Efficient Multi Modal Public Transportation for Hyderabad focusing on City's Metro Rail

Submitted to Kautilya School of Public Policy in Partial Fulfillment

of the Requirement for the Degree of

Master of Public Policy (MPP)

2023-25

Subhash Varma Gottumukkala

2023004814

Under the Supervision of

Dr. Vishnu S Pillai

Assistant Professor, Kautilya School of Public Policy

Kautilya School of Public Policy,

Gandhi Institute of Technology and Management

(Deemed to be University)

Rudraram, Telangana 502329

April 07, 2025

SELF-DECLARATION

This is to certify that the thesis titled **Efficient Multi Modal Public Transportation for Hyderabad focusing on City's Metro Rail** is my original work and has not previously formed the basis for the award of any Degree, Diploma, Associateship or Fellowship to this or any other University.

Subhash Varma Gottumukkala

April 07, 2025

ACKNOWLEDGMENT

I extend my deepest gratitude to my capstone supervisor, Dr. Vishnu S Pillai for his invaluable guidance, constructive feedback, and constant encouragement throughout the research and my journey at Kautilya. His mentorship helped shape this work into what it is today.

I would also like to thank the Dean Amb. Syed Akbaruddin for shaping a learning space that constantly pushed me to think deeper, and grow consistently. His guidance and insights have been instrumental in my academic journey.

This wouldn't have been possible without the support of the incredible people I worked with during my internship. I sincerely thank Mr. Gopal Krishnan from TGIIC and Mr. Amartya Awasthi along with Mr. Nikhil Kumar and Ms. Reshma Mathews from ASCI, for not only trusting me with meaningful responsibilities during internship but also for encouraging me to stay committed to my capstone. Their flexibility and support helped me manage both paths without compromise.

I thank all the experts who have accepted my request to participate in the research interviews and providing the valuable insights.

I am grateful to all the faculty members at Kautilya whose teachings, encouragement, and mentorship have been foundational in developing the skills and perspectives needed to deliver this research. Each of them has, in their own way, contributed to my growth.

A special thanks as well to the staff at Kautilya and to my cohort, whose presence, camaraderie, and everyday moments made this journey truly memorable. You've all added a dimension to my learning that goes far beyond the classroom.

Table of Contents

List of Figures

Abstract

Hyderabad's public transportation system faces major challenges, including poor multimodal integration, last-mile connectivity gaps, and increasing private vehicle dependency. Despite investments in metro rail, buses, and suburban trains, inefficiencies in fare integration, service coordination, and institutional governance have limited public transit adoption. This study examines these barriers using bibliometric analysis, secondary research, followed by four expert interviews. Findings highlight the need for improved last-mile solutions, seamless intermodal transfers, and stronger regulatory oversight. The study also explores electric vehicles (EVs) as a sustainable option for enhancing last-mile connectivity and electrifying the bus fleet. Using Kingdon's Multiple Streams Framework (Kingdon, 1984) and the Nodality, Authority, Treasure, Organization (NATO) policy model by Hood (1983), the study recommends strategies like unified digital ticketing, improved last-mile connectivity, integrated fare systems, and institutional strengthening. A seamless, technology-driven transport network can enhance accessibility, reduce congestion, and promote sustainability. Hyderabad has been chosen as the focus region due to its recognition as India's fastest-growing city according to Knight Frank India. Though the study is Hyderabad focused, the recommendations can be applied based on the context with an aim to elevate the entire public transport network to the service levels of the metro, which is widely seen as aspirational in terms of efficiency, reliability, and commuter experience.

Keywords: *Public Transport, Multimodal Integration, Last-Mile Connectivity, Electric Vehicles, Hyderabad, Metro Rail*

1. Introduction

Urban mobility is a fundamental component of economic development and social inclusion in rapidly growing cities (Solanki et al., 2015). Public transportation systems play a critical role in reducing traffic congestion, minimizing environmental impacts, and enhancing the quality of urban life (Lako & Gjevori, 2023). For these public transportation systems to be effective seamless integration between different modes thereby an efficient multimodal transportation system is essential. Hyderabad is the focus of this research because of its rising prominence as an “economic powerhouse” (The New Indian Express, 2023) and the growing challenges of urban mobility that come with “population boom” (Singh, 2024). Public transportation in Hyderabad, like in most cities in India (Choudhary, 2023), has not been fulfilling its intended purpose of providing efficient urban mobility. The number of private vehicles in the Greater Hyderabad Municipal Corporation (GHMC) area has risen sharply, leading to worsening congestion, air pollution, and a decline in overall urban mobility. A report from Telangana’s Road Transport Authority (RTA) in 2023 indicates that in the Greater Hyderabad Municipal Corporation (GHMC), "the number of two-wheelers and four-wheelers increased from 39.5 lakh to 56.9 lakh and from 9.2 lakh to 14.1 lakh, respectively, between 2017 and 2023" (The Times of India, 2023). The two metro lines of the Hyderabad Metro Rail Limited (HMRL) became operational in 2017 followed by the third metro line in 2020 (Swarajya, 2020), However, the data presented above on the increase in number of private vehicles during this time period clearly shows that the metro network has not achieved its goal of providing an efficient public transport system. This inference is reinforced by Singh (2015), who states that people tend to shift to private modes of transportation when public transportation systems do not meet their needs. This growing reliance on private transport highlights the urgent need for a more efficient public transit system. Despite its potential, Phase I of the metro network, which spans 69.2

kilometers, faces challenges, with a lower daily ridership than the projected ridership at the project's inception (Paul Oommen, 2022). In addition to the metro network, Hyderabad also struggles to address public transport needs through road-based transit, specifically the city bus services provided by the Telangana State Road Transport Corporation (TGSRTC). A report by the Times of India notes that TGSRTC operates around 3,000 buses in the GHMC area, compared to the required 6,000 buses for the city (Jose, 2022).

Studies indicate that public transport adoption is directly influenced by factors such as affordability, reliability, ease of transfer, and service quality (Litman, 2024). However, Hyderabad's public transport ecosystem suffers from operational inefficiencies, an aging bus fleet, and limited integration between different transport modes (Mohammed, 2024). As a result, commuters often resort to private vehicles, exacerbating road congestion and diminishing the intended benefits of large-scale transit investments.

1.1 Public Transportation in Hyderabad

In the Hyderabad's public transportation network three modes are considered broadly for the scope of this research, the Telangana State Road Transport Corporation (TGSRTC, formerly TSRTC), the Multi-Modal Transport System (MMTS) which is the Local Train network, and the Hyderabad Metro Rail Limited. They serve millions of daily commuters crucial for the city's mobility.

1.1.1 Telangana State Road Transport Corporation (TGSRTC)

TGSRTC, the state-run bus service, plays a crucial role in Hyderabad's daily commute. Around 2,800 buses operate across the city, carrying a significant share of the population. However, a large portion of the fleet is aging, with many buses nearing the end of their service

life, raising concerns about reliability and safety (Mohammed, 2024). Beyond infrastructure concerns, the demand for TGSRTC services has surged. Ridership grew from 4.3 million in 2022 to 6 million in 2025, marking a nearly 40% increase. A major contributor to this spike was the introduction of a free bus travel scheme for women in December 2023, which significantly boosted female ridership from 2.7 million to 3.5 million daily (Baski, 2025). However, the total fleet size has remained largely unchanged at around 9,384 buses statewide, resulting in overcrowding and extended wait times, particularly during peak hours. Commuters frequently report delays of 15–20 minutes, often causing late arrivals. To address this, TGSRTC has set ambitious goals rolling out 3000 electric buses for the city, starting with an initial batch of 500 (Baski, 2024). The state government has put itself a target for an entirely electric bus fleet within the next few years, a step toward sustainable urban transport.

1.1.2 Multi-Modal Transport System (MMTS)

Designed to improve connectivity between Hyderabad and its suburbs, the MMTS suburban rail network started in 2003 now covers 123.52 km across multiple routes, few of them include Hyderabad(Nampally)–Lingampalli, Hyderabad(Nampally)–Falaknuma, and Secunderabad–Bollarum. For years, MMTS has been a lifeline for suburban commuters, but recent trends indicate a sharp decline in both ridership and service levels (Baski, 2024a).

Following the pandemic, daily ridership dropped dramatically from above “160,000 to just 40,000” making the South-Central Railway (SCR) to cut daily services from “121” to “100”. Many commuters have cited frequent delays, cancellations, and extended halts as reasons for shifting to alternative modes of transport (Baski, 2024a). Plans to expand MMTS to Shamshabad (RGIA) and Ghatkesar-Yadadri routes remain stalled due to funding delays. The Ghatkesar-Yadadri extension, sanctioned in 2016-17 for ₹430 crore, is still awaiting the state government’s

₹290 crore contribution, leaving commuters in these areas with limited rail options (Baski, 2024b).

1.1.3 Hyderabad Metro Rail Limited (HMRL)

The Hyderabad Metro, one of India's largest metro networks, was developed with an investment of ₹22,148 crores. Phase 1, which spans 69 km across three corridors, has significantly improved urban mobility, and the upcoming Phase 2 aims to add another 116.2 km. Additionally, the government has proposed extending the network by 45 km to northern areas like Medchal and Shamirpet, further strengthening connectivity and easing congestion (Hyderabad Metro Rail Limited, 2024).

Celebrating its seventh anniversary, the report from L&T Metro Rail (2024) highlighted the metro's consistent performance, with an average daily ridership exceeding 4.75 lakh and peak ridership reaching 5.63 lakh passengers (7.43 lakh trips) in 2024. The statement highlights that 63.5 crore passengers have used the metro from its commencement while maintaining an impressive 99.8% punctuality rate showing its reliability and efficiency.

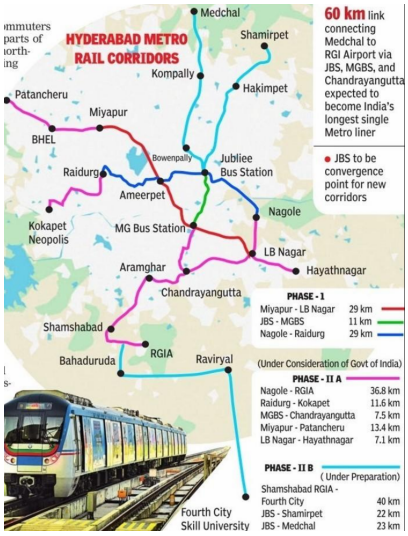

Figure 1 Metro Rail Network in Hyderabad (Existing and Planned) (Hyderabad Metro Rail Limited, 2025)

1.2 Transport policies - India

India's urban population accounts to 36% in 2023 according to world bank urbanization prospects data increasing from 31.6% in 2011 according to Ministry of Housing and Urban Affairs. Urban transportation in India is grappling with the pressures of rapid urbanization, rising vehicle ownership, and fragmented public transport systems. As cities grow denser, ensuring smooth connectivity across different modes of transport is crucial to ease congestion and make urban mobility more sustainable. The government policies in the recent past have an integrated approach from isolated projects with a goal to create public transport a preferred choice for mobility.

The National Urban Transport Policy (NUTP) in 2006 highlighted the importance of moving people rather than vehicles. Though the policy set a vision for multimodal integration, it failed to bring in strategies to integrate various modes - metro rail, bus services, and non-motorized transport (NMT) - cycling and walking infrastructure (Verma et al., 2021). The Smart Cities Mission in 2015 also introduced transport solutions to improve urban mobility, but in practice, many cities still struggle with uncoordinated and disjointed public transport networks.

Metro Rail Policy in 2017 is one of the crucial points in urban mobility. The policy has led to expansion of metro rail networks in Indian cities. 21 Indian cities till date compared to five in 2014 (Mishra, 2024) have invested capital in Metro Rail system over other transit systems. The Central Government in August 2024 approved combined investment of "INR 30,000 crore for Bengaluru, Pune and Thane metro projects which are expected to complete by 2029" adding to the present length of metro under construction throughout the country to "1018 Kms" which makes to around "2000 Kms" when operational surpassing the USA (Mishra,2024). Apart from the positives of moving large number of people and providing efficient transit, metro rails often

struggle to reach their full potential due to weak first mile and last-mile connectivity. Well planned feeder bus services, pedestrian-friendly infrastructure, and cycling lanes play a major role for maximizing accessibility to metro (Verma et al., 2021).

