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Last Mile Connectivity in the Indian Scenario: A literary review

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Abstract

The last few decades have witnessed several dynamics in the global transportation scenario like shifting toward a sustainable transport system, implementing integrated land-use transport planning concepts, a strengthened transportation system with stable Artificial Intelligence (AI) and Internet of Things (IoT), and a sturdy structure combining Information Technology (IT) and sustainable parameters. Last Mile connectivity (LMC) is a globally acclaimed sustainable measure in urban transportation. It discourses the issues commonly faced in recent times concerning environmental, economic, and social aspects of transit systems. In this paper, the authors have attempted to review various articles and literature documents concerning the global and contextual scenarios to understand the status of LMC in India. Published methodologies by multiple researchers are followed to analyze the literature documents, and subsequently, the descriptions and synthesis are summarized in outlined sections. Thus, this paper aims to understand the policy and implementation approaches for LMC in Indian cities and analyze the impact on the current transportation scenario. Finally, it outlines the status of LMC and briefly promotes the future scope toward building a sustainable environment holistically.

Keywords: Last Mile Connectivity (LMC), Indian cities, transportation, urban, Mass Rapid Transit Systems (MRTS)

1. Introduction

Cities play an essential role in the overall economic growth of a developing country. The different indicators of sustainable development considering inclusivity depend on the physical, social and institutional infrastructure. India's rising economy since the 1900s has seen significant demand for transportation infrastructure and services (IIHS, 2015). Effective and dependable urban transport is still critical in sustaining the expanding Indian economy.

Sustainable policies in India are impeded by urban issues like severe congestion, increased greenhouse gases due to vehicular emissions, increasing road fatalities, and declining air quality. The economic output is affected when we observe slower traffic speed and growing commuting time.

India has witnessed a rise in greenhouse gas emissions of 335% since the 1990s (Pandey, 2020). India is the World's third-largest emitter of greenhouse gases after China and US (Timperley, 2019). Transport emissions are the most substantial contributor to greenhouse gas in India. As accounted for in 2014, road transport is the major contributor to the transport sector, with about 90% of the GHGs emissions (Jagmohan, 2020).

In 2015, over five lakhs road fatalities were registered, out of which 1.5 lakhs were killed. 52% of the accidents are observed on national and state highways, and only 5% on Indian roadways. Road network has grown to just 39%, whereas vehicle registration has increased to 158% (Mishra, 2017). Every year, the miserable air quality in India creates a severe environmental and public health disaster, sacrificing 1.2 million citizens (Mishra, 2019).

Urban policies by the Government of India (GoI), like the Sustainable Urban Transport Policy (SUTP, 2020), National Urban Transport Policy (NUTP, 2014), and Metro Rail Policy (MRP, 2017), promote the benefits of using integrated land use and transport system, encouraging the use of public transport system, indorsing service of Non – Motorized Transport (NMT) instead of fuel operated vehicles and financing and strengthening Mass Rapid Transit System (MRTS) to resolve issues like congestion, reduce travel time and cost and decrease carbon emission per capita.

Last Mile Connectivity (LMC) describes the movement of people and goods from a public mass transportation center to and from the journey's origin and destination (like home, workplace, market, and others). Sustainable LMC modes have existed for the last two centuries; it has been evolving with demand in the multiplied magnitude of urban growth and sprawl (EEA Report, 2019).

Based on the STation Access and Mobility Program (STAMP), inadequate connectivity to the Metro stations has been one of the critical explanations for the commuters not using the metro as a mode (WRI, 2018). Thus, ultimately obstructing the concept of sustainable urban transportation.

This paper attempts to understand India's LMC scenario in selected cities where LMC is proposed or implemented at a certain level, with varied characteristics and demands. The understanding is derived from adopted policies, schemes and strategies, and research. Thus, the literature analysis is categorized into the core–topic–based and contextual-based literature. Accordingly, the needs and gaps are assessed based on the author's perception and derivation. Therefore, the analysis has formulated a synthesis through these secondary data sources.

2. Data Collection

The data source for this study is entirely covered through secondary sources. The literature sources include published articles, e-books, reports, dissertation reports, broadcast news, government websites, other reliable websites, and government documents undertaken in the last two decades.

