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Last-Mile Connectivity: Challenges and Solutions in Urban Transport

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A B S T R A C T

Last-mile connectivity (LMC), or the smooth connection between mass transit hubs and commuters' final destinations, is a recurrent difficulty for urban transportation systems in developing countries. In India, poor last-mile infrastructure has restricted ridership and strengthened reliance on private vehicles, resulting in traffic, air pollution, and unequal access despite significant investments in metro, bus rapid transit, and suburban rail systems. The scope and significance of LMC are examined in this paper, which also identifies obstacles such fragmented transit ecosystems, inadequate feeder services, inadequate infrastructure for bicyclists and pedestrians, unregulated intermediate public transportation, and safety concerns related to gender. Data-driven planning, formalizing shared mobility, transit-oriented development, integrating bikeshares, gender-sensitive design, autonomous and electric micro-mobility, and urban aerial ropeways are some of the creative options that are further examined. The opportunities and difficulties of putting sustainable last-mile ideas into practice are demonstrated by case studies from Detroit and Bengaluru. The study comes to the conclusion that improving LMC is crucial for boosting equitable, resilient, and sustainable urban mobility as well as for lowering emissions and increasing the number of people using public transportation.

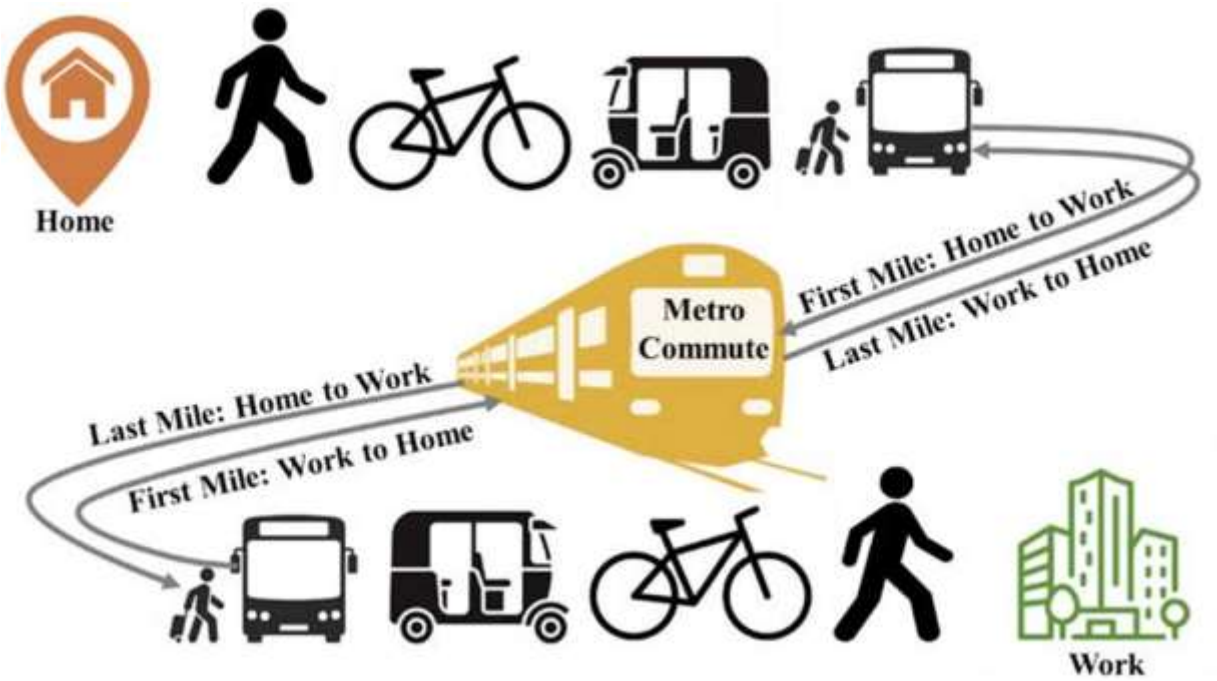
Keywords: : • Last-mile connectivity (LMC) • Urban transportation • Private vehicles• Traffic congestion • Air pollution • Shared mobility• Emissions reduction

1. INTRODUCTION

In emerging countries, cities are the main drivers of economic growth, and strong infrastructure is essential to sustainable development. Since the early 1900s, India has experienced fast economic growth and urbanization, which has significantly raised the need for dependable and effective transportation infrastructure. But insufficient last-mile infrastructure is forcing commuters to use unofficial or private vehicles, which increases traffic, pollution, travel times, and lowers productivity. With emissions up 335 percent during the 1990s, India is currently the third-largest producer of greenhouse gases, and almost 1.2 million people die each year from poor air quality.