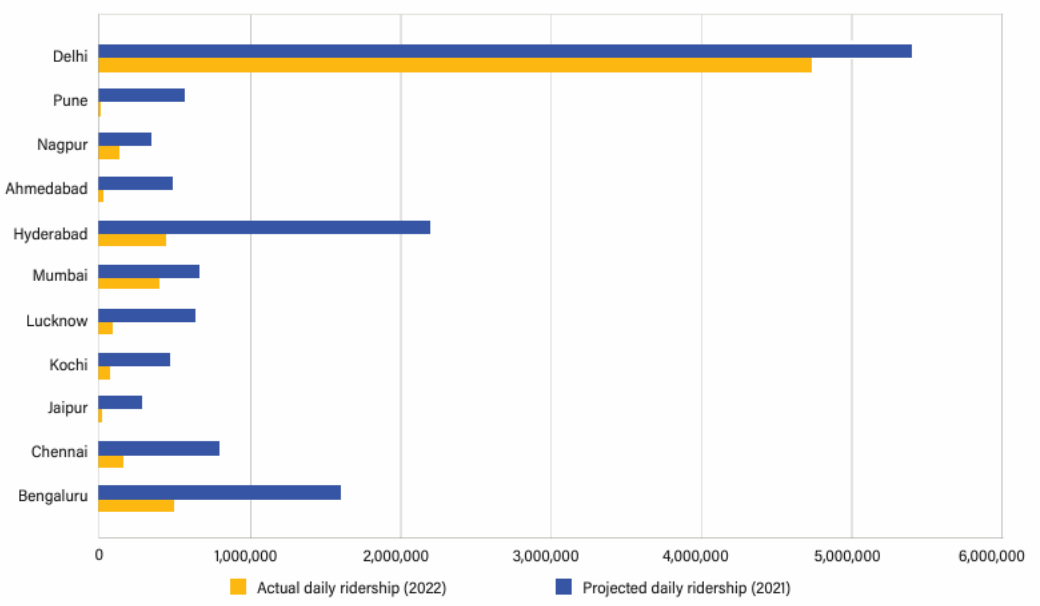

Figure 2 Projected and Actual Ridership in India (Mukherjee et al., 2023)

Non-Motorized Transport (NMT) is an often-overlooked important aspect in Indian public transportation scenario. Pedestrian pathways and cycling infrastructure are crucial in making public transport more accessible reducing public reliant on private motorized vehicles. Studies show that cities with good NMT infrastructure have higher ridership across public transport modes (Verma et al., 2021). But the Indian urban transport policies though talk about the importance of these modes, that hasn't turned into reality while allocating resources to NMT, leading to its present situation in Hyderabad and most of the Indian cities.

Despite all the advancements, institutional coordination remains a major hurdle to achieve multimodal integration. The Unified Metropolitan Transport Authority (UMTA) was introduced under the National Urban Transport Policy (NUTP) to streamline planning and

operations across transport agencies. This had a weak implementation due to bureaucratic inefficiencies and jurisdictional conflicts (Verma et al., 2021). Without stronger institutional mechanisms any effort to integrate different transport modes will always lead to a system that is still fragmented and ineffective.

Kingdon's Multiple Streams Framework (Kingdon, 1984) is adopted with an additional technology stream, to get the understanding on how the technological innovation with electric vehicles can be leveraged for policy development. This approach is to examine how policy windows open not just from problem, policy, and political streams, but also from dynamic technological activities such as R&D, market creation, and adoption patterns that influence and are influenced by policy choices (Voß 2007; Elzen et al. 2011; Goyal et al. 2021). Similarly, Christopher Hood's NATO framework (Hood, 1983) is used for structuring the recommendations as this framework gives a comprehensive understanding of what kind of tools are to be used for policy formulation.

The primary motivation of this study is to explore ways to enhance the effectiveness of the current public transportation system in Hyderabad, focusing on both the operational metro network and the proposed metro network under Phase II, which includes an additional "116.2 kilometers of metro lines" (Kaushik, 2024), TGSRTC services, and surface rail system (MMTS/ Local trains). Current limitations in "lack of integration", between the three modes of transportation, issues with "last mile connectivity" (Krishna & Chattaraj, 2020) have hindered the metro rail's success in effectively addressing the public transportation in Hyderabad. The study is intended to address the following research questions.

a) How does the last-mile connectivity influence the commuter's choice between public and private mode modes of transportation in Hyderabad?

b) What are the existing barriers and various practices that can be implemented to improve the integration of public transportation modes in Hyderabad?

c) What lessons can be learned from successful multi-modal transportation systems in other cities that could be applied to enhance public transport in Hyderabad?

d) What are the policy interventions that can incentivize public transportation usage over private vehicles for Hyderabad.

e) How can the transition from internal combustion engines of private vehicles to electric vehicles act as a leverage for increasing public transportation usage?

The aim of this research is to analyze the barriers to efficient multimodal public transportation in Hyderabad and propose pathways for improving urban mobility by addressing the above research questions. By using bibliometric analysis, secondary data, and semi structured interviews with experts, the study provides a comprehensive examination of the factors influencing public transport adoption. The work also explores the role of electric vehicles (EVs) in enhancing last-mile connectivity and transitioning to a more sustainable urban transport ecosystem.

This report is structured as follows: Chapter 2 is the reasoning on the research questions to be addressed from this study. The Literature Review in chapter 3 discusses existing research on multimodal transportation and on the two frameworks used - Kingdon's Multiple Stream Framework and Christopher Hood's NATO framework. The chapter 4 outlines the methodology of the study - the research approach, including bibliometric analysis, secondary data and expert interviews. The analysis and findings in chapter 5 presents key insights from primary and secondary research, highlighting barriers to efficient public transportation and strategic

interventions. Chapter 6 is the discussion by triangulation from the research methods employed to identify converging themes and policy implications. Chapter 7 covers the recommendations which are based on the NATO framework and finally the chapter 8 and 9 are concluding remarks to summarize key takeaways and future scope suggesting areas for further research respectively.

2. Research Questions

A well-functioning multi-modal public transportation system is essential to address urban mobility challenges. However, several barriers hinder its efficiency in Hyderabad. This section is to reason out the five research questions based on the literature to understand barriers as well as opportunities in creating an integrated, accessible, and sustainable public transport network for the city.

a) How does the last-mile connectivity influence the commuter's choice between public and private mode modes of transportation in Hyderabad?

   One of the challenging tasks cities faces is to ensure seamless last-mile connectivity. When the users face challenge to find an easy way to reach final destination from metro stations or bus stops, they tend to shift towards to private vehicles (Kanuri et al., 2019; Tejaswi et al., 2023). Adding to that the research by Kanuri et al., (2019) shows that the lack of dependable shared mobility options and inadequate pedestrian infrastructure is weakening the metro rails effectiveness. The various implemented simple solutions like introducing e-scooters and bicycles at metro stations to bridge this gap are making public transport more convenient and appealing (L&T Metro Rail Hyderabad, 2023; Times of India, 2018; The News Minute, 2018)**.** Collaboration between Hyderabad Metro Rail and a ride-hailing app, resulted in over a crore ride for last-mile connectivity, shows the potential of such integrated solutions (Times of India, 2024; HMRL, 2024).

b) What are the existing barriers and various practices that can be implemented to improve the integration of public transportation modes in Hyderabad?

For a multi-modal transport system to be efficient, all the public transportation modes have to be well integrated. In Hyderabad, metro and bus services operate mostly in silos, making it difficult for any user dependent on multiple modes for commute (Choudhary et al., 2023). Measures like unified ticketing and real-time information sharing can bring a seamless travel experience (Lakshmi, 2021). Technology also plays an important role in this aspect. Intelligent Transport Systems (ITS) and Mobility-as-a-Service (MaaS) platforms are already offering real-time travel information, digital ticketing, and seamless transfers. They have transformed urban mobility in cities (Choudhary et al., 2023). India has been at a slower pace in adopting these kinds of systems. Scaling up these efforts can be a major step creating more integrated and commuter-friendly transit systems for Indian cities.

c) What lessons can be learned from successful multi-modal transportation systems in other cities that could be applied to enhance public transport in Hyderabad?

A universal approach to urban mobility will not serve the intended purpose, as no two cities have can be compared. Hyderabad can draw lessons from successful global models while adapting solutions to its local context. Singapore's EZ-Link card system provides seamless integration across buses, metro, and taxis, while London leverages real-time data analytics for service optimization (Bajaj, n.d.). In India, Kochi's MaaS platform integrates metro services with buses and auto-rickshaws, offering a model for Hyderabad to emulate (Choudhary et al., 2023).

d) What are the policy interventions that can incentivize public transportation usage over private vehicles for Hyderabad.

Policy interventions are also important in encouraging a shift from private vehicle use to public transport. There have been strategies such as congestion pricing, subsidized fares, and investments in pedestrian-friendly infrastructure which led to increased public transport ridership (Lakshmi, 2021). However, Hyderabad still faces policy gaps - insufficient funding for bus services, parking spaces (Baski, 2025) for users and also lack of focus on non-motorized transport infrastructure (Choudhary et al., 2023).

e) How can the transition from internal combustion engine vehicles to electric vehicles act as a leverage for increasing public transportation usage?

Apart from connectivity or integration, service quality and reliability are key factors in making public transport a viable alternative to private vehicles. Transition to electric vehicles (EVs) presents an opportunity to enhance both. In India, policies like the FAME I and II scheme, PM E-drive scheme (2024) and Telangana's Electric Vehicle Policy (2020) aim to accelerate EV adoption for improving public transport. The EV adoption here is with respect to both paratransit services and state operated bus services. If successfully implemented, such initiatives to transition can act as a pivotal point or a window to improve the quality and reliability, making them a more attractive choice for daily commuters.

3. Literature Review

3.1 Efficient Multimodal Public Transportation

The construct - Efficient Multi Modal Public Transportation is derived greatly from the research by Litman (2024), Poojani & Stead (2016) and Hensher & Rose (2006). These studies were considered as they provide a comprehensive view of multimodal transportation and with evaluation methodologies considering the challenges and policies concerned to developed as well as developing countries. They have shown this construct to encompass five main pillars – "Availability and Coverage", "Accessibility", "Reliability" and "Affordability", "Ease of Transfer".

Availability and Coverage refers to the extent to which public transportation options are available both with respect to time as well as geographical reach that people can access it when and where they need it. A good public transportation system will have buses, metro rail, and other transit options being able to serve a wide geographic area and operate at according to preferred time of commuters. When public transport is readily available, people are less likely to depend on private vehicles. The research by Tanwar & Agarwal (2024) found that cities with well-connected public transit networks see a significant drop in personal vehicle use, as residents have reliable alternatives for commuting. The research employed a three-step method for assessing multimodal transportation system trip time performance by identifying factors, generating various individual indices, and evaluating the Multimodal Transport System Travel-Time Performance Index.

Accessibility is mainly about the ease with which commuters are able to use public transportation, not just physical infrastructure or with respect to ingress or egress to a mode of

transportation but also in terms of information. Can commuters easily find a bus stop or metro station? Are schedules and routes clearly communicated? Gahlot et al. (2013) emphasized that cities that improve accessibility see an increase in ridership, as more people find public transport convenient and user-friendly.

For people to trust and depend on public transport, it needs to be consistent. When the preferred commute option runs on time, commuters can plan their journeys with confidence. But unreliable service with frequent delays, cancellations, or long wait times can push people toward private vehicles. Mwaka et al. (2023) found that when public transport users frequently face delays, they are more likely to switch to personal cars or two-wheelers. Reliable systems, on the other hand, build trust and encourage long-term public transport use.

Cost plays a major role in public transport usage. If ticket prices are too high, people, especially those from low-income groups may not be able to afford regular travel. On the other hand, reasonably priced fares make public transport a viable choice for all economic groups. Yang et al. (2020) highlighted that affordable public transport helps people, especially low-income to access better job opportunities thereby improving their quality of life.

An efficient multimodal system makes it simple and convenient for commuters to switch from one mode of transport to another whether it is transitioning from a metro to a bus or using last-mile connectivity options like auto-rickshaws, ride hailing services or feeder buses. Tanwar & Agarwal (2024) have shown that the cities with well-integrated transit systems have higher public transport adoption rates.

The first mile and last-mile connectivity in Indian cities, has been fortunately bridged by the Para transit options like shared Autorickshaws, ride hailing platforms in the recent past and

by very limited feeder or shuttle services. Very few cities like Delhi and Ahmedabad have taken steps to address this crucial gap to improve transfers. For example, the Delhi Metro has integrated feeder buses and auto-rickshaw stands, and the Bus rapid transit (BRT) in Ahmedabad offers designated spaces for auto-rickshaws and bicycles to make transfer between different modes easier (Goel & Tiwari, 2016). The mobile applications providing real-time updates on bus and metro schedules (Vyas & Patel., 2024) also help commuters plan their journeys better, reducing the uncertainty and making public transport a better option.

For a city's public transport system to be an efficient one, all the mentioned factors must align. When implemented right, a well-integrated multimodal transport system can reduce traffic congestion, cut down on pollution, and improve overall urban mobility, making cities more livable and sustainable.

3.2 Recent studies on public transportation system in India

The latest research on multimodal public transportation in India were studied. The studies in this sectioned were considered as they contextualized the necessity and gave the perspective on Indian specific challenges and the policy needs. They highlight the importance of existing institutional structures, infrastructural development needs and technological adoption for a better integrated public transportation system.

Chadalawada (2022) investigates on various strategies to improve public transport by seamless integration of various modes of transport in the context of smart cities in India. He considered buses, trains, bicycles, and shared mobility options as the transport modes in his work. The research showed the importance of a cohesive transportation ecosystem for a convenient commute for the user. The methodology employed analyses the urban transit models

with the case studies of four cities: Tokyo, Singapore, Berlin, and San Francisco. Various metrics such as Average Travel Speed, Passenger Load Factor, Coverage Area, Accessibility Index, and Emission Reduction Rate were used to analyze the performance of multi-modal systems in these cities. The findings highlight that successful integration of multi-modal transportation is based on three factors - robust infrastructure, adaptive technology, and coordinated governance. The study also emphasizes on the utilization of real time data to enhance the responsiveness of transit systems.