3. Methodology

The literature sources are reviewed by understanding several methodologies developed by various researchers and concurring to adapt a modified method. The process includes the following steps; First, to define the type, content, and field of literature to be studied; Second, to search the literature documents; Third, to select the literature acquired by refining; Fourth, to examine the types of literature documents applicable for this particular study through literature-based analysis and; Fifth and the final one is the representation of the finalized set of documents (Wolfswinkel et al., 2011). A detailed description of the steps is mentioned hereafter.

The first step includes defining the literature source types, contents, and fields to be studied. The studies undertaken and reported during the last 20 years (i.e., 2000 – 2021) have been selected for the current literature review. Thus, it consists of searching literature based on main keywords like “last mile connectivity,” urban transportation,” “urban transportation issues,” and “India,” and further refining the search with extended sentences like “urban transportation issues in Indian cities,” “benefits of implementing last-mile connectivity,” “indicators of last-mile connectivity” and other proceedings.

The second step involves exploring various literature databases with the specific literature search based on step one outcomes. It also includes modification of the search process by using appropriate websites and investigating based on inferences.

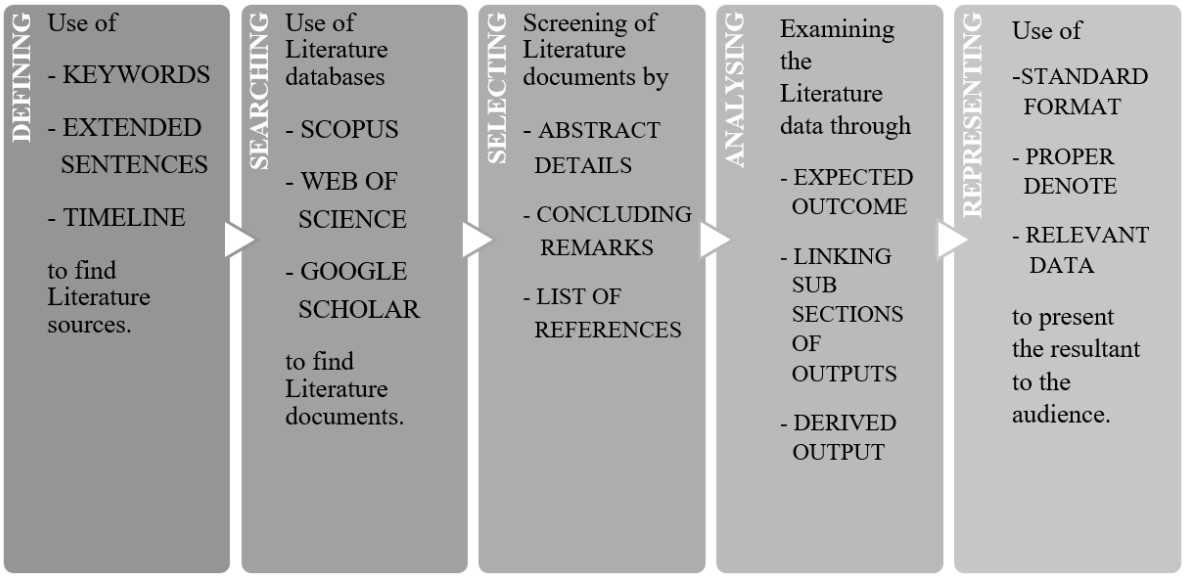
The third step is to enhance the listed literature sources by screening the acquired literature documents by filtering out similar data based on abstract details, concluding remarks, and lists of references.

The fourth step is to analyze the received data concerning the literature documents selected through the earlier stages. It includes the criteria of keywords set being matched with the expected outcome of the study, the sub-sections of the key domains of literature being matched with one another to justify the relevance and interconnection between them, and then finally to derive the common outcome from the selected domain of literature as a new subset to cater the topic chosen for study.

The final step includes a structured format to represent the organized and relevant data developed by the entire process.

FIGURE 1 Indicates a graphical representation of the process as discussed.

