Authority.*

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The Significance of Parking in Integrated Multimodal Public Transport: A Case Study of Mumbai

Prachi Merchant and Dhaval Desai

Metropolitan cities with high population densities continue to grow due to significant job opportunities and their ability to maintain and produce efficient businesses. At the same time, rapid urbanisation and the imperative to mitigate environmental impacts have placed multimodal transport systems at the forefront of urban planning. However, inadequate and inefficient public infrastructure, traffic congestion, and increasing pollution have compromised the quality of urban life, especially in the emerging economies of the Global South.

Though transport planners often ignore parking when creating urban mobility plans, it plays a critical role in bridging the gap between various modes of transport. Strategically located and efficiently managed parking facilities support seamless transitions between private vehicles and public transit—including intermediate public transport modes such as autorickshaws and taxis, cycling, and walking—fostering sustainable and efficient mobility.

Several cities worldwide have set benchmarks in integrating parking into multimodal transport systems. For example, parking regulations in Tokyo, Japan's capital city, mandate proof-of-parking certification for all private car owners. They also prioritise developing parking facilities near transit facilities, significantly reducing private vehicle usage within urban areas (1).

Similarly, Denmark's Copenhagen has implemented policies integrating parking with its well-developed cycling infrastructure, making it easier for commuters to combine car and bike use. Imposing a multifold increase in its parking fees, the city's budget for 2024-25 introduced a parking policy to ensure that cars "take up less space in the streets of Copenhagen to create more room for new green areas and more urban life" (2).

Several US and European cities have successfully deployed park-and-ride systems to allow commuters from the city peripheries to park their vehicles and switch to public transit for the remainder of their journey, reducing inner-city traffic congestion and emissions (3). Furthermore, these cities use pricing incentives to make park-and-ride systems attractive compared to inner-city parking.

Cities like San Francisco (US) have introduced the SFpark programme, a tech-based smart parking solution using dynamic pricing and real-time monitoring to manage parking demand efficiently (4). Similarly, Singapore's electronic road pricing system integrates parking with urban traffic management, ensuring optimal space utilisation and discouraging excessive reliance on private vehicles (5).

In Amsterdam (Netherlands), visitors can park their cars at a Park+Ride site at a favourable rate and continue their journeys to the city centre by public transport. Amsterdam also focuses on multimodal mobility hubs, offering integrated parking, cycling, and public transport interchange facilities (6).

Conversely, Global South cities, particularly in India, face various challenges in emulating such best practices, including land availability, cultural attitudes toward car ownership, and financial constraints. This essay evaluates Mumbai's attempts to streamline parking as an essential component of its transport planning, especially the proposed establishment of the Mumbai Parking Authority (MPA) under the Brihanmumbai Municipal Corporation (BMC) as an empowered participatory body. It identifies actionable solutions that can help cities foster sustainable and efficient transport.

Traffic Scenario in Mumbai

In 2023, Mumbai registered 4.47 million new vehicles, up from 1.86 million in 2011 and 3.86 million in 2020 (7). Figure 1 shows the decadal growth in mode-wise vehicular registration. With the city's road network remaining about the same, the substantial increase in vehicles has worsened traffic congestion and pollution. Mumbai is the 54th most congested city globally and fourth-most congested in India, with an average driving time of more than 21 minutes/10 km (8).

Figure 1: Mumbai Transport Scenario and Vehicular Registration Trend

Mumbai has the highest vehicle density of 1,900 vehicles/km, nearly thrice than Delhi's.						
Registration Year	**2-wheelers**	**3-wheelers**	**4-wheelers**	**Buses**	**Other vehicles**	**Total**
2011	1,044,000	108,000	586,000	120,000	121,000	1,979,000
2020	2,290,000	221,000	1,239,000	19,000	93,000	3,862,000
2023	2,653,000	235,000	1,442,000	21,000	125,000	4,476,000

Source: Compiled by the authors from the Ministry of Road Transport and Highways' Vahan Dashboard and Brihanmumbai Municipal Corporation data (9) (10).

The city's 1,950 km road length is used by private vehicles, public transport buses, intermediate transport modes like autorickshaws and taxis, and for hawking. Additionally, pedestrians are forced to use the congested roads for walking since street vendors often encroach upon footpaths and pavements. Haphazard on-road parking has also substantially encroached on the already inadequate pedestrian space, adding to the road congestion.

Mumbai's public transport network consists of the 427.5 km-long suburban railway covering the Mumbai Metropolitan Region, catering to 7.5 million passengers daily (11). The metro rail transit, with three operational lines and one partially operational line covering 59.19 km (12), carries approximately 700,000 passengers daily. The city's sole monorail line covers 19.54 km, with a daily ridership of 18,000 passengers (13). The bus transit operated by the Brihanmumbai Electricity Supply and Transport (BEST), a BMC undertaking, is a citywide service with 3,182 operational buses (including BEST-owned and ones procured on a wet lease) carrying three million passengers (14). Table 1 summarises the efforts taken up by various organisations towards the provision of public transport in Mumbai.

Table 1: Details of Public Transport Modes in Mumbai

Mode	Network Length & capacity	No. of Lines	Daily Ridership
Suburban Railway (15)	• Length: 427.5 km • Capacity of a 12-car train: 3,600 (carries over 7,000 during peak hours)	• 7 (Western, Central, Harbour, Trans-harbour, Vasai-Roha, Neral-Matheran and Panvel Karjat)	7.5 million

Mode	Network Length & capacity	No. of Lines	Daily Ridership
Mumbai Metro (16)	• Operational: 59.19 km • Under construction: 143.65 km • Proposed: 115.o km • Total: 340.66 km	• Operational: 3 • Partially operational: 1 • Under construction: 8 • Approved: 1 • Proposed: 4	~7,00,000
Monorail (17)	• 19.54 km (operational) • Capacity: 100,000 passengers/day	• 1	18,000
BEST Buses (18)	• Buses in operation: 3,182	--	33 lakh (overall), ~1,000 commuters per bus

Source: Compiled by the authors.

Despite such a robust multimodal network, having multiple agencies responsible for each public transport mode has resulted in fractured institutional management. For example, the BMC plans and maintains the city's road network (19), while the Mumbai Metropolitan Regional Development Authority (MMRDA) operates the monorail and metro rail services (20). BEST operates the city buses (21), while the Mumbai Bus Malak Sanghatana organises private bus operators, including travel agencies managing school buses, company buses, intercity buses and tourist buses (22). Though suburban train services provide the maximum public transport service across the Mumbai Metropolitan Region, they are governed by the Central and Western Railway zones of Indian Railways, which operate independently. With unique mandates and priorities, these organisations compete with rather than complement each other.

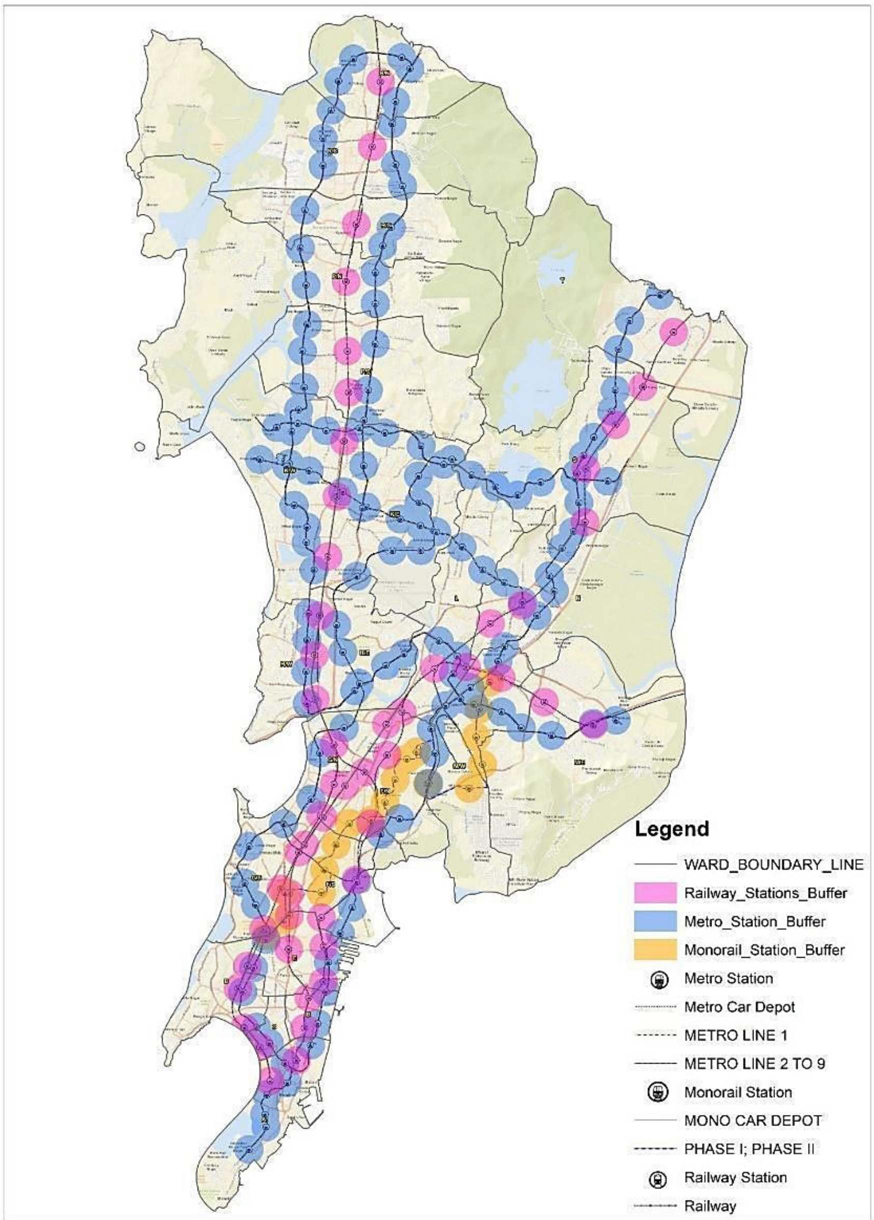
Besides the high share of public transportation, there are 1.76 million two-wheelers, 433,000 cars, and over 80,000 tractors (23).

With no restriction on buying vehicles, no assessment of available parking places, and virtually free-for-all parking anywhere, the traffic congestion has worsened, resulting in long traffic snarls, restricted mobility, decreased work efficiency, and compromised quality of life. Evaluating the public transport network, intermodal organisation, and institutional set-up gives a clearer understanding of the factors leading to high traffic congestion.

Mumbai's Intermodal Transport Organisation

Figure 2 shows the coverage of the suburban railway, the existing and proposed metro rail lines, and the monorail network. It indicates a buffer of 500 metres around the respective stations to understand the need for last-mile connectivity and their interrelation (24). The map also shows how the existing linkages mainly provide linear, north-south transport corridors with few east-west connections. Though future projects are likely to address such public transportation gaps, the city will still be significantly dependent on feeder services, intermediate public transport, and other modes of transport through robust physical and institutional integration.

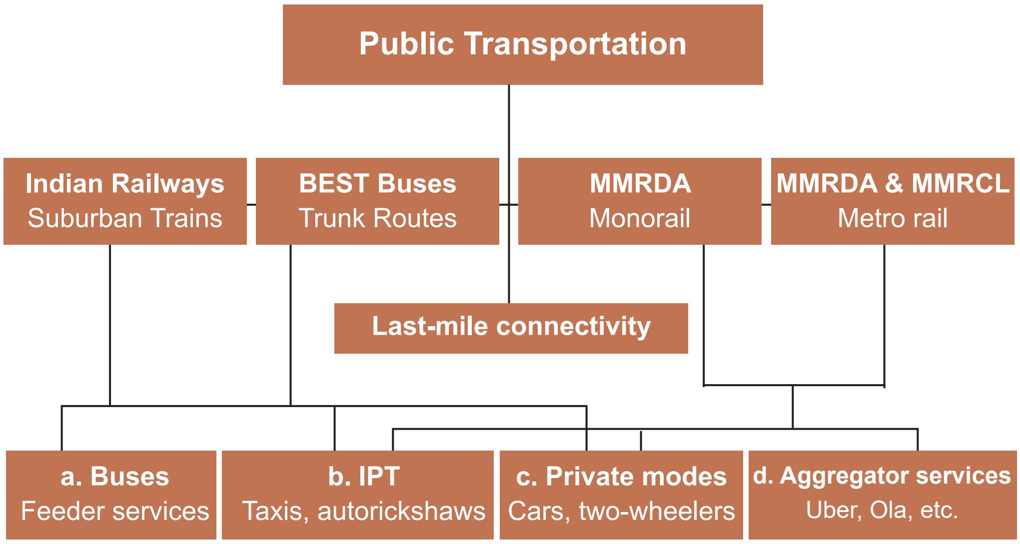
Figure 2: Metro, Monorail, and Suburban Railway Network with Buffer Zones



Source: Extracted from Maharashtra's Bike Taxi Committee Report, 2022 (25).

Figure 3 charts the public transportation modes and the preferred feeder and transport modes for last-mile connectivity. The lack of physical space to plan for an integrated solution by creating a multimodal hub has exacerbated Mumbai's mobility challenges. The existence of multiple institutions, each working with a unique mandate, adds to the complexities of planning such multimodal hubs where people can switch transport modes to complete their journeys seamlessly.

Figure 3: Institutions of Public Transport and Last-Mile Connectivity Modes



Source: Authors' own.

Multimodal transport hubs with seamless physical modal integration combine short and intermediate public transport with train, metro, monorail and bus services, benefiting commuters with convenient pick-up and drop-off areas and first- and last-mile connectivity. They also ensure park-and-ride facilities for private vehicles and non-motorised transport. Integrated mobility hubs reduce ground transportation emissions and enable people to connect to cleaner transportation modes in a safe, comfortable, and accessible environment. Several cities in the West, including Dresden in Germany (26), Oahu and New York City in the US, Rotterdam and Arnhem in the Netherlands, and Västerås in Sweden, have established mobility hubs as a strategy to reduce ground transport emissions and facilitate more effective land use (27).

Institutional Integration of Parking with Public Transportation

Adequate parking with proper space allocation is integral to multimodal public transport planning. The following three examples highlight the vertical and lateral need for integration for a seamless travel experience and why some efforts have failed or succeeded.

Parking for Ease of Access to Buses: Public Parking by BEST

The MPA (28), proposed by the BMC's Roads and Traffic Department, has recommended the Mumbai Parking Pool, which opens up government, commercial and private premises for public parking. Such a shared parking pool can be created on a single technology platform without infringing upon the ownership or revenue-earning rights of the respective landowners. BEST was the first agency to join the parking pool by allowing day parking from 8:00 am to 8:00 pm at its 24 bus depots when the entire bus fleet is in operation. It also allotted open spaces at 28 bus stations for day-and-night parking, sharing all parking data with the BMC's technology platform (29). The parking scheme, introduced in June 2015, received a poor response because of the high parking fees. However, the scheme saw an uptake, opening a new revenue stream for BEST, following a reduction in parking fees, as recommended in the proposed MPA's report (30). The BEST earned a revenue of INR 500,000 (US$6,000) from daily parking and monthly parking passes in the first 15 days following the reduction of parking fees in July 2017 (31). This mechanism provided new public parking spaces in prime residential and commercial areas. It also reduced haphazard on-road parking and promoted commuter convenience by introducing the park-and-ride concept at bus depots on critical BEST trunk routes.

Though parking is a BMC function, the municipal corporation's robust institutional coordination with BEST, over which it has operational and governance control, allowed the seamless use of its depots for parking.

Parking Provision to Access Suburban Railway

The Western and Central Railways, the two zones of the Indian Railways operating Mumbai's suburban railway system, offer a well-established system of last-mile connectivity through pick-up and drop-off facilities and parking on their lands adjoining the stations/railway tracks. The provision of parking right outside the railway stations for four-wheelers and two-wheelers allows commuters easy transfers between private and public transport modes. For example, the Central Railway has 62 pay-and-park facilities on its suburban system catering to the eastern suburbs from Chhatrapati Shivaji Maharaj Terminus in the south to Panvel on the Harbour Line and Ambernath-Badlapur on the far northern end of the suburban rail network (32). Similarly, the Western Railway also offers parking outside its suburban railway stations from Churchgate in the south to Dahanu in the far north.

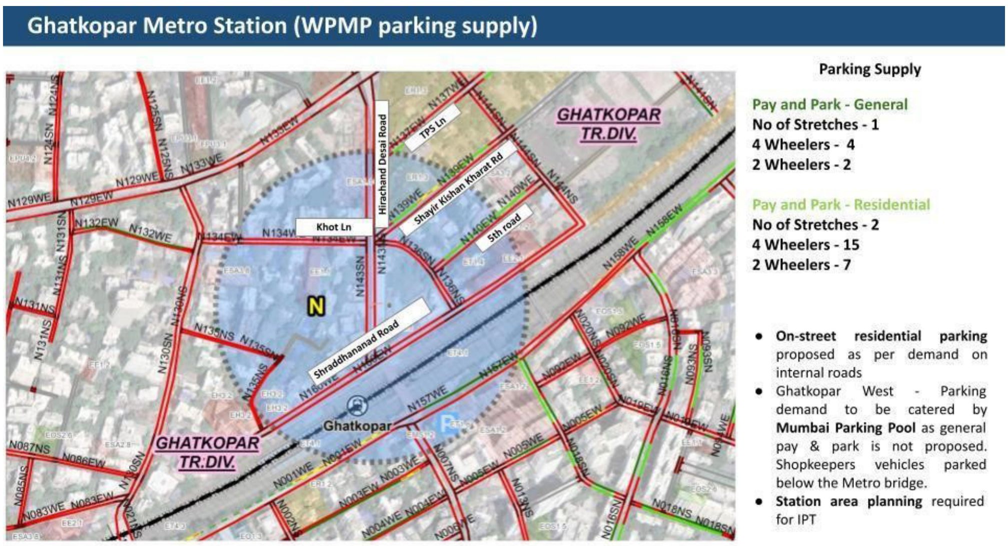
While the sizeable lands available with the Western and Central Railways facilitate parking and multimodal last-mile connectivity, lands owned by the BMC just beyond the jurisdiction of the railways are not part of any systematic planning for integrating parking into its transport strategy.

Parking Provision to Access Metro Rail

The MMRDA and the Mumbai Metro Rail Corporation Limited (MMRCL) follow the Indian government's metro guidelines that provide improved last-mile connectivity through feeder bus services, e-rickshaws, rentable smart cycles, e-scooters, and partnerships with cab aggregators (33).

However, as the policy prescribes, metro stations disallow parking within a 200-metre radius, hindering last-mile connectivity or park-and-ride facilities for private vehicles. A physical inspection of the Ghatkopar metro station on Mumbai Metro Line 1 reveals that though the BMC's two outsourced on-street parking spaces are packed to capacity for over eight hours on weekdays, they are unable to fulfil the ever-increasing park-and-ride demand (34). Figure 4 shows the map of Ghatkopar station area.

Figure 4: Parking Facilities Proposed by MPA



Source: Extracted from the MPA's report (35).

Integration Proposed by the Mumbai Parking Authority

The MPA recognises the disjointed institutional mechanism that leads to failed parking management at two levels: (i) within the parking function and (ii) among various organisations.

The first level of integration within the parking function is addressed by understanding the purpose, various laws and Acts that govern parking, and the roles of the multiple agencies involved. The BMC Act specifies the provision of on- and off-street planning and management of parking in Mumbai (36). However, the state's Motor Vehicle Act vests parking regulation/enforcement with the Mumbai Traffic Police (37). On the other hand, the Road Transport Offices under the state's transport department manage the vehicle registrations, levy and recovery of taxes, and formulation and implementation of various traffic and transport policies (38). Multiple agencies manage traffic signage, which is often contradictory in messaging and marking. Table 2 indicates the existing roles of various organisations for parking.

Table 2: Current Institutional Set-Up for Parking Functions

Agency/Department	Functions
Transport Department, Government of Maharashtra	Policy
Regional Transport Office	Vehicle registrations, taxes
Brihanmumbai Municipal Corporation	Planning, management and monitoring
Brihanmumbai Municipal Corporation, Mumbai Transport Police, Mumbai Metropolitan Region Transport Authority, Regional Transport Office	Signage and Markings

Source: Authors' analysis (39).

The MPA has proposed bringing multiple organisational functions under the BMC by amending the BMC Act to smoothly carry out all roles under its jurisdiction, as indicated in Figure 5.

Figure 5: Functions of the Proposed MPA

Source: Extracted from the MPA's report (40).

MPA has proposed parking integration under a unified matrix. It recommends a multidisciplinary, participatory model, with municipal officers, civil society members, and expert consultants, headed by the Additional Municipal Commissioner or the Joint Commissioner of the Mumbai Traffic Police. The Deputy Municipal Commissioner (Assessment) and the Deputy Municipal Commissioner (Technical), as the CEO, will manage the executive roles. It will have an 11-member committee of nominated members representing the MMRDA, MMRCL, BEST, Regional Transport Office, Maharashtra State Road Development Corporation, Mumbai Port Trust, the state's Public Works Department, Western and Central Railways, and the Chhatrapati Shivaji International Airport to guide and coordinate its various functions.

The MPA's executive team will be divided into:

- Secretariat for communication, planning, geographic information system, IT, legal, and administration.
- Engineering for tendering on- and off-street parking lots, signages, and other infrastructure.
- Decentralised ward-level implementation teams comprised of ward officers, transport planners, and a communications team to monitor and enforce parking rules through parking wardens.

The MPA has also recommended organisational integration by combining the IT systems of all departments/agencies to create compatible datasets to facilitate information dissemination about the Mumbai Parking Pool through web- and mobile-based apps. This will cut down parking discovery time and provide safe parking, reducing haphazard and on-street parking, eventually leading to increased efficiency and a better quality of life. Citizens can quickly discover, pre-book, and pay for a parking space.

Conclusion

The creation of the London Mayoralty accelerated transport policy integration, setting an example of how the devolution of powers can improve existing networks. Establishing a single institutional framework under Transport for London enabled integrated ticketing, hopper fares, service frequency, and the daily fare cap, transforming London's transport network (41).

The Philadelphia Parking Authority (PPA) effectively manages and provides convenient on- and off-street parking in 'Center City' garages, surface lots throughout the city, and airport parking, contributing to the city's economic vitality. The PPA's mission also includes the operation of the automated red-light and speed camera enforcement system, regulating taxicabs, limousines, transportation network companies, and other transportation-related activities (42).

The Calgary Parking Authority's holistic approach to managing and administering parking resources through dedicated parking policies focusing on the environment and implementing sustainable business practices in parking operations has contributed to vibrant, safe and accessible communities. The revenue generated from parking goes back to the City of Calgary to enhance quality of life (43).

Worldwide, the successful integration of parking with transport strategies and plans has a cohesive institutional and organisational set-up, with empowered mandates to provide last-mile connectivity and land availability.

Since the lack of statutory recognition and empowerment has restricted the establishment of the much-hyped unified metropolitan transport authorities to provide integrated multimodal transport in Indian cities (44), the proposed MPA could be an ideal model to address sector- and function-specific integration of parking into India's urban transport strategies. Assured and digitally-aided parking will increase efficiencies, reduce congestion and vehicular emissions, and contribute to economic growth.

Prachi Merchant *is a senior urban planner, and a former team lead for setting up the Mumbai Parking Authority within the Brihanmumbai Municipal Corporation.*

Dhaval Desai *is a Senior Fellow and Vice President at ORF Mumbai.*

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Rethinking Governance to Accelerate the Transformation of Urban Mobility

Roshan Toshniwal

In the past two decades, Indian cities have witnessed unprecedented growth in the number of people and motor vehicles, causing severe strain on their limited infrastructure. Investments in urban road and public transport infrastructure have been unable to keep pace with vehicular growth trends, mainly because of the lack of coordination between stakeholders and fragmented urban transport governance (1). This widening gap has increased traffic incidents and congestion, deteriorated urban air quality, and severely affected the quality of life.

The National Urban Transport Policy (NUTP) 2006 recommended setting up unified metropolitan transport authorities (UMTAs) to facilitate seamless planning and cooperation between mobility stakeholders in urban areas (2). The key functions of the UMTAs included preparing comprehensive mobility plans, establishing transport investment programmes, managing urban transport funds (UTFs), and coordinating between various transport service providers, regulators and other stakeholders.