The study by Dawda (2024) highlights that the public transportation planning in Indian cities has historically been focused on private vehicles and rail-based systems neglecting bus transit, which led to a fragmented system. The research investigates the role of para-transit services which is often an overlooked aspect in terms of first and last-mile connectivity. The study utilizes data on urbanization trends, vehicle registration, road accidents, travel speeds, air quality, and ridership of different public transport modes. The recommendations include the need for a more balanced approach in investment, advocating for optimizing the bus networks and a better integration of para-transit services with public transport. The study emphasizes the necessity of establishing comprehensive institutional frameworks to develop urban mobility system to address the diverse needs of India's rapidly growing cities.

Similarly, the work by Desai & Dawda (2024) addresses the challenges and proposes solutions for creating efficient, sustainable, and user-friendly public transport systems in urban India through integration across institutional, operational, informational, and fare aspects. The methodology involves qualitative analysis based on expert opinions, case studies, and the evaluation of existing systems and global best practices. The key findings emphasize the critical need for Indian cities to transition towards integrated and sustainable multimodal transport

systems to address the challenges posed by rapid urbanization and increasing demand for efficient public transport. It stresses the importance of Unified Metropolitan Transport Authorities (UMTAs) in fostering coordination and integration. The need for integrating informal public transport, addressing the mobility needs of women and marginalized groups, and importance of fare and information integration of various modes are also highlighted.

Mukherjee et al. (2023) conducted a three-city survey of 7,200 metro commuters in India to understand current metro user demographics, last-mile choices, and preferences. The study revealed that Indian metro systems attract young (19–35), middle-income commuters with monthly household incomes between INR 10,000 and INR 40,000 ($121.26–$485.06 USD as of June 12, 2023). The study also found that affluent users are not attracted to the system, and low-income users are priced out of it.

The study highlights that the Indian metro commuters are highly sensitive to last-mile wait times and costs. Women are especially averse to waiting and may opt for more expensive services to avoid waiting. This study emphasizes prioritizing high-frequency, low-cost shared services and improving pedestrian infrastructure around metro stations. It suggests that last-mile planning should be based on spatial demography around stations, driving last-mile service design from a commuter-oriented perspective, and mandating a clear, periodic last-mile data-gathering process. The research also found that metro users primarily walk or use low-cost shared last-mile modes, which is likely due to the demographic's high price sensitivity that makes more costly on-demand last-mile modes unviable. Also, users, especially women, are averse to waiting for last-mile modes, and a last-mile mode whose frequency exceeds 10 minutes is unlikely to be preferred. They are willing to travel up to 20 minutes to access metro stations, including the time spent waiting for last-mile modes. This figure is consistent across cities and income groups,

indicating that the “catchment region” of a metro station is determined more by access time than by a fixed area. (Mukherjee et al., 2023)

The study by Tejaswi et al. (2024) using Structural Equation Modelling in Hyderabad found that inadequate first and last-mile connectivity contributes to low occupancy in new mass rapid transit systems, highlighting its significant impact on mode choice. This research analyzed the causal relationships between trip chaining and mode choice, revealing that for work trips using active or public modes, the decision-making process is simultaneous, emphasizing the importance of seamless connectivity. Mukherjee et al (2023) found that poor access to metro stations is a primary reason for underutilization, with commuters seeking improvements in feeder service frequency, waiting times, and fares. This suggests that addressing these last-mile factors is crucial to attract commuters to public transport over private vehicles in Hyderabad.

Sagar & Ghuge’s (2015) work on public transport in Hyderabad points to a lack of coordination between different modes like buses and the MMTS. This study identified that many passengers already undertake modal shifts, indicating a need for better integration. To improve this, the research suggests enhancing connectivity between bus routes and MMTS stations, introducing dedicated feeder bus services synchronized with train schedules, and utilizing information technology to provide integrated information to commuters. These practices, derived from surveys and analysis of existing transport scenarios in Hyderabad, aim to create a more seamless and attractive transport system.

Learning from cities with successful multi-modal systems highlights the importance of integration across various levels. Singapore's synchronized MRT and bus services with a unified payment system demonstrate the effectiveness of operational and fare integration. Bogotá's BRT system with its "trunk and feeder" route approach offers a model for efficient network integration

(Dawda, 2025). Applying these lessons to Hyderabad would involve focusing on better coordination between existing modes, implementing a unified ticketing system, and optimizing route networks to improve commuter convenience and encourage public transport usage.

Research suggests that policy interventions such as subsidizing public transport fares and implementing strategic pricing for private vehicle usage, like parking fees, can encourage a shift towards public transport (Fei, 2016). The provision of free public transport for specific groups, as seen in Hyderabad for women through Mahalakshmi Scheme has significantly improved the ridership (Baski, 2025).

The transition to electric buses by the Telangana State Road Transport Corporation (TGSRTC) in Hyderabad can enhance the appeal of public transport by reducing pollution and noise, contributing to a healthier urban environment. Research indicates that electric buses have lower operating costs, which could lead to more affordable fares or reinvestment in service quality, making public transport a more attractive option compared to private vehicles, whether electric or combustion engine-based (Castellino, 2025). Government initiatives promoting electric public transport and the modernization of fleets can improve the overall image of public transport, potentially attracting more riders (HT Auto, 2024).

3.3 Application of Kingdon's Multiple Stream Framework

Kingdon's (1984) Multiple Streams Framework (MSF) has been widely framework for agenda-setting stage in policymaking. Goyal et al. (2021) expanded this framework introducing a new stream called technology stream. The study shows how technological advancements influenced the adoption of the General Data Protection Regulation (GDPR) in the European

Union. The study demonstrated how policy entrepreneurs leveraged windows of opportunity to align the problem, policy, and political streams, ultimately bringing in regulatory change.

The disruptive technologies introduce new regulatory challenges, making policymakers to assess existing frameworks (Voß (2007); Elzen et al. (2011) as cited in Goyal et al. (2021)). By incorporating a technology stream into MSF, the study by Goyal et al. (2021) provides a comprehensive understanding of how technological change influences problem identification, solution development, and political momentum.

The section in this research on leveraging the transition of Internal combustion engine to Electric Vehicle to improve last mile connectivity and the services of road-based transport is based on this approach by applying MSF with the technology stream. Similar to how Goyal et al. (2021) illustrated the link between data protection concerns and GDPR, this analysis explores how EVs can be integrated into public transport policy.

3.4 NATO Framework for Recommendations

To arrive at the policy insights and recommendations, this study relies on NATO (Nodality, Authority, Treasure, and Organization) model proposed by Christopher Hood and the individual tools are explained in *The Tools of Government in the Digital Age* (Hood & Margetts, 2007). This model gives a framework to understand government instruments for policy implementation. “Nodality” refers to the government's role in the collection and dissemination of information effectively. The state can influence public behavior and policy outcomes through communication strategies (Hood, 1983; Hood & Margetts, 2007). “Authority” is about governments' legal and regulatory powers to mandate or prohibit actions. Through legislation and regulations, authorities can enforce compliance and direct societal behavior (Hood, 1983;

Hood & Margetts, 2007). “Treasure” denotes the financial resources available to governments, such as taxation, subsidies, and grants. By allocating or withholding funds, governments can incentivize or disincentivize specific behaviors and support policy objectives (Hood, 1983; Hood & Margetts, 2007). “Organization” is related to the internal resources and capabilities of the government, including its agencies, personnel, and infrastructure. Through organizational capacity, governments can directly provide services and implement policies (Hood, 1983; Hood & Margetts, 2007). As the multimodal transportation is with inbuilt complexities this model gives insights on what policy recommendations can be implemented for the overall goal to enhance efficiency of transportation system.

Though not under the NATO model, several studies have shown the importance of policy various policy instruments that are to be implemented for better transportation systems in urban agglomerations. Hood’s NATO model helps in giving a comprehensive view through which these instruments can be categorized and implemented. Previous research on public transport efficiency by Desai & Dawda (2024) mentions about the role of regulatory interventions and financial incentives in shaping transport accessibility and reliability. The study on smart mobility by Banister (2008) mentions about leveraging real-time data and digital infrastructure to improve system integration which is a nodality-based policy tool.

4. Relevance of the Study and Existing Research Gaps

This research addresses critical gaps in the existing research on public transportation planning and implementation of Hyderabad, by focusing on enhancing the effectiveness of existing public transportation through the integration across different modes. This research could influence decision-makers and relevant stakeholders to adopt transformative solutions that not only improve urban mobility but also contribute to resilient transport network for Hyderabad.

Most of the existing literature, focuses on improving operations of individual mode of transportations in Hyderabad. The study by Krishna and Chattaraj (2020) evaluates the public transportation of Hyderabad using VISUM software to identify key performance indices and to propose new bus and metro routes to improve accessibility and to reduce congestion. Sagar and Ghuge (2015) emphasize the need for integrating different modes of transportation by effective use of information technology to understand passenger movement. The study by Tejaswi et al. (2024) uses Structural Equation Modeling (SEM) and confirmatory factor analysis. It identifies different decision-making patterns for work and non-work trips. While this research is important to understand travel behavior, it concentrates on individual-level decision-making rather than systemic improvements in transport infrastructure or service integration.

The reports UITP Case Study (2019) and Hyderabad Metro Rail Limited (2024) highlight the efforts made by agencies like L&T Metro Rail Hyderabad and HMRL to enhance multimodal connectivity through physical infrastructure, technological solutions, and service-level integrations. Though these initiatives show practical progress, they are in descriptive, implementation-focused formats and lack evidence-based research on their effectiveness

These show that there is limited research on a broader policy front on multimodal public transportation system in Hyderabad. Though the studies on individual modes shed light on individual aspects of mobility, there is a gap in research in assessing the impact of these multimodal strategies on commuter behavior, inclusivity, or long-term sustainability outcomes. Addressing this gap is crucial for informing data-driven policies and guiding investments that can enhance the efficiency and sustainability of public transport in Hyderabad.

Adding to the above, this study also explores how the adoption of electric vehicles (EVs) can be leveraged for improving public transportation use. The report by International Energy Agency (IEA) (as cited in Chaturvedi et al., 2022) says that "By the end of 2019, India reported a cumulative diffusion of 11,200 electric cars, representing just 0.1% market share." But the Press Information Bureau has released statement saying "With the launch of the National E-Mobility Programme, the government has set ambitious goals to accelerate the adoption of electric vehicles (EVs), targeting more than a 30% market share by 2030" (Press Information Bureau, Government of India, 2018, as cited in Chaturvedi et al., 2022). This makes it imperative to explore the impact of the EV adoption on the public transport usage for urban agglomerations.

The connection between enhancing multimodal public transportation and adopting electric vehicles (EVs) in paratransit and state-operated bus services - TGSRTC in Hyderabad, is an unexplored area with regards to improving city's public transport ecosystem. Integrating EVs into the overall public transportation system is a necessary, but not a sufficient condition. Factors like institutional coordination, urban planning, the financial outlay for infrastructural development, etc., are necessary for overall improvement. The complexity of integrating informal transport services and the nascent nature of EV infrastructure have contributed to this gap. This study tries to contribute to this space with the latest development of reliable EV

technologies and push from governments both at the central and state levels with policies incentivizing electric vehicles for public transportation. The central aim is to understand how this integration can significantly improve the quality of these services, potentially elevating the overall public transport scenario in Hyderabad to levels comparable with the metro rail, contributing to a more sustainable and efficient urban transport system for the city.

5. Methodology

This research adopts multi method qualitative research approach based on inductive logical reasoning with the central phenomenon being “enhancing multi modal public transportation in Hyderabad”. The research will commence with analysis of secondary research followed by expert interviews to gather comprehensive insights on the existing barriers for efficient multi modal transportation in Hyderabad.

Secondary analysis helps in establishing existing knowledge and patterns from previous research adding to the Bibliometric Analysis which is to identify the trends in academia on the construct and helps in providing an objective view of how the field has evolved without any bias. The expert interviews provided qualitative insights based on the practical situation and helps in complementing the secondary analysis and also in validating the findings.

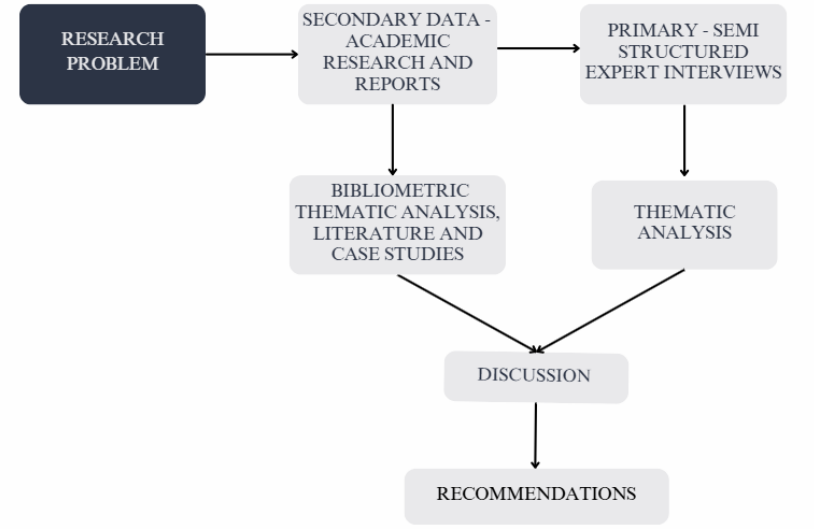

Figure 3 Research Flow Chart (Source: Self)

The methods employed are briefly explained below

- **Secondary Research:** This stage includes bibliometric analysis, reviewing academic research and governmental reports, and policy documents related to public transport

in Hyderabad to establish a foundational understanding of the challenges and opportunities present.