Figure 1: Representing the Methodology



4. Literature Review: Salient Findings

The literature review is categorized into four main sections. In the first section, an understanding of the concept of last-mile connectivity is interpreted through the views of different researchers; the subsequent sections deal with insights into how LMC is being perceived globally, how LMC is perceived in Indian urban transportation policy frameworks, and an overview of the LMC propositions in selected Indian cities respectively.

Section 1: Understanding the concept of LMC: Several researchers-initiated studies related to transit-oriented development, introducing the terminology and concept of last-mile connectivity in the last bit of the 20th Century. Some prominent researchers who worked on it are Calthorpe, Cervero, and Bernick. Their works have marked the concept of modern-day Transit Oriented Development (TOD), Compact city development, and likewise. Several techniques like mixed-used development, ride-sharing, shared parking possibilities, and walking-cycling were some of the solution-based models suggested to encourage environmentally-friendly transportation systems and address the envisioned future issues by researchers who encountered the severity of the then-existing transportation model (Cervero, 1988).

The concept of Transit village was recommended for Greenfield developments where it describes creating sustainable and attractive communities in cities and suburbs. A critical discussion like creating suburban development/ inner-city community and the proactive role of the local government and the transit agency was also highlighted in these studies (Bernick & Cervero, 1997).

The issues that have increased the number of motor vehicles and their emissions near the mass transit nodes can be resolved by considering the studies on the concept of walk and ride. Based on the distance of travel and assisted built environment infrastructure, the idea of walking, cycling, or adding a bus trip to transit nodes can be implemented in the desired routes (Cervero, 2001).

Attempting to understand the First and Last Mile Connectivity (FLMC), it can be interpreted as a first/last mile trip is the trip between a Mass Rapid Transit (MRT) station and the origin or destination of the journey (Mo et al., 2017). In urban transport, the term finds relevance in transit systems; it is referred to as both the initial and final leg of delivering connectivity - from origin to transit nodes and from transit nodes to destination (Chidambara, 2015). The 'first and last mile' describes the beginning and end of an individual's public transport journey (Thomson et al., 2020). First and Last Mile Connections (FLMC) are a critical part of a study to ensure that every transit rider can easily and safely get to and from their transit connection (Sand and Beckerman, 2016). Empirically, Last Mile Connectivity (LMC) can be explained as the connection of a commuter to and fro from the origin and destination of their journey to the mass public transportation mode.

Section 2: How LMC is perceived globally: Current global issues include various urban transportation drawbacks like high pollution levels, high transportation fares, and fatalities. LMC helps in mitigating the problems identified above and also ensures financial feasibility. It also reduces the chances of congestion, delays, and waiting time for journeys by implementing real-time information. It has the potential to invite many shared transportation mode options. LMC policies are essential in determining economic feasibility and implementing various multidisciplinary guidelines (EEA, 2019). The key driver of transportation is the access and mobility factors, not the travel mode (Hanson, 2015). Thus, we must ensure easy access and mobility enhancements to facilitate any particular way for certain benefits. Researchers have even concluded that policies like SDG promotes the use of the different modern mode of transport rather than ensuring that commuters reach their destination areas (Brussel et al., 2019). Studies have also witnessed that High-Speed Railways (HSR) have a practical perspective for regulating regional economic growth inequality (Jiao et al., 2020). Shared mobility has many social benefits like creating street space and diversity in public places, and financial benefits like making commercial set-ups and parking demands, along with environmental benefits like vehicles-mile traveled, car emissions, congestion, and traffic reduction. The barrier to shared mobility in some contexts can result from the social structure that exists; in that case, local government plays a vital role in shaping the policies. The shared mobility option is based on the type of users in the proximity to the transit stations (Sand et al., 2016). FLMC is one of the significant components in influencing the quality of the overall journey taken by the commuter, so assessing the quality of FLMC is also a determinant in ensuring its efficiency (Venter, 2020). There are different ways adopted in several study areas that are contextual solutions. For instance, some areas require reducing passengers' waiting time to improve the quality of the experience (Wang, 2015); in contrast, some might need to implement the LMC mode or infrastructure. It has also been observed that Public Transit Accessibility (PTA) remained challenging due to computational inefficiency in many study areas. The spatial dimensions determine the choice of PTA in the study area. Financial feasibility is also essential in deciding the PTA modes (Liu et al., 2018). Thus, a successful LMC results from the contextual solution being identified and implemented over time.