Building Urban Mobility Governance: Defining the Role of UMTAs

UMTAs in million-plus cities were established under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM), a reform-linked infrastructure investment programme of the erstwhile Ministry of Urban Development (3). Of the 35 JNNURM cities, only 15 initiated the formation of a UMTA during the JNNURM period (2005-2011). While Rajasthan and Karnataka proposed state-level UMTAs in 2007, Andhra Pradesh, Jharkhand, and Odisha proposed UMTAs for a group of cities in 2009 (4). Several governments created UMTAs only to access funds during JNNURM's tenure without assigning them any decision-making powers. Consequently, many states and cities failed to move beyond the 'intent' stage, and UMTAs continue to languish as bills are still to be enacted in the state legislatures. At the same time, several ceased to function after the mission period. For example, despite the state introducing a bill in the state legislature in 2016, the Rajasthan government has yet to formalise a UMTA in Jaipur (5).

The 2017 Metro Rail Policy rekindled the formation and operationalisation of UMTAs for cities to secure central government assistance for metro rail projects (6). Chennai notified the UMTA Rules in 2019 and amended them in 2021 to expand its metro network (7), while Kerala legislated a state Act for Thiruvananthapuram, Kochi, and Kozhikode in 2019 (8). Similarly, Jammu and Srinagar sanctioned UMTAs in their respective metropolitan areas in 2021 (9).

Though these strategic reforms and policies have laid the groundwork to create UMTAs in cities to seek central funds to build and expand their metro rail networks, they have remained largely ineffective in paving the way for holistic, multimodal urban mobility solutions. For example, since its establishment in 2007, Karnataka's Directorate of Urban Land and Transport has had limited budgets to coordinate land use planning and the implementation of urban transport initiatives (10). It remains entirely dependent on implementing agencies to prioritise project investments. The Bengaluru Metropolitan Land Transport Authority, which received a statutory status in January 2023 (11), is yet to commence operations, while the Kochi Metropolitan Transport Authority is in a state of despair four years since its inception due to a lack of funds (12), leadership, and political will (13). Despite these measures, only eight cities with operational metros have initiated UMTAs, while four others are in process (14). Even the most well-functioning UMTA in Chennai, chaired by the chief minister and the transport minister, has limited powers to intervene and promptly enforce plans. This scenario indicates gaps in the conceptualisation and functioning of UMTAs, diluting them as mere advisory bodies rather than empowered authorities.

Consequently, UMTAs—established to streamline the functioning of different agencies involved in urban transportation and facilitate multimodal integration, fare structures, research, studies, and awareness by framing and implementing comprehensive policies—remain functionally impaired, paralysing their ability to solve urban mobility challenges in urban India. The absence of regulatory and budgetary powers has also diluted their purpose (15). The enforcement agencies, such as municipal corporations, traffic police, public transport service providers, and regional transport offices, function in silos. They are neither obligated nor incentivised to implement the policies and plans framed by UMTAs.

Table 1: Existing UMTAs in India

State	Cities	Established under	Date
Jharkhand	Ranchi, Jamshedpur, Dhanbad	NUTP 2006 (16)	--
Telangana (erstwhile Andhra Pradesh)	Hyderabad	Government order (17)	2008
Maharashtra	Mumbai	Government resolution (18)	February 2008
Odisha	Bhubaneswar, Puri	NUTP 2006 (19)	November, 2009
Tamil Nadu	Chennai	Government Order (20)	January 2019
Maharashtra	Pune	Government Order (21)	June 2019
Kerala	Thiruvananthapuram, Kozhikode	The Kerala Metropolitan Transport Authority Act (22)	2019
Kerala	Kochi	Kochi Metropolitan Transport Authority (KMTA) (23)	November 2020
Jammu & Kashmir	Jammu & Srinagar	Government order (24)	February 2021
Karnataka	Bengaluru	The Bengaluru Metropolitan Land Transport Authority Act (25)	2022

Source: Compiled by the author from state government notifications.

JNNURM also proposed the constitution of UTFs to sustain targeted investments in urban mobility and enable the effective functioning of UMTAs (26). The UTFs in Karnataka, Punjab, and Rajasthan have recurring sources of revenue through a cess levied on the sale of fuel for vehicles in urban areas, the registration of new and old vehicles, unique registration numbers, and a cess on the stamp duty of property. In addition, some state UTFs also receive donations from corporate social responsibility, share from parking fees, betterment levies, and so on (27). While these funds are adequate for UMTAs to commence operations, they are grossly inadequate for initiating capital-intensive transport projects.

The Road Ahead: Learnings from International Best Practices

An integrated transport authority structure like Transport for London (TfL) (28), Singapore's Land Transport Authority (29), and Hong Kong's Transport Department (30) will ensure better empowerment and accountability of UMTAs. In 1998, the Seoul Metropolitan Transport Government integrated the management of transportation, disasters, and security checks under the Seoul Transport Operation and Information Service (TOPIS). It uses cutting-edge technology to monitor traffic, public transportation, and surveillance, and provides prompt response in case of any untoward incident or disaster. The seamless data flow from TOPIS enabled policy enforcement and planning interventions with improved coordination between operators and relevant administrative bodies (31).

UMTAs in Indian cities can replicate the success of TOPIS by fostering seamless data sharing between enforcement agencies. The Smart Cities Mission (SCM) initiated investments in digital infrastructure, the Internet of Things, data storage, and analytical capabilities (32). While 'Chennai Smart City', a special purpose vehicle established under SCM, invested in an integrated command and control centre (33) to improve services, the Hyderabad traffic police improved throughput using an intelligent traffic management system (34). UMTAs could leverage and assimilate these investments in processing big data repositories and further enhance digital infrastructure to curate solutions and enable efficient planning and policymaking. A central repository and ownership of data sources will increase transparency, reduce the duplication of resources, and improve coordination and cooperation across stakeholders.

Mobile data consumption in India soared to 24 GB per capita per month in 2023, growing at a compound annual growth rate of 21.1 percent over the previous five years (35). The use of affordable mobile internet has enabled smart mobility services and provided impetus to digital commerce, especially post-COVID-19. OMI Mobility Institute's 'Ease of Moving Index 2022' indicates that 97.95 percent of the respondents use smartphones in cities. Almost everyone uses an application to receive goods, especially food and hyperlocal services, explaining the changing consumption trends (36). While platform aggregators have been early movers, the government-backed Open Network for Digital Commerce (ONDC) can provide access to data on consumption patterns, logistics, and supply chain systems in different locations of the cities. ONDC uses an open-source framework, and data transfer is backed by a robust blockchain; however, only some vendors have opened their services' data (37). In addition to GPS data from public transport, data from ONDC can enable UMTAs to tread the existing data sources, plug the missing links, and ideate a joint solution to build the road ahead.

Despite amplifying traffic-related communication in real-time, all mega cities in India are experiencing severe congestion with considerably increased commute times. The incessant vehicular traffic during peak periods is attributed to the unchecked growth in private vehicle ownership, limited road infrastructure, and inadequate public and shared mobility capacity. Granular traffic data will enable UMTAs to analyse the infrastructure gaps and prioritise investments. UMTAs must curate planning and policy solutions by collating all the data and information on mobility.

London's TfL has unlocked annual economic benefits and savings of up to USD162.5 million annually by opening its transit data (38). It curated hackathons using open data that cost USD1.25 million annually, enabling more than 600 applications, with over 42 percent of commuters in London using these to improve their travel experience. The city has benefited immensely from saved commute time, reduced congestion and pollution, new employment opportunities, and greater innovation (39).

Reforms to operationalise UMTAs are essential to improve the performance of Indian cities as mobility sets the pace for their future. Investments in technology, from artificial intelligence to big data analytics, will enable UMTAs to stay ahead of the curve and plan to mitigate untoward risks due to climate change. As such, the authority will manifest itself as a harbinger of technological advancement in data processing and management so all the relevant stakeholders and agencies can pivot around its capabilities.

***Roshan Toshniwal** is Head of the Centre for Future Mobility at the OMI Foundation Trust.*

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Policy Approaches to Integrate Micromobility with Urban Transport Systems

Damodar Pujari And Dhaval Desai

Micromobility refers to small, lightweight vehicles typically designed for short-distance travel, often within urban areas. Given their limited size, speed, and range, these vehicles are ideal for providing 'first-mile' and 'last-mile' connectivity (1) in urban settings. The Organisation for Economic Co-operation and Development's International Transport Forum defines micromobility as using small, low-speed vehicles, typically under 500 kg, for personal travel within urban environments. This category includes bicycles, electric scooters, and bicycles, as well as other compact, human-powered or electric-powered vehicles used for short-distance travel (2). An increasing focus on micromobility has pushed the adoption of automated, connected, electric, and shared (ACES) mobility alternatives in urban areas.

The unprecedented growth of India's urban population has placed enormous stress on traditional transportation systems. India's urban population is estimated to reach 600 million by 2030 (3). With increasing disposable incomes, more urban Indians will likely use personal vehicles, especially four-wheelers, which also hold tremendous aspirational value. At the same time, the growing reliance on personal vehicles, inefficient public transportation, rising fuel costs, and increased climate awareness will increase the demand for efficient and environment-friendly alternative transport modes.

India's shared mobility market is expected to grow at a compounded annual growth rate of 12.5 percent by 2030 (4), driven by urbanisation, changing consumer preferences towards mobility solutions, electric vehicle (EV) penetration, and other factors. Therefore, encouraging the adoption of shared mobility and integrating this into the country's urban transport ecosystem could significantly reduce vehicle ownership in India, thus curbing the environmental impact and easing urban congestion.

Given the demand for swifter last-mile connectivity, central, state, and local governments must strive to identify optimum last-mile connectivity models. Several urban local bodies (ULBs), such as the Navi Mumbai Municipal Corporation, Dwarka, and Ahmedabad, and parastatal agencies, such as the City and Industrial Development Corporation of Maharashtra and the Mumbai Metropolitan Region Development Authority, have floated tenders inviting private players to introduce such services for their citizens (5). Micromobility has thus become an essential area of urban transport policies, focusing on personalised mobility solutions for crucial last-mile connectivity.

In this scenario, the micromobility sector must focus on three critical issues:

- Agenda setting,
- Policy instruments and physical integration, and
- Policy architecture to ease last-mile connectivity.

This essay evaluates each issue, presents global best practices, comprehensively reviews current policy architecture, and recommends future policy directions.

International Best Practices: Macro Planning Focus on Micromobility

European cities have established that a sustained policy focus and targeted investments can mainstream micromobility into the city's transport ecosystem.

Copenhagen, Denmark: Since the beginning of the twenty-first century, Copenhagen has taken concerted steps to make cycling an integral part of its town and infrastructure planning, while periodically upgrading its cycle strategies and policies. From the Copenhagen Cycle Policy (2002-2012), the Copenhagen Transport and Environment Plan (2004), the Cycle Priority Plan (2006-2016), and the ongoing Copenhagen Bicycle Strategy (2011-2025), the city has successfully mainstreamed cycling in its transport policy and societal mindset (6). Copenhagen invested €80 million (US$84 million) in its bicycle strategies and infrastructure between 2010 and 2014.

Copenhagen's bicycle-sharing schemes are priced to encourage frequent use while ensuring financial sustainability (7). The city also subsidises the cost for low-income users. Copenhagen aims to increase the number of daily bicycle trips to 240,000 by 2025, from a baseline of 110,000 in 1970 and 150,000 in 2015. The city registers 1.44 million km of cycle rides daily, with 49 percent of all trips to work or school made on bicycles (8).

With extensive cycling infrastructure and enhanced safety features—including a city-wide network of cycle lanes segregated from pedestrians and vehicle traffic and a commitment to sustain investments in new cycle lanes on all major commuter routes—Copenhagen has emerged as the world's most bicycle-friendly capital (9).

London, England: London's congestion pricing model charges higher fees for vehicles entering the city centre during peak hours, thus encouraging the use of micromobility options over private cars (10). The goal of London's congestion charge was not to raise revenues but to free up road space to encourage the increased use of public transport by offering Londoners alternative and sustainable commute options across the city (11).

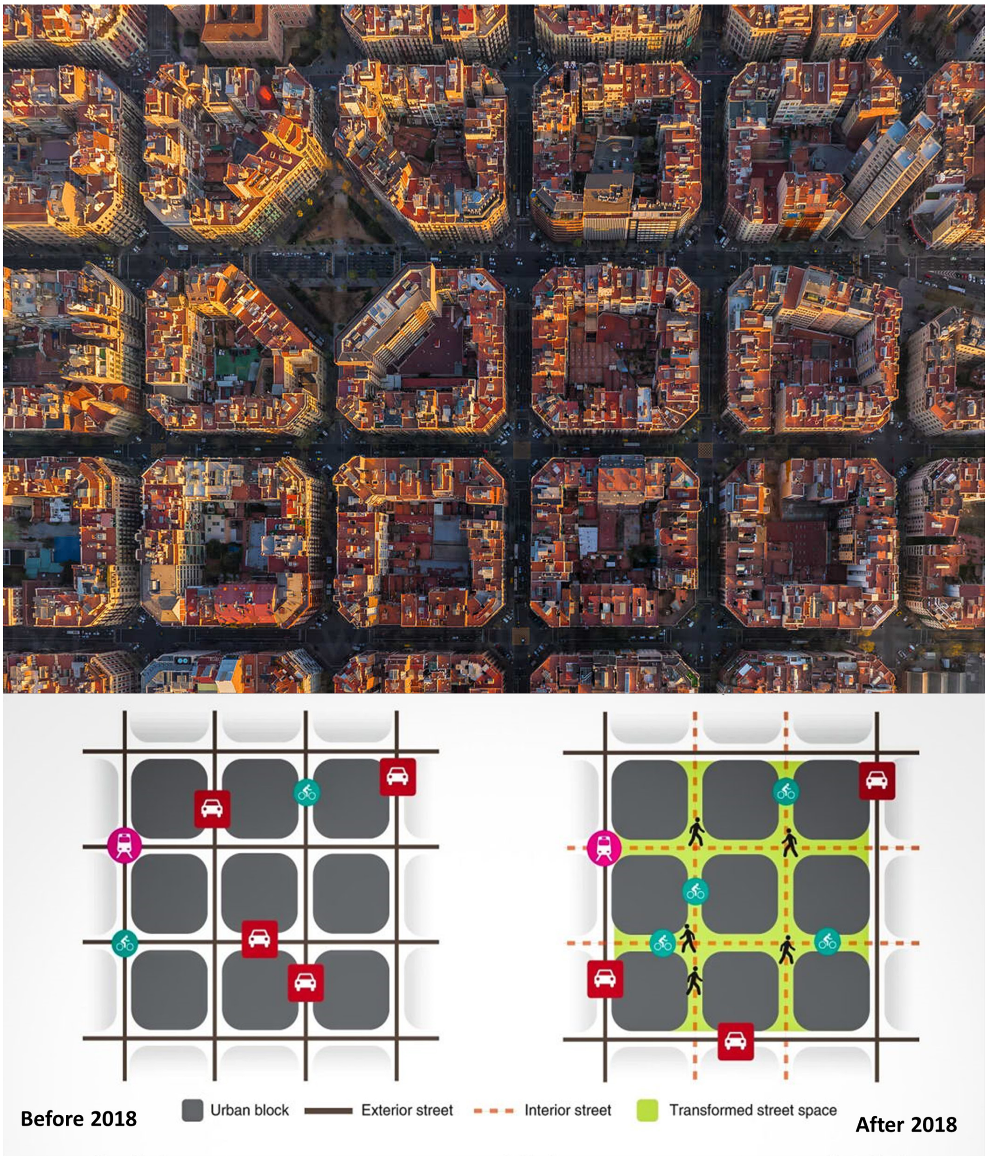
Since its introduction in 2003, congestion charges limited traffic movement by 18 percent during weekdays, reduced road congestion by 30 percent, boosted bus travel in central London by 33 percent, and enabled a 10 percent modal shift from private vehicles to walking, cycling, and public transport (12).

However, despite these measures, in 2023, London's traffic congestion levels increased to comparable levels in 2003, making it the city with the world's worst traffic congestion (13). Nevertheless, the congestion charge achieved its primary goal of reducing the road and public space occupied by vehicles, increasing the public space for cyclists and pedestrians, and enhancing public transport use.

London's ultra-low emission zones, introduced in 2019 to build on the achievements of the congestion charge, have also begun delivering encouraging results in improving the city's air quality and providing a healthier living environment (14).

Barcelona, Spain: Till 2022, cars occupied 85 percent of Barcelona's streets (15). While transport infrastructure occupied a quarter of the city's urban space, over half was used solely by cars (16). The city's 2013-2018 Urban Mobility Plan sought to reverse this scenario. It prioritised moving people over vehicles by introducing 'superblocks' (*superille* in Spanish and Catalan) backed by a comprehensive community participation strategy. The superblocks strategy designed 400x400 m units across 120 intersections in the city to recover public space for communities and encourage the use of public transport. The city plans to have 503 superblocks by 2030 (17).

Figure 1: Barcelona's Superblocks



Source: Cities Forum (18) and CityChangers.org (19).

The strategy has enhanced public spaces by reclaiming road space from private vehicles and created a strong public transport system, including multiple complementary shared transport and micromobility options that provide easy access with safety, punctuality, and comfort (20). The city has also implemented a tiered pricing structure for its shared mobility services, with lower rates for regular users and higher rates for occasional users (21).

Agenda-Setting to Promote Micromobility in India's Cities

The COP26 transport declaration (22) sparked a global demand for ACES micromobility solutions. Worldwide, more than 2,000 public bicycle sharing (PBS) models have successfully provided accessible and convenient last-mile connectivity (23). This trend has prompted policymakers to adopt similar approaches within their jurisdictions. India's domestic EV policies at the central and state levels (such as in Maharashtra (24), Karnataka (25), and Rajasthan (26)) mandate the increased adoption of EVs by citizens and fleet operators.

Decarbonisation, ease of mobility, decongesting cities, providing affordable mobility alternatives for all social classes, and increasing the ridership of flagship transport services (like buses and metros) are the primary driving factors that prompt the swift adoption of electric last-mile solutions. Notably, the Central Motor Vehicle (5th Amendment Rule) 2014 (27) opened several new avenues to spur India's domestic EV market. This amendment introduced a new classification of EVs, termed battery-operated EVs (the technical equivalent of a bicycle), enabling fleet operators and delivery platform companies to electrify their fleets in compliance with state regulations.

City-level decarbonisation plans are prompting local administrations to reduce their greenhouse gas (GHG) emissions from the transport sector. For example, Mumbai aims to achieve carbon neutrality by 2050 (28). In 2021, the city's transportation GHG footprint is around 82,21,902-ton CO_2 equivalent (approximately 24 percent of its total GHG emissions), with vehicular exhaust contributing around 44 percent (29). Megacities like Mumbai can use their existing PBS policy frameworks (30) to create battery-operated EV infrastructure to reduce last-mile GHG emissions.

Emerging market dynamics, such as e-commerce and better town planning, are also aiding in shaping last-mile connectivity in India. State EV policies nudge cash-rich e-commerce companies and individuals to explore carbon-neutral transport alternatives. The rising interest in leisure mobility and heritage tourism in metropolitan cities has encouraged residents to explore their cities through a new perspective, providing an enormous opportunity for carbon-neutral transportation (31).

Policy Instruments and Physical Integration

Well-designed policy instruments that allow the seamless onboarding of private players by ULBs and public bodies to support last-mile connectivity can stimulate clean micromobility modes in cities. How public offices engage private service providers for last-mile connectivity dictates the cost structures, geographical spread, revenue mechanisms, and overall positioning of these services within the city.

However, significant variations in the policy approaches at the state and local levels have hampered the wider adoption of such micromobility solutions. For instance, in Karnataka, the Directorate of Urban Land Transport (DULT) (32) introduced regulations for dockless bicycle-sharing schemes. Similarly, Maharashtra has announced policies to promote electric vehicles, including support for electric two-wheelers (33). However, unlike DULT, it lacks a state-wide policy framework on last-mile connectivity. Likewise, most Indian states ignore last-mile connectivity in their transport policies. The lack of a policy focus and specific regulations for micromobility and shared mobility have created uncertainty for operators and pushed the status quo for users.

Public offices often resort to competitive bidding practices like tenders and auctions to allot operational rights for last-mile connectivity businesses. However, these documents typically ignore cost externalities, including repair and maintenance and charging infrastructure. Many tender documents also include incompatible business conditions, such as advertisement revenue. Such factors have diminished the chances of breaking even for private operators in a cash-starved sector. Consequently, ULBs and public transport undertakings fail to engage with newer private companies, and start-ups compromise on innovative technologies and business practices. Such approaches have meant that the last-mile connectivity space is accessible only by a few players with the capacity for mega investments and enormous operational expenditure.

This scenario underscores the significance of states and ULBs adopting innovative contracting practices that ensure fair competition and promote efficient service delivery in the evolving urban mobility markets. Such contracts must move away from the 'standard' bidding process, specify entry and eligibility conditions, and have clear exit clauses to prevent public offices from getting stuck in long-term contractual obligations if the service provider fails to deliver.

Most public land in Indian cities is under fragmented public ownership (34). A parastatal or regional development authority, the railway or metro authorities, or the ULB typically own public lands in urban areas. Each of these entities caters to the mobility requirements of the city population through transport modes, including bus, metro rail, and feeder bus services, aided by private intermediate public transport, such as autorickshaws and taxis.

Therefore, governments must consider three critical interventions to ensure seamless integration across the various public transport modes and overcome the challenges posed by the lack of a unified national policy on micromobility and inconsistencies in state-level regulations.

- First, they must comprehensively assess the city's mobility footprint by preparing the population trip metrics to provide clarity and cost transparency in tenders and expression of interests.

- Second, given the land and electricity costs and other necessary resources required for parking dockless shared mobility vehicles, they must develop a unified onboarding mechanism to ensure that no transport modes are left underserviced. Such a unified mechanism will offer clarity for companies willing to invest in micromobility projects and assure the tenurial security of their contracts.

- Third, the government must divert public investment to create micromobility infrastructure to ensure wider acceptance of last-mile connectivity solutions. Prioritising investment to create dedicated lanes, parking facilities, and charging stations will aid the widespread adoption of micromobility solutions and support carbon-neutral, sustainable growth.

Policy Architecture to Boost Last-Mile Connectivity

Governments and transport planners must not consider micromobility in isolation, and must integrate it into the broader framework of urban mobility planning. India's National Urban Transport Policy (35) and initiatives like the Smart Cities Mission (36) and the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme (37) provide an enabling environment. However, the existing regulatory framework is fragmented, highlighting the urgency for cohesive national policies that can streamline state and municipal regulations. A unified approach will not only facilitate the scaling up of micromobility services across diverse urban settings but will also address safety and infrastructure deficits, which remain significant barriers to widespread adoption.

International experiences offer valuable lessons in shaping India's micromobility agenda. Cities like Copenhagen, Barcelona, and London have shown the transformative potential of dedicated infrastructure like bike lanes and pedestrian-friendly neighbourhoods. Integrating micromobility with public transportation systems in these cities has greatly improved first- and last-mile connectivity, reduced the reliance on private vehicles, and contributed to significant emissions reductions. India can replicate these best practices, but it will require targeted investments in urban infrastructure, robust safety regulations, and mechanisms for public engagement.

Policymakers must prioritise the integration of micromobility with existing transportation systems, both formal (metros and buses) and informal (autorickshaws), to create a seamless, multimodal urban mobility network. This agenda will be created by collaboration between stakeholders—government bodies, private micromobility operators, urban planners, and civil society.

The future of micromobility in India hinges upon developing a cohesive, inclusive, and forward-thinking policy framework. Such a framework should focus on regulatory consistency, infrastructure investment, safety, and affordability while drawing on international best practices. As the country looks to meet its climate commitments and alleviate the challenges posed by rapid urbanisation, micromobility offers a practical, scalable solution that can significantly contribute to a more sustainable and liveable urban future.

Damodar Pujari *is Manager-Policies at Yulu. Bikes.*

Dhaval Desai *is a Senior Fellow and Vice President at ORF Mumbai.*

Endnotes

(1) First-mile connectivity involves the transportation of passengers from the starting point to a central transport hub or main transit network using personal or intermediate public transport modes. Last-mile connectivity covers the journey from the main transport hub to the destination, such as reaching your final address after getting off a train or bus. Efficient first- and last-mile connectivity is critical for seamless travel.