- **Semi-Structured Interviews**: This stage includes conducting semi-structured interviews helps in getting detailed information also offering flexibility to the responses. Engaging with transportation experts, urban planners, and relevant experts helps to gather qualitative insights regarding the current state and potential improvements for integrating different modes of Hyderabad's public transport system. The questionnaire for the interview is attached in Annexure I.

The previous research on urban transportation and planning aimed at "gaining insightful perspectives" and for "facilitating better decision making" often employ qualitative approaches for the study (Urban Design lab Educations Pvt. Ltd., 2023). The secondary research makes use of existing data giving historical trends and also contextualizing insights to evaluate gaps and validate them with government reports and academic research (Odongo & Ma, 2021). There are also constraints with respect to lack of expert knowledge to gain insights for facilitating better primary date collection.

Bibliometric analysis using a keyword co-occurrence network is being conducted to explore the trends or pattern in the academic research. Through the examination of frequently co-occurring keywords and thematic clusters, emerging trends are identified. The analysis is being conducted using the 'bibliometrix' package in R, a widely adopted tool for bibliometric and science mapping analysis (Aria & Cuccurullo, 2017). The indexed keywords are considered for the keyword co-occurrence network "as these can capture the content of the article in more depth than the more specific author keywords in the same paper" (Su & Lee 2010; Aria & Cuccurullo 2017 as cited in Pillai & Matus (2020))

Doringer (2020) says expert interviews will provide contextual knowledge as well as practical insights to understand the implementation gaps, diverse perspectives and to explore different solutions that secondary data may not provide. Van Renswouw et al. (2022) amplifies this that the expert insights reflect real world challenges and solutions making them vital for formulating implementable strategies.

By integrating secondary data analysis with expert interviews, this approach ensures a comprehensive understanding of the barriers and opportunities for enhancing multi-modal public transportation systems.

6. Analysis

6.1 Bibliometric Analysis

Bibliometric analysis helps in systematically evaluating academic literature, identifying key research trends and also in understanding emerging themes and research over time. Bibliometric analysis also used to “avoid bias in determining the research frontier” (Pillai & Matus, 2019). The keywords used in SCOPUS search are ("public transport*" AND urban*) AND (availability* OR coverage* OR accessibility* OR reliability* OR affordability OR "Ease of Transfer*" OR improve* OR policy* OR strategy* OR recommend* OR "best practice*") “with ‘*’ used for a fuzzy search” (Pillai & Matus, 2019) across three time periods that include the initial research upto 2005, then decadal – 2006-2015, 2016- 2025. This division into three time periods helps to compare how research patterns, themes, and studies have changed over time. The first period is to understand the baseline covering early developments, the second and the third are to identify emerging trends, understand shift in policy focus and technological advancements. The “bibliometrix” (Aria & Cuccurullo 2017, as cited in Pillai & Matus (2021)) package of the R programming language is used to do the bibliometric analysis.

The figure below is the Keyword Co-occurrence Network of the research up to 2005 which resulted in 1060 articles in the Scopus search.

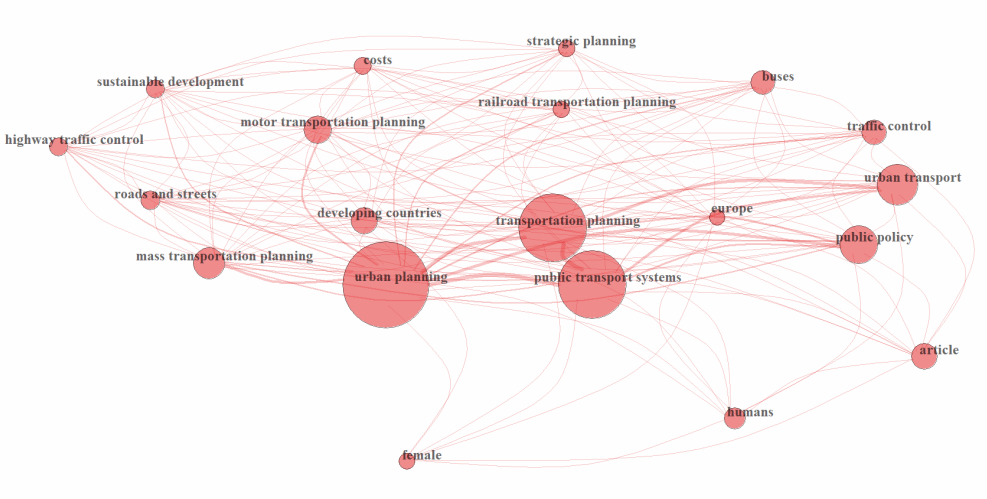

Figure 4 Keyword Co-occurrence Network (Up to 2005 - 1060 Articles)

The co-occurrence network for this period provides insights into early research trends in public transportation. "Urban planning" appears as the most significant keyword, emphasizing that early research focused on city-level transport planning. "Transportation planning" and "public transport systems" are also highly interconnected, indicating that structuring transport systems was a major concern and also "Developing countries" emerges as an important node emphasizing that public transport discussion across low-income countries. The strong links between "sustainable development" and "transportation planning" indicate an awareness of the environmental impacts of urban mobility. “Buses" and "mass transportation planning" remain crucial aspects, reinforcing the dominant mode of public transport studied during this period. "Costs" appears as a connected node, showing that financial considerations were a key aspect of transport planning. When looking at the missing aspects of the network - Technology and digital solutions are largely absent, reflecting the limited integration of smart mobility solutions in early studies. Metro rail systems do not appear prominently, suggesting that metro-specific research had not yet gained traction. "Female" appears as a minor node, highlighting the lack of dedicated studies on gender-sensitive transportation.

The co-occurrence network visualization for the period 2006-2015 resulted in 2116 articles and shows notable shifts in public transport research, compared to the earlier dataset.

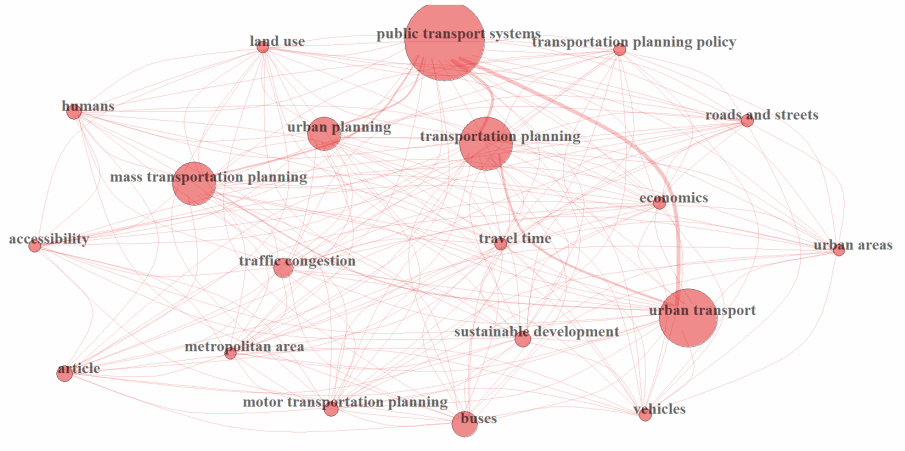

Figure 5 Keyword Co-occurrence Network (2006-2015 - 2116 Articles)

Public transport systems emerge as the most significant node, reflecting the growing emphassis on structured and integrated transit networks. "Urban transport" and "transportation planning" continue to be central themes, reinforcing the need for well-coordinated mobility frameworks. Unlike the previous period, terms such as "travel time," "economics," and "traffic congestion" now feature prominently, indicating an increased focus on efficiency, financial feasibility, and congestion mitigation in transit planning. Sustainability begins to take shape, showing a gradual shift towards eco-friendly transport models.

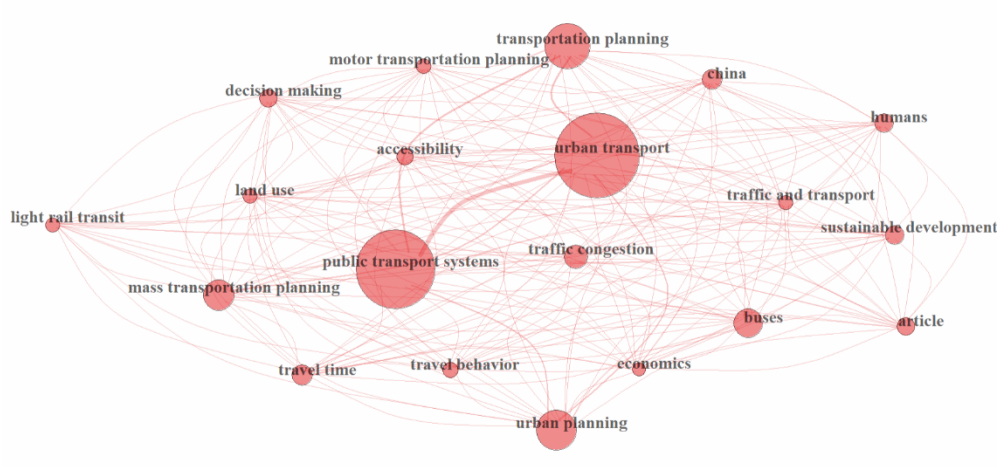

Figure 6 Keyword Co-occurrence Network (2016-2025 -7216 Articles)

For the last 10 years i.e. between 2016 and 2025 the Scopus search resulted in overwhelmingly large number of 7216 Articles. This period shows expansion of research on public transport, with notable shifts towards behavioral, technological, and localized urban transit challenges. "Urban transport" again becomes the dominant node, reflecting increasing emphasis on multimodal networks and their impact on overall urban mobility. "Traffic congestion" remains a persistent issue, highlighting that despite research advancements, congestion challenges remain unsolved. "Travel behavior," "decision making," and "light rail transit" indicate a shift towards studying commuter preferences, policy decision-making, and alternative transit modes. China appears as a keyword, indicating growing research interest in Asia's transport models and their applicability worldwide.

Though there is increase in research volume, issues like congestion and accessibility, remain in the focus which is due to the work not being context specific. Public transport solutions must be uniquely designed for individual cities rather than following a generic model. Hyderabad faces different spatial, economic, and commuter behavior challenges than cities in Europe or North America, requiring localized planning and adaptive policies. While smart mobility solutions have been introduced in global transit systems, they do not appear as

dominant nodes in the bibliometric network, suggesting a lag in technological integration within urban transport research. While more transit modes are studied, achieving true seamless connectivity between them is still a work in progress.

The bibliometric analysis across three periods (Up to 2005, 2006-2015, and 2016-2025) shows a significant evolution in public transport research, shifting from urban planning and mass transit to policy-driven, behavior-focused, and multimodal strategies. However, recurring challenges such as traffic congestion, accessibility, and economic feasibility persist, emphasizing that public transport challenges remain unresolved.

A key takeaway can be that a universal approach to urban transit solutions is insufficient cities like Hyderabad require localized, data-driven, and adaptable policies that cater to unique infrastructural and commuter behavior patterns. Moving forward, integrating smart mobility, AI-driven transport management, and city-specific multimodal strategies will be crucial for addressing Hyderabad's public transport challenges effectively.

6.2 Qualitative Insights from Literature Review

The analysis in this section is based on addressing the research questions from the relevant literature, policy documents and developments in the urban mobility space. The systematic approach followed for the analysis in this section is based on the following figure

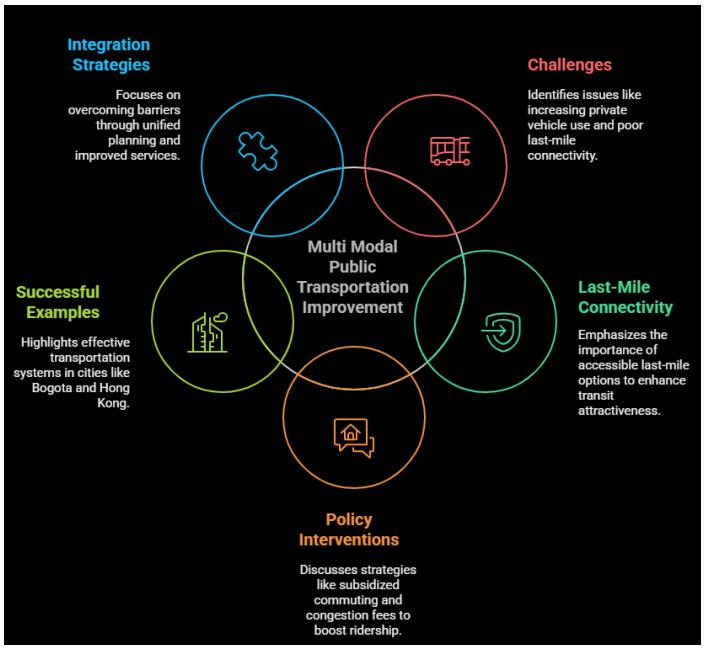

Figure 7 Systematic Approach for Analysis of Past Literature (Source:Self)

Hyderabad faces challenges in providing efficient and sustainable public transportation, underscored by the increasing number of private vehicles despite the operation of the Hyderabad Metro Rail. This trend, also observed in other Indian cities (Choudhary & Achari, 2023) indicates a gap in the effectiveness of existing public transit systems.