Section 3: How LMC is perceived in Indian urban transportation policy frameworks: With a population of about 1210.85 million and an urban population of about 377 million people, India has an average population density of about 382 persons per square kilometer. Bangalore, Chennai, Delhi, Kolkata, and Mumbai have a population density of about 4,381; 26,553; 10,000; 24,306; and 25,357 per sq. km., respectively (Census, 2011). The transport sector is mainly categorized into rail, road, air, and water.

Amongst all the types of transport, road transport is one of the leading transport sectors, with a share of about 87% of passenger traffic and 60% of freight traffic movement (MoRTH, 2022). Amongst the different categories of roads, rural roads (71%) constitute the highest share of total road length, followed by district roads (10%) and urban roads (9%), Projects Roads (5%), State Highways (3%), and National Highways (2%). Urban areas have higher road density compared to Rural and all India levels. The density of highways is also not a correspondent of the longer trips. Instead, a study shows that the proportion of shorter trips is more in greater-density highway states than the lower-density ones (Tiwari and Nishant, 2018).

One of India's evolving branches of rail transport is the Metro Railways. It was initiated and designed by Indian Railways at Kolkata in 1984, funded by the central government, and currently is operating in several cities with financial models like a mixed model of Public-Private Partnership (PPP) or a 50:50 joint venture model between the state and central, or fully funded by the state, and likewise (MRP, 2017).

The government of India (GoI) initiatives, in several documents like National Urban Transport Policy (NUTP), National Urban Policy Framework (NUPF), and National Transit Oriented Development (TOD) policy, discussed the implementation of sustainable transportation programs like TOD and multimodal integration at different levels, Last Mile Connectivity (LMC), Non – Motorized Transportation (NMT), and promoting the use of walking and cycling in neighborhoods.

Section 4 An overview of the LMC propositions in selected Indian cities: The different contextual and unified LMC types proposed through research in various Indian cities are discussed in TABLE 1.

Table 1: LMC propositions by various researchers for the Indian context or Study Area

	Author/ Document	Interpretation
Generalized Overview	(Kumar et al., 2011) Case of Delhi	Multimodal transportation systems can be considered sustainable modes of transport over private cars in Indian cities. An improved design that enables parking, transfer facilities, and card access can result in minimized Out of Vehicle travel time (OVTT).
	(WRI, 2017) Case of Indian cities	An interconnected system based on distance was proposed as: walking within 1 – 2 Kilometers cycling within 2 – 4 Kilometers Intermediate Public Transport (IPT) within 3 – 6 Kilometers Bus/ Taxi/ Car/ 2 – Wheeler within 5 – 10 Kilometers.
E - Vehicle	(Jhanwar and Shukla, 2021) Case of Ahmedabad	In cities like Ahmedabad, e – rickshaws are recognized as a convenient mode of feeder service in the BRTS system.
Non – Motorized Transportation	(Chidambara, 2015) Case of Delhi	Researches identify NMT as an LMC solution for green mobility in the study area in Delhi.
	(Kumar et al., 2015) Case of Indian cities	NMT is the combined system for walking, cycling, and cycle rickshaws, i.e., a green mode of transport. The share of NMT in Indian cities has declined since 1980, except in cities like Chennai and Patna. The presence of NMT in Indian cities was inevitable from earlier times as either the primary mode of transport or a last-mile connector.