The connection between mass transit hubs and commuters' final destinations, or Last-Mile Connectivity (LMC), is a crucial factor in deciding how effective and appealing public transportation is. A journey comprises the essential connection to and from stations, whether by foot, bicycle, or brief car rides; it does not start or finish with getting on or off a bus, metro, or train. The success of urban transit systems and commuter choices are greatly influenced by the caliber of these links.

Despite significant investments in suburban rail, bus rapid transit, and metro systems, ridership is weakened by feeder service gaps, poor intermodal integration, and poor infrastructure for bicyclists and pedestrians. The usage of public transportation is further discouraged by issues like gender-specific safety concerns, unregulated intermediate public transportation, and fragmented planning. Therefore, addressing LMC is crucial to developing equitable, sustainable, and user-friendly transportation systems in India. Improving last-mile options via non-motorized transportation, integrated shared mobility, and creative strategies like urban ropeways or driverless shuttles can lower emissions, ease traffic, and advance fair access. For India's urban sustainability, resilience, and economic growth to advance, last-mile planning must be comprehensive and citizen-centric.



2. Needs and Importance of Last-Mile Connectivity

The efficiency of urban public transportation systems depends on Last-Mile Connectivity (LMC), which connects commuters' final destinations with important transit hubs. Insufficient LMC frequently compels people to use private automobiles, which increases traffic, pollutes the air, and lowers the number of people using public transportation. By facilitating seamless transfers between metros, buses, feeder services, and non-motorized modes, effective LMC improves modal integration and network efficiency. It also boosts patronage by expanding the transit systems' catchment area. By encouraging low-cost alternatives like bike lanes, walkways, and shared mobility, it promotes cost-effectiveness and infrastructure optimization by lowering the need for extensive parking or road construction. Additionally, a well-designed LMC promotes social fairness by guaranteeing accessibility for women, the elderly, and individuals with disabilities, enhances road safety and livability, and benefits the environment by lowering emissions. In the end, improving LMC is about creating robust, inclusive, and sustainable urban mobility systems—all of which are essential for India's economic success and the achievement of sustainable development goals.

3. Approach to Last-Mile Connectivity

In order to find accessibility gaps and maximize feeder services, the research places a strong emphasis on data-driven planning with the use of tools such as GTFS, SUMO, and GIS-based catchment analysis. In order to ensure their dependability and safety, it advocates for the formalization of intermediate public transportation (IPT), including e-rickshaws, shared cars, and vans, through licensing, fare control, and integration with mobility apps. Transit-Oriented Development (TOD), which encourages high-density, mixed-use, and walkable districts surrounding transit stations, places a significant emphasis on land-use and station area development. .In order to guarantee fair access, the strategy also emphasizes the physical integration of bikeshare docks and cycling infrastructure, the construction of secure pedestrian pathways, and gender-sensitive design (well-lit walkways, CCTV, inclusive facilities). Innovative solutions for Indian cities include emerging technology like urban aerial ropeways, smart parking with park-and-ride integration, and autonomous and electric micro-mobility. In order to improve last-mile connectivity, the strategy combines digital platforms, inclusive policies, sustainable practices, and engineering requirements. It emphasizes that increasing ridership, decreasing dependency on private vehicles, lowering emissions, and developing just and sustainable urban mobility systems all depend on improving LMC.

4. Current Scenario in India

sIndian cities are rapidly becoming motorized, with private automobiles predominating—cars make up approximately 15.3% of the fleet, while two-wheelers make up around 72.6%. Only about 25% of travels are made on public transportation, while the use of private vehicles is growing.

Policy changes have slowed the rise of electric cars, but they are still becoming more popular, particularly e-rickshaws and two-wheelers, which currently account for 6.5% of registrations (2024).

Due to urban sprawl and population growth, the demand for travel within cities has increased significantly over the last ten years, with 17.5% more daily trips and 28.6% longer trip lengths. But because infrastructure has not kept up, there is now a lot more traffic, slower speeds (15–20 km/h in Tier-1 cities), increased CO_2 emissions (18% of total urban emissions), and poor air quality.

Despite significant investments in BRT, suburban rail, and metro, public transportation suffers from last-mile connectivity (LMC) gaps, which include inadequate infrastructure for bicyclists and pedestrians, a dearth of feeder services, and fragmented integration. Because of this "last-mile penalty," commuters are more likely to drive their own cars, which reduces the efficiency of public transportation.

The safety, economic, and accessibility issues that women and vulnerable groups confront further lessen their reliance on public transportation. Overall, Indian urban transportation is still ineffective, unfair, and unsustainable from an environmental standpoint in the absence of more robust LMC solutions.

Motorization and dependence on private automobiles have increased: Since 2000, the number of new car registrations has increased ninefold. The bulk of vehicles are cars (15.3%) and two-wheelers (72.6%).

- Electric Vehicle Uptake: The proportion of EVs rose from 0.1% to 6.5% in less than a decade.

There is an increasing demand for urban transport, as seen by the 17.5% increase in route prices and the 28.6% increase in journeylengths.