Hyderabad's lack of proper last-mile connectivity significantly hampers the efficiency of its public transportation systems, including buses, Metro Rail, and MMTS. In areas like Cyberabad, despite substantial development and dense residential growth, commuters face challenges due to insufficient public transport options and fragmented connectivity. An article shows how commuters must rely on multiple share autos and long walks to cover short distances, highlighting the inadequacy of Telangana State Road Transport Corporation (TSRTC) services in addressing last-mile needs (The News Minute, 2020). Similarly, MMTS users suffer from erratic train schedules and lack of feeder services, discouraging reliance on this mode of transport. While initiatives like Hyderabad Metro's partnerships with Rapido and Mana Yatri

have introduced subsidized rides to improve connectivity at Metro stations, these efforts remain limited in scope and fail to address broader systemic issues (The Hans India, 2024 & Times of India, 2024). Urban planning bodies like UMTA have largely underperformed in integrating various transport systems, leaving gaps in seamless transit (The Hindu, 2023). Without robust infrastructure and strategic planning, commuters are forced to depend on private vehicles, increasing congestion and pollution across the city.

An efficient multimodal transportation system seamlessly integrates various modes of transportation, such as buses, metro rail, surface rail transit systems, bicycles, and pedestrian pathways, to facilitate smooth, cost-effective, and sustainable mobility. An efficient system fosters a modal shift from private vehicles to public transit by addressing last-mile connectivity issues and integrating solutions for enhanced user experience (Banister, 2008).

6.2.1 The Critical role of Last Mile Connectivity

Last-mile connectivity is a pivotal factor in determining the appeal and utility of public transportation systems A lack of adequate last-mile options often discourages potential users, even if their primary transit system (such as the metro) is efficient and well-connected. Studies consistently show that inadequate last-mile connectivity reduces the attractiveness of public transit options, thereby increasing reliance on private vehicles.

Dedicated bus routes from residential and commercial areas to metro stations i.e. feeder service to metro can significantly enhance accessibility (Cervero & Wu, 2016). Frequency, reliability, and integration with the metro schedule are crucial for the success of feeder bus services. Careful route planning, optimized schedules, and real-time tracking are essential for maximizing their effectiveness. Similarly, Auto-rickshaws, shared taxis, and ride-hailing services

can provide flexible and demand-responsive last-mile solutions, particularly in areas with lower population density or during off-peak hours. Partnerships with ride-hailing companies can provide on-demand last-mile transportation, extending the reach of public transit (Clewlow & Mishra, 2017). Subsidized ride-hailing fares for connecting to public transit hubs can incentivize usage. These options bridge the gap between fixed-route transit and individual needs. Shared paratransit (such as shared auto-rickshaws) options are especially popular in Hyderabad's context. Improved feeder services, such as bicycle-sharing programs, e-rickshaws, and pedestrian-friendly infrastructure, have also shown to enhance public transport ridership (Kawathekar et al., 2024).

Mukherjee et al. (2023) recommendations include prioritizing low-cost shared services and non-motorized access infrastructure, operating last-mile shared services at high frequencies, basing last-mile planning on the spatial demography around stations, driving last-mile service design using a commuter-oriented perspective, and mandating a clear, periodic last-mile data-gathering and analysis process. The study also emphasizes that there is no universal approach to deploying last-mile services at metro stations and highlights the necessity of robust, periodic data collection and analysis to plan viable commuter-centric last-mile services.

6.2.2 Policy Interventions to Incentivize Public Transportation Usage

These interventions often focus on reducing costs and improving accessibility. Research highlights that the individual incentives, such as discounted transit passes, pre-tax payroll deductions, or subsidies for mixed-mode commuting (e.g., combining transit with ride-hailing), can significantly increase ridership (County Health Rankings & Roadmaps, 2023). Siddiq et al., (2020) analyze strategies to boost public transit usage. They propose two mechanisms a) Governments provide subsidies to commuters adopting a mixed-mode of transportation

(combining public transit with ride-hailing) and fund these subsidies by imposing congestion fees on personal vehicles entering city centers or b) Instead of levying congestion fees, governments secure funding for subsidies through partnerships with private sector entities.

6.2.3 Examples of Successful Policy Interventions (County Health Rankings & Roadmaps, 2023)

Several successful policy interventions have promoted public transportation and reduced single-occupancy vehicle use. The U.S. federal government offers a transportation subsidy program for federal employees in the National Capital Region, covering commuting costs via public transit. Some states, like Oregon, provide energy tax credits to businesses that incentivize employees to use public transit. Cities such as Alexandria, Virginia, integrate incentives into transportation management plans to encourage walking, cycling, and transit use.

Additionally, time-shift incentives like the Commuter Connections Flextime Rewards program in Washington, D.C., help reduce congestion by promoting off-peak travel. Many municipalities, including Austin, Seattle, Nashville, and Portland, offer transit pass programs for students and employees. Portland's Transportation Wallet (TW) program provides transit, bike, and scooter credits, easing parking demand and congestion. In 2019, TW expanded to offer transportation credits to affordable housing residents, increasing transit accessibility and promoting sustainable mobility.

6.2.4 Successful Multimodal Transportation Systems

To get valuable insights from the best practices adopted globally for Hyderabad's context, Bogota and Hongkong have been considered to understand their approach towards multimodal public transportation. Bogota is a closer comparison to Hyderabad because of its developing

country context, resource constraints and its implementation of cost effective and successful bas rapid transit system Transmilenio. Bogota shows how strong institutional frameworks, dedicated infrastructure for public transport, the integration of non-motorized transport to its main public transportation mode can bring in efficiency to the system. Whereas, Hongkong is a high dense urban environment with a stronger transit-oriented development and very well integrated transit system across metro, buses, ferries, and walking infrastructure. Above all, the city is considered for its financially self-sustaining model and technological innovation in fare and mobility management.

6.2.4.1 Bogota

Bogota, the capital city of Colombia experienced rapid population growth from 1980's due to migration from other parts of Colombia. Bogotá's approach to public transportation is a model for efficiency, affordability, and sustainability which transformed the urban mobility in the city. One of its most successful achievements is the TransMilenio Bus Rapid Transit (BRT) system, that provided a Mass transport network by buses but at a fraction of the cost of metro rail systems (Nair & Kumar, 2005). The city built dedicated bus lanes, efficient bus station infrastructure, and an organized ticketing system, ensuring fast and reliable service for commuters. TransMilenio from its designing stage has focused on being inclusive, serving the entire city, the lower-income residents living on the periphery. The integration of feeder bus routes extended its reach, making public transport accessible to a larger population thereby reducing the dependence on private vehicles (Hub, 2019).

Bogotá also took a holistic approach to urban mobility by building pedestrian and cycling infrastructure. This promoted non-motorized transit option as a practical alternative. This strategy not only eased congestion and also promoted sustainable commuting. Bogotá

implemented policies to discourage private vehicle use, including restrictions on car circulation during peak hours and designated car-free days. These measures significantly reduced traffic congestion, improved air quality, and lowered accident rates (*TransMilenio: Renewing Bogotá's Transport System*, 2016).

6.2.4.2 Hongkong

Hong Kong's public transportation system is acclaimed for its efficiency internationally. This is because of the success of Mass Transit Railway (MTR) Corporation. MTR operates the city's metro and bus networks. In 2012, the MTR achieved a farebox recovery ratio of 185%, the highest globally, indicating that fare revenues not only covered operational costs but also generated substantial profits (Padukone, 2013). This is largely attributed to the MTR's "rail plus property" model, in which the corporation integrates property development with transit infrastructure. By owning and developing real estate such as shopping malls, office buildings, and residential complexes adjacent to transit stations, MTR capitalizes on the increased land value and passenger traffic, creating a symbiotic relationship between urban development and public transportation (Padukone, 2013).

The city's urban planning also enhances its public transport system's effectiveness. The high-density compact form of the city makes majority of residents live within accessible distance to public transit options. This planning reduces reliance on private vehicles and promotes public transport usage (Lo et al., 2008). Moreover, the integration of various transportation modes such as buses, minibuses, ferries, and trams into a cohesive network brings in resilience to the system. Intermodal connectedness allows for flexible route choices and efficient transfers, making the network's ability to withstand and recover from disruptions (City University of Hong Kong, 2024).

These two cities present diverse, adaptable best practices that address both structural limitations and strategic opportunities relevant to Hyderabad's goal of building an efficient and sustainable multimodal transport system. Though the analysis shows the success of these two cities, it does not imply recommending to implement the same practices to Hyderabad or any of the Indian Cities. The main objective was to emphasize the approach of fulfilling the objectives of an integrated approach. The outcome should be aligned with local conditions.

6.2.5 Barriers and Strategies for Improving Public Transport Integration in Hyderabad

Hyderabad's public transport integration faces significant challenges due to institutional fragmentation, infrastructural and technological constraints. Multiple agencies operate in silos resulting in uncoordinated planning and execution, which results in duplicated routes adding to the inconsistent schedules in MMTS and TGSRTC services. The Metro Rail network, leaving peripheral areas underserved. Encroached footpaths and inadequate parking add to plight of first and last-mile connectivity issues. The absence of real-time passenger information systems and unified ticketing further deters seamless transitions between modes, contributing to a reliance on private vehicles. In terms of inclusivity aspect, Low-income groups from the peripheral areas of the city face mobility barriers, relying on private transportation and on relatively higher costing paratransit options like shared auto rickshaws, Ride hailing services, etc. due to poor accessibility to public transit modes.

Metro rail systems have emerged as a transformative mode of urban transit globally, offering a range of direct and indirect benefits. The reliability, quality, comfort, and convenience aspects of the metro rail makes them a preferred choice for commuters. In terms of infrastructure elevators, signage boards, priority seating, and reduced platform gaps for accessibility to the elderly and persons with disabilities brings in the aspect of encouraging users to avail the

services. Metros symbolize aspirational urban mobility, attracting commuters who previously relied on private vehicles due to inefficiencies in other public transport modes.

The indirect impacts or the positive spillovers of metro systems go beyond transportation. They bring in behavioral changes among commuters by promoting punctuality, cleanliness, and respect for shared spaces. These qualities can be applied across other public transport modes to elevate the entire urban mobility ecosystem with steps like a better bus shelter infrastructure, real time information of buses, clear lighting for safety, upgrading buses with electric vehicles (EVs) for sustainability and low-floor designs for accessibility, improving last-mile connectivity with reliable and convenient options, investing in infrastructure improvements, such as pedestrian walkways, cycle lanes can enhance accessibility and encourage public transport usage, etc.

By aspiring to the Metro's benchmarks in terms of service quality, reliability, and user experience, Hyderabad can create a cohesive multimodal transport network that caters to diverse commuter needs while driving sustainable urban development.

6.3 Primary Analysis

To gain a deeper understanding of the challenges and opportunities in Hyderabad’s public transportation system, four expert interviews were conducted with professionals actively engaged in the sector. These experts include researchers, transport planners, an urban planner, and a senior official from the Telangana State Road Transport Corporation (TGSRTC). Their insights, drawn from both academic research and hands-on experience in policy implementation and transport operations, provided a comprehensive perspective on the current state of urban mobility in Hyderabad. The thematic analysis of these interviews highlights key structural,

financial, institutional, and behavioral factors influencing the efficiency and accessibility of public transport in the city.

6.3.1 Emerging Themes from the Primary Analysis of Expert Interviews

The thematic analysis of the expert interviews brings into light several key challenges and opportunities in Hyderabad's public transportation system. These insights have been categorized into broad themes based on the Gerund and In-Vivo codes which are attached in Annexure 4. These themes reflect the systemic issues and potential strategies for improving urban mobility.

1. Challenges in Last-Mile Connectivity

Last-mile connectivity remains a critical barrier to effective public transportation in Hyderabad. Experts pointed out that the Hyderabad Metro Rail (HMRL) and Telangana State Road Transport Corporation (TGSRTC) operate in silos, often competing rather than complementing each other. This lack of coordination hinders smooth transitions between transport modes, reducing efficiency and discouraging public transport use. A key concern raised in the interviews was the disproportionate cost of last-mile connectivity. While metro fares are relatively affordable, additional expenses incurred in reaching metro stations often make the total journey costlier than private transport. As one expert mentioned, "Last-mile cost may be higher for some people." Hyderabad, like many Indian cities, heavily relies on informal transport such as shared autos and bike taxis for first- and last-mile connectivity. However, these modes operate without regulatory oversight, leading to issues of fare inconsistency, safety concerns, and reliability. As one respondent noted, "People just accept that shared auto is a thing," reflecting both its necessity and its limitations. Ideally, buses should act as feeders to the metro system, but in Hyderabad, they often run parallel to metro routes rather than serving as connectors. This

duplication of services reduces efficiency and leads to a fragmented transport system. One expert commented, “They are not acting as a feeder, basically,” underscoring the lack of a coordinated multimodal network.

2. Institutional & Policy Barriers in Public Transport

The lack of effective policy implementation and institutional coordination emerged as a significant challenge. The absence of a strong coordinating body leads to inefficiencies. While the Hyderabad Unified Metropolitan Transport Authority (HUMTA) exists on paper, its actual influence is minimal. One interviewee stated, “HUMTA is there, but it is not effective.” This suggests a need to empower HUMTA with greater decision-making authority and resources. Even when transport policies exist, they are often not effectively enforced or executed. One expert noted, “We just need a body to regulate, understand, and optimize.” The lack of policy enforcement results in inefficiencies in route planning, fare structures, and inter-agency collaboration. The absence of a clear long-term vision for Hyderabad’s public transport has resulted in ad hoc expansions that do not necessarily align with demand patterns. Experts emphasized the importance of evidence-based planning to avoid uncoordinated development.