	Author/ Document	Interpretation
	(Jain and Patil, 2021) Case of Indian cities	As evidenced by studies, NMT is the sustainable mode of urban transportation but is often overlooked when implementing development plans for the transportation network. NMT benefits include user benefits, social equity objectives, congestion reduction, land-use impact, energy conservation, and pollution reduction. Contextual proposals are essential in implementing NMT efficiency in cities.
	(Tiwari and Jain, 2013) Case of Indian cities	The recommendation for space in the existing roads is to provide lanes based on the principle of equal allocation and thus should prioritize pedestrians, cyclists, and public transport and then suffice private vehicles. In Indian cities, building bridges, highways, and subways has led to increased motor vehicles and reduced NMT use. NMT infrastructure is essential for uplifting NMT use.
Pedestrianization	(Gupta, 2016) Case of Indian cities	Pedestrianization is essential and needs various restructuring in Indian cities to be enabled suitably. Government schemes and stakeholder participation are key factors in the implementation scheme.
	(ITDP, 2017) Case of Indian cities	Apart from creating better inclusive mobility facilities, pedestrianization helps in many other ways, like increasing shopping facilities (economy exchange), reducing accidents, decreasing pollution levels, and ensuring the fitness of people and others. Pedestrian activity, political intervention, and assisted infrastructure can gradually transform a place into a pedestrian-friendly zone.
	(Nag et al., 2019) Case of Kolkata	In India, though there is a high density of pedestrians, a good amount of disproportion is observed in terms of the infrastructure supporting it. Pedestrian satisfaction depends on various factors; some identified ones in Kolkata's context are infrastructure facilities, location, trip purpose, and income.

The financial structure in India supports walking and cycling. Metropolitan of Delhi, Mumbai, and Kolkata have the highest number of walking trips, and Delhi and Kolkata have the highest number of cycling trips. Assessing the policies in different cities, it can be inferred that the roads are focussed on making motorized corridors (CSE, 2013).

However, the identified implementation gaps observed in Delhi is that most of the private vehicle user respondents pointed out the reason for not using the public transit/ shared mobility as a result of non-availability of LMC options/ inefficient LMC/ distance from transit node (Chidambara, 2012). If prepared in isolation, Transit nodes and LMC can improperly utilize resources that might not be sustainable (Chidambara, 2015). It is concluded in studies that many times the fundamental strategies are overlooked over the high-yielding transit facility infrastructure. Using modes like auto-rickshaws as a feeder service can be more efficient than making them a competitor of Buses on arterial roads (Bhaduri et al., 2018). India reports a threefold increase in urban vehicular population than the total urban population. The study suggests that integrating physical infrastructure with information and financial integration can bring about a change for a sustainable system. A change will only withstand if it is ecologically non-impacting, economically advantageous, socially conventional, and has improved the quality of life of its users (Nag et al., 2019). In Bangalore, 70% of the survey respondents stated that poor infrastructure to access the metro was the reason for not using it. It has also been

noted that unplanned and unaccounted scenarios for last-mile connectivity have resulted in the occurrence of para-transit modes and their profit. A study in Delhi shows that 40% of the travel time and 48% of the travel cost goes on 18% of the travel distance for accessing the public mass transportation modes (Kanuri, 2019). A case study of the Indian context inferred the use of different private vehicles due to a lack of infrastructure/ planning to support last-mile connectivity (LMC). It concluded with the importance of a user perception study for LMC as one of the significant factors to be included while implementing plans (Shashidharan, 2019). Assessing the quality of existing infrastructure by the users is essential to understanding the gap and evaluating the need (Nag et al., 2020). Thus, this can be interpreted as contextual findings related to the mismatch between transportation demand (possibility) and supply.

It is increasingly being realized that adding more buses or any other public mass transit modes to the road may not lead to the desired goal of sustainable mobility. Instead, focusing energies on improving the user experience of walkers and cyclists is also more in line with future needs. Bike-sharing has emerged as a popular and effective way of solving the last-mile connectivity problem in many European cities. In India, bike-sharing initiatives have been tried in Mumbai and Pune by Cycle Chalo and traffic-ridden Bengaluru through Nama Cycle, launched by the Indian Institute of Science, an app called Mobycy in Gurgaon, Mo Cycle or My Cycle in Bhubaneshwar and smart bicycle stand in New Town, Kolkata. It has been observed that in most of these cases, the outcome is not as successful as expected. However, still, there is hope for these plans to operate successfully, as 13 – 21 percent of India uses the cycle as the primary means of transport (TERI, 2016).

Challenges in transportation include gaps in Laws and Regulations, fragmented Institutional frameworks, distorted land markets affecting transport infrastructure development, lack of comprehensive design standards for transport infrastructure, human resource challenges, absence of reliable transport data, inefficiencies in bus-based Public Transit (PT) services, and energy security. The proposed policy reforms might combine re-aligning legal and regulatory instruments with a comprehensive development plan, institutional restructuring at different levels in an integrated approach, resource mobilization, planning reforms, and transferability of best practices. Urban transportation is crucial for economic development, and urban mobility is multi-dimensional regarding policy and operational implications (IIHS, 2015).