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Enhancing Connectivity:
Challenges and Strategies for Physical and Operational Integration of Multimodal Transport Systems

Organising Informal Public Transport

Nandan Dawda and Firsat Fasih Mulla

In India, only 6 percent to 9 percent of all trips are served by public transport, compared to 30 percent and 35 percent in most other countries worldwide (1). According to the 2011 Census (2), India had 465 cities with a population of more than 100,000, 4,041 statutory towns (3) governed by local bodies, and 3,894 census towns (4). However, only 127 cities have operational bus systems (5). Statutory and census towns rely solely on unorganised transport modes, often called intermediate public transport (IPT) or paratransit systems. With a fleet of 7.1 million (6), autorickshaws provide the most extensive IPT services in urban India. Even in cities where mass transport systems are operational, IPTs not only complement public transport by fulfilling first- and last-mile connectivity (7) (8) but also cover the inadequacies of existing public transport systems. The modal share of IPT is as high as 22 percent in Amritsar, Punjab (9). In Nagpur (Maharashtra), autorickshaws account for 19.8 percent of daily trips (10), compared to just 9.8 percent for formal bus services. Similarly, in Lucknow (UP), IPT has a 17 percent modal share against the 3 percent share of formal public transport (11).

IPT Operations in India

Walking, bicycling, and IPTs are typically the most preferred modes for trips shorter than 5 km (12). Despite the disruptions in urban transport caused by platform aggregators such as Ola and Uber, autorickshaws continue to operate on a 'hail-and-ride' or as a shared service in most cities, covering up to 100 km daily with an average ridership of 45 passengers (13). They are regulated through permits issued by state transport departments. These vehicles are self-organised, with individual operators forming unions, cooperatives, and associations (14).

Despite being crucial to urban mobility, autorickshaws are criticised for their unorganised nature, unhealthy practices, and operational inefficiencies. They face operational challenges and lack institutional and infrastructural support, often resulting in issues such as road congestion, unauthorised parking, and concerns over women's safety. Autorickshaws also attract criticism for not complying with fare metres, overcharging passengers, and overcrowding (15). The absence of a mechanism for disseminating information about demand and other traffic trends to autorickshaw drivers has resulted in a mismatch between demand and supply.

In such a scenario, ride-hailing platforms have emerged as a medium to organise the sector, meet demand, standardise fares, and address sectoral issues through data-driven approaches while also aiming to provide access to mobility for a large section of the population.

Platform Fleet Service

The launch of G-Auto in Ahmedabad, Gujarat, seeded the idea of aggregating autorickshaws in 2009 (16). However, Ola pioneered the big-scale digital aggregation of city transport by introducing its platform-based, demand-responsive cab services in 2010. Subsequently, dozens of other aggregators entered the market. Uber and Rapido entered the market in 2013 and 2015, respectively, and together, with over 30 other aggregators, they cater to around four million rides daily across 200 cities (17). Initially offering only cab/taxi services, these platforms gradually began to include autorickshaws. Aggregator apps now provide a range of vehicles, including bike taxis, shuttle vans, and various types of cabs.

Platform Problems

Aggregator services have greatly benefited users by addressing safety and information issues while organising IPT as a fleet. However, their practice of charging unreasonably high commissions has often been detrimental to the driver community.

High Commissions: In their quest to penetrate the mobility sector, platform aggregators promised lucrative incentives to drivers, but this did not last long. Aggregators started charging drivers commissions as high as 30 percent of the trip fare (18). Consequently, many drivers have expressed dissatisfaction with the current system and reported that not all trips are profitable for them, with some even being loss-making (19).

Absence of Social Security: Autorickshaw and cab drivers often do not own their vehicles (20), and pay the vehicle owners a daily share of their earnings or a fixed monthly rent. Many of them come from low-income families with limited opportunities for more lucrative employment. Most aggregators fail to provide social security and protection to this vulnerable group—a 2020 report revealed that 95.3 percent of drivers had no accidental, health, or medical insurance (21).

Poor Regulation: Aggregators operated in a regulatory grey area for many years until the introduction of the Motor Vehicle Aggregators Guidelines 2020 (22). The guidelines introduced regulations on fares, capped commissions at 20 percent, and mandated health insurance for drivers. However, the implementation of these national guidelines is limited in the absence of any enforcement mechanism (23). With transport being a matter of state jurisdiction, many states have either ignored the guidelines or delayed forming enforcement mechanisms.

Cancellation Penalties: An aggregator can permanently block or blacklist a driver's account for cancelling trips more than a pre-specified number of times (24). This policy has added to the drivers' stress levels.

Information Asymmetry: The platforms use algorithmic pricing for trips using multiple factors such as time, distance, route, demand, surcharges, and type of city to calculate the base price. However, the calculation for these fares is not transparent (25), creating significant information asymmetries and irrationally high surge pricing algorithms.

Alternative Equitable Platform Models

A few new aggregator models have evolved with technology advancements and open data availability. Models such as Namma Yatri and InDrive have attempted to address such shortcomings.

Namma Yatri: Karnataka's Namma Yatri (Our Passenger), a direct-to-driver app (26) built on the open-source Beckn Protocol defined by the Open Network for Digital Commerce (ONDC) (27), attempts to overcome the issue of high commission charges. The platform operates on a subscription model with a minimal service fee. It enables users to book an autorickshaw or cab with direct payments to the driver. This system eliminates intermediaries, ensuring a commission-free transaction process.

Bengaluru's Auto Rickshaw Drivers Union volunteered to facilitate the app's pilot programme by providing inputs, pricing consultations, and policy advice. Namma Yatri has approximately 400,000 registered drivers across eight cities (28). The platform maintains transparency by providing extensive information on its website, including the number of drivers online, search metrics, trip conversion rates, and trends. This empowers drivers to make informed decisions about their positioning and operations. The Economic Survey of India 2023-24 mentioned Namma Yatri as an ONDC success story (29).

InDrive: InDrive, an online aggregator of cabs and autorickshaws, operates on a peer-to-peer pricing model, allowing users to negotiate fares and other conditions with the driver directly (30). The platform imposes zero surge charges and a minimal commission of only 10 percent, including 5 percent platform commissions and the Good and Services Tax (31). Entering the Indian urban transport market in 2022, the California-based InDrive has expanded to 12 Indian cities, including Delhi NCR, Bengaluru, Mumbai, Chennai, Kolkata, Chandigarh, Jaipur, Lucknow, and Ludhiana.

Namma Yatri and InDrive represent efforts towards equitable platformisation, moving away from hefty commissions charged by traditional aggregators. In both cases, drivers receive fares directly from customers, which fosters confidence and a sense of fairness among drivers. Namma Yatri demonstrates an equitable approach by including autorickshaw unions as stakeholders in decision-making processes.

Integrating IPT Through Mobility-as-a-Service

Mobility-as-a-service integrates various forms of transport and related services into a single, comprehensive platform, offering users the convenience to plan, book, and pay for multiple types of mobility services.

For example, Kerala's Kochi Open Mobility Network (KOMN) drives the integration of multimodal urban transport by allowing all mobility applications within the network to communicate seamlessly (32). KOMN adopts an open interoperability approach similar to the Internet and UPI payments, and will enable commuters to combine different trips, book ferries, use metro services and buses, and even rent bicycles through any of the integrated applications. It plans to expand its services to include finding parking spots and electric vehicle charging stations and expand partnerships in the hospitality and healthcare sectors. Six taxi unions have joined KOMN to offer their services (33).

In April 2024, the Kochi Metro joined the ONDC, allowing commuters to book services through other aggregator apps like Yatri, Rapido, RedBus, and Paytm (34). The goal is to consolidate all formal and informal mobility ticketing into one application.

Learnings From Global Examples

Improving IPT by Promoting Professionalism: Kigali, the Rwandan capital, improved IPT modes such as minibuses and bike taxis, which account for twice the modal share of public transport. Kigali expanded IPT's use through various negotiations and reforms. The Rwanda Utilities and Regulatory Authority (RURA), the central regulatory body overseeing utilities, including transport, encouraged IPT operators to move towards professionalism instead of imposing outright bans on their operations (35). Since 2003, RURA has implemented several reforms to address the challenges of fragmented and informal minibus services. These measures included gradually phasing out lower-capacity vehicles and introducing safer, more efficient alternatives. This approach successfully engages stakeholders from the informal transport sector and enhances services by granting regulated monopolies to operators.

In addition, RURA has issued licences to bike taxis, restricting them to specific zones to maintain balanced distribution while reducing internal competition. These reforms have led to a significant 80 percent increase in public transport ridership, while the number of routes in the transport network nearly doubled within three years, from 42 to 78 (36).

Financial Mechanism to Formalise IPT: Senegal's capital Dakar, with a population of 3.2 million, relied heavily on privately-owned minibuses for public transport, with nearly 3,000 minibuses meeting over 80 percent of the city's transport demand. To replace the old and poorly maintained minibuses, known as car rapides, the Dakar Urban Transport Executive Council (CETUD) financed 75 percent of the purchase cost for new vehicles. Minibus owners formed cooperatives, which collectively took the responsibility for repaying the loans. Additionally, the owners received a scrappage bonus for their old vehicles. These cooperatives appointed salaried drivers with the provision of social protections (37).

The cooperatives established financing associations responsible for managing human resources, insurance, and other affairs. The CETUD regulated the routes, frequencies, and service distribution. Over the last two decades, 65 percent of the fleet has been replaced, and the share of regulated public transport has increased from 20 percent to 50 percent (38).

Comprehensive Mapping of Informal Bus Service: A key challenge in IPT sector reform is the near-total lack of data. The availability of detailed data can unlock the full potential of IPT services. It requires in-depth information on transport modes, drivers, operations, and users, as well as insights into the microeconomic, political economy, and sustainability aspects of the sector (39).

Alexandria, an Egyptian city with 5.6 million inhabitants, is developing two major transport projects: the Abu Qir metro line and the Raml tram rehabilitation. While these projects have disrupted mobility within the city, authorities have begun exploring alternative transport options. In collaboration with a prominent local university, the city authorities comprehensively mapped bus routes in the city's local paratransit network. This included extensive data collection, such as geographic information system-based network routes, boarding and alighting points, and service frequency. The data was incorporated into the city's Sustainable Urban Mobility Plan, helping IPT operators meet temporary transportation demand during construction (40).

Conclusion

The significance of autorickshaws and IPTs and the prevalent aggregator platform inequities highlight a pressing need for equitable mobility solutions. Any app-based solution to organise IPTs into a fleet must consider drivers as critical and integral stakeholders. The high modal share of paratransit underscores their complementary role further (41), highlighting the importance of multimodal integration in the urban transport sector.

Nandan Dawda *is a Fellow with ORF's Urban Studies Programme.*

Firsat Fasih Mulla *is an intern at ORF Mumbai.*

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Physical and Operational Integration in Public Transport: Assessing the Regional Rapid Transit System in India's National Capital Region

Samir Sharma

Integrating multimodal transport systems is vital for efficient, convenient, and sustainable urban mobility in densely populated cities. Globally, successful models of physical and operational integration—such as those in London (1), Paris (2), and Amsterdam (3) in Europe, Toronto (4) in North America, Bogota (5) in South America, and Singapore (6), Tokyo (7), and Hong Kong (8), in Asia—demonstrate how strategic coordination among multiple transport modes (such as rail, metro, bus, and last-mile connectivity) can enhance the commuter experience by reducing travel times, improving accessibility, and ensuring seamless transitions. These models emphasise synchronised schedules and interoperability, aligning with the rising expectations of commuters and the demands of modern cities.

In India, urban transport systems face significant challenges in achieving such integration. While major cities like Delhi, Mumbai, and Bengaluru have commissioned ambitious transport projects, the lack of coordination among different transport modes often results in commuter inconvenience, traffic congestion, and low user satisfaction and ridership. Fragmented governance, uncoordinated ticketing systems, infrastructure gaps, and inadequate last-mile connectivity hinder the effectiveness of these systems in addressing the needs of India's rapidly urbanising population.

The emerging rapid rail transit system (RRTS) in India's National Capital Region (NCR) offers valuable insights into addressing these issues. With its focus on high-speed regional connectivity, seamless interchange points, and interoperability with existing transit systems, the RRTS provides a promising model for other Indian cities.

Attributes of Integrated Multimodal Transport Systems

Integrating public transport modes is essential for developing efficient, user-friendly, and sustainable urban and regional transport systems. The effective physical and operational integration of multimodal systems enhances accessibility, simplifies transfers, reduces travel time, and improves the overall user experience, promoting public transport over private vehicles (9).

Efficient physical and operational integration essentially needs the following attributes:

Interoperability: Interoperable transit systems eliminate transfer penalties for passengers between public transport lines. However, interoperability requires close coordination between agencies, integrated planning, and uniform technical standards and specifications of various transit systems. They must utilise common platforms and have integrated stations for different transport modes to minimise the walking distance for passengers (10). The concept of a 'network of networks' plays a pivotal role in having interconnected transit systems where different public transport networks work in tandem, offering seamless transfers and reduced wait times (11). Stations like Shinjuku in Tokyo, Japan, are designed to enable seamless transitions between multiple rail and subway networks operated by Japan Railways, Tokyo Metro, and private railway companies (12). Similarly, Berlin Hauptbahnhof, the German capital's main railway station, integrates diverse transit modes such as regional trains, intercity trains, the S-Bahn (suburban rail), and U-Bahn (subway), with optimised transfer times to enhance connectivity (13).

Multimodal Complexes for Physical Integration: Convergence of different transport modes at mobility hubs is crucial to reduce transfer penalties and facilitate easy and quick transfers. Such multimodal hubs require integrated master planning, land pooling, and integrated facility management, ensuring they are the focal points for multimodal connections (14). For example, Châtelet–Les Halles in Paris and Amsterdam Centraal Station are ideal models of physically integrated multimodal hubs. Both stations feature expansive layouts with wide corridors and concourses, enabling seamless transfers between multiple transit services. Clear wayfinding and well-organised platforms further enhance the passenger experience (15).

Signage and Information Systems: Clear and consistent signage and real-time information displays across the multimodal system offer real-time service updates, providing intuitive navigation through stations and terminals. Toronto's Union Station showcases the potential of physical integration in Canada, which has a multilevel design to ensure seamless modal transfers between rail, subway, and streetcar services, with improved pedestrian pathways and signage (16).

Coordinated Scheduling: Efficient operational integration hinges on aligning the timetables of various transport modes to minimise waiting times and facilitate smooth transitions between services. Coordinated scheduling is crucial for optimising the "time factor" for commuters, particularly in a complex, high-volume transit system (17). Singapore's multimodal transport system, encompassing mass rapid transport (MRT) and bus networks, optimises connectivity between MRT stations and major bus interchanges with integrated schedules and routes. Additionally, commuters can use the ubiquitous EZ-Link card, a contactless smart card that allows seamless intermodal transfers across various transport modes (18).

Public Transport Route Integration: Integrating routes and services of various modes ensures service complementarity. Public transport routes focusing on 'trunk and feeder connectivity' are pivotal in increasing ridership and reducing car dependency. For example, Bogotá's TransMilenio bus rapid transit system utilises a hierarchical network structure, where the high-capacity trunk lines form the system's backbone, operating along major arterial roads. Lower-capacity feeder lines provide first- and last-mile connectivity, linking residential areas to the trunk network (19).

Real-time Data Sharing and Integration: Systems sharing real-time data on vehicle locations, delays, and other operational metrics across all modes can help commuters plan their journeys, while sensors at stations monitor crowd density, adjusting train frequencies accordingly. Transport for London operates one of the world's most integrated real-time data platforms, covering buses, the Underground, Overground, Docklands Light Railway, and trams (20).

Integrated Customer Service and Communication: Unified customer service and communication strategies across multiple modes ensure consistent support and information for passengers. Hong Kong's public transport system provides multilingual customer support and facilitates navigation and problem-solving for both local residents and international visitors (21).

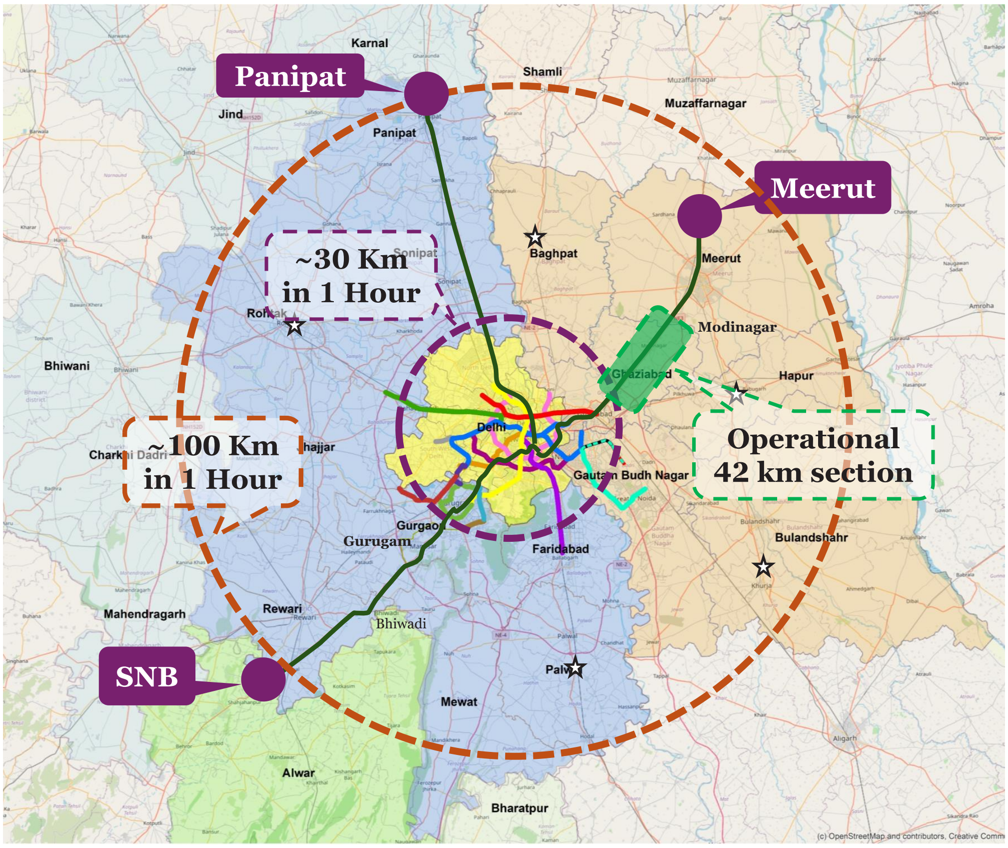
Delhi's Regional Rapid Transit System Project

RRTS is a rail-based, semi-high-speed transit system with a design speed of 180 km/h and an average speed of 100 km/h. The National Capital Region Transport

Corporation (NCRTC) is implementing the RRTS in India's National Capital Region (NCR), encompassing the National Capital Territory of Delhi and several peripheral districts of adjoining states. The region has a 58 million population and is among the world's largest and fastest-growing urban agglomerations (22).

The RRTS will act as the backbone of the NCR's urban and regional transportation, providing the fastest, comfortable, and safest mode of public transport, fostering balanced and sustainable regional urban development. The RRTS corridors emphasise the 'network of networks' approach with a long-term vision. Figure 1 maps the three RRTS corridors, which will converge at a common elevated station at Sarai Kale Khan and inter-connect within one hour to Meerut, Ghaziabad, Noida, Sonipat, Panipat, Gurugram, and Manesar, located within 100 km from Delhi.

Figure 1: The National Capital Region's Upcoming Regional Rapid Transit System Corridors



Source: NCRTC (23).

Table 1 shows the key features of the three RRTS corridors.

Table 1: Three Prioritised Upcoming Regional Rapid Transit System Corridors

	Delhi-Ghaziabad-Meerut RRTS	Delhi-Shahjahanpur-Neemrana-Behror (SNB) RRTS	Delhi -Panipat RRTS
Total Length (Km)	82	107	103
Travel Time (Min)	~60	~70	~65
No. of stations	25	16	17

Source: NCRTC (24).

About 42 km of RRTS corridor between Sahibabad and Meerut South, with nine stations, has been operational since August 2024 (25). It has already completed about four million passenger trips, significantly reducing commuter travel times, and creating a more comfortable, futuristic travel experience (26).

Multimodal Integration in RRTS Network Design

Interoperability of RRTS Corridors: Transfer and wait times are significant deterrents to the use of public transport. They introduce uncertainty and inconvenience in daily commutes, making public transit less appealing than private vehicles. The Delhi RRTS original project design had three separate terminals. Following a series of multistakeholder consultations, the NCRTC realised that the interconnectedness and interoperability of the three corridors were essential to enable the seamless movement of commuters across the NCR. Accordingly, it changed the project design with interoperable services for all the corridors at Sarai Kale Khan, giving commuters travelling from Meerut to Shahjahanpur-Neemrana-Behror (SNB) or from Panipat to SNB an option to continue their journey in the same train depending on their destination. This integration will reduce travel bottlenecks, provide operational flexibility, and reduce transit time and capital cost of construction.

Physical Integration of RRTS: Phase 1 of the RRTS (Delhi-Meerut, Delhi-SNB, Delhi-Panipat) will be integrated with the national transport network, offering easy connections to airports, railway stations, and inter-state bus terminals (ISBTs). It will also provide efficient connections with intracity public transport networks such as the metro rail and bus system. The RRTS will integrate with other modes at multiple locations in Delhi, such as at Sarai Kale Khan (ISBT, Railways, Pink metro line), INA (with Yellow and Pink metro lines), Munirka (Magenta metro), Anand Vihar (ISBT, Indian Railways, Blue and Pink metros), and Kashmere Gate (ISBT, Yellow, Red and Violet metro lines). Such multi-location integration will increase the RRTS's catchment area and promote ridership.

Besides Delhi, the RRTS efficiently integrates with the NCR's other metro rail networks (Gurugram, Noida, Ghaziabad, and Meerut), unifying regional transport with city transport networks. This multimodal integration will enable 'everywhere to everywhere' travel opportunities with seamless and convenient travel options between various city centres and seamless last-mile connectivity through the connected metro and bus lines. Table 2 summarises the RRTS's physical integration at multiple locations in the NCR.

Table 2: Multimodal Integration of RRTS with Other Modes of Transport

Modes	Multimodal integration with RRTS
Metro Rail Systems	• Delhi Metro: With seven metro lines at Ghaziabad, Anand Vihar, New Ashok Nagar, Sarai Kale Khan, Jor Bagh, Aerocity, Indraprastha, Kashmere Gate, Munirka • Meerut Metro: At Begumpul • Gurugram Rapid Metro: At Udyog Vihar • Bawal Metro: At Panchgaon, Kherki Daula
Airports	• Indira Gandhi International Airport, Delhi: At Aerocity Metro Station
Indian Railways	• Hazrat Nizamuddin and Anand Vihar Railway Stations
ISBTs	• Sarai Kale Khan, Kashmere Gate, Anand Vihar and Panchgaon
Other Bus Terminals/ Depots	• Kaushambi Bus Depot, Sahibabad Bus Adda, Ghaziabad New Bus Adda, Bhaisali Bus Adda (Meerut), Bawal, etc.

Source: NCRTC (27).

Multimodal Complexes: With the convergence of multiple transport modes, transport hubs allow passengers to switch easily and quickly from one mode to another. These multimodal transport complexes need strategic placement, as well as user-friendly navigation systems and amenities. The upcoming Sarai Kale Khan Multimodal Transit Complex in Delhi will be a mega integrated transit hub for the three interoperable RRTS corridors, the Nizamuddin Railway station of Indian Railways, ISBT, city bus terminal, and Pink metro station. The 42.59-acre complex currently handles about 600 buses and 130,000 people per day. It is designed to hold 500,000 people/day by 2051, providing multimodal connectivity infrastructure as envisioned by the PM Gati Shakti

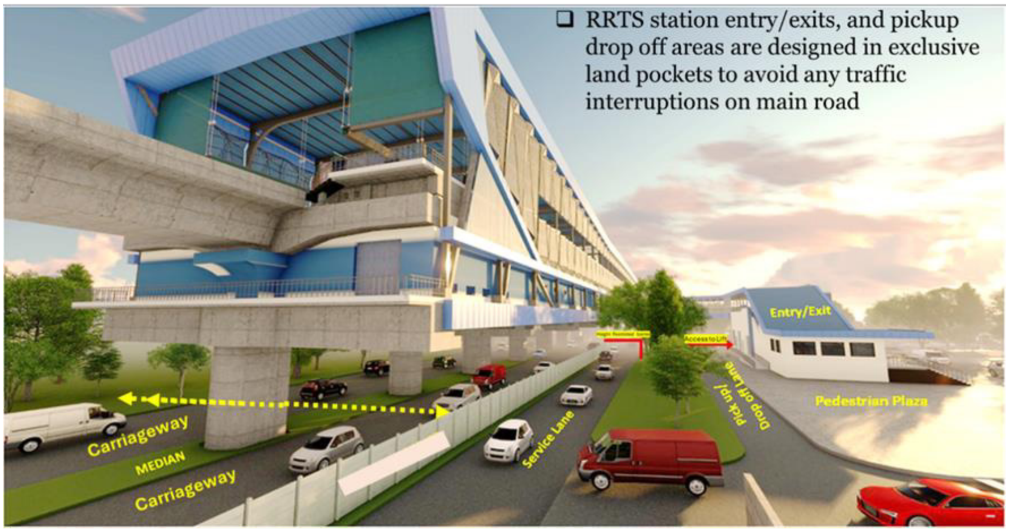
National Master Plan (28). The complex will have an 8.5m wide integrated skywalk (with travelators, escalators, and elevators) connecting various modes of transport with the railway station for ease of transfer. A centrally located interchanging public plaza will organise diverse modes of transport such as the RRTS, ISBT, metro rail, city bus terminal, and auto, taxi, parking and private vehicle drop-off areas. It will also have continuous segregated walkways and multi-utility zones to cater to local requirements. Figure 2 shows the 3D plan of Sarai Kale Khan's physical integration of various modes.