3. Financial & Operational Constraints

The financial sustainability of Hyderabad’s public transport system is a major concern. The low farebox recovery ratio (the percentage of operational costs recovered from ticket sales) poses financial challenges. As one expert stated, “Farebox recovery is low, so we will always have a funding gap.” This suggests a need for alternative revenue streams such as congestion pricing, land-value capture, or sales tax measures. While the transition to EVs is seen as a positive step, experts cautioned that the upfront investment is substantial. One respondent remarked, “EVs require a massive upfront investment,” emphasizing the need for phased

implementation and innovative financing models. While PPPs have been explored as a means to enhance public transport infrastructure, challenges such as long payback periods and low-Key Performance Indicators (KPIs) have limited their effectiveness. One interviewee noted, “PPP has a long payback period and low KPIs,” highlighting the need for more sustainable partnership models. Some experts suggested new funding models, such as tax-based financing or dedicated urban transport funds. A successful example from global cities was mentioned: “Public transport should be funded by a sales tax measure.”

4. Accessibility & Equity in Public Transport

Public transport should be inclusive and serve all socio-economic groups equitably. However, several challenges were highlighted. Experts observed that lower-income groups struggle with high transport costs, while higher-income groups prefer private vehicles due to convenience and comfort. One interviewee commented, “People who can afford private vehicles will continue using them.” Women and disabled commuters face significant barriers in using public transport. While the metro is perceived as safer for women, buses remain inaccessible to many disabled users. One respondent noted, “Metro is safer for women, but buses are not accessible for the disabled.” This highlights the need for gender-sensitive and disability-friendly transport planning. Public transport should ideally be the most affordable option, but high fares for last-mile services push lower-income commuters towards walking long distances. One respondent stated, “Our bus ticket fares are ridiculously high.”

5. Role of Technology & Infrastructure

Technology and infrastructure development play a crucial role in shaping the efficiency of urban mobility. The absence of real-time tracking and digital ticketing hinders efficiency. One expert suggested, “Developing an app will increase transparency, accountability, and efficiency.”

Safe and walkable streets are essential for effective public transport, but Hyderabad lacks basic pedestrian infrastructure. One respondent remarked, “People don’t walk because they are unable to walk.” This indicates the need for pedestrian-friendly policies, including foot overbridges and designated walkways. The availability of parking near metro stations directly impacts ridership. An expert emphasized, “Parking becomes an attraction for success,” suggesting that improved parking infrastructure could encourage more metro usage. Making public transport data available can facilitate better coordination. One respondent said, “Publishing bus data can improve integration.”

6. Behavioral & Cultural Factors in Transport Choices

Behavioral aspects significantly influence public transport usage patterns. Private car ownership is often associated with social status, which discourages the use of public transport. One interviewee noted, “Owning a car is a certificate of entitlement.” The perception of public transport as inferior to private transport affects ridership. One respondent stated, “Metro is such a powerful system,” indicating that the perception of comfort and reliability influences commuting decisions. Many commuters remain reluctant to shift to public transport unless it offers clear advantages. One expert remarked, “People won’t use public transport unless it competes with private transport on time.”

7. Need for Holistic Urban Mobility Planning

The future of public transport in Hyderabad requires a well-integrated and sustainable approach: Experts pointed out that new developments in Hyderabad are not adequately served by public transport. One respondent stated, “We are not going to places where the new city is growing.” A seamless transport experience requires better multimodal integration. As one interviewee emphasized, “Multimodal integration should be seamless.” Future transport planning

must incorporate green technologies. One respondent noted, “Green hydrogen will be the next step after EVs.”

This analysis reveals that Hyderabad’s public transport system faces systemic barriers in integration, affordability, accessibility, financial sustainability, and institutional coordination. Addressing these challenges requires policy reforms, infrastructure development, financial innovations, and behavioral interventions to make public transport more efficient, inclusive, and sustainable.

6.4 Multiple Streams Framework for Leveraging EV Transition to Improve Public Transportation: The Readiness of EVs for Last-Mile Connectivity and State-Run Bus Fleet Electrification

Kingdon’s Multiple Streams Framework (MSF) provides a useful lens to analyze how the shift from internal combustion engine (ICE) vehicles to electric vehicles (EVs) can serve as a lever for public transport adoption. MSF outlines three streams problem, policy, and political align for a policy window to open (Kingdon, 1984). Traditionally, MSF captures problem identification, policy solutions, and political will but does not explicitly account for the readiness and reliability of emerging technologies. To accommodate the technological innovation paradigm, this study considers incorporating technology as an additional stream enhancing the framework’s applicability in contemporary mobility transitions inspired from the research by Goyal et al. (2021).

Problem Stream: Adoption of EVs for Last-Mile Connectivity and State-Run Bus Electrification

Ensuring accessible and efficient last mile connectivity is the main challenge for Hyderabad. The absence of reliable feeder system to the main modes of metro rail, bus and local trains makes the users rely on private vehicles. Paratransit options - Auto rickshaws, rides hailing services fortunately filled this gap but they are not formal and there are problems in both demand and supply side with respect to these services such as lack of fixed pricing, availability and safety aspects, etc. (Dawda, 2024). The adoption of electric vehicles in this space with supply side incentives for fleet services like parking space, charging infrastructure at transit points addresses the inbuilt demand from commuters for last mile mobility from these points.

Adding to the last mile connectivity, transitioning state-run bus fleets also brings in an opportunity to improve the services offered. Metro rails are often seen as benchmarks in service quality, reliability, and user experience. They set standards that other modes aspire to match. Since there is a push for transitioning to electric fleets. TGSRTC can now create an effective ecosystem that matches with metro standards, ensuring better integration and service efficiency. The positive spillover effects of metro systems can drive improvements across the entire urban transport ecosystem, fostering higher ridership and reducing dependence on private vehicles.

Policy Stream: Demand-Side Policies to Promote EV-Based Last-Mile Solutions and Bus Electrification

Effective demand-side policies can boost EV adoption for last-mile travel and public bus electrification. Research indicates that government financial incentives, such as subsidies and tax benefits, influence consumer attitudes and bring in behavioral changes thereby enhancing EV adoption intentions (Ansab & Kumar, 2024). A global analysis of 20 countries revealed that ownership tax benefits, increased charger density were identified as key drivers in expanding EV markets (Xue et al., 2021).

For bus electrification, policies should focus on procurement subsidies, public-private partnerships, and fleet transition targets. Incentives for state transport corporations, along with operational subsidies, can improve financial feasibility.

Political Stream: Government Willingness to Push for EV Adoption and Bus Electrification

The electric vehicle adoption in Hyderabad is reinforced by various national and state policies. India's FAME I & II policies (Ministry of Heavy Industries, 2021) were replaced by PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) scheme in October 2024. A budget of Rs. 10,900 crores which also includes for deploying 14,028 electric buses in Indian cities along with installation of 88,500 chargers by 2028-29 has been pledged gives an overview of efforts by Central Government to decarbonize public transport (Ahangar, 2024). "The scheme has a greater emphasis on providing affordable and environment friendly public transportation options for the masses. The scheme will be applicable to the e-2Ws and e-3Ws registered for commercial purposes (PM E-Drive, 2024). The detailed overlay of budget is given in the figure below.

Vehicle Segment	Maximum No. of Vehicles to be Supported	Total fund support from MHI (Cr.)
e-2 wheelers	24,79,120	1,772
e-Rickshaws & e-cart	1,10,596	192
e-3 wheelers L5	2,05,392	715
e-Ambulances	**To be notified separately**	500
e-Trucks	**To be notified separately**	500
e-Buses	14,028	4,391
EV PCS	72,300	2,000
Testing agencies upgradation	-	780
Admin Expenses	-	50
Total	**28,81,436**	**10,900**

Figure 8 Budget Overlay (PM E-Drive, 2024)

Similarly, the Telangana state EV incentives show strong political will for EV adoption. Telangana's EV policy (2020-30) supports this shift with purchase incentives and charging infrastructure development (Government of Telangana, 2020). The Telangana Chief Minister has announced plans to procure 3,000 electric buses within two years to combat urban pollution (Mahesh, 2024). The Telangana State Road Transport Corporation (TGSRTC) is set to add 286 electric buses in Hyderabad by mid-2025, supplementing the existing fleet of 254 e-buses. The state offers a 100% exemption on road tax and registration fees for electric vehicles, including two-wheelers, three-wheelers, and buses through its EV policy (Hans India, 2025). With national and state policies aligned, Hyderabad has a favorable environment to integrate EVs into public transport. Local government support, public awareness, and stakeholder collaboration are key to making EV policies successful. Partnerships between government, private firms, and research institutions can further accelerate this transition. For public bus electrification, strong political leadership is essential for funding, procurement, and regulations. Telangana's EV push offers Hyderabad a chance to lead in electric mobility by prioritizing bus fleet electrification.

Technology Stream: Readiness and Feasibility of EVs for Last-Mile Connectivity and Bus Electrification

The EV technology has become reliable in the recent past. The adoption of technology stream in this framework is to promote EVs for last-mile connectivity and public buses. Advances in battery efficiency, charging infrastructure, and affordability have made EVs a practical option (IEA, 2024). Falling battery costs, expanding charging networks, and government initiatives like PM E-Drive combined with EV policy of the state show that Hyderabad has the necessary ecosystem for EV-based transit.

For state-run buses, improvements in battery storage, fast charging, and vehicle-to-grid (V2G) integration have strengthened operational feasibility. Hyderabad can use these advancements to set up charging depots, explore battery-swapping, and implement smart fleet management (Madaram et al., 2024).

Adding a technology stream to Kingdon's MSF makes it more relevant to urban mobility challenges. Hyderabad's EV transition aligns with the problem, political, and policy streams, while the technology stream ensures feasibility. By electrifying last-mile transit and public buses, the city can improve metro connectivity, reduce congestion, and promote sustainable transport (Castellino, 2025). With strong policies, political backing, and continued innovation, Hyderabad can lead India's EV-driven public transport revolution.

In the context of Hyderabad's public transport, EVs within the technology stream represent a necessary, but insufficient condition. While offering cleaner, potentially more efficient operations, their adoption doesn't guarantee systemic change. The technology stream based on EV readiness, infrastructure, and reliability, must align with the problem stream (inefficient, polluting transport), the policy stream (incentives, regulations), and the political stream (government will, stakeholder support). EVs, therefore, are a necessary technical component, but their effectiveness is based on the convergence of other streams to create a policy window for transformative change.

7. Discussion by Triangulation

Bibliometric Analysis showed a consistent global academic focus on traffic congestion, accessibility, and urban planning related to public transport. It highlighted the evolving emphasis from basic infrastructure to policy-driven, behavior-focused, and multimodal strategies. It also shows a delay in the integration of smart mobility solutions in research, despite their global adoption. The essential part of it is the trend emphasizing the necessity of localized solutions over generalized universal approaches and technology driven solutions.

Analysis from the past literature reinforces the real-world manifestation of these challenges in Hyderabad, with increasing private vehicle use, inadequate last-mile connectivity, and fragmented transit systems. It emphasizes on the critical role of last-mile connectivity and the need for diverse solutions. The secondary research also highlighted on the potential of EVs for enhancing public transit and the importance of policy interventions. Also amplifies the bibliometric analysis on the need for a user centric approach, and also the importance of local data.

The analysis from Expert Interviews shows the need to address the inbuilt structural, financial, institutional, and behavioral barriers identified in the other data sources. The analysis provided nuanced insights into the complexities of implementing transit solutions in Hyderabad's specific context, including the pros and cons of EV implementation. It emphasizes the need for an efficient unified transport authority. It also confirms the real-world data that is needed to make informed policy decisions.

7.2 Converging Themes

All the three methods of analysis converge on the aspect of traffic congestion and accessibility challenges, highlighting its enduring significance. Secondary research and expert interviews strongly emphasize the pivotal role of last-mile solutions, supported by the bibliometric analysis's focus on user-centric approaches. The bibliometric analysis explicitly calls for localized solutions, corroborated by secondary research and expert interviews. Secondary research identifies EVs as promising, while expert interviews provide practical insights into implementation challenges and opportunities. Secondary research and expert interviews both identify the need for better institutional coordination, and the expert interviews brought in the need to improve the efficiency of the organizations before integration. The expert interviews and secondary data, brought up the idea, that the whole public transportation system needs to aspire to the service quality of the metro. All three data sources, highlight the importance of the user centric approach.

The convergence of the theoretical construct of efficient multimodal public transportation and the analysis through the methodology shows that the theoretical concept aligns with the analytical part of the research. For example, the converging theme of last-mile connectivity is based on Accessibility and Coverage discussed as part of the construct - “efficient.” Similarly, the theme of integration is also a factor in this construct. From this, it can be inferred that conceptual frameworks back this study’s insights.

8. Recommendations based on NATO Framework

The recommendations are under a broader umbrella of making sure that all forms of public transport, strive to have the same level of service as the metro rail that has evidently come in secondary and primary analysis.