There is a lopsided modal share, with only 25% using public transit and 35–45% traveling in private vehicles.

5. Challenges in Last-Mile Connectivity

The operational, social, and infrastructure barriers that impede seamless integration with public transportation are the main focus of the challenges with Last-Mile Connectivity (LMC) that you described in your research. A fragmented public transportation system is one of the primary issues, requiring commuters to make awkward and time-consuming transfers between the bus, metro, and intermediate modes like cars or e-rickshaws. People are discouraged from taking public transit and are instead encouraged to drive their own cars when there are no reliable feeder services to job centers. Even though walking and bicycling are more environmentally friendly, they are still ignored due to hazardous crossings, uneven sidewalks, poor lighting, and a lack of bike lanes. Last-mile motorized vehicles, such as cars and e-rickshaws, are frequently dangerous, unregulated, and inconsistent in their fares, resulting in traffic congestion and eroding user confidence. Similarly, the potential of bike-sharing systems is undermined by their poor integration with transit stations; gender-specific safety issues become a significant barrier, with women experiencing harassment, unsafe waiting areas, and inadequate lighting during last-mile travel; and the lack of inclusive infrastructure, such as tactile paving, ramps, and childcare-friendly facilities, excludes vulnerable groups like women with dependents, the elderly, and people with All of these issues suggest that public transportation will remain underutilized unless last-mile services are safe, accessible, affordable, and well-integrated.

6. Unregulated motorized last-mile modes that are unsafe.

Even though unofficial shuttle vans, shared cars, and e-rickshaws are popular motorized last-mile transportation options in Indian cities, their operations are usually risky, unregulated, and not well connected to public transportation systems. Without designated pick-up or drop-off locations close to metro stations, these services typically operate in congested, chaotic areas that hinder traffic and generally reduce accessibility. Additionally, there is a lot of price variation because there is no fare regulation, especially during rush hours or in underprivileged areas. Many commuters report engaging in dangerous driving practices, such as aggressive driving, improper stopping, and speeding. These practices greatly reduce the appeal and trustworthiness of these services as reliable last-mile options. The unstructured nature of motorized last-mile transportation disproportionately affects vulnerable commuter groups, such as women, the elderly, and those with impairments. Even if metro services are nearby, these customers are less likely to use public transportation if station areas do not have gender-sensitive design, proper lighting, or safety considerations. According to the paper, metro systems in Indian cities will continue to fall short of their potential for reducing dependency on vehicles and improving mobility equity until motorized feeder services are institutionalized, regulated, and integrated.

7. Impact of Poor Last-Mile Connectivity

There are numerous detrimental effects of poor last-mile connection on sustainability and urban transportation. Insufficient feeder services, hazardous bicycle and pedestrian infrastructure, and a lack of intermodal integration deter commuters from taking public transportation in many Indian cities. Despite living close to bus or metro lines, this phenomenon—often referred to as the "last-mile penalty"—pushes individuals toward private cars like two-wheelers or app-based taxis. Because of this, mass transport systems continue to be underutilized, which lowers the returns on significant public investments as parking shortages, pollution, and traffic congestion get worse. Vulnerable groups including women, students, and low-income workers are also disproportionately impacted by poor last-mile access; these groups frequently face safety hazards, inconsistent services, and a lack of reasonably priced options. When combined, these issues lengthen commutes, lower productivity, raise emissions, and jeopardize the larger objectives of equitable and sustainable urban development.

8. Solutions for Last-Mile Connectivity

1. Park & Ride and smart parking integration.

2. Making unofficial last-mile transportation methods regulated and legitimate.3. City aerial ropeways.

4. Bikeshare ports ought to be positioned together at transportation stops.

5. Considering gender when designing infrastructure.

6. Designated bike lanes and secure infrastructure.

9. Case Studies

Case Study 1: Bengaluru Metro saw a 15–20% increase in ridership thanks to upgraded feeder buses and bikeshare programs.

Case Study 2: In London, e-mobility incentives, MaaS apps, and bikeshare programs increased accessibility and decreased the number of car trips.

10. Conclusion

According to the report's conclusion, improving last-mile connectivity (LMC) is crucial to the prosperity of India's and other quickly urbanizing regions' urban public transportation systems. The efficacy of metro, BRTS, and suburban rail is hampered by poor integration, insufficient facilities for bicyclists and pedestrians, unregulated intermediate transportation, and concerns about the safety of women and other vulnerable users. If these obstacles are not removed, public transportation runs the risk of being underutilized, which would drive commuters to use their own cars and exacerbate traffic, pollution, and inequality. As a result, national policies must incorporate a resilient, inclusive, and people-centric LMC framework that is in line with international sustainability objectives. In order to promote the use of public transportation, lessen its negative effects on the environment, and guarantee fair mobility for everyone, civil engineers, planners, and legislators must work together to develop safe, affordable, and sustainable solutions.

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