Figure 2: Design of Sarai Kale Khan Multimodal Complex

Source: NCRTC (29).

Traffic Integration at entry/exits of RRTS stations: Planning RRTS station entry/exits in separate off-road spaces to segregate RRTS traffic from mainline road traffic is essential to minimise disruptions to road traffic caused by passenger pick-up and drop-off activities and to enable seamless physical integration with other transport modes. These off-road zones allow for designated areas where vehicles can stop safely without obstructing the flow of on-road traffic. Positioning access points slightly away from main roads reduces the need for abrupt stops or lane changes, enhancing safety and traffic flow. Additionally, these off-road station areas are designed with dedicated lanes for feeder buses, autorickshaws, and taxis, facilitating efficient multimodal passenger transfers. This approach ensures passengers can easily access RRTS stations, promoting operational efficiency and an improved commuter experience (see Figure 3).

Figure 3: Segregated RRTS Entry/Exit Location

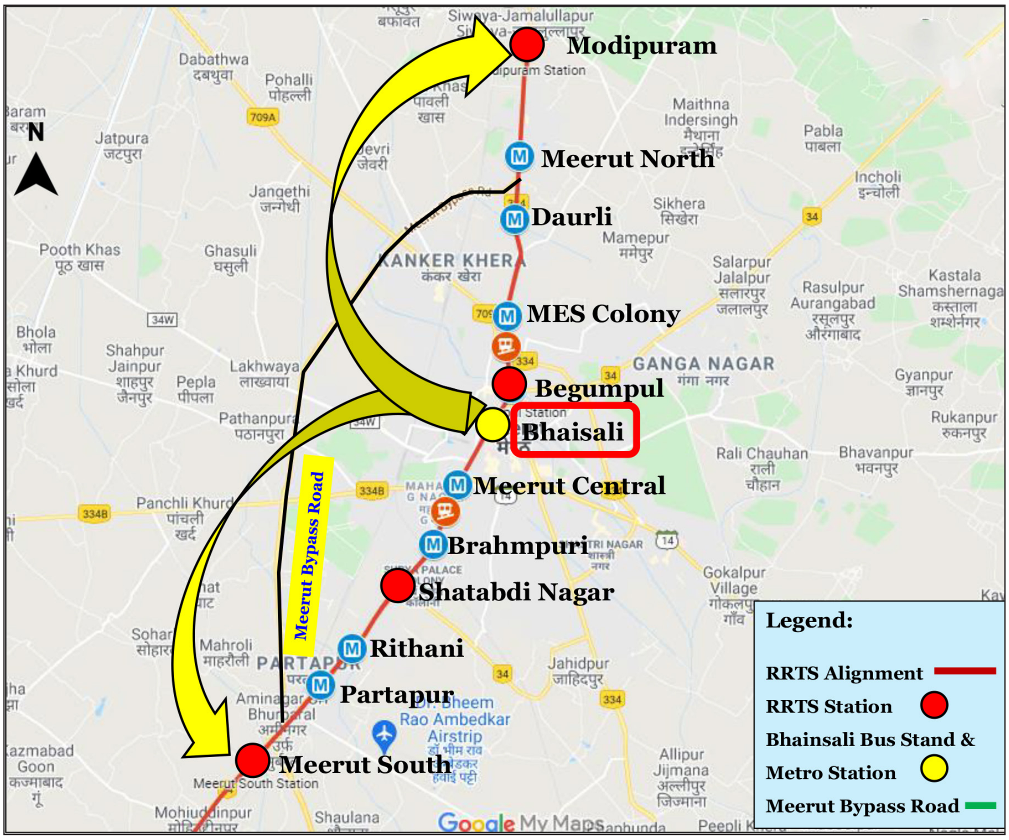


Source: NCRTC (30).

Relocating Bhainsali Bus Terminal in Meerut: The bus terminal at Bhainsali is in a densely populated commercial area on Meerut's busy Delhi Road. The Bhainsali ISBT receives about 1,400 bus arrivals/departures daily via Delhi Road (31). Given its location, the terminal causes frequent stoppages for the boarding/deboarding of passengers, creating traffic congestion. Additionally, using e-rickshaws and other means of transport worsens traffic conditions, contributing to delays, pollution, and unsafe conditions, and adversely impacting the bus system's operational productivity (32).

The NCRTC offered a solution to this problem by proposing to relocate the ISBT near the RRTS-cum-metro station at Meerut South and Modipuram (33), enabling its efficient physical integration with four transport modes (see Figure 4). This relocation will ease transfers and help passengers alight at ISBTs and use the Meerut Metro for first-/last-mile connectivity. ISBT passengers will also gain easy access to other major cities in the NCR due to the terminal's proximity to the RRTS station. The multimodal integration of three modes at these locations will also provide passengers with a seamless journey experience, reducing their reliance on private vehicles.

Figure 4: Bhainsali Bus Terminal Shifting

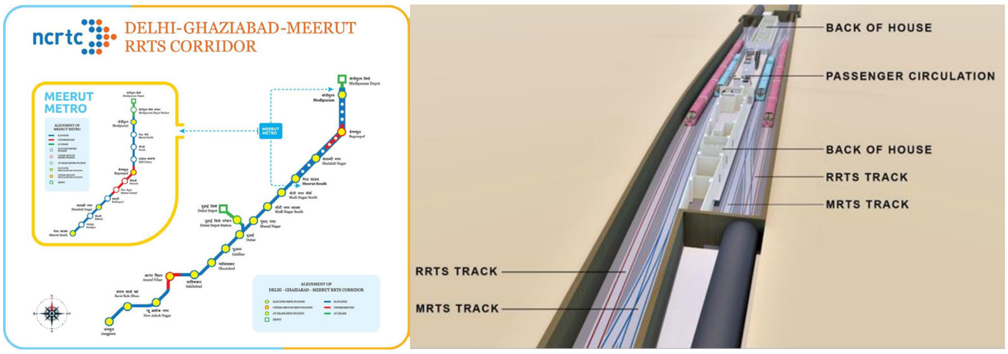


Source: NCRTC (34)

Integrated RRTS-cum-Metro Corridor in Meerut: The original project proposed aligning the RRTS and Meerut Metro's north-south rail on the same road. This plan had significant issues, as constructing two separate railway infrastructures along the same route would create complex engineering challenges, increase project costs, and impact ridership.

The NCRTC proposed merging the RRTS and Meerut metro projects into one larger project by developing an integrated RRTS-cum-metro corridor, where the metro would serve as a feeder service to the RRTS (35), and save INR 60 billion (~ US$700 million) of public money. The 21-km RRTS-cum-metro corridor with 13 stations is now in the advanced stages of construction. The RRTS will act as a fast service with only four stops, whereas the metro will halt at all 13 stops. All stations will have loop lines to allow the RRTS to bypass the non-stopping stations. Figure 5 below indicates the alignment and station details of the integrated corridor.

Figure 5: Integrated RRTS-cum-Metro Corridor in Meerut



Source: NCRTC (36)

Operational Integration of RRTS – Bus Routes and Paratransit: The Ghaziabad City Transport Services Ltd. operates electric buses via seven routes, offering feeder connectivity to four stations of the Delhi-Meerut RRTS corridor's operational section from various areas in Ghaziabad. The NCRTC provided dedicated pick-up/drop-off areas to efficiently integrate bus services with the RRTS at each location. It also integrates route and schedule information into the RRTS Connect mobile app (37). The NCRTC will soon integrate live GPS bus location with this app.

Additionally, the Uttar Pradesh State Transport Corporation has approved and notified 17 feeder bus routes to/from five RRTS stations between (including) Sahibabad Station and Duhai Depot RRTS Station (38). The NCRTC has also partnered with three feeder operators (ETO, Rapido, and Speed Trip (P) Ltd.) to provide e-rickshaws, bike taxis, and cabs from various stations along the Delhi-Meerut RRTS Corridor (39).

Conclusion

Successful global models of multimodal transport integration from cities like Tokyo, Singapore, and London highlight the essential factors for creating seamless and efficient urban transit systems: cohesive infrastructure planning, digital integration, reliable scheduling, and user-centric services. In contrast, urban India faces challenges with fragmented infrastructure, limited digital integration, and inconsistent schedules, often hindering the commuter experience.

The Delhi RRTS presents a promising solution emphasising efficient intermodality, real-time data usage, and commuter convenience. Its multimodal transit complexes and integration of existing terminals with planned transit systems will facilitate easy transfers between modes, expanding the system's reach and enhancing ridership for the overall public transport system.

By adopting similar practices—such as coordinated operational frameworks and multi-agency collaboration—other Indian cities can foster improved commuter accessibility, reduce traffic congestion, and align with global urban mobility standards. Through these enhancements, India's urban centres can advance towards a more integrated, sustainable, and commuter-friendly multimodal transportation future.

__Samir Sharma__ is a multimodal integration expert with the National Capital Region Transport Corporation.

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Reimagining Urban Mobility for Gender Inclusion in India Beyond Safety

Mitali Nikore and Brinda Juneja

Robust urban transport infrastructure is vital to ensure ease of mobility in cities. Efficient public transport fosters an equitable society, connecting people to work, education, and services. However, an effective public transport system must serve all equitably.

Women and girls are the primary public transport users in Indian cities, accounting for 22 percent of daily work travellers; they use public, intermediate public, and non-motorised transport modes for 84 percent of their work trips (1). Therefore, a gender-inclusive approach to multimodal transport systems is crucial to promoting equitable mobility, as safety concerns often deter women's participation in public life, creating a cycle that further diminishes their presence in public spaces.

The Need for Gender-Inclusive Urban Mobility

Urban planning has historically overlooked the diverse needs of populations, limiting women's access to socioeconomic opportunities. Cities have primarily catered to men, neglecting women, girls, sexual and gender minorities, and people with disabilities.

Women face numerous challenges, including safety issues, affordability concerns, limited access to transportation options, and infrastructure deficiencies. These deficiencies include inadequate pedestrian facilities, poorly maintained bus and train stations, and a lack of security in crowded public transport. Moreover, women contend with an increased risk of harassment in public spaces and often have complex travel patterns involving multiple stops (trip-chaining). A World Bank study reveals that 79 percent of women in India have experienced sexual harassment in public spaces and transport, discouraging their use and perpetuating safety concerns (2). Women typically face challenges in public transport across four stages:

- Access to/from stops: Poorly lit, deserted streets in the first and last mile of the journey
- Waiting at stations: Deserted areas, especially during off-peak hours
- Boarding/alighting: Crowded stations causing missed transport due to jostling
- In-vehicle travel: Risk of sexual harassment in mixed-gender compartments

These obstacles and normative barriers, such as social restrictions and norms, limit women's capacity to navigate urban spaces freely.

Cities worldwide are implementing innovative strategies to address gender disparities in urban mobility. For example, Bogota (Colombia) and Cape Town (South Africa) have real-time safety apps, awareness campaigns, undercover officers, and women-friendly transportation features (3). London's 'Action on Equality' plan (2016-2020) enhanced various aspects of public transit, while Mexico City's 'Hazme el Paro' project introduced a harassment reporting app (4).

Cities like Lisbon (Portugal) and Istanbul (Türkiye) showcase practical multimodal approaches in their integrated public transport systems. Lisbon has enhanced connectivity and reduced congestion by combining eight modes, including buses, trams, metro, and ferries, while Istanbul has upgraded its public transport system with technological innovations to improve user experience and accessibility (5). Istanbul's Ulasim Asistani app facilitates journey planning across various modes, while a QR-code payment system simplifies fare collection. These initiatives demonstrate the potential of technology-driven, data-informed solutions in creating more inclusive urban mobility systems (6).

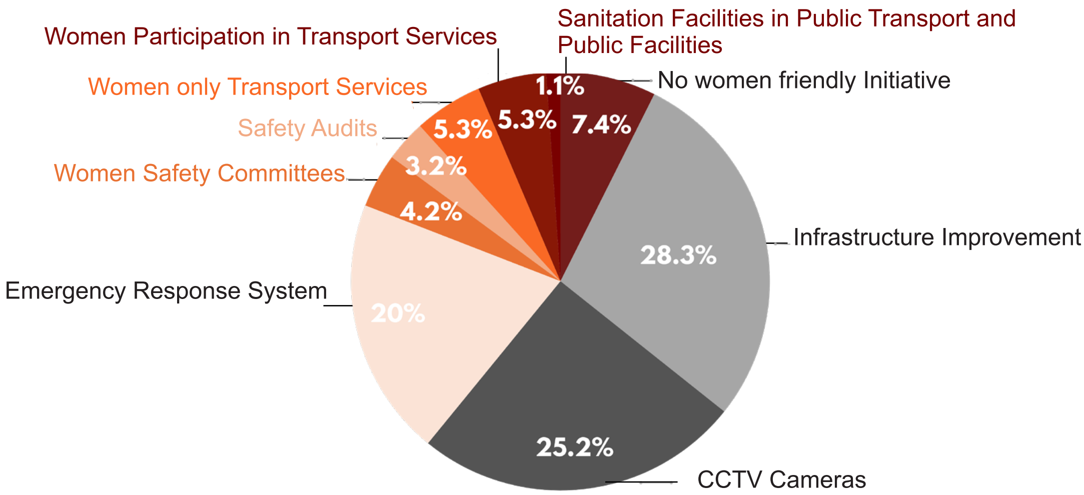
Indian cities, too, are beginning to apply a gender lens to urban mobility, particularly in response to safety and inclusion concerns. The Delhi Transport Corporation, for example, introduced the Mohalla Bus Sewa to address last-mile connectivity challenges (7). Many cities have also implemented the National Common Mobility Card that helps collect gender-disaggregated data on transportation usage patterns across India (8), enabling a more nuanced understanding of gender-specific travel needs and behaviours, and informing more inclusive urban mobility policies and infrastructure design.

Current Gender-Inclusive Urban Mobility Initiatives in Indian Cities

Nikore Associates conducted an in-depth secondary data analysis of 50 cities across India's 28 states, focusing on their comprehensive mobility plans (CMPs), initiatives by metro rail and bus corporations to create gender-inclusive infrastructure and various state schemes. The National Urban Transport Policy laid the groundwork for developing CMPs in Indian cities, which have since become crucial in addressing urban transportation challenges, including women's safety concerns (9).

Of the 50 cities analysed, 42 had incorporated gender-inclusive and safety provisions in their CMPs, including improved infrastructure, CCTV systems, emergency responses, increased presence of women police officers, safety audits, and promoting women's participation in transport services (see Figure 1).

Figure 1: Gender Incisive Initiatives in CMPs in Indian Cities



Source: Calculated by the authors from data available on the state government websites.

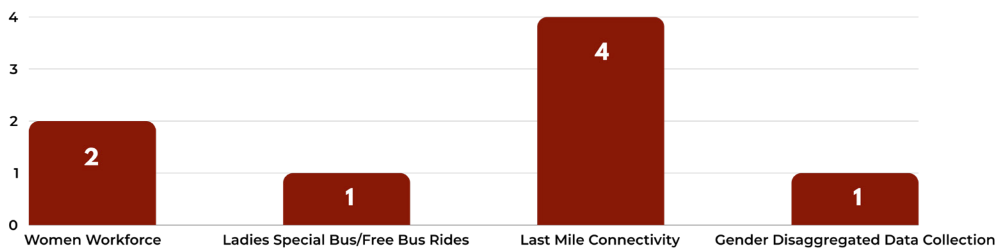
Of the 50 cities studied, 17 had operational metro systems with gender-inclusive amenities, including reserved coaches, CCTV surveillance, and the presence of women marshals (see Figure 2). Six metro systems had implemented women-only coach reservations, while eight offered designated reserved seats. Notably, over half of the metro systems had installed CCTV cameras as a standard security measure, underscoring a commitment to passenger safety.

Figure 2: Gender Inclusive Initiatives in Metros (of 17 Metro Systems Analysed)

Source: Calculated by the authors from data available on the city metro rail websites.

However, bus systems lagged in implementing gender-inclusive measures. Only eight of the 50 cities had undertaken initiatives to improve commuting efficiency, enhance last-mile connectivity, introduce women-only buses, collect gender-disaggregated data, and increase women's participation in the transport workforce (see Figure 3).

Figure 3: Gender Inclusive Initiatives by Bus Corporations (of 50 Cities Analysed)



Source: Calculated by the authors.

Only 12 states had implemented schemes targeting women bus and e-rickshaw riders. State government programmes frequently featured free bus rides, with eight states offering them regularly. Four states—Rajasthan, Haryana, Gujarat, and Maharashtra—provide complimentary rides on days like International Women's Day and *Raksha Bandhan*. Women commuters are allowed free travel in government-run buses with ordinary fares up to 30 km in cities and towns in the state.

Several states have also pioneered diverse strategies to improve accessibility and safety for women. For example, Karnataka's Shakti scheme, launched in July 2023, provides women with fare-free rides on non-premium, state-run buses to enhance women's participation in education and employment (10). The PM Gati Shakti National

Master Plan for Multimodal Connectivity integrates 16 ministries, including railways and roadways, on a digital platform to facilitate coordinated planning and implementation of infrastructure connectivity projects (11).

According to a survey on the Shakti scheme (12), over 60 percent of women respondents reported gaining additional work opportunities due to eased mobility constraints, particularly for long-distance travel. Furthermore, more than half the respondents noted that the scheme greatly assisted with "mobility of care", i.e., using buses to complete household chores and errands.

Looking Beyond Primary Safety Concerns

The above analysis reveals that current gender-responsive mobility initiatives primarily focus on enhancing safety measures and financial accessibility. Though most reforms centre around safety, they often fail to address comprehensive safety concerns, as they focus on specific parts of the journey rather than the entire transport ecosystem. Additionally, there is a pressing need to think beyond them by incorporating measures related to universal access, inclusive infrastructure and design, addressing inclusion barriers, and improving multimodal connectivity, as demonstrated by Lisbon, Istanbul, and London.

Consultations by Nikore Associates with over 100 organisations, including transportation authorities, urban planning departments, and women community groups, between 2020 and 2023 revealed several issues beyond the safety paradigm.

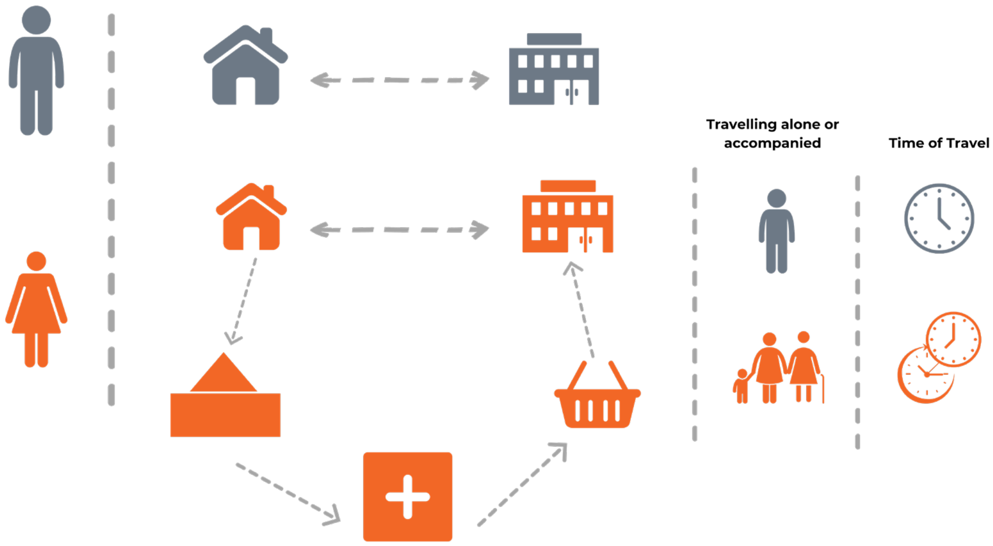
First, the absence of female frontline workers creates hesitation among women in using safety features. Overcrowding increases the risk of harassment. Long-distance transport, like railways, is underutilised by women due to poor accessibility and the need for multiple mode changes.

Second, women encounter gender-blind design elements throughout their journey. These range from poorly lit streets and broken footpaths in the first and last mile to safety concerns at deserted transit stops during off-peak hours. They also face risks of sexual harassment in mixed-gender compartments, occupied reserved seats, and a lack of storage provisions for packages. The scarcity of off-peak services and early closures mainly affects women who work non-standard hours or require flexible travel schedules.

While these barriers are typically associated with single-mode travel, women often engage in trip chaining, presenting the third unique challenge. Trip chaining presents unique challenges for women, particularly regarding coordinating various transportation modes.

A 2020 user perception survey conducted by C40 Cities Finance Facility and GIZ in Bengaluru found that approximately 83 percent of women respondents took trips twice a day, with some making three or even four trips (13). More women travelled for household care work than men, and fewer women travelled during late evening hours than men.

Figure 4: Trip Chaining Patterns



Source: Toolkit for Enabling Gender-Responsive Urban Mobility and Public Spaces (14).

The inconsistent availability and timing of different services often result in extended waiting periods, leading to safety concerns. Moreover, the lack of diverse transportation options at transit hubs further complicates multimodal journeys.

Public transport systems frequently prioritise connections between residential areas and workplaces, overlooking other locations that women commonly visit, making it difficult for women to integrate different modes of transport into their journeys seamlessly. A prime example of this issue is the scarcity of intermediate public transport options at major public transport stations, hindering efficient and safe travel.

Infrastructure limitations further complicate the situation. Different modes of transport require distinct infrastructure, making seamless connections difficult. For instance, integrating bus and rail systems necessitates the construction of transfer stations, which can be costly and time-consuming. There is also an absence of integrated physical facilities, such as multimodal terminals, hampering efficient transitions between transport modes.

Addressing these challenges through thoughtful design and policy implementation is crucial to creating inclusive, efficient urban transport systems that support women's equal participation in social and economic activities.

Recommendations

Cities must implement a comprehensive four-pillar strategy to address the multifaceted challenges women face in urban mobility (15):

1. Assessing the ground situation
2. Strengthening planning and policies
3. Building capacity and raising awareness, and
4. Improving infrastructure and services

Cities could start by comprehensively evaluating their existing public transport systems, collecting gender-disaggregated data on ridership patterns, travel times, and routes, and conducting safety audits of transport infrastructure, including stations, stops, and vehicles. Surveys to understand gender-specific needs and concerns and identify policy gaps in addressing gender issues can provide a baseline for prioritising interventions.

Building on this assessment, cities could strengthen their planning and policies to embed gender inclusivity in all aspects of public transport by revising transport policies to include gender considerations, establishing gender-responsive budgeting for transport projects, and mandating women's participation in transport planning committees. They must develop guidelines for gender-inclusive design in transport infrastructure with a focus on enhancing multimodal connectivity. The Gender and Policy Lab in Chennai, established under the Nirbhaya Fund (16), demonstrates significant progress in creating inclusive urban transport systems by focusing on multimodal integration and enhancing women's safety and accessibility (17).