A strategy for efficient multimodal public transportation for Hyderabad must address institutional fragmentation, prioritize multimodal integration, and leverage data-driven decision-making. By applying Christopher Hood's NATO framework (Nodality, Authority, Treasury, and Organization), the study tries for a systematic and effective implementation of recommendations, leading to a truly integrated and an efficient public transport network.

1. Nodality (Information & Communication Tools)

- Develop a Unified Public Transport Application: A real-time digital platform integrating Hyderabad Metro, TGSRTC buses, MMTS trains, and last-mile options like shared autos, e-scooters, and ride-hailing services. This should provide real-time schedules, fare information, and a single digital payment system.
- Open Data for Mobility Solutions: Publicly share transit data for private developers to create MaaS (Mobility as a Service) applications, facilitating real-time route optimization and ticketing.
- Establish a comprehensive data collection and analysis system to monitor transport demand, service performance, and user feedback.
- Ensure feeder bus routes and shared EV mobility solutions (e-autos, bike rentals) are integrated into metro stations and the bus shelters.

2. Authority (Regulations & Policy Interventions)

- Grant the HUMTA the legal authority to issue and enforce regulations related to service standards, operational efficiency, and intermodal coordination across all public transport operators (metro, bus, MMTS) and give it powers to impose penalties on agencies or operators for non-compliance with regulations, such as delays, service disruptions, or lack of adherence to integration requirements.
- Mandate that all transport operators share real-time data with the HUMTA and with each other to facilitate coordinated operations and provide accurate information to passengers and all ticketing systems to be compatible with the unified ticketing system, with penalties for operators who fail to comply.

3. Treasure (Financial Incentives & Funding Mechanisms)

- Fare Integration & Subsidies: Introduce city-wide travel passes that allow seamless transfers across Metro, MMTS, and TSRTC buses at discounted rates, particularly for students, low-income groups, and women. The additional part of this can be offering discounted fares for commuters using integrated ticketing systems, encouraging multimodal trips and rewarding regular public transport use.
- Land-Value Capture for Transit Expansion: Utilize increased land values near metro stations and transit corridors to generate funds for further infrastructure investment (similar to Hong Kong's MTR model).
- Public-Private Partnerships (PPPs) for Feeder Services: Incentivize private operators to provide reliable last-mile solutions (e-scooters, e-autos) with government-backed

financial assistance and also encourage private players by providing a similar partnership for the development of charging infrastructure at transit hubs.

4. Organization (Institutional & Capacity Building)

- Empower Hyderabad Unified Metropolitan Transport Authority (HUMTA): Strengthen its role to coordinate Metro, MMTS, and TGSRTC operations, ensuring seamless transfers and schedule alignment. HUMTA should be given greater decision-making authority and funding to integrate planning, policy enforcement, and performance monitoring.
- Create Multimodal Transit Hubs: Develop well-designed, pedestrian-friendly transit hubs integrating metro, bus, and MMTS services with clear signage and wayfinding systems.
- Electrification of Bus & Last-Mile Fleets: Prioritize e-bus adoption under PM E-Drive policy and establish charging stations at metro stations for e-autos and e-bikes or partner with established players in the market.
- Improve Governance & Accountability: Establish key performance indicators (KPIs) for transit agencies, focusing on efficiency in their functioning.

9. Concluding Remarks

This study is an examination of the state of multimodal public transportation in Hyderabad, and identifying key challenges and opportunities for improving city's urban mobility. The recommendations are from the triangulation of bibliometric analysis, secondary data evaluation, and expert interviews. This method provided a broader understanding of the systemic inefficiencies that hinders the effectiveness of public transit in the city.

The study also considered the future plans of the state government for Hyderabad's public transportation with respect to investments on metro rail, MMTS, and bus services. But the lack of seamless integration between these modes, inadequate last-mile connectivity, and institutional fragmentation will continue to pose barriers to efficient public transport if not addressed. The rapid increase in private vehicle ownership over the years, further underscores the need for strategic interventions than broader investment plans. The Hyderabad Metro Rail, despite its operational efficiency, has failed to attract a substantial modal shift from private vehicles due to weak connectivity with other public transit modes. Similarly, the Telangana State Road Transport Corporation (TGSRTC) struggles with fleet shortages, aging buses, and an inconsistent fare structure, which limits its ability to serve as an effective feeder system to the metro. The MMTS, once considered a vital suburban rail network, has seen declining ridership due to service reductions and funding constraints.

The research also underscores the importance of last-mile connectivity solutions in determining public transport adoption. The reliance on informal transport like shared auto-rickshaws and ride-hailing services to bridge connectivity gaps has led to affordability and safety

concerns. Without well-integrated feeder services and pedestrian-friendly infrastructure, public transport will continue to be a less viable alternative to private vehicle use.

From a policy perspective, Hyderabad's public transport challenges are not unique but reflective of broader urban mobility issues in India. The study has demonstrated that successful global cities like Bogotá and Hong Kong have managed to create robust multimodal transport networks through policy coherence, institutional coordination, and financial sustainability mechanisms such as land-value capture. Lessons from these models emphasize the need for comprehensive governance reforms, financial incentives for transit-oriented development, and investment in smart mobility solutions.

To address these challenges, this study has proposed actionable recommendations based on the NATO framework (Nodality, Authority, Treasury, and Organization). Empowering the Hyderabad Unified Metropolitan Transport Authority (HUMTA) is one of the crucial steps that came out from triangulation amongst various others towards improving the city's public transport efficiency.

Additionally, the transition to electric vehicles (EVs) brings an opportunity to enhance public transit level of service. Kingdon’s Multiple Streams Framework (MSF), with an added technology stream, was applied to analyze how EV adoption could serve as a policy window for improving last-mile connectivity and electrifying the public bus fleet. The research followed by analysis outlined that the EV-based shared mobility solutions and EV fleet deployment in TGSRTC can significantly enhance public transport quality taking advantage of user perspectives based on the positive spillovers from metro.

To make Hyderabad, a city with an efficient multimodal public transportation requires a combination of institutional reforms, policy innovations, and behavioral shifts. A well-integrated transit network, supported by data from technological adoptions, and sustainable mobility solutions, can make public transport the preferred mode of urban mobility. Apart from these the integral efficiency of the organizations, accountability in implementation with the help of real-time data and stakeholder collaboration will ensure the efficiency in Hyderabad's public transport system to meet the demands of its rapidly growing population.

10. Future Scope

Future research on multimodal public transportation in Hyderabad can focus on several key areas to enhance efficiency, integration, and sustainability. A significant gap identified through expert interviews is the lack of localized institutional research that can facilitate data-driven decision-making. Establishing dedicated transport research centers within local universities and policy institutions can bridge this gap by conducting impact assessments and advising urban transport authorities like HUMTA. Additionally, fostering first-principles thinking from an early age can help cultivate a culture of public transport awareness. Introducing electives in school curricula on the benefits of public transportation, environmental sustainability, and urban mobility planning can influence long-term behavioral change and reduce dependency on private vehicles.

Future research can be on exploring AI based mobility service, demand-based route prioritization, optimizing last mile service availability, etc. and potential risks that can be resulting on AI based services. Though the lessons from Bogota and Hongkong were to draw inspiration but not for implementation, there can be further research on feasibility of public-private partnerships (PPPs) for Hyderabad's context in last-mile mobility where in the small operators can feed into the three modes of transport and electric bus deployment require further study to assess financial viability and scalability and on the cautionary factors that should be taken into consideration before the fleet electrification. Behavioral research is also essential in understanding incentives that encourage public transport adoption, mostly in the context of finding the impact of positive direct spillovers of Metro rail on other modes of transport.

References

Ahanger, S. (2024, September 20). PM E-DRIVE to power India's shift to E-Buses - TECHARC. https://techarc.net/pm-e-drive-to-power-indias-shift-to-e-buses/

Ansab, K.V. and Kumar, S.P. (2024), "Influence of government financial incentives on electric car adoption: empirical evidence from India", *South Asian Journal of Business Studies*, Vol. 13 No. 2, pp. 226-243. https://doi.org/10.1108/SAJBS-03-2021-0088

Aria M, Cuccurullo C (2017) bibliometrix: An R-tool for comprehensive science mapping analysis Journal of Informetrics 11, 959–975.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, 15(2), 73-80. https://doi.org/10.1016/j.tranpol.2007.10.005

Baski, S. (2025, March 3). Passenger footfall rises by 40%, but RTC fleet remains stagnant at 9k buses. *The Times of India*. https://timesofindia.indiatimes.com/city/hyderabad/passenger-footfall-rises-by-40-but-rtc-fleet-remains-stagnant-at-9k-buses/articleshow/118667382.cms

Baski, S. (2024a, October 24). Railways decides to take up Ghatkesar-Yadadri MMTS project on its own. *The Times of India*. Retrieved from https://timesofindia.indiatimes.com/city/hyderabad/railways-to-independently-develop-ghatkesar-yadadri-mmts-project-amid-state-inaction/articleshow/114557759.cms

Baski, S. (2024b, August 5). Delays, cancellations & alternatives push Hyderabad MMTS service to slow lane. https://timesofindia.indiatimes.com/city/hyderabad/delays-cancellations-alternatives-push-hyderabad-mmts-service-to-slow-lane/articleshow/112270470.cms

Castellino, C. (2025, March 19). Will EV Catalyse India's Public Transport? *The Secretariat.* https://thesecretariat.in/article/will-ev-catalyse-india-s-public-transport

Cervero, R., & Wu, K. (2016). Transit-oriented development and travel behavior: A review of the evidence. *Transport Reviews, 36*(3), 297-319. https://doi.org/10.1080/01441647.2015.1033095

Chadalawada, R. (2022). Optimizing public transit networks an exploration of how multi-modal transportation systems can be integrated in smart cities. *World Journal of Advanced Research and Reviews, 15*(01), 829–841. https://doi.org/10.30574/wjarr.2022.15.1.0630

Chaturvedi, B., Nautiyal, A., Kandpal, T., & Yaqoot, M. (2021). Projected transition to electric vehicles in India and its impact on stakeholders. *Energy for Sustainable Development*, *66*, 189–200. https://doi.org/10.1016/j.esd.2021.12.006

Choudhary, R., Nath, K., Arora, D., Rajeev, A. V., Raj, A., & Sharan, M. (2023). Integration of Public Transport for a Seamless System in Hyderabad. *Tata Institute of Social Sciences Hyderabad.*

Choudhary, S. P., Achari, A., (2023). Need for Integrated Multi-Modal Transportation in India. *IJRAR23A1273 International Journal of Research and Analytical Reviews*, *January 2023*. https://doi.org/10.1729/Journal.32737

City University of Hong Kong. (2024, January 19). *Enhancing the resilience of urban public transport systems through greater network interconnectedness*. https://www.cityu.edu.hk/research/stories/2024/01/19/enhancing-resilience-urban-public-transport-systems-through-greater-network-interconnectedness

County Health Rankings & Roadmaps. (2023). *Individual incentives for public transportation*.

Dawda, N. (2024). *Towards A Comprehensive Framework for Public Transport System Planning in India.* ORF Occasional Paper No. 455. Observer Research Foundation. https://www.orfonline.org/public/uploads/posts/pdf/20241123112003.pdf

Dawda, N. (2025, January 17). Bridging gaps in Indian transport: The path to seamless integration. *orfonline.org*. https://www.orfonline.org/expert-speak/bridging-gaps-in-indian-transport-the-path-to-seamless-integration

Desai, D., & Dawda, N. (Eds.). (2024). *New approaches for integrated multimodal urban transport systems.* Observer Research Foundation and Global Policy Journal. https://www.orfonline.org/public/uploads/posts/pdf/20241228102901.pdf

Doringer, S. (2020). 'The problem-centred expert interview'. Combining qualitative interviewing approaches for investigating implicit expert knowledge. *International Journal of Social Research Methodology*, *24*(3), 265–278. https://doi.org/10.1080/13645579.2020.1766777

Elzen B, Geels FW, Leeuwis C, van Mierlo B (2011) Normative Contestation in Transitions "in the Making": Animal Welfare Concerns and System Innovation in Pig Husbandry. Research Policy 40(2), 263–275. https://doi.org/10.1016/j.respol.2010. 09.018.

Express News Service. (2023, February 27). Hyderabad becoming economic powerhouse: Report. *The New Indian Express.* https://www.newindianexpress.com/cities/hyderabad/2023/Feb/27/hyderabadbecoming-economic-powerhouse-report-2551233.html

Fei, S. (2016). Parking versus public transport subsidies: case study of Nanjing, China. *Transportation Letters, 8*(2), 90–97. https://doi.org/10.1179/1942787515Y.0000000011

Gahlot, V., Swami, B. L., Parida, M., & Kalla, P. (2013). Availability and accessibility assessment of public transit system in Jaipur city. *International Journal of Transportation Engineering, 1*(2), 81–90. https://www.ijte.ir/article_3234_760af2999fb018935359adfab87d4309.pdf

Goel, R., Tiwari, G., 2016. Access–egress and other travel characteristics of metro users in Delhi and its satellite cities. IATSS Res. 39 (2), 164–172.

Government of Telangana. (2020). *Telangana Electric Vehicle Policy 2020-30*.