A study in Chennai identified short-term and long-term objectives for FLMC solutions; the short-term plan includes physical, fare, path, data, and institutional integration, whereas long term indicates local authority schemes on comfort, convenience, and usability, the introduction of guidelines, and promotion campaigns (UMI, 2019). A study in the context of Delhi inferred that micro-scale factors like safety, security, comfort, convenience, infrastructure, and mobility than mesoscale factors like land-use diversity, densities, and street design or, in other words, the attribute that can be mapped (Bivina et al., 2020).

5. Synthesis

The literature review was categorized under two main sections: core topic–based and contextual–based. Each of these sections is divided into two sub-sections, and further, an elaboration of the sub-sections is formulated, as mentioned in TABLE 2.

Table 2: Subsections of Literature Review

Core – Topic-Based Literature		Contextual Based Literature	
Definition of LMC	Global trends of LMC	Types of LMC Proposed/ Adopted	Post-Implementation Evaluation of LMC
Evolution of the concept of LMC. The definition proposed by researchers.	Advantages associated with implementing FLMC. Choice of Mode to and from MRT. Different types of FLMC Modes. Quality of FLMC. Methodology to determine, design, and operate FLMC.	Various policy frameworks by the Government agencies. Several implementation programs in different cities.	The gaps were observed post-implementation of LMC. Existing transportation problems in India.

Concerning the studies, it has been observed that researchers and the regulatory framework are discussing several factors associated with LMC, like defining it, establishing its needs, project implementation programs, identifying the typology of LMC, and classifying a gap in the existing strategies and implementation schemes and likewise. Similarly, it has also been observed that there is a negligible amount of conversation on establishing the need for defining the LMC boundary. It is of prime concern to outline the users for whom we plan to implement the LMC. The diverse influence zones from the MRTS corridor are anticipated to have varied development patterns concerning the LMC planning.

In the global context, LMC has been observed as a sustainable measure. Post-implementation evaluation in several contexts has witnessed that the application of LMC has addressed the contextual issues of carbon footprint, congestion, vehicular emissions, pollution levels, and fatalities (Mercier et al., 2015) (Garces et al., 2021) (Mohiuddin, 2021). This, in turn, has increased MRTS ridership, reducing private vehicle operation.

The several policies adopted in India comprise the application of sustainable modes like NMT and e-transit vehicles as a program under the umbrella of LMC policy. It also includes the implementation of pedestrianization and cycling infrastructure as an initiative. The matter of discussion is which initiative is relevant in which scenario. Still, there is a gap in the point of identification of the type and scale of the survey to be undertaken for a system. Other concerns include the involvement of stakeholders as a part of the project at different levels. The success of any executing project depends on the user group's needs and especially for long-term infrastructural investments.

6. Concluding Remark

The future objective is based on a few factors identified as an outcome of this study. For instance, it highlights the importance of outlining the LMC's boundary that has to be planned. The boundary can be categorized as station area-based, city-based, regional development, and any other suitable category applicable to the context. It also classifies the need to create a framework for evaluating the scope of LMC in the context of India. An existing framework will ensure smooth application standards and an effective, sustainable project. It also enables detailing the inspection criteria even during the project's implementation phases. Thus,

ensuring modification or progress based on the report generated. The study causes the need for a universal guiding document defining the process and stages to be endured to understand the contextual demand and, thus, can form the base of the implementation project. The contextual study also recognizes the need for a multidisciplinary approach in executing an LMC project and the importance of instrumenting a transparent, information technology-based system interface along with a structured organogram clearly defining the responsibilities and duties of the posted personnel involved in the process. Another essential tool in the method is understanding the user's perception in studies and various implementation levels that will confirm the project's utility and ensure the sustainable goals of equality, affordability, economic growth, clean energy, good health, and well-being. It creates impact evaluation programs to mark the process assumptions in the initial phases of projects.

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