The third pillar focuses on capacity-building and awareness, which are crucial to implement gender-inclusive policies effectively. Cities must conduct gender-sensitivity training for all transport staff, from planners to drivers, and launch public awareness campaigns about women's rights and safety in public transport. They must establish partnerships with women's organisations for ongoing feedback and advocacy, and develop robust reporting mechanisms for harassment and safety issues. Fostering collaboration among transportation agencies to align schedules across different modes and minimising wait times at transfer points can facilitate multimodal integration. Implementing technology platforms that enable seamless data sharing and interoperability between different transport systems is crucial. Additionally, introducing smart ticketing solutions allowing the use of a single ticket across multiple transport modes can significantly improve user experience.

Finally, cities must implement tangible improvements in infrastructure and services by enhancing lighting and visibility at stations and stops, installing CCTV cameras and emergency call buttons in vehicles and stations, and designing wider aisles and lower handrails in vehicles to accommodate diverse users. They must also invest in building multimodal terminals to facilitate easy transfers between different transport modes and incorporate features such as ramps, elevators, and safe waiting areas. Providing separate women's sections or women-only vehicles during peak hours, increasing service frequency during off-peak hours, implementing integrated ticketing systems for seamless multimodal journeys, and creating safe walking paths and cycling lanes connected to public transport can address many barriers women face while using public transport.

By systematically implementing these four pillars, cities can transform their public transport systems to be genuinely gender-inclusive, safe, and accessible for all users. This comprehensive approach improves women's mobility and enhances the overall quality and efficiency of public transport, benefiting the entire urban population. It represents a shift towards urban planning that recognises and responds to the diverse needs of all citizens, creating more equitable and vibrant urban environments.

Above all, operational integration, the use of technology, effective stakeholder collaboration, and learning from successful global models are critical for success. This comprehensive approach will benefit women's safety and accessibility while contributing to economic growth and social development.

Mitali Nikore *is the Founder of and Chief Economist at Nikore Associates.*

Brinda Juneja *is a Research Manager at Nikore Associates.*

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Improving Bus Services and Fostering Multimodal Integration Using Smartphone GPS Datasets

Himani Jain and Krishna Khanna

Using aggregated smartphone global positioning system (GPS) data for transport planning is a relatively new concept in Global South cities. This data is vital for optimising public transport and shared transport services, infrastructure design, and multimodal integration.

Big data has a variety (structured/unstructured), volume (huge quantity), and velocity of data points generated at high frequency or in real-time (1). Automatic vehicle location (AVL) data from GPS, coupled with geographic information system-based route, stop, and schedule datasets aid big data analytics to optimise adaptable transit systems through the generalised transit feed specification (GTFS) (2) (3). However, in the absence of similar real-time, high-frequency people's movement data, which traditional transport surveys cannot obtain, the GTFS data used to calculate specific indices has not yet reached the desired level of granularity.

Dynamic, rapid, and responsive data on people's movement gathered through smartphone GPS pings have attributes comparable to travel diary surveys (4). Although individual movement data risks compromising user privacy, data aggregation allows city planners to access this invaluable data anonymously (5).

Global mobile and vehicle GPS data-based projects include monitoring real-time vehicular traffic, pedestrian movements, public transport, and foreign visitors to enhance urban planning, tourist management, and traffic flow (6). Rio de Janeiro (Brazil) and Boston (the US) use mobile phone data to generate origin-destination (OD) trip matrices for home-work and inter-zone travel, providing robust insights for urban planners (7). Tokyo utilised 1.4 million car trajectories to design customised bus services and optimise routes and stops (8).

The US uses smartphone GPS data to track city park visits, preferred timings, and user choices (9). Singapore, Jakarta (Indonesia), Rome and Milan (Italy), Florida (the US), Puebla and Monterrey (Mexico), and Seville (Spain) use it to develop traffic flow, OD, and route trajectory insights at the micro (station and street-level) and city level (10). However, using smartphone GPS data has yet to go beyond research to replace the traditional, expensive, and time-consuming household, mobility and trip diaries, and vehicle count surveys, specifically in Global South cities.

In India, shared modes like buses and walking are popular (11), but integrating bus transit systems presents physical and operational challenges (12). Ease of access to public transport stops (13), transport network connectivity, and service connectivity (14) impact the public transport system's accessibility and reliability. Regular, granular monitoring of ODs, access/egress time and routes using phone GPS data can promote user-centric public transport design and improve accessibility, aiding multimodal integration efforts amongst urban local bodies, city transport undertakings, and regional transport offices.

This study focuses on improving bus system accessibility in the National Capital Territory of Delhi using smartphone GPS data combined with GTFS to analyse movement patterns. This data-driven approach addresses the gaps in access, connectivity, and service reliability, ultimately fostering a user-friendly public transport design.

Attributes of GTFS and Smartphone GPS Data

In 2020, Delhi had 6,672 buses, covering an area of 1,484 sq. km. The Delhi Transport Corporation operated 56 percent of the buses, with the remaining operated by the Delhi Integrated Multimodal Transit System (DIMTS) (15). Notably, the daily ridership declined from 4.98 million in FY 2015 to 4.15 million in FY 2019, with a reduced fleet size (16).

The current study extracted geospatial datasets of 4,192 bus stops and 1,212 bus routes, and the DIMTS real-time GTFS data of 2,935 cluster buses (17). It used CITYDATA's (18) trip data for October 2020 compiled from smartphone GPS pings

(19). It anonymised and aggregated a dataset of 301,504 trips obtained from 140,814 unique devices from over 1,000 Android applications. The spatial resolution of data received was 5 m by 5 m.

The smartphone GPS dataset has inherent limitations in the absence of socioeconomic and socio-demographic attributes. This study evaluated the dataset's robustness for transit planning (20) along the three parameters to minimise this limitation:

1. Validation of smartphone access against Census 2011 age-sex data: Table 1 notes that the distribution of smartphone users in Delhi during the study was similar to that of the 2011 Census (21). The National Capital Territory of Delhi had 11.3 million active internet users, and 99 percent of users accessed the internet on their mobile phones (22).

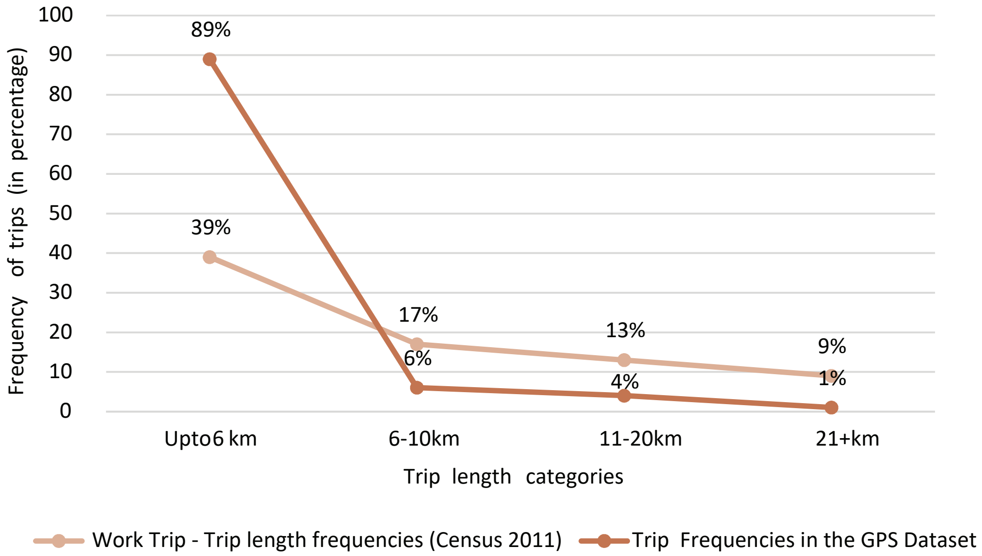
Table 1: Percentage Distribution of Internet Users to the Population of Delhi

(All units in percentage)	Age categories							Gender distribution	
	0 to 14	12 to 15	16 to 19	20 to 29	30 to 39	40 to 49	50+	Male	Female
Percentage of Internet users*	-	11	13	31	21	13	10	58	42
Population#	27		10	21	16	12	14	65	35

*Source: *IAMAI and Nielsen (23), #Census 2011 (24).*

2. Trip length frequency distribution: Figure 1 shows the statistical correlation of the trip length frequency distribution obtained from smartphone GPS and the 2011 Census (25). Compared to the trip length frequency distribution of the 2011 Census data, smartphone data showed a similar trend of declining trips as the trip length increased, indicating actual population travel patterns.

Figure 1: Trip Length Frequency Distribution Across 2011 Census and Smartphone Datasets (26)



Source: Authors' analysis based on Smartphone GPS data (27) and Census 2011 data (28).

3. Validation of density of origin (home location) with ward-level literacy and asset ownership: There is considerable variation in internet usage among low- (13 percent) and high-income groups (87 percent) (29). This study assumed the first trip generated by each smartphone device between 6-9 am to originate from a 'home location'. Table 2 shows no significant correlations between home location density, asset ownership, or literacy levels. Thus, the random distribution of data among areas with varied literacy levels and incomes prevented the over-representation of higher literacy or higher income neighbourhoods.

Table 2: Chi-Square Correlation Estimates Between the Number of 'Home Location' to Literacy and Asset Ownership at the Municipal Ward Level

Result of Bivariate Correlation		Number of Devices	Literacy Rate	Scooter Ownership	Car Ownership
Number of Devices	Pearson Correlation	**1**	**-0.08**	**-0.04**	**0.03**
	Sig. (2-tailed)		**0.171**	**0.546**	**0.598**
	N	**289**	**289**	**264**	**264**

Source: Authors' analysis based on Smartphone GPS data (30), Census 2011 (31).

This study scaled the 'home locations' from smartphone GPS to the ward-level population from the 2011 Census (32). Since GTFS is available only for DIMTS-operated cluster buses (< 50 percent of the operational fleet), the results and findings are not representative of bus service supply in Delhi. Without socio-demographic information, the study was limited to trip details and travel patterns, and, therefore, presented a methodology—and not a commentary—on Delhi's bus services.

Opportunities for Bus Operational Planning

This study evaluated public transport accessibility using the datasets of bus stops, metro stations, and bus routes (33). Thirty municipal wards do not have any DIMTS-serviced bus stops or metro connectivity. These wards cover a 128 sq. km area (34) and house about 14 percent of Delhi's population (35).

Using the smartphone dataset, the study identified 15 wards with many home locations (36). For most of these wards, the trip length frequency distribution from smartphone datasets showed that 70 percent of the trips were less than 5 km, i.e. with origin and destination in the same ward. Delhi commuters have a mean trip length of 10.2 km, with only 25 percent of commuters using buses for less than 5 km trips (37). Thus, the study isolated all optimal trips between 5-20 km as 'potential bus trips'. Consequently, it estimated 15-20 percent of the trips in the select wards as 'potential bus trips,' as shown in Table 3.

Table 3: People's Trip Length Frequency Distribution (in percent) across 15 Select High 'Home Location' Wards Without Public Transport Connectivity Using Smartphone GPS Data

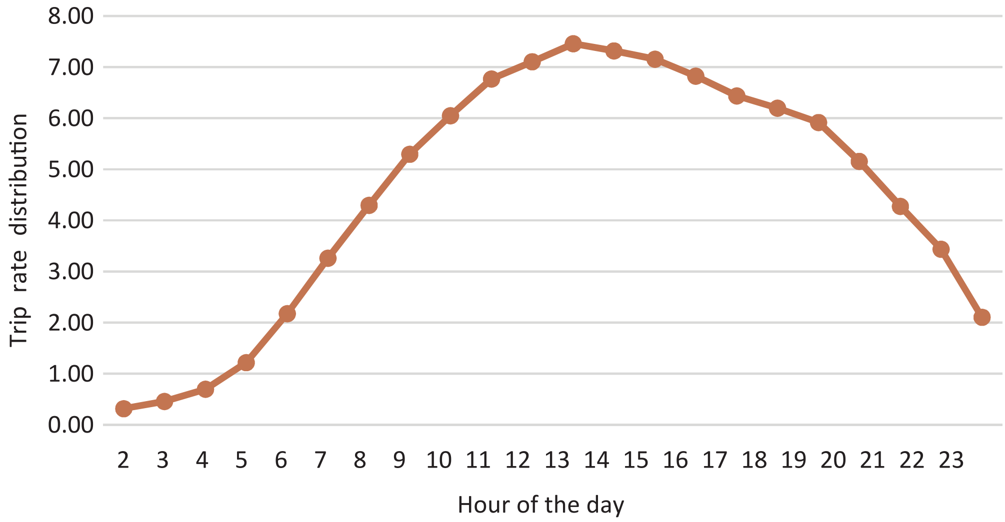
Ward Names	0-2 km	2-5 km	5-10 km	10-15 km	15-20 km	20+ km
Ram Nagar	98	0	1	1	0	0
Mohan Garden	88	2	2	0	5	2
Meetheypur	88	4	4	2	2	0
New Ashok Nagar	71	18	6	4	1	1
Sangam Vihar West	71	20	4	1	4	0
Jaitpur	70	18	4	2	6	1
Aya Nagar	68	20	4	3	2	4
Karawal Nagar East	63	24	8	2	0	1
Tigri	63	27	5	2	4	0
Bindapur	62	24	5	3	5	0

Ward Names	0-2 km	2-5 km	5-10 km	10-15 km	15-20 km	20+ km
Quammruddin Nagar	60	28	6	3	3	0
Bhati	57	31	5	3	1	3
Sadh Nagar	56	31	6	6	1	0
Kishan Ganj	50	38	6	4	1	0
Idgah Road	50	33	9	5	3	0

Source: Authors' analysis based on Smartphone GPS data (38) and Delhi ward shapefile (39).

The inter-ward mismatch between the 'potential bus trips' demand and bus-service supply presents a fresh perspective on hourly gaps in bus services in Delhi. The study analysed scaled smartphone GPS data for people's trips per hour across wards (see Figure 2).

Figure 2: Trip Rate Distribution (in percentage) of People's Trips Across the Day



Source: Authors' analysis based on Smartphone GPS data (40).

The study applied the following equations to calculate the supply gap.

For a ward pair i and j:

The demand for bus trips at an hour k is given by,

People's trips in range (5-20 km)between i and j
= Number of trips (gps pings)generated from ward i to j X
scaling factor for ward i X trip rate at hour k

Supply for bus passengers in ward pair ij
= number of buses moving between ward pair ij at hour k X seating capacity of bus fleet;

Percentage Gap
= (Supply of bus passenger trips in ward pair ij at hour k ÷ Demand for bus trips between ward pairij at hour K) X 100

It used average trips generated on all Mondays in October 2020 to assess the connectivity gaps by calculating the hourly demand variation of trips against the bus supply for a ward pair. It analysed the scaled data of over 1.22 million trips/day for 5-20 km across 5,488 unique ward-pair combinations.

At that trip hour, almost 67 percent of trips (41) occurred between ward pairs (42) without direct DIMTS bus services (43). Only 16 percent of trip origin-destination ward pairs had adequate (44) DIMTS bus services at that trip hour, as shown in Table 4.

Table 4: Proportion of Trips in Different Bus Demand Supply Categories

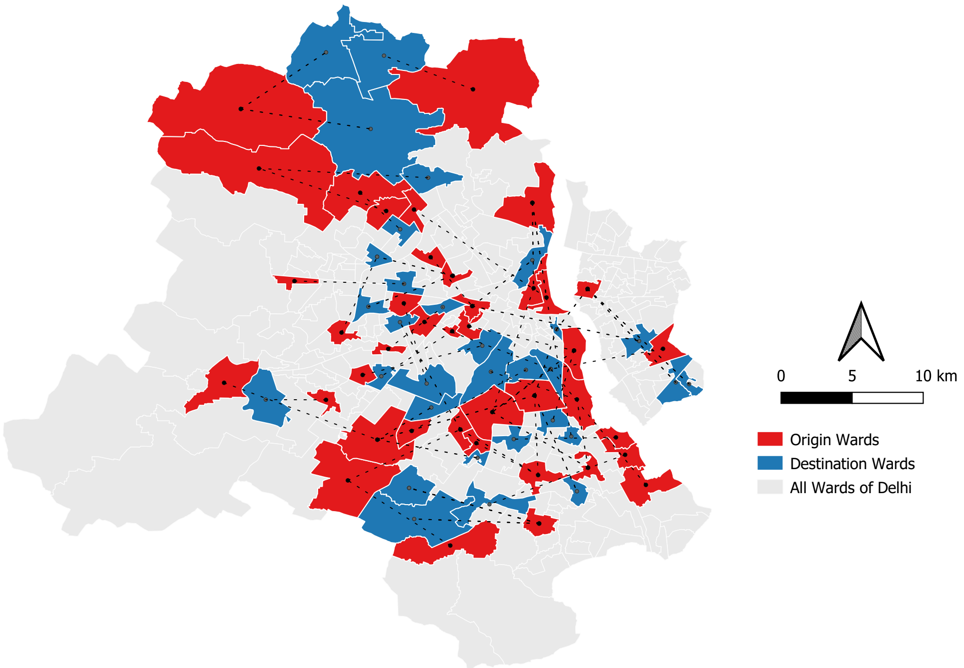
Bus demand-supply categories	Description of category	Potential bus trips
No Supply	Potential bus trip covered by other modes - (100 per cent gap) no bus services	67 percent
High Gap	Potential bus trip is partly (25 percent) covered by buses - up to 75 percent mismatch in demand and supply	10 percent
Medium Gap	*Potential bus trip is partly (50 percent) covered by buses- up to 50 percent mismatch in demand and supply*	3 percent
Low Gap	Potential bus trip is majorly (75 percent) covered by buses - up to 25 percent mismatch in demand and supply	3 percent
Supply Adequate	Bus supply matches or exceeds (>=100 percent) the potential bus trips supply meets the 100 percent demand and or is more	16 percent

Source: Authors' analysis based on Smartphone GPS data (45) and Delhi ward shape file (46).

The authorities must push more ward combinations towards the low gap/adequate supply category for Delhi to meet its aim of 80 percent public transport modal share (47). Information on underserviced ward pair combinations can aid authorities with planning for the *Mohalla* buses (48) (49) and enhance existing bus services.

Similarly, morning peak hour gaps were found across several ward pairs with bus services (see Figure 3). The dual demand loads of students and workers commuting during morning hours partially explain these gaps. Thus, the granular hourly data from smartphone GPS can help optimise bus operations spatially and temporally, informing route and schedule planning.

Figure 3: Ward Pairs Requiring Additional Buses to Meet the Supply Gap During Peak Hours (7-10 am)

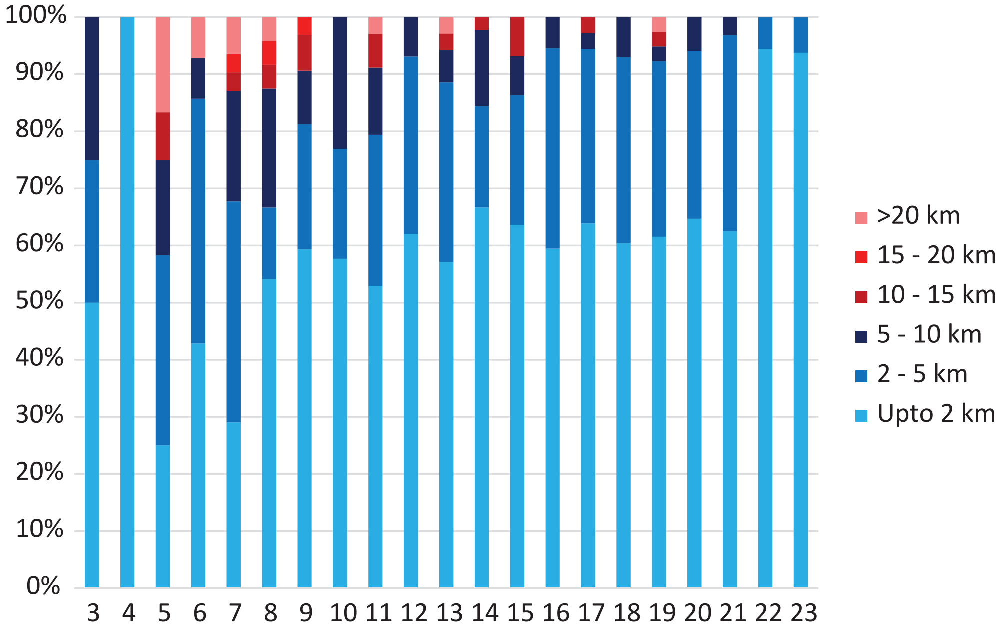


Source: Authors' analysis based on Smartphone GPS data (50) and Delhi ward shape file (51).

Opportunities for Bus Infrastructure Planning

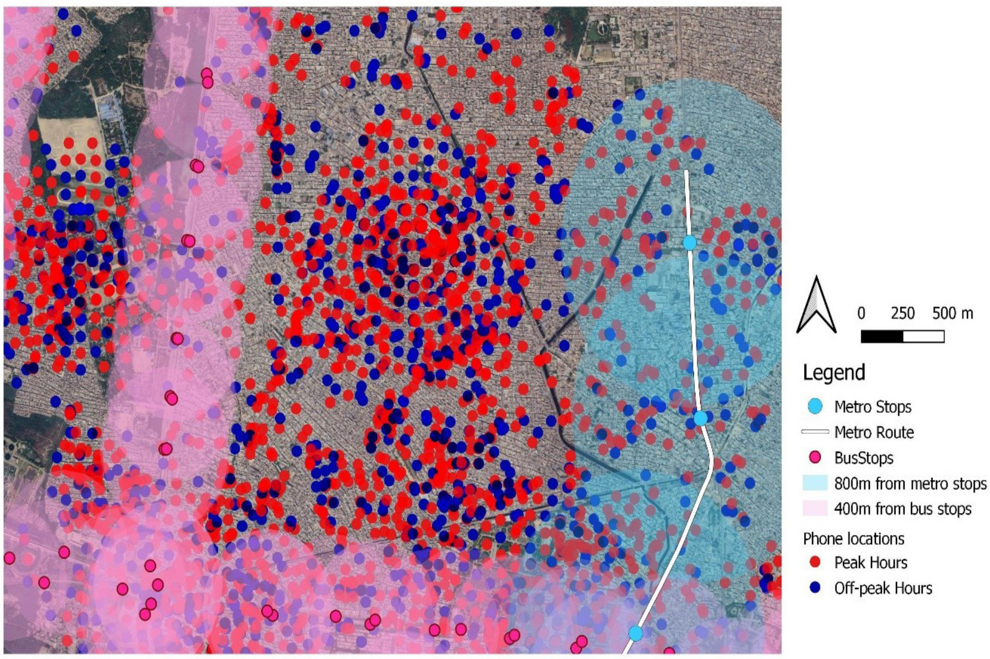
Due to their higher volume and finer granularity, smartphone datasets provide detailed insights at cheaper costs and faster turn-around time. The hourly analysis highlighted activity hubs in order of the footfalls, as shown in Figure 4. Additionally, long periodic heat maps showed the concentration of people and their trips at the point of interest, as highlighted in Figure 5.

Figure 4: Hourly Trip Length Frequency Distribution Originating from Karawal Nagar East



Source: Authors' analysis based on Smartphone GPS data (52) and Delhi ward shape file (53).

Figure 5: Ping Density at Karawal Nagar During Peak and Off-Peak Hours



Source: Analysis based on Smartphone GPS data (54), Delhi ward shape file (55), and Delhi static data (56).

Due to limited vehicle access in households, women and students depend more on bus transport services for their daily needs (57). Accessibility lags to public transport stops, as highlighted in Figure 5, disadvantage the underserved population and promote private vehicle usage. Thus, smartphone GPS data heat maps offer a robust basis for identifying land-use sites/areas to improve physical accessibility to bus stops.

Conclusion

Public transport projects with long implementation spans generally suffer from insufficient periodic evaluation of travel patterns through detailed stratified surveys. Smartphone GPS and bus automatic vehicle location data can optimise existing public transport services, and inform, monitor, and supplement long-term public transport planning to improve ridership and provide smooth multimodal connectivity.

- The city authorities and public transport operators must identify priority areas for infrastructure investments utilising smartphone GPS data. They should use smartphone data over a generic buffer or network-wide enhancement for a sharper destination or point of interest access from the origin.

- Public transit operators must utilise smartphone GPS data to analyse people's dynamic movement patterns to identify demand-supply gaps and optimise their services and connectivity. However, considering their limited socio-demographic representation, the utility of such datasets must be limited to estimating mass travel patterns.

- Unified with GTFS across agencies, smartphone data can aid in creating graded response plans, sync schedules, and seamless service operations across multiple models, such as feeder services, buses, and metro.

The utility of bus automatic vehicle location data increases multifold with the addition of smartphone GPS trip datasets that are cheaper, less time-consuming, and provide real-time insights. Such data helps map the impacts of seasonality and detect variable mobility trends and patterns, leading to fleet optimisation, enhancing bus services and better multimodal integration.

***Himani Jain** is a Senior Programme Lead at the Council on Energy, Environment and Water.*

***Krishna Khanna** is a Programme Associate at the Council on Energy, Environment and Water.*

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Unlocking Seamless Mobility:
Ways and Methods for Ensuring Informational and Fare Integration of Multimodal Transport Systems

Evaluating Trip Planner Performance Across Global Cities

Nandan Dawda

Population growth and economic expansion have led to rapid urbanisation worldwide, increasing the reliance on private vehicles for personal mobility. The development of cities has raised significant concerns regarding urban transport infrastructure sustainability (1). While public transport systems play a vital role in achieving sustainable urban mobility, they often face intense competition from private and informal modes of transport (2). As such, reconfiguring and harmonising public, private, and paratransit transport systems is essential to foster sustainability (3).

In this context, the concept of an integrated and sustainable multimodal transport system has emerged as a critical solution. Such a system encompasses five dimensions of integration: (i) physical, (ii) operational, (iii) institutional, (iv) informational, and (v) fare or pricing integration (4). Of these, informational integration is relatively straightforward to achieve through the development of trip planner apps. Numerous cities worldwide have implemented trip planners for information integration (5), but they lack an assessment framework to evaluate their features and functionality.

This essay develops a comprehensive evaluation framework for trip planner apps and applies it to assess their performance across 25 cities globally. The analysis encompasses 20 Indian cities (Surat, Vadodara, Kolkata, Nasik, Nagpur, Chennai, Chandigarh, Bhopal, Bengaluru, Ahmedabad, Kanpur, Prayagraj, Agra, Varanasi, Indore, Amritsar, Pune, Mumbai, Bhubaneswar, and Delhi) and five international cities (London, Singapore, Hong Kong, Paris and New York). This evaluation provides a detailed understanding of the effectiveness of these trip planners in supporting an integrated and sustainable multimodal transport system.

Learnings from Global Case Studies

A detailed analysis of trip planner apps in three international cities that have catalysed integrated and sustainable multimodal transport systems (London, Hong Kong and Singapore) provided the basis for developing the framework. The analysis identified the necessary features for an efficient trip planner. These were converted into a questionnaire format to evaluate the information integration of cities.

London (6)

Transport for London's (TfL) trip planner is notable for its comprehensive and user-centric design, supporting multimodal urban mobility. The homepage features six key sections: Plan a Journey, Status Updates, Maps, Fares, Help and Contacts, and More. Users can plan journeys between specific origins and destinations, tailored to departure or arrival times, with options to save personalised records for future use. The planner incorporates live arrival updates, enabling real-time journey adjustments. A 'nearby' function utilises geolocation to identify nearby transport services.

The trip planner integrates information for all public transport modes, including the Tube, Docklands Light Railway, London Overground, TfL Rail, trams, buses, and river buses. Dynamic status updates provide current, weekly, and future information on delays, service reductions, and closures. Additional details about station facilities, such as lifts and escalators, and traffic conditions by postcode, road, and place, enhance usability. It also covers regional transport services, including airlines and the national rail.

Maps play a vital role, offering 12 categories of static information, including Tube, rail, bus, cycle, river, and congestion charge maps. These are complemented by guides for step-free access, walking routes, and night-time travel. Maps for low-emission zones, visitor information in multiple languages, and audio maps for people with disabilities further enhance inclusivity. The fare section calculates trip costs, provides details about Oyster cards with top-up options, and allows users to save journey and payment histories. It also includes accessibility features, crime reporting, and travel tips for tourists. TfL Go exemplifies a well-rounded platform for integrated urban transport solutions, catering to a wide range of user needs.

TfL also launched the TfL Go app in 2020 to help users plan routes and comply with the COVID-19 pandemic protocols while using public transport (7). The app's 'step-free' mode displays information regarding step-free access at stations and step-free interchanges between lines.

Hong Kong (8)

HKeMobility, Hong Kong Mobility's trip planner, is a comprehensive platform that is available as a website and a mobile application. Besides providing detailed information about all public transport modes (including mass transit railway, buses, green and red minibuses, ferries, trams, taxis, residential services, and water taxis), it also facilitates journey planning for private vehicles, and walking. This multimodal comparison ensures extensive coverage of the region's transport network, enabling users to evaluate and select the most suitable travel option.

HKeMobility's multi-format traffic information system provides traffic updates in four distinct formats: traffic snapshots, traffic webcasts, journey time indicators, and speed map panels. Traffic snapshots offer periodic updates for key locations across districts, while traffic webcasts deliver real-time video feeds from cameras installed at major roads and interchanges. Journey time indicators provide estimated travel durations for specific routes, aiding in planning and time management, while the speed map panel represents traffic conditions across different areas, categorised as smooth, slow, or congested traffic.

Additionally, the platform's traffic news section publishes traffic and transport updates on disruptions. These features make HKeMobility a robust tool for urban mobility management, providing users with a rich array of options and real-time information to enhance travel efficiency.

Singapore (9)

Singapore's trip planner, developed by the Land Transport Authority (LTA), reflects a robust and integrated approach to urban mobility management. The trip planner incorporates diverse transport options (including bus services, metro rail transit, light rail transit, cycling routes, and taxi stands), providing a holistic platform for journey planning.

It categorises bus services into five types: public buses, premium buses, city direct buses, shuttle buses to attractions, and shuttle buses to hospitals. The platform offers valuable information about bus accessibility, indicating wheelchair-friendly services and the availability of seating and standing space, including details for limited standing capacity. Such data significantly enhance user convenience and support inclusivity in public transport.

The planner also provides detailed, zone-wise information on taxi stands within the central business district, facilitating better access to taxi services in a highly urbanised area. Additionally, cycling routes are integrated, supporting sustainable transport options. Overall, the trip planner is an advanced, user-focused approach to integrated transport planning, offering detailed and accessible information that caters to the diverse mobility needs of Singapore's residents and visitors.

Developing a Framework to Evaluate Trip Planners

Based on the key features of the three trip planners discussed above, this essay develops an evaluation framework for trip planners encompassing six key components: (i) trip planner, (ii) status updates, (iii) maps, (iv) fare, (v) help and contact, and (vi) other information, as shown in Figure 1.

Trip Planner: The trip planner includes seven indicators. It should allow journey planning between the various origins and destinations of all public transport modes. It should provide real-time arrival and departure information, feeder service availability, and flexibility for date and time inputs. It must display full-day service availability and information on points of interest in the city.

Status Update: The five indicators for the status updates component should inform users about schedule disruptions, service reductions (for instance, decreased frequency or route numbers), and real-time closures. Traffic information such as delays, closures, speeds, and crossing times should be available via webcasts or traffic snapshots. Real-time parking availability and charges should also be included.

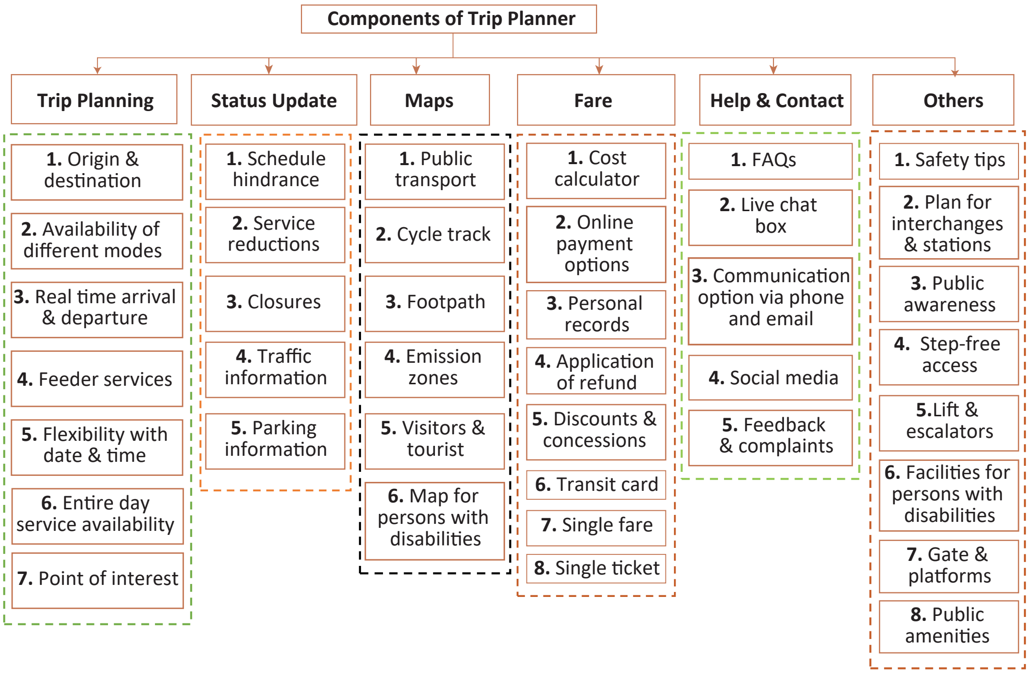
Maps: The maps component should feature six indicators, including displaying operational transport routes, cycle tracks, footpaths, and emission zones. They should also include tourist maps in multiple languages and maps designed for persons with disabilities, such as audio maps.

Fare: The fare component should have eight indicators, including fare information, trip cost calculators, personalised payment histories, refund facilities, discount details, transit card information, and single-ticket systems.

Help and Contact: The help and contact component should include five indicators: FAQs, live chat, contact details, social media links, and feedback reporting.

Other Information: The other information component should encompass eight indicators covering safety tips, transit interchange plans, accessibility for people with disabilities, transit gate/platform details, and public amenities such as ATMs and toilets.

Figure 1: Framework for Trip Planner Evaluation



Source: Author's own.

Evaluating the Performance of Trip Planners

An assessment of the performance of trip planners across 25 cities globally (10) was conducted using a checklist comprising 39 binary questions (Yes/No), as presented in Table 1.

Table 1: Questionnaire to Evaluate Trip Planners' Performance

Component		Questions for indicator	YES	NO
TRIP PLANNER	Q.1	Does the trip planner allow passengers to plan their trip by entering different origins and destinations?		
	Q.2	Does the trip planner incorporate all the available public modes of transport?		
	Q.3	Is real-time information regarding arrival and departure timings of transit units available?		
	Q.4	Does the trip planner display information regarding available feeder services at the transit stop?		
	Q.5	Does the trip planner allow future trips to be planned with respect to the intended travel date and time?		
	Q.6	Does the trip planner showcase service availability for an entire day?		
	Q.7	Does the trip planner include information regarding important points of interest in the city?		
STATUS UPDATE	Q.1	Is information regarding schedule hindrances of different public modes of transport available on the trip planner?		
	Q.2	Is information regarding service reduction displayed in real-time on the app?		
	Q.3	Is real-time information about the closure of different public transport services available on the trip planner?		
	Q.4	Is real-time traffic information on major intersections and roads (such as delays, closures, webcasts, speed, and crossing time) available on the trip planner?		
	Q.5	Is information about real-time parking availability and parking charges available on the trip planner?		
MAPS	Q.1	Are operational maps of public transport services in the city available on the trip planner?		
	Q.2	Are maps of cycle tracks across the city available on the trip planner?		
	Q.3	Are maps of footpaths across the city available on the trip planner?		
	Q.4	Is the emission (pollution) zone map available on the trip planner?		
	Q.5	Are visitor and tourist maps available on the trip planner?		
	Q.6	Does the trip planner include any maps to assist persons with disabilities (for instance, audio maps)?		

Component		Questions for indicator	YES	NO
FARE	Q.1	Does the trip planner have a cost calculator?		
	Q.2	Does the trip planner have an online payment facility?		
	Q.3	Does the trip planner include a record of payment history?		
	Q.4	Does the trip planner include a facility to apply for a payment refund?		
	Q.5	Does the trip planner provide information about discounts and other concessions?		
	Q.6	Is information about transit cards available on the trip planner?		
	Q.7	Is a single fare facility available on the trip planner?		
	Q.8	Is a single-ticket facility available on the trip planner?		
HELP AND CONTACTS	Q.1	Does the trip planner have a frequently asked questions section?		
	Q.2	Does the trip planner include a live chat option?		
	Q.3	Are multiple communication details (physical address, phone number, and email) available on the trip planner?		
	Q.4	Are social media links for easy communication available on the trip planner?		
	Q.5	Does the trip planner include an option to provide feedback and record complaints?		
OTHER INFORMATION	Q.1	Does the trip planner provide tips for passengers to travel safely?		
	Q.2	Does the trip planner provide information about interchanges and stations with detailed signs and markings?		
	Q.3	Does the trip planner contain information for public awareness on public transport?		
	Q.4	Does the trip planner include information about step-free access to transit options to enable easy movement of passengers?		
	Q.5	Does the trip planner provide information about lifts and escalators at stations?		
	Q.6	Does the trip planner provide information on facilities for persons with disabilities?		
	Q.7	Is information regarding gates and platforms of transit stops available on the trip planner?		
	Q.8	Does the trip planner provide information about public amenities (such as ATMs, public toilets, shopping, and so on) at transit stops?		

Source: Author's own.

The evaluation involved analysing each city's actual trip planners, both web-based and mobile applications. For each feature identified in the framework, the trip planner was awarded a score of 1 if the feature was present, and a score of 0 if absent. The overall score for each trip planner was determined by summing the individual scores. The maximum possible score for any trip planner was 39 (a maximum of seven for trip planner, five for status update, six for maps, eight for fare, five for help and contacts, and eight for other information), while the minimum was 0.

Table 2 summarises the performance evaluation results. The microscopic evaluation of trip planners across various categories indicates that London achieved the highest performance in the ‘maps’ category (attaining a score of 6/6), while in the fare category, New York excelled with a perfect score (8/8). London and Paris demonstrated their performance in the ‘help and contacts’ category (each securing 5/5). Notably, no city achieved a perfect score in the categories of ‘trip planner’, ‘status update’, and ‘other information’. However, Mumbai and New York emerged as the top performers in the ‘trip planning’ category (each scoring 5/6), whereas Paris achieved the highest score in the ‘other information’ category (7/8).

Table 2: City-Wise Trip Planner Scores (Across Six Components)

City Name	Trip Planner							Status Updates					Maps						Fare								Help and Contacts					Other information								City Score
	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6	7	8	1	2	3	4	5	1	2	3	4	5	6	7	8	(Out of 39)
Surat (11)	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	10
Vadodara (12)	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Kolkata (13)	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	9
Nasik (14)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
Nagpur (15)	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	4
Chennai (16)	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Chandigarh (17)	1	0	1	0	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	8
Bhopal (18)	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	12
Bengaluru (19)	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	7
Ahmedabad (20)	1	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	12
Kanpur (21)	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	6
Prayagraj (22)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2
Agra (23)	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	5
Varanasi (24)	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	6
Indore (25)	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	7
Amritsar (26)	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	8
Pune (27)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	4
Mumbai (28)	1	1	1	1	0	1	1	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	0	1	1	20
Bhubaneswar (29)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	6
Delhi (30)	1	0	1	1	0	1	1	0	1	1	0	1	1	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	0	0	1	1	1	0	22
London (31)	1	1	1	0	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	33
Singapore (32)	0	1	1	0	0	0	0	0	1	1	0	0	1	1	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	10
Hong Kong (33)	1	1	0	1	1	0	1	1	1	1	1	0	1	1	0	0	1	0	1	0	0	0	1	0	1	1	0	0	1	0	0	1	0	1	0	0	1	0	1	21
Paris (34)	1	1	1	0	1	1	0	1	1	1	1	0	1	0	0	0	0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	28
New York (35)	1	1	1	1	1	1	0	1	1	1	0	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	0	0	26

Source: Author's analysis.

The macroscopic evaluation of these trip planners reveals that London outperformed all international cities with a score of 33 out of 39, while Delhi has the best-performing trip planner in India (22/39) followed by Mumbai (20/39). Based on their scores, the trip planners can be categorised as 'very good', 'good', 'average', 'poor', and 'very poor' (see Table 3).

Table 3: Trip Planner Performance

Trip planner performance	Range	Name of the city
Very Good	32-39	London
Good	25-32	Paris, New York
Average	17-24	Mumbai, Delhi, New York
Poor	9-16	Surat, Kolkata, Bhopal, Ahmedabad, Singapore
Very Poor	0-8	Vadodara, Nasik, Nagpur, Chennai, Chandigarh, Bengaluru, Kanpur, Prayagraj, Agra, Mathura, Varanasi, Indore, Amritsar, Pune, Bhubaneswar

Source: Author's analysis.

The Way Forward

Large metropolitan cities such as Mumbai and Delhi exhibit a relatively high degree of integration in terms of information systems. In contrast, Kolkata, despite being comparable in scale and significance to these metropolitan cities, demonstrates an inadequate integration of information systems. Among the Indian cities analysed, the most deficient aspect pertains to the 'other information' component, which encompasses details on amenities, station facilities, and related services. This is followed by the availability of real-time status updates, which are accessible only in a limited and partial form in seven out of the 20 cities studied.

Several critical measures are required to enhance the efficacy of urban transport planning applications. Establishing a standardised template for trip planners that is harmonised across web- and mobile-based platforms across all Indian cities is essential to ensure uniformity and consistency and provide a seamless user experience. Furthermore, promoting these applications through social media and other outreach platforms is crucial to increase user awareness and accessibility. Such initiatives will contribute to the widespread adoption of trip planners, ultimately improving the efficiency and usability of urban transport systems in Indian cities.

Moreover, incorporating real-time data on vehicle arrivals, departures, and delays can significantly improve user experience by providing accurate and up-to-date scheduling information. A comprehensive integration of multimodal transport options, including buses, metro, and last-mile connectivity solutions, can facilitate seamless route planning. Furthermore, including features such as fare estimations and accessibility information for individuals with disabilities and integrating these with digital payment systems can enhance user convenience. Additionally, localised support for multiple languages and offline functionality can broaden the application's accessibility. Prioritising user-friendly interfaces and robust data accuracy can foster increased adoption and efficiency.

Nandan Dawda *is a Fellow with ORF's Urban Studies Programme.*

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Multimodal Shared Mobility and Open Networks

Mohit Kalawatia and Balaje Rajaraman

India has witnessed exponential growth in population and urbanisation in recent years, leading to an unprecedented rise in the demand for the efficient and sustainable transportation of people and goods. In 2023, commuters in five major Indian cities spent about two hours commuting daily to and from work (1). Notably, over 90 percent of commuters use multiple transit modes (such as autorickshaws, buses, and metro trains) for daily travel (2).

With daily commuters expected to reach 480 million by 2031 (3), there is a pressing need to enhance public transit systems in urban areas. However, creating an integrated transit system remains a challenge, with public transit often divided between core public transit systems, such as metros and buses, and unorganised intermediate public transit options, such as autorickshaws, e-rickshaws, bike taxis, cabs, and private shuttles, which are essential for first- and last-mile connectivity (4). As cities expand and congestion becomes a pressing issue, India must embrace the concept of smart mobility. Innovative technology can transform the way people travel and commute, leading to an overall improvement in the quality of urban life.

Recognising this need, the Indian government has taken significant steps towards leveraging technology to promote smart mobility across the country. The National Urban Transport Policy (2014) promotes the concept of shared mobility, with a vision to move people and not vehicles (5). The National Data Sharing and Accessibility Policy promotes a technology-based culture of data management and data sharing and access (6). The government has also focused on transit-oriented development, aiming to create seamless, user-friendly transit solutions through coordination between public agencies and private stakeholders (7). Initiatives like the Atal Mission for Rejuvenation and Urban Transformation and Smart Cities Mission also reflect this commitment, leading to significant infrastructure investments (8).

The Open Network for Digital Commerce (ONDC) is a key initiative (9). This open network aims to accelerate the adoption of shared and public transportation by increasing discoverability, facilitating the exchange of critical information (such as schedules, ticket/ride availability, and live tracking), and enabling seamless multimodal transport by dissolving integration barriers between different modes of transportation. The ONDC's open architecture promotes interoperability and integration between various mobility service providers by providing standardised application programming interfaces (APIs), which allow different services to connect, exchange data, and transact. This simplifies the onboarding process for new mobility services, eliminating the need for each new player to integrate separately. As of September 2024, the ONDC’s mobility domain is active in 12 cities, facilitating over one million trips weekly via autorickshaws, cabs, metro rails, and city buses, with participation from 480,000 drivers, who have cumulatively completed 55 million trips and earned over INR 8.67 billion (US$103 million) in revenue (10).

The Indian government has made substantial investments in building smart cities and adopting intelligent transportation systems to further the ‘ease of living’ vision articulated by Prime Minister Narendra Modi (11). These efforts aim to enhance connectivity, optimise resource utilisation, reduce carbon emissions, and improve citizens' overall quality of life. By embracing smart mobility, India can unlock benefits, such as reduced traffic congestion, improved air quality, enhanced safety, and increased accessibility to transportation services.

Key Components of Seamless Mobility

A multidimensional approach focusing on first- and last-mile connectivity is crucial to accelerating the efforts to enhance the ease of living. Such an approach involves leveraging multimodal mobility solutions and promoting shared mobility.

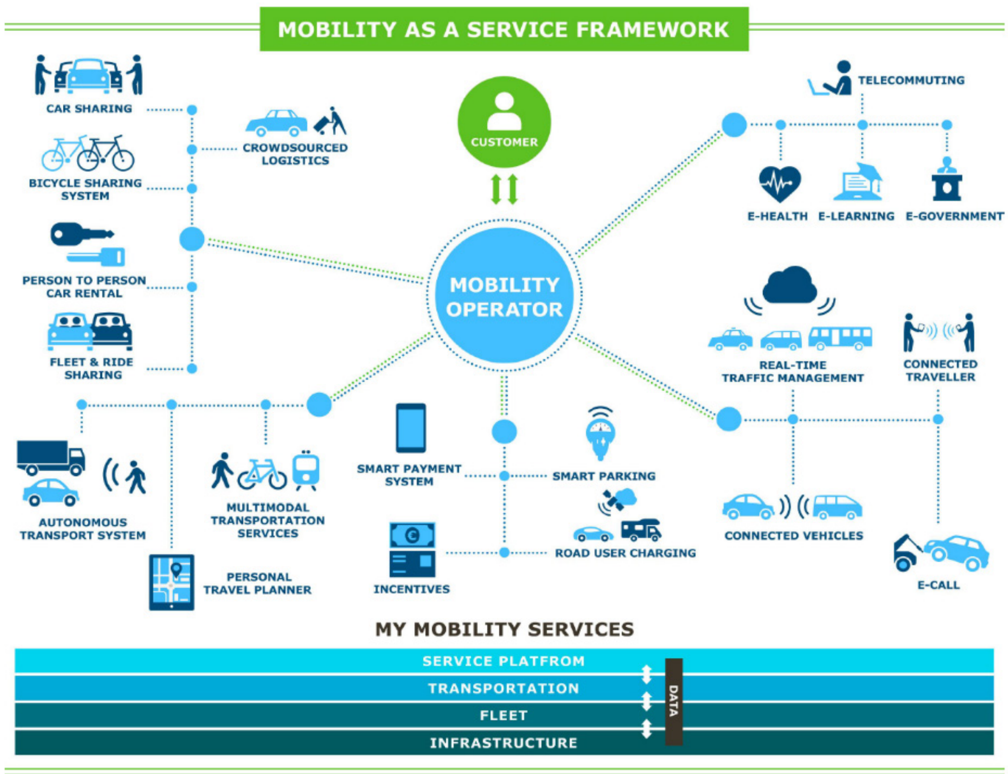
Multimodal Mobility: A key component of a multidimensional approach to smart mobility is integrating multimodal transportation systems. This involves creating seamless connections between transport modes, such as buses, trains, metro, taxis, and autorickshaws. By developing an interconnected network, commuters can choose the most efficient and cost-effective route for their journeys. Multimodal mobility enhances convenience, helps decongest roads, reduces travel times, and minimises environmental impact.

Shared Mobility: Shared mobility—focusing on ridesharing, carpooling, and bike-sharing—is crucial to reducing the vehicular burden on urban roads while providing effective first-mile and last-mile solutions.

Each shared car can remove nine to 13 vehicles from the road, significantly alleviating traffic congestion (12). Furthermore, the International Transport Forum's modelling for Lisbon showed that converting cars on the road to shared assets reduced congestion by 30 percent and freed up 90 percent of parking space (13). In India, NITI Aayog has highlighted ridesharing as one of the most effective means of shared mobility (14). By promoting shared mobility, cities can reduce traffic congestion and emissions and make transportation more affordable and accessible for all citizens.

Encouraging Mobility as a Service: Mobility as a service (MaaS) platforms are essential for integrating various transportation services into a single, accessible interface, allowing users to plan, book, and pay for multiple types of mobility services through one platform (15). Figure 1 shows the MaaS framework integrating different transport modes and transport-related services into a single, overarching, on-demand mobility service.

Figure 1: MaaS Framework



Source: Future Mobility Finland (16).

MaaS platforms can integrate public transit, ridesharing, car rentals, and more, offering a streamlined user experience. These platforms promote public and shared transport, reducing the dependency on personal vehicles, and alleviating traffic congestion and pollution. By adopting MaaS, urban areas can provide more flexible and efficient transportation options, catering to the diverse needs of commuters while supporting sustainable urban mobility.

Key Challenges

Implementing a multimodal shared urban mobility system faces several challenges, including data standardisation, interoperability, fare systems integration, and coordination among various stakeholders. Addressing these challenges is crucial to ensuring the success and widespread adoption of shared mobility solutions.

Data Standardisation: Data standardisation is a fundamental challenge in developing an integrated multimodal mobility system. Different transportation services often use disparate data formats and standards, making it challenging to integrate information seamlessly across platforms (17). The inconsistency in data formats leads to compatibility issues, necessitating a standardised approach to data collection and sharing. Moreover, the lack of common standards further impedes the creation of a cohesive mobility ecosystem, while ensuring data quality and accuracy remains crucial for making informed decisions.

Data Interoperability: Interoperability between transportation systems and services is vital for a seamless user experience. However, many transportation providers use proprietary systems that are not designed to communicate with other platforms, hindering interoperability (18). Overcoming technical barriers, such as differing communication protocols and software architectures, is essential for achieving interoperability. Additionally, robust frameworks are needed to protect data privacy and security while enabling the necessary data sharing.

Fare Systems Integration: Integrating fare systems across different modes of transport is critical for providing a unified and convenient user experience. However, it presents several challenges due to the diverse fare structures among transportation services, which complicates developing a unified payment system (19). Technological integration is required to implement a single-fare system that works across various modes of transport, necessitating significant investment and coordination. Ensuring user acceptance of the integrated fare system is also essential for its success, which requires comprehensive user education and support.

Coordination Among Stakeholders: The effective implementation of multimodal shared mobility requires coordination among various stakeholders, including government agencies, transportation providers, technology companies, and users. Fragmented governance and a lack of coordination can lead to inefficiencies and hinder the development of integrated solutions. Different stakeholders often have competing interests and priorities, making it challenging to reach a consensus on key issues (20). Navigating regulatory hurdles to ensure compliance with various laws and regulations adds further complexity to the coordination process.

Looking Forward

The focus of the mobility frameworks must shift from where vehicles are going to where individuals want to go. This new approach aligns with commuter expectations when choosing between private vehicles or public transit. Notably, commuters typically care less about routes, stops, and schedules, and more about reaching their destinations quickly, affordably, and sustainably.

Under the existing conditions, commuters in India have two options. First, they can use their private vehicles (such as cars or bikes), which they have already invested in and perceive as more economical than purchasing new tickets or shared mobility subscriptions. Alternatively, they can adapt to the constraints of the current transportation system, such as fixed schedules, and finalise first- and last-mile connectivity. From the commuter's standpoint, the existing transportation system can feel restrictive and inefficient.

Regulators will need to look beyond public transport systems like metros and buses by leveraging and encouraging systems that can adapt to individual commuters' needs. Several countries have started promoting and leveraging MaaS platforms to enable this.

For example, Berlin's Jelbi MaaS platform was launched by the state-owned transport company Berliner Verkehrsbetriebe in 2019 (21). Jelbi has been established as an arms-length, start-up type research and development organisation to ensure the agility to deliver the project quickly and focus on customer experience. Jelbi integrates all public transport and shared mobility options into one app, allowing Berliners to find, plan, book, and pay for all their trips. Its features include journey planning, real-time information, vehicle location and availability, payment processing, and multimodal journey time and cost comparisons. It currently covers public transport, e-scooter sharing, bike sharing, cargo bike sharing, car sharing, taxis, and e-moped sharing. More than 60,000 Berliners used the Jelbi app in the first year of its launch (22).

Similarly, implementing the ONDC's open network model has emerged as an attractive and timely alternative to fast-track the adoption of multimodal mobility services in India. The ONDC can dissolve barriers that typically hinder the integration of new players, allowing MaaS to thrive without the need for each new entrant to establish complex integrations.

The ONDC Network, powered by open APIs, present a transformative opportunity to address the challenges of implementing multimodal shared mobility solutions. By enabling seamless integration between diverse transportation modes, the ONDC facilitates the creation of a cohesive and user-centric mobility ecosystem. Open APIs allow different transportation providers, including public transit, ridesharing, and micro-mobility services, to connect and share data in real time, fostering interoperability and enhancing the user experience.

One of the primary benefits of the ONDC as an open network model is its ability to break the silos that traditionally separate different transportation systems. By standardising data formats and promoting transparency, open APIs enable various mobility services to work harmoniously, allowing commuters to plan, book, and pay for their journeys through a single interface.

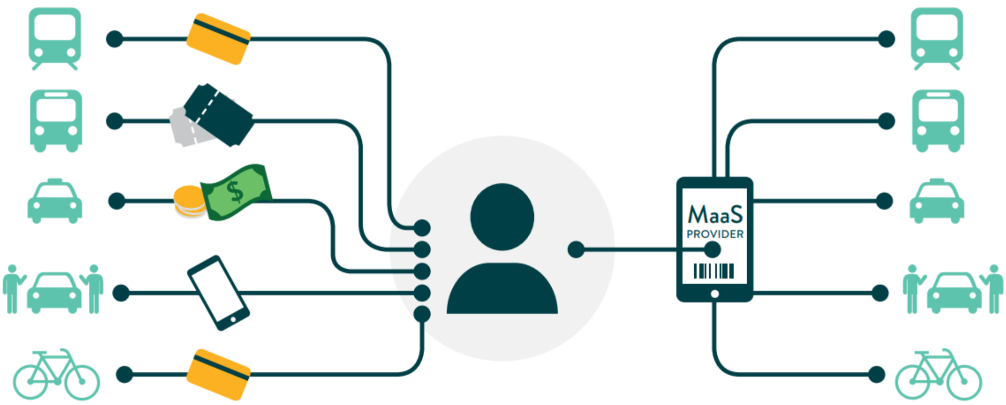
Instead of creating new data standards, policymakers should encourage transport players to adopt existing open data standards like the general transit feed specification (GTFS) and general bikeshare feed specification for scheduling. GTFS is an open data standard that allows transit agencies to share information about their services in a widely accessible format for various rider-facing applications. It is composed of two parts: GTFS Schedule and GTFS Realtime.

GTFS Schedule describes the structure of a transit system, including details about agencies, stops, routes, and trips, as well as service schedules, such as operating days, stop times, and service frequency. It can also include additional data like vehicle paths, transfers, fare information, text translations, and in-station navigation paths. GTFS Realtime provides live updates on transit operations, such as arrival time predictions, current vehicle locations, and service alerts. This component enhances the static data in the GTFS Schedule by delivering real-time information to users. These components enable a comprehensive understanding of transit services, covering scheduled and live updates.

This level of integration not only simplifies the travel experience for users but also optimises resource utilisation, reduces congestion, and lowers emissions, aligning with the broader goals of sustainable urban mobility.

To ensure smooth and efficient data standardisation, the ONDC has also developed agile connectors that enable ticket booking across metro systems, even when each uses different standards, thus overcoming a critical challenge in public transport integration.

Figure 2: Fragmented Transportation Scenario and MaaS



Source: International Association of Public Transport (23).

The ONDC also promotes innovation by providing developers and third-party service providers a platform to create new solutions that address specific mobility needs. By leveraging the data shared through open APIs, these innovators can build applications that offer personalised, efficient, and cost-effective transportation options. This approach not only empowers commuters by giving them more choices but also drives competition among service providers, ultimately leading to improved quality and affordability of mobility services.

Adopting the ONDC could significantly accelerate the transition in India's cities to a more integrated and sustainable transportation system that provides seamless scheduling, a single-window ticketing system across modes, and real-time or near real-time information sharing among transport operators. By supporting a multimodal approach prioritising first- and last-mile connectivity, the ONDC can help reduce the reliance on private vehicles, making urban transportation more accessible and equitable.

As India continues to invest in smart mobility initiatives, embracing open networks with open APIs will be key to unlocking the full potential of multimodal logistics, paving the way for a future where transportation is not just about moving vehicles, but about moving people efficiently, sustainably, and inclusively. The ONDC embraces an ecosystem-led approach that focuses on "what works at scale" instead of "scaling what works" (24).

Mohit Kalawatia *is Manager-Policy at the Open Network for Digital Commerce.*

Balaje Rajaraman *is Senior Manager, Network Expansion, at the Open Network for Digital Commerce.*

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Integrating Fares, Information, and Informal Transit

Partha Mukhopadhyay and Gurkirat Singh Juneja

Amid looming climate concerns, engineering a shift to public transport is now imperative. India, where car ownership is yet to increase substantially beyond the large metros, can achieve a modal shift from private to public transport. Prioritising information and fare integration across transport modes can help achieve this shift without compromising user needs.

The essay enumerates the types of fare integration and evaluates transport use in India, which is biased towards 'informal' or 'popular' modes, while the global focus is on formal modes. It concludes by charting a policy roadmap for a fast-urbanising India to optimise public transport use.

Fare Integration

Multiple rides are necessary when travel patterns are too dynamic for transport networks. With fare integration, multiple rides will not add to the cost and deter usage. It also avoids the inconvenience of multiple ticket purchases, which is, admittedly, becoming less relevant with the increasing use of digital and biometric payments.

Fare integration can be intra-modal (changing from one bus to another) or inter-modal (from bus to metro rail and vice versa). The intra-modally integrated metro and bus rapid transit (BRT) systems and all-day tickets are also a form of fare integration.

Integration can be unrestricted via a single flat fare, as it is in New York City (1). It can also be mode-independent (i.e., invariant for travel from A to B), irrespective of the mode. Fare integration can also be ride-independent (i.e., the number of transfers in a journey does not matter). Though the fare for transfers in distance-based modes may seem costly, they are more cost-effective because of their telescopic nature. For example, in the metro system, the fare from A to C is usually less than the sum of fares from A to B and B to C (2). Fare integration can also be mixed, as is in London, where initial transfers are costly but subsequent transfers are free due to a daily fare cap (the maximum daily amount transit systems can charge each user) (3).

All such existing fare integration practices require formal but not necessarily public provision. While fare integration with private provision is possible with specific types of contracts, it poses a challenge in countries like India, where commuters often prefer 'informal' or 'popular' transport modes, such as autorickshaws, and other modes of intermediate public transport that fulfil the formal public transport system's sizeable unmet demand. Therefore, practical fare unification that benefits commuters is possible only if all informal transport modes are brought into an integrated fare system.

Information Requirements

However, fare integration alone will not be beneficial if the connecting schedules are mismatched, with long and unpredictable transfer waiting times. While geo-tracking vehicles and using predictive traffic models can reduce the unpredictability related to the arrival of connecting transport with some degree of error, they need accurate information on travel patterns and interchange points, particularly during peak-hour commutes. Unlike user surveys, digital tickets that record origin, transfers, and destination generate reliable data to improve the network.

Transport Behaviour in Urban India

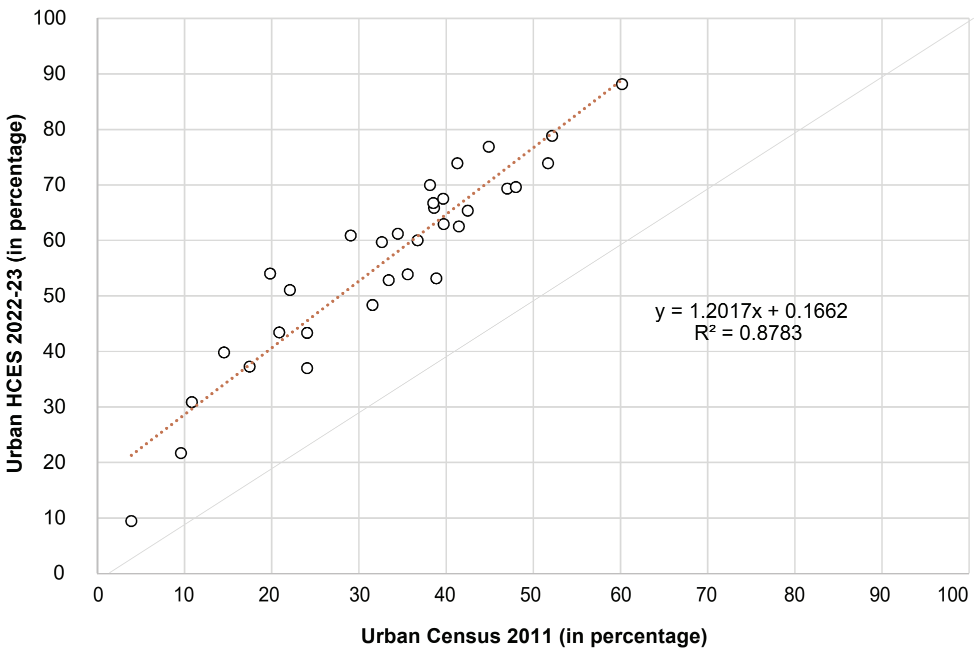
Based on data from the 2011 Census and the National Sample Survey Office's Household Consumption Expenditure Survey 2022-23 (HCES), Figure 1 (A and B) shows that car and two-Wheeler ownership has risen since 2011 levels, with several states ranking higher than the national urban average of 63.3 percent. Two-thirds of households in urban India now have access to private transport. Car ownership is growing evenly, while two-wheeler ownership is growing faster in states where it is already high.

Figure 1 (C and D) showcases the use and expenditure, respectively, on different modes for households with a private vehicle (measured as those who spend on fuel) and those without. The measure is given for those who use a given mode and those who only use the given mode to generate a multimodal index (4). Most households use multiple modes (see Figure 1 C). Further, even those with private vehicles use buses and trains for daily commutes (5), but do so less frequently than those without private cars. A high proportion of both groups use autorickshaws.

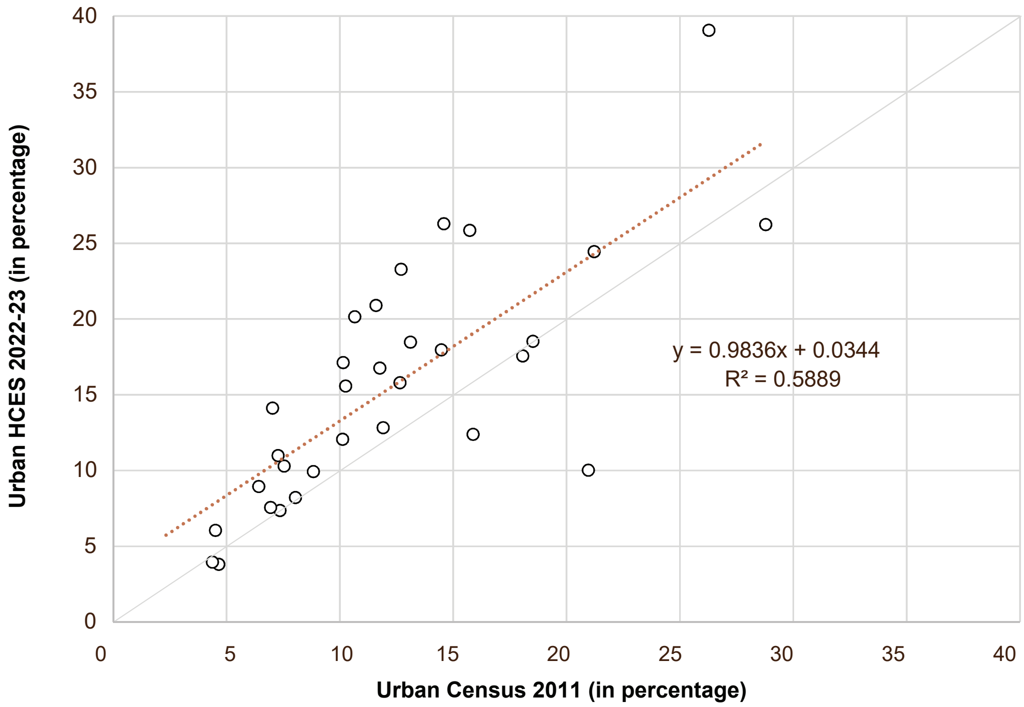
Vehicle-owning households spend almost three-fourths (73 percent) of their total transport expenditure on fuel. The largest share of non-fuel expenditure in these households is on school transport (see Figure 1 D). However, a high portion of expenditure is again on autorickshaws, even more for non-vehicle-owning households.

Figure 1: Two-Wheeler and Car Ownership (Based on Census 2011 and Household Consumption Expenditure Survey 2022-2023)

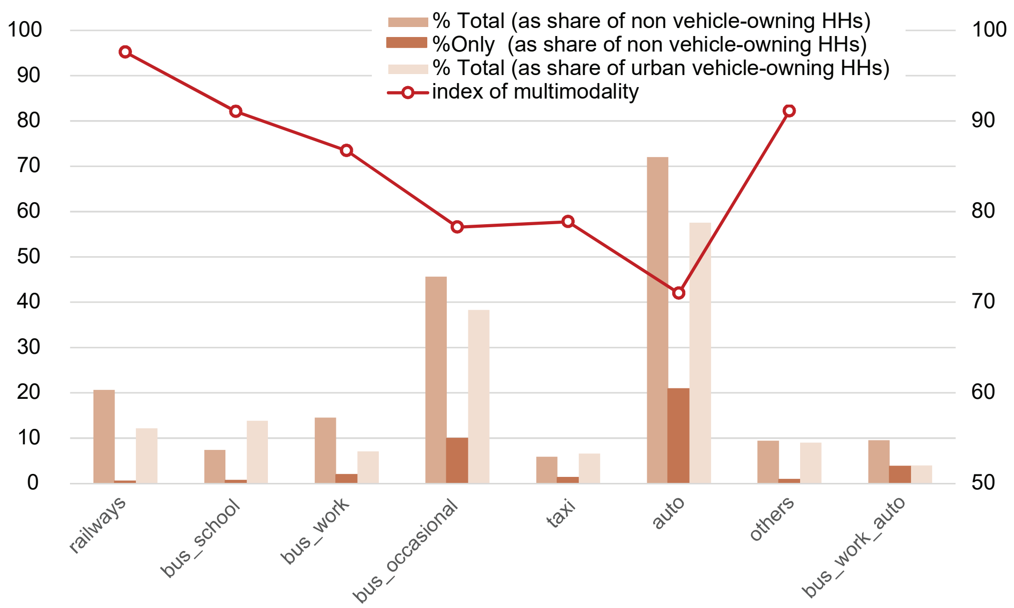
A: Two-Wheeler Ownership in Census 2011 and HCES 2022-23



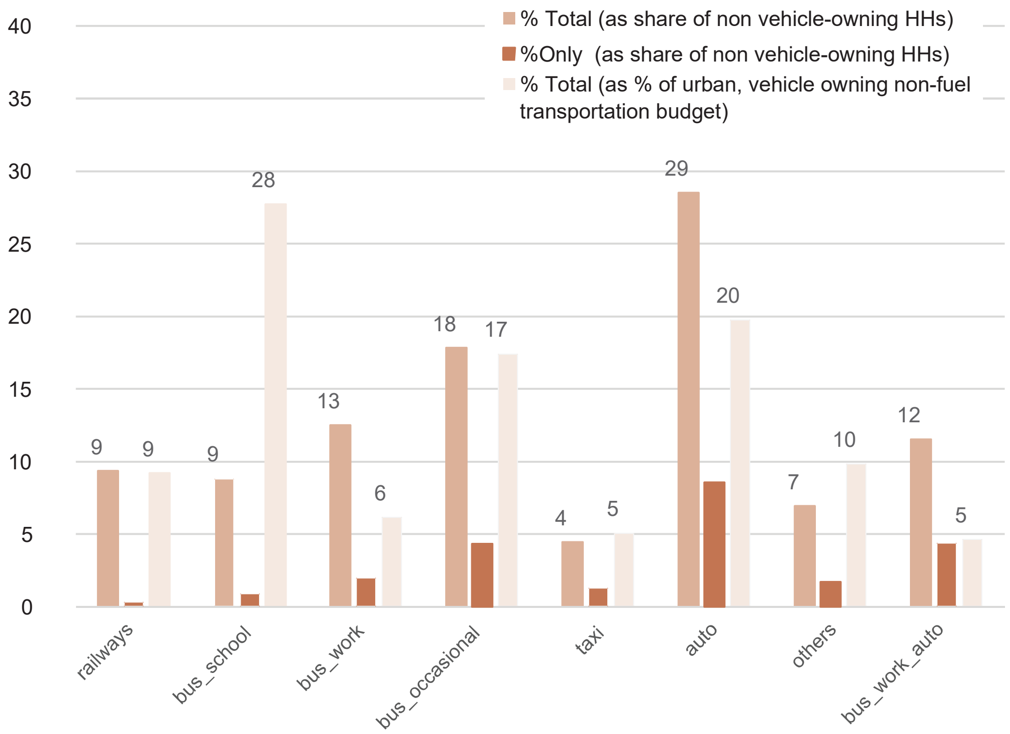
B: Car Ownership in Census 2011 and HCES 2022-23



C: Share of Urban Households Using Different Transport Modes



D: Urban Household Expenditure on Transport Node as a % of Non-fuel Transport Expenditure

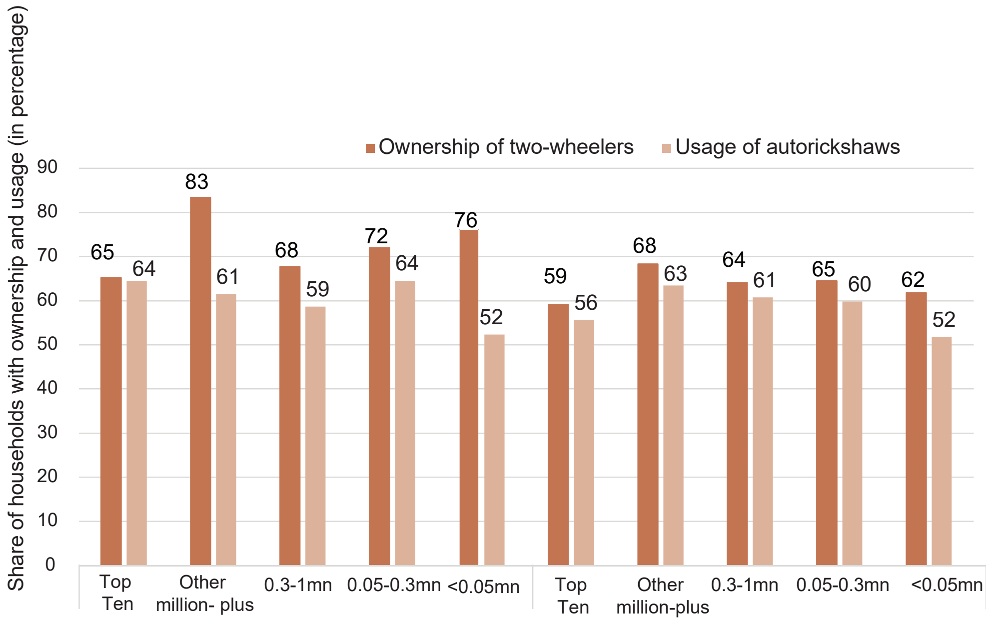


Sources (A, B, C, D): Census 2011 (6) and HCES 2022-23 (7). The HCES sample consisted only of car owners.

The authors thank Dr. Shamindra Roy for his help with this analysis.

Figure 2 showcases the two-wheelers ownership and autorickshaws usage across different city-size classes. Almost a third (31 percent) of India's urban population is in million-plus cities, and over half (54 percent) are in towns of less than 300,000. The mid-size cities between these two datasets account for the rest, about one-seventh (14 percent) of the total urban population. The National Sample Survey Office classifies households into affluent (about 1 percent) and non-affluent categories in all city-size classes. The ownership of two-wheelers is higher in affluent categories across city-size classes and is also high in the non-affluent categories. The high usage of autorickshaws across city-size categories also reflects a striking uniformity. Autorickshaws are likely to be a shared transport mode in all except the largest million-plus cities. Thus, any plan for a genuinely 'integrated multimodal transit system' in India must consider the enormous contributions of such 'informal' or 'popular' modes.

Figure 2: Two-Wheeler Ownership and Usage of Autorickshaws Across City-Size Classes



Source: Census 2011 (8) and HCES 2022-23 (9).

Global Experience

Technology has transformed transport over the past decade. Taxi aggregator apps such as Uber provide modal choice, fare certainty, and relative certainty on wait times, but are almost always for private travel (although two-wheeler taxis can be comparatively inexpensive, providing some benefit) (10).

Another significant technological change is digital ticketing, which generates critical data on travel patterns in addition to being more convenient for users and enabling them to prepay transport service providers, allowing for the better planning of routes and service frequency, as highlighted by Hong Kong's Octopus Card (11) and the use of digital ticketing data by Kerala State Road Transport Cooperation to improve public transport planning (12). Gender- and age-disaggregated data can also foster inclusive and equitable public transport services (13). The General Transit Feed Specification (GTFS) (14), a common standard, helps integrate multiple service providers and helps to evaluate the performance of public transport services in terms of service quality in peak and off-peak hours, travel time reliability, and more (15).

Technology Leapfrog

Low-income countries can leapfrog in matters of transport-related technology (16). Kenya's Digital Matatus (17) project (18) has generated a public map of routes, stops, and schedules similar to formal bus systems via community action. Cashless payment modes that are convenient for users and safer for operators are widely accepted (19), even in the 'popular'/ 'informal' transit modes. Kenya is also introducing digital ticketing to enhance the commuter experience further. Open data standards, like GTFS and low-cost GPS, make it possible to improve the predictability of wait times and push that information to the users. However, some privacy concerns (20) persist since few countries have data protection laws (21). Furthermore, digitalisation can also exclude certain sections (22), especially the poor and elderly (23).

Some countries have even tried to integrate the 'popular'/ 'informal' transit with interventions like BRT systems (24), but such integration can be "drastic" (25) (26). However, such efforts have mainly incorporated current transit operators into the 'formal' systems to preserve livelihoods. Consequently, they have replaced one system with another, losing vital features of the 'popular'/ 'informal' transit (27).

Frequency and Vehicle Size

Information about service frequency is critical, especially when service is intermittent. Larger the 'popular'/'informal' vehicles need a minimum passenger count per trip for viability. During off-peak hours, this reduces the frequency, which, in turn, reduces the number of users, enabling a vicious cycle. However, smaller vehicles could provide high-frequency service in big cities, reducing the need for frequency information.

Experience with Fare Integration

Digital payments have supported several variations, including time-varying fares. London (28) and Paris (with the new Navigo Liberté+) (29) use a daily cap, and New York City uses a weekly cap (30). Prices vary from a cap of £8 (about US$10) a day for London (in zones 1 and 2 only) to £49 (about US$62) a month for all public and regional transport in Germany. Singapore has no cap but allows five free transfers in a single journey (31). Sao Paulo's Bilhete Único (one ticket) offers transfers between rail and bus, which is typically the case in most cities having such facilities (32). Limiting the use of the same card or device can foster integration among cards and other digital payment modes. Inter-modal fare integration is uncommon in developing countries, though some cities like Delhi allow stored-value cards (33) across modes (34).

The Challenge of Integrating 'Popular' Modes

The real challenge lies in integrating 'popular transport' modes. For example, bolekaja in Nigeria, tuk-tuk in Thailand, becab in Indonesia, peruas in Brazil, jeepneys in the Philippines, and microbus in Vietnam cater to the daily commute needs of a large population (35). Given their market-oriented approach and use of manoeuvrable vehicles, these modes serve locations that may be unserved or underserved by public transport, solving the first- and last-mile connectivity problems for most commuters.

Many popular transport modes in India run on cleaner fuels, such as LNG/CNG (autorickshaws) or electricity (e-rickshaws) (36). Shared services using such vehicles provide a higher average passenger-km per litre than buses due to the high average occupancy. Autorickshaws and e-rickshaws are also easier to electrify because of their relatively quick charging time. Due to their high frequency and the ability to pick up and drop off passengers closer to their origins and destinations, they can wean people away from private transport. A 2019 study found that 37 percent of arrivals and 32 percent of departures from stations in Delhi were by informal transit, such as autorickshaws (37).

While 'popular'/ 'informal' transit is rarely integrated with formal modes or organised, some cities have been able to do so. In Kolkata, autorickshaws are 'self-organised' in a route network (with the vehicles displaying route numbers). Users can travel across the city, paying separate fares, offering users a high-frequency commute alternative with assured seating. Major bus and metro stations in Kolkata also have autorickshaws, and over 70 percent of the city's households are less than 500 meters from an autorickshaw route (38). However, though the 2019 amendments to the Motor Vehicles Act enabled the formalisation of such systems as licensed networks, the network's regulation and fares continue to exist in a liminal space as a modus vivendi between police and associations of autorickshaw drivers.

Fare integration can also be achieved by making one or all modes free. Over 100 cities globally run free bus services (39). Women can now travel free on buses in many Indian cities. Further, in India, two-wheeler users will likely be more attracted to use free buses. To further incentivise such a shift, a public transport cess, equivalent to a monthly loan repayment fee, can be levied on each private vehicle. Bus services can be procured using a gross cost contract model such as that used in Delhi or the PM e-bus SEWA scheme for electric buses. The operator will meet capital and operating costs not from passenger fares but through a payment (broadly, a per km amount set by bidding) from the government, fully financed by revenues from the public transport cess.

The Way Forward

Given this scenario, what kind of fare and information integration will engineer a shift to public transport? Larger cities can consider the following interventions:

- Integrating metro rail (where present) fares with daily caps (INR 50, or about US$0.50) with free travel on holidays,
- Providing a free bus system funded by a public transport cess, and
- Allowing shared autorickshaw routes with regulated fares, like in Kolkata, to lure private transport users, especially two-wheeler users, to public transport.

All uses need a digitally verifiable method, like a QR code or card. Information from this digital card/code could help optimise existing bus routes and metro extensions. Free bus travel and a daily cap on metro rail, coupled with low, shared autorickshaw fares, will keep total costs low. Smaller towns can experiment by providing high-frequency connections to and from key destinations, using gross cost contracts for autorickshaws or small vehicle routes.

These components exist—in part or wholly—in many cities. They must be brought together everywhere, or as a start, in the million-plus cities. Over time, as feasible and sensible, the vehicles (buses, autorickshaws, and e-rickshaws) could become electric, as a bid condition of the gross cost contracts. This will create an integrated, sustainable, and functioning public transport system across metros and smaller cities.

Partha Mukhopadhyay *is a Senior Fellow at the Centre for Policy Research, New Delhi, India.*

Gurkirat Singh Juneja *is a Research Associate at the Centre for Policy Research, New Delhi, India.*

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Towards a Common Fare Policy for Metro Rail and Buses in Indian Cities

Aditya Rane

Public transportation is pivotal to urban mobility. It connects citizens with essential services such as jobs, education, healthcare, and recreation. As cities expand, the need for efficient, affordable, and seamless public transport becomes even more critical. However, in many Indian cities with metro rail systems, disparate fare structures between buses and the metro present a significant challenge, making multimodal travel costly and inconvenient (1).

Fare disparities can be addressed by a Unified Metropolitan Transport Authority (UMTA), which can play a transformative role in fostering a common fare policy and structure across different public transport modes. As a nodal agency, the UMTA can coordinate the efforts of multiple stakeholders, including municipal corporations, metro operators, and state/urban local body-run bus services, to streamline fare policies and align them with broader urban mobility goals. By integrating fares, the UMTA can ensure that public transport becomes affordable and user-friendly, encouraging higher ridership. Although India's National Urban Transport Policy recommended establishing UMTAs in all million-plus cities in 2006 (2), only a few cities, such as Chennai, Hyderabad, Mumbai, Pune, Vijaywada, Jaipur, Lucknow, and Kochi, have done so (3).

This essay examines the significance of fare integration across public transport modes. It analyses the current fare structures, draws insights from case studies of other cities, and explores the challenges of implementing a unified fare policy. It highlights the importance of universal travel passes and welfare schemes to ensure equitable access, especially for vulnerable commuters. Moreover, it emphasises the UMTA's role in regulating fares and achieving a unified and user-friendly public transport system based on best practices from Pune and Mumbai in Maharashtra, Tamil Nadu, and other global models.

Absence of a Common Fare Policy: The Pune Example

The Pune Metropolitan Region relies on the Pune Mahanagar Parivahan Mahamandal Ltd. (PMPML) buses (a bus rapid transit system) and the Pune Metro to meet its public transportation needs. The PMPML operates a fleet of 2,079 buses, serving over 1.3 million passengers daily (4). Its broad coverage and affordable fare structure make buses a critical part of Pune's mobility network. In contrast, as explained on its official website, the Pune Metro covers 33 km across its corridors, with plans to expand further. Despite its efficiency, the metro currently caters to around 150,000 daily passengers, with its ridership expected to grow as the network expands (5). However, the fare disparity between the two modes discourages many passengers from switching to the metro for regular travel, highlighting the need for fare integration across the two systems (see Table 1).

Table 1: Fare and Concession Comparison Between PMPML Buses and Pune Metro

PMPML Daily Pass charges		Pune Metro Daily Pass charges	
Distance (in Km)	**Bus Fare (AC, Non-AC)**	**Distance (in Km)**	**Charges**
Full-day unlimited travel within Pune and Pimpri Chinchwad City	INR 50 (US$$0.59)	Full-day unlimited travel within Pune and Pimpri Chinchwad City	INR 100 (US$1.18)
PMPML regular fare		**Pune Metro fares**	
Distance (in Km)	**Bus Fare (AC, Non-AC)**	**Distance (in Km)**	**Fare**
2	INR 5 (US$0.05)	2.7	INR 10 (US$0.12)
6	INR 10 (US$0.12)	5.9	INR 15 (US$0.18)
10	INR 15 (US$0.18)	9	INR 20 (US$0.24)
14	INR 20 (US$0.24)	15.9	INR 25 (US$0.29)
20	INR 25 (US$0.29)	18.7	INR 30 (US$0.35)
26	INR 30 (US$0.35)		
32	INR 35 (US$0.41)		
38	INR 40 (US$0.47)		

PMPML regular fare		Pune Metro fares	
Distance (in Km)	Bus Fare (AC, Non-AC)	Distance (in Km)	Fare
42	INR 45 (US$0.53)		
48	INR 50 (US$0.59)		
54	INR 55 (US$0.65)		
60	INR 60 (US$0.71)		

Sources: Pune Mahanagar Parivahan Mahamandal Ltd (6) Pune Metro Rail Project (7).

The PMPML provides daily, monthly, and quarterly passes at discounted rates, significantly reducing commuting costs. For example, the PMPML daily pass costs INR 50 (US$0.59), allowing passengers unlimited travel across the city on AC and non-AC buses, while the Pune Metro's daily pass costs INR 100 (US$1.18) for unlimited travel, effectively doubling the cost for similar mobility.

Table 2: Fare and Concession Comparison Between PMPML Buses and Pune Metro

Category	PMPML	Pune Metro
Students	100 percent subsidy for schools managed by Pune Municipal Corporation), 75 percent discount for private schools under Pune Municipal Corporation	30 percent discount
Senior Citizens	50 percent discount for senior citizens (65+ years)	Not Applicable
Persons with Disabilities	Free passes for select disabilities, 50 percent discount for the visually impaired with one companion	Not Applicable
Freedom Fighters and National Awardees	Free travel passes	Not Applicable

Sources: Pune Mahanagar Parivahan Mahamandal Ltd (8), Pune Metro Rail Project (9).

The PMPML offers fare concessions of 50 percent to senior citizens and students, and 75 percent for people with disabilities with support from the Pune and Pimpri Chinchwad municipal corporations, making bus travel more inclusive and accessible for these vulnerable groups. However, such concessions are not yet available on the Pune Metro, further restricting access for those who rely on affordable public transportation. The concessions offered to the weaker sections of society, such as free or heavily subsidised travel in buses, play a crucial role in promoting mobility.

However, even these concessions are not extended to metro services, making metro travel less accessible for such groups and potentially limiting their ability to benefit from multimodal transport options.

A common fare policy across the PMPML buses and Pune Metro, offering equal fare concessions and travel passes on both modes, can promote inclusivity and encourage multimodal travel. Despite the high fare structure and no concessional travel option for any vulnerable group, metro operations require viability gap funding (due to the enormous capital investments in metro construction) to sustain operations. Aligning fare structures and concessions through a common policy will make the metro more accessible without compromising financial sustainability.

Financial Impact of Shifting from Bus Rapid Transit to Metro: Challenges for Vulnerable Users

A recent study (yet unpublished) conducted by the Institute for Transportation and Development Policy (ITDP) India involving a survey of PMPML users reveals that commuters use these services for around 22 km daily on average. If these users were to shift to the Pune Metro, their daily travel costs would increase significantly.

Table 3: Monthly Travel Cost Comparison Between PMPML Buses and Pune Metro

Particulars	PMPML	Metro
Daily round-trip cost	INR 30 (US$0.35)	INR 50 (US$0.59)
Last-mile connectivity by bus/shared autorickshaw (30 percent of metro fare)	INR 0	INR 15 (US$0.18)
Total daily round trip cost	INR 30 (US$0.35)	INR 65 (US$0.77)
Monthly travel cost	INR 750 (US$8.84)	INR 1,625 (US$19.16)
Percentage of income spent on travel (₹5,000-₹20,000 income group)	6 percent	13 percent

Source: ITDP India (10).

Table 3 shows how the monthly travel cost for PMPML users is INR 750 (US$8.84) on average, significantly lower than the INR 1,625 (US$19.16) for metro commuters travelling the same distance. The higher cost of using the metro is due to higher base fares and the added expenses of last-mile connectivity (such as share-auto or feeder buses).

For low-income commuters, students, and senior citizens—who rely on affordable public transport—the significant cost disparity discourages a shift to the metro despite its faster and more reliable service. Implementing common fare policies, integrated ticketing, or universal travel passes covering both modes could mitigate these costs, ensuring equitable access and seamless multimodal transport.

The Case for Fare Integration and Universal Passes

To encourage the use of multimodal transport and ensure equitable access, Pune and other Indian cities must implement a universal fare policy that aligns bus and metro fares. The Pune Unified Metropolitan Transport Authority, established in 2019 (11), must serve as the central body to establish an affordable fare structure for the bus and metro systems that implements common welfare schemes across both modes. Universal travel passes for both modes will significantly reduce travel costs for regular users. Furthermore, extending bus welfare schemes, such as concessions to students, senior citizens, and persons with disabilities, to metro services will promote affordability across both modes.

A common fare policy, universal passes, and fare integration will also eliminate the additional cost of separate tickets for different legs of a journey.

This will:

- Lower the overall travel cost, including last-mile connectivity
- Encourage seamless intermodal travel, benefiting commuters who need bus and metro services
- Increase ridership for both transport modes, improving the sustainability of public transportation in the city and region.

Success Stories: Mumbai, Tamil Nadu, and Singapore

Mumbai: Alignment Between Bus and Suburban Rail Fares

Mumbai offers a compelling example of fare alignment between the Brihanmumbai Electric Supply and Transport (BEST) bus network and the Mumbai Suburban Railway to form a robust and affordable public transportation system. The Mumbai Suburban Railway is widely regarded as the city's lifeline, spanning 465 km (12) and operating over 3,000 train services daily (13). The system is used by over 7.5 million passengers daily (14). BEST buses provide feeder services to all suburban rail stations to complement this rail network. BEST, which operates a fleet of 3,800 buses, ensures seamless last-mile connectivity, enabling commuters to access railway hubs conveniently (15). Nearly 90 percent of BEST services provide feeder connectivity to Mumbai's suburban railway stations.

Suburban railway and BEST buses maintain low base fares starting at INR 5 (US$0.059), ensuring affordability for a broad section of commuters. While fare structures diverge beyond the initial stages, with varying increments between the two systems, BEST buses effectively complement the suburban railway by serving as feeders for shorter commutes. Commuters rely on BEST buses for first- and last-mile connectivity and use suburban trains for longer journeys. This synergy between modes ensures that the low base fares align well with travel patterns, facilitating seamless, cost-effective commutes across Mumbai's public transport network (see Table 4).

Table 4: Fare Comparison Across Mumbai's Public Transport Modes

BEST Buses		Mumbai Suburban Rail	
Distance (in Km)	Non-AC Bus Fare	Distance (in Km)	II Class Fare
5	INR 5 (US$0.05)	9	INR 5 (US$0.05)
10	INR 10 (US$0.12)	28	INR 10 (US$0.12)
15	INR 15 (US$0.18)	53	INR 15 (US$0.18)
>15	INR 20 (US$0.24)	78	INR 20 (US$0.24)
		94	INR 25 (US$0.29)
		119	INR 30 (US$0.35)

Sources: Brihanmumbai Electric Supply and Transport Undertaking (16), Amazing Maharashtra (17).

Both modes offer base fares starting at INR 5 (US$0.059), with the maximum fare capped at INR 30 (US$0.35), promoting affordability even for long-distance travel (see Table 4). Additionally, daily unlimited travel passes for both services are available for INR 50-INR 60 (US$0.59-US$0.71), allowing commuters to travel across the city for about INR 100 (US$1.18) while seamlessly switching to buses and suburban railways. Concessions for students, people with disabilities, and cancer patients are provided on both services, further enhancing accessibility.

Tamil Nadu: Uniform Fare Across State and Private Buses

The fares for Tamil Nadu State Transport Corporation (TNSTC) buses and private stage carriage buses are structured under a common fare policy regulated by the state's transport department. Table 5 illustrates the range of fares: starting at INR 4 (US$0.047) for 2 km, increasing gradually to INR 18-INR 28 (US$0.21-US$0.33) for 40 km, depending on the type of service—ordinary (regular service within city and villages), town (intracity services), express (limited stop/non-stop service between city and villages/town). This fare parity ensures that passengers can access public and private buses without worrying about fare disparities (18). The consistent fare structure simplifies travel across modes and operators, providing affordable, multimodal access for passengers.

Table 5: Fare Structure Across Public and Private Bus Services

Distance (Km)	Ordinary	Town	Express
2	INR 4 (US$0.04)	INR 5 (US$0.05)	INR 6 (US$0.07)
4	INR 5 (US$0.05)	INR 6 (US$0.07)	INR 8 (US$0.09)
10	INR 8 (US$0.09)	INR 9 (US$0.11)	INR 12 (US$0.14)
20	INR 13 (US$0.15)	INR 14 (US$0.17)	INR 20 (US$0.24)
40	INR 18 (US$0.21)	INR 19 (US$0.22)	INR 27 (US$0.32)

Sources: Arasu Bus (19).

Singapore: Seamless Integration Through Distance-Based Fares

Singapore's public transportation system is known for its integrated, distance-based fare policy across mass rapid transit (MRT), light rail transit (LRT), and bus services. A single fare system applies across these modes, ensuring that passengers are charged based on the total distance travelled, irrespective of the number of transfers between buses and trains (20). This multimodal fare policy eliminates additional costs for mode switches, making it easier and more affordable for commuters to use a combination of services in a single journey.

Singapore ensures inclusivity in its fare structure by offering uniform concession schemes across all three transport modes. The key groups eligible for these discounts are senior citizens (reduced fares for those aged 60 and above); persons with disabilities (special fare concessions to promote accessibility); students (discounted fares to support affordable travel for school and college students); and workfare recipients (additional fare relief as part of Singapore's Workfare Transport Concession Scheme to help low-income earners).

Table 6: Fare Structure for Singapore's MRT, LRT, and Bus Services Based on Distance Travelled

Distance (km)	Adult Fare	Senior/Disabled Fare	Student Fare
0 - 3.2	INR 1.09 (US$0.81)	INR 0.65 (US$0.49)	INR 0.48 (US$0.36)
3.3 - 6.2	INR 1.69 (US$1.26)	INR 1.10 (US$0.82)	INR 0.78 (US$0.58)
6.3 - 9.2	INR 2.09 (US$1.56)	INR 1.32 (US$0.99)	INR 0.94 (US$0.70)
9.3 - 15.2	INR 2.52 (US$1.88)	INR 1.60 (US$1.19)	INR 1.15 (US$0.86)
15.3 - 19.2	INR 2.64 (US$1.97)	INR 1.95 (US$1.46)	INR 1.25 (US$0.93)
Above 23.2	INR 2.97 (US$2.22)	INR 2.10 (US$1.26)	INR 1.32 (US$0.99)

Sources: Land Transport Authority (21).

The consistent fare policy and concession system across public transport modes ensure that vulnerable groups have affordable access to the entire transport network without restrictions on the mode of travel.

Singapore's Land Transport Authority (LTA) is a single regulatory body that governs and plans public transport. It is responsible for setting fare structures, monitoring compliance, and ensuring financial sustainability while balancing affordability. Under the LTA's oversight, Singapore's transport system operates efficiently, promoting seamless travel through unified payment solutions like the EZ-Link and NETS FlashPay cards (22). This governance model ensures that fare policies remain consistent, transparent, and commuter-friendly across the network.

This model of centralised fare regulation and unified payment systems allows commuters to use a single travel card for all modes, fostering cashless, multimodal travel while maintaining affordability and accessibility across Singapore's public transport system.

Conclusion and Recommendations

Indian cities face the dual challenge of managing fragmented public transport systems while meeting the growing demand for seamless multimodal mobility. Drawing lessons from Indian global cities where integrated transport authorities have successfully harmonised fare policies, travel passes, and real-time information systems, Indian cities can adopt similar models. Experience shows that cities with empowered transport authorities and unified platforms offer commuters a predictable, efficient, and inclusive travel experience. The following recommendations aim to address these gaps and establish an integrated public transport ecosystem in Indian cities:

1. **Empower UMTA as a fare regulator:** The UMTA should be the city's central fare regulator, with powers to align policies and ensure consistent concession schemes across buses and metro. This will eliminate fare disparities between the two modes and introduce universal discounts for students, senior citizens, women, and disabled individuals. The UMTA's role must also extend to coordinating fare revisions and monitoring revenue-sharing frameworks between the two transport systems, ensuring financial sustainability.

2. **Develop a unified information platform:** Launch a centralised mobile app managed by the UMTA with support from metro and public transit agencies. The app should offer real-time schedules, ticketing, disruption alerts, and alternative travel options for buses and metro services, enabling seamless and informed multimodal travel. This platform must optimise route planning, provide alternate travel options during service disruptions, and encourage ridership by making travel more predictable and user-friendly.

3. **Introduce universal travel passes with concessions:** Implement city-wide travel passes regulated and managed by the UMTA, in coordination with metro and bus agencies. These passes should cover buses and metro services, reducing the financial burden on frequent travellers. The UMTA should oversee the integration of welfare schemes, ensuring accessibility for all commuter groups while promoting the efficient use of both modes. Streamlining payments through unified travel passes can minimise operational bottlenecks, enhancing the commuter experience and fostering a more inclusive, user-friendly public transport system.

4. **Accelerate adoption of National Common Mobility Cards:** The UMTA should implement the National Common Mobility Card (NCMC) (23) across all public transport systems to ensure seamless, cashless payment for commuters. The NCMC is an interoperable smart card designed to enable payments across various transport services, including buses, metro, and even tolls and retail outlets across India. With the UMTA coordinating its adoption, passengers can switch between transport modes without needing multiple tickets or payment methods, encouraging multimodal travel and simplifying fare collection for operators.

5. **Align welfare schemes across modes:** The UMTA should ensure that welfare schemes (such as concessions for students, senior citizens, women, and people with disabilities) are uniformly applied across buses and metro services. This alignment will promote inclusivity and ensure that both services are accessible to all. To maintain financial sustainability, the urban local body/state government should take responsibility for providing viability gap funding) to metro operators, similar to the funding already provided to public transit agencies for bus operations.

This integrated approach will foster public trust, encourage consistent use of public transport, and create a financially viable ecosystem for all transit modes.

***Aditya Rane** is Senior Associate, Transport System & Electric Mobility, at ITDP India.*

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