Goyal, N., Howlett, M., & Taeihagh, A. (2021). Why and how does the regulation of emerging technologies occur? Explaining the adoption of the EU General Data Protection Regulation using the multiple streams framework. *Regulation & Governance*, 15(4), 1020-1034. https://doi.org/10.1111/rego.12387

Hensher, D. A., & Rose, J. M. (2006). Development of commuter and non-commuter mode choice models for the assessment of new public transport infrastructure projects: A case study. *Transportation Research Part a Policy and Practice*, *41*(5), 428–443. https://doi.org/10.1016/j.tra.2006.09.006

He, S. Y., Zhu, Y., & Ma, L. (2024). The public transport disadvantaged in a highly transit-oriented city: An analytical framework, key challenges and opportunities. *Journal of Transport Geography, 120*, 103983. https://doi.org/10.1016/j.jtrangeo.2024.103983

HMRL. (2024, July 3). Seamless connectivity, multimodal integration. *HMRL.* https://hmrl.co.in/seamless-connectivity-multimodal-integration/

Hood, C., & Margetts, H. Z. (2007). *The Tools of Government in the Digital Age*. Palgrave Macmillan.

HT Auto. (2024, December 6). Telangana to replace 3,000 diesel buses with electric buses in Hyderabad to cut pollution. *HT Auto.* https://auto.hindustantimes.com/auto/news/telangana-to-replace-3-000-diesel-buses-with-electric-buses-in-hyderabad-to-cut-pollution-41733453727966.html

Hub, G. I. (2019, May 24). *TransMilenio bus rapid transit Colombia*. https://inclusiveinfra.gihub.org/case-studies/transmilenio-bus-rapid-transit-colombia/#foot-ref-4

Hyderabad Metro Rail, the world's biggest PPP project, becomes second largest metro network in the country after Delhi. (2020, February 8). *Swarajya*. https://swarajyamag.com/insta/hyderabad-metro-rail-the-worlds-biggest-ppp-project-becomes-second-largest-metro-network-in-the-country-after-delhi

Hyderabad Metro Rail Limited. (2025, February 10). *JBS set to become India's largest Metro junction, surpassing Delhi's Kashmere Gate*. https://hmrl.co.in/jbs-set-to-become-indias-largest-metro-junction-surpassing-delhis-kashmere-gate/

Hyderabad Metro Rail Limited. (2024, September 30). *Hyderabad Metro Phase 2 gains momentum*. https://hmrl.co.in/hyderabad-metro-phase-2-gains-momentum/

IEA. (2024). *Global EV Outlook 2024*. IEA, Paris. https://www.iea.org/reports/global-ev-outlook-2024

Jose, D. (2022, August 18). Hyderabad needs 6,000 buses, only 3,100 in Telangana State Road Transport Corporation fleet. *The Times of India*. https://timesofindia.indiatimes.com/city/hyderabad/hyderabad-needs-6000-buses-only-3100-in-telangana-state-road-transport-corporation-fleet/articleshow/93648452.cms

Kanuri, C., Venkat, K., Maiti, S., & Mulukutla, P. (2019). Leveraging innovation for last-mile connectivity to mass transit. *Transportation Research Procedia, 41*, 655–669. https://doi.org/10.1016/j.trpro.2019.09.114

Kaushik, S. (2024, September 30). Hyderabad Metro Phase 2 expands to 116 km with airport link. *Deccan Chronicle*. https://www.deccanchronicle.com/southern-

states/telangana/hyderabad-metro-phase-2-expands-to-116-km-with-airport-link-1826931\

Kawathekar, K., Bahadure, P., & Bakde, V. (2024). *Literature review on metro public transport accessibility optimization by walking, cycling and using non-motorized vehicles in Indian cities*. *Library Progress International*, 44(3).

Kingdon, J. W. (1984). *Agendas, alternatives, and public policies*. Boston: Little, Brown and Company.

Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*, *42*(8), 846–854. https://doi.org/10.1080/0142159x.2020.1755030

Krishna, G. V., & Chattaraj, U. (2020). *Analysis of Urban Public Transportation Network in Hyderabad: Telangana*. International Conference on Civil Architectural and Environmental Sciences (ICAES-20). https://www.semanticscholar.org/paper/Analysis-of-Urban-Public-Transportation-Network-in-Krishna-Chattaraj/2ed3f34763c174319900eaefa65c6c959a68e4ff

Lako, A., & Gjevori, S. (2023). Urban Public Transport as a Basis for Sustainable Mobility Development in the Transition from Private Vehicles to Urban Public Transport: A Case Study of Elbasan. *International Journal of Sustainable Development and Planning, 18*(11), 3609–3615. https://doi.org/10.18280/ijsdp.181126

Lakshmi, K. V. (2021). Planning Urban Transport Infrastructure in Hyderabad Metropolitan Area. *Hyderabad Unified Metropolitan Transport Authority.*

L&T Metro Rail (Hyderabad) Limited. (2024, November 28). *Hyderabad Metro Rail celebrates 7 years of transforming urban mobility* [Press release]. https://www.ltmetro.com/wp-

content/uploads/2025/01/28-11-2024-Press-Release-Hyderabad-Metro-Rail-Celebrates-its-7th-Anniversary-181-Chief-Guest.pdf

Lehmann, S. (2023). Research Methods in Urban Design: A framework for researching the performance and resilience of places. *Buildings*, *13*(6), 1548. https://doi.org/10.3390/buildings13061548

Litman, T. (2024). *Evaluating public transit benefits and costs*. Victoria Transport Policy Institute https://www.vtpi.org/tranben.pdf

Madaram, V. G., Biswas, P. K., Sain, C., Thanikanti, S. B., & Balachandran, P. K. (2024). Advancement of electric vehicle technologies, classification of charging methodologies, and optimization strategies for sustainable development - A comprehensive review. *Heliyon, 10*(20). https://doi.org/10.1016/j.heliyon.2024.e39299

Mahesh, K. (2024, December 5). Govt will buy 3,000 electric buses, promote EVs to curb pollution: CM. *The Times of India.* https://timesofindia.indiatimes.com/city/hyderabad/telangana-govt-announces-purchase-of-3000-electric-buses-to-combat-pollution/articleshow/116019794.cms

Ministry of Heavy Industries. (2021). FAME II Scheme: Accelerating EV adoption in India.

Mishra, T. (2024, August 16). Cabinet approves metro rail projects worth Rs 30,000 crore in Bengaluru, Thane, and Pune. *The Economic Times*. https://economictimes.indiatimes.com/news/economy/infrastructure/cabinet-approves-metro-rail-projects-worth-rs-30000-crore-in-bengaluru-thane-and-pune/articleshow/112574039.cms

Mohammed, S. (2024, April 7). Large number of TSRTC buses approaching threshold for scrapping. *The Hindu.* https://www.thehindu.com/news/national/telangana/large-number-of-tsrtc-buses-approaching-threshold-for-scrapping/article68036640.ece

Mukherjee et al. (2023). "Improving Metro Access in India: Evidence from Three Cities" Working Paper. WRI India. Available online at https://doi.org/10.46830/wriwp.23.00009

Mwaka, C. R., Best, K. L., Gamache, S., Gagnon, M., & Routhier, F. (2023). Public Transport Accessibility for People with Disabilities: Protocol for a Scoping Review. *JMIR research protocols*, *12*, e43188. https://doi.org/10.2196/43188

Nair, P., & Kumar, D. (2005). Transformation in Road Transport System in Bogota: An Overview. The ICFAI Journal of Infrastructure, September 2005.

Odongo, J. O., & Ma, D. (2021). Perspectives in Urban Planning Research: Methods and tools. *Current Urban Studies*, *09*(04), 759–778. https://doi.org/10.4236/cus.2021.94045

Padukone, N. (2013, September 23). The unique genius of Hong Kong's public transportation system. *The Atlantic*. https://www.theatlantic.com/china/archive/2013/09/the-unique-genius-of-hong-kongs-public-transportation-system/279528/

Patton, M. *(2015) Qualitative Research and Evaluation Methods. 4th Edition, SaGE Publications, Thousand Oaks.* Scientific Research Publishing. https://www.scirp.org/reference/referencespapers?referenceid=1915688

Personal vehicles cross 70L mark in Greater Hyderabad. (2023, October 30). *The Times of India*. https://timesofindia.indiatimes.com/city/hyderabad/personal-vehicles-cross-70l-mark-in-greater-hyderabad/articleshow/104809589.cms

Pillai, V. S., & Matus, K. J. M. (2020). Towards a responsible integration of artificial intelligence technology in the construction sector. *Science and Public Policy, 47*(5), 689–704. https://doi.org/10.1093/scipol/scaa073

Pillai, V. S., & Matus, K. (2019). *Regulation of AI technologies in the construction industry*. HKUST IEMS Working Paper No. 2019-65.

Planning Commission (2012). *Recommendations of Working Group on Urban Transport for 12th Five Year Plan*. http://planningcommission.nic.in/aboutus/committee/wrkgrp12/hud/wg_urban Transport.pdf

PM E-DRIVE. (2024). *Department of Heavy Industries. Government of India.* https://pmedrive.heavyindustries.gov.in/

Pojani, D., & Stead, D. (2016). The Urban Transport Crisis in Emerging Economies: An Introduction. *The urban book series* (pp. 1–10). https://doi.org/10.1007/978-3-319-43851-1_1

Population of cities in India 2024 - StatisticsTimes.com. https://statisticstimes.com/demographics/country/india-cities-population.php

Sagar, P., & Ghuge, V. V. (Eds.). (2015). *Towards achieving multimodal integration of transportation systems for seamless movement of passengers - case study of Hyderabad* (8th ed.). Urban Mobility India Conference & Expo, New Delhi (Transforming Mobility for Liveability). http://www.urbanmobilityindia.in/Upload/Conference/bc71cd29-a4bb-4a5c-b04e-e5842b421a6d.pdf

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2001). *Experimental and Quasi-Experimental designs for generalized causal inference*. https://iaes.cgiar.org/sites/default/files/pdf/147.pdf

Siddiq, A., Tang, C. S., & Zhang, J. (2020). *Incentive mechanisms for improving public transit adoption*. SSRN. https://anderson-review.ucla.edu/wp-content/uploads/2021/03/Siddiq-Tang-Zhang_2020_SSRN-id3540566.pdf

Singh, S. B. J. (2024, July 11). Population boom in Hyderabad hindering development, say experts. *The New Indian Express.* https://www.newindianexpress.com/states/telangana/2024/Jul/11/population-boom-in-hyderabad-hindering-development-say-experts

Singh, S. K. (2015). Scenario of urban transport in Indian cities: challenges and the way forward. In *Springer proceedings in business and economics* (pp. 81–111). https://doi.org/10.1007/978-81-322-2310-8_5

Solanki, H. K., Ahamed, F., Gupta, S. K., & Nongkynrih, B. (2015). Road transport in Urban India: Its implications on health. *Indian Journal of Community Medicine, 41*(1), 16. https://doi.org/10.4103/0970-0218.170959

Su, H. N., & Lee, P. C. (2010). Mapping Knowledge Structure by Keyword Co-occurrence: A First Look at Journal Papers in Technology Foresight. *Scientometrics, 85*(1), 65–79.

Tanwar, R., & Agarwal, P. K. (2024). Assessing travel time performance of multimodal transportation systems using fuzzy-analytic hierarchy process: A case study of Bhopal City. *Heliyon*, *10*(17), e36844. https://doi.org/10.1016/j.heliyon.2024.e36844

Tejaswi, S. P., Balijepalli, C., & Prasad, C. S. R. K. (2024). Revealing commute choice factors: A SEM analysis of public transport and active modes in Hyderabad, India. *Journal of Urban Planning and Development, 149*(4), 04023043.

Telangana Electric Vehicle and Energy Storage Policy 2020–2030. (2020). *Department of Industries and Commerce. Government of Telangana.* https://www.nsws.gov.in/s3fs/2021-08/Telangana%20EV%20policy.pdf

The Hans India. (2025, January 23). TSRTC to Launch 286 Electric Buses in Hyderabad for Sustainable Public Transport. https://www.thehansindia.com/telangana/tsrtc-to-launch-286-electric-buses-in-hyderabad-for-sustainable-public-transport-939345

The Hans India. (2024, October 19). *Metro ties up with Mana Yatri to boost last-mile connectivity*. The Hans India.

The Hindu. (2023, March 15). *Revival of UMTA awaited; it is a key to resolve roadblocks to Hyderabad infra projects*. The Hindu.

The News Minute. (2018, July 24). After electric cars, now Hyderabad Metro Rail sets up electric bikes. https://www.thenewsminute.com/telangana/after-electric-cars-now-hyderabad-metro-rail-sets-electric-bikes-85291

The News Minute. (2020, January 16). *Dwindling fleet, no last mile connectivity: Buses in Hyderabad's IT sector are sparse*. The News Minute.

Times of India. (2024, November 2). *Hyderabad aims for 100% electric buses by 2025: A green revolution in public transport*. https://timesofindia.indiatimes.com/city/hyderabad/hyderabad-aims-for-100-electric-buses-by-2025-a-green-revolution-in-public-transport/articleshow/114890914.cms

Times of India. (2024, December 22). *Metro commuters overcome last-mile connectivity issues, take 1 crore rides*. Times of India. https://timesofindia.indiatimes.com/city/hyderabad/metro-commuters-overcome-last-mile-connectivity-issues-take-1-cr-rides/articleshow/116546651.cms

TransMilenio: renewing Bogotá's transport system. (2016.). Centre for Public Impact (CPI). https://www.centreforpublicimpact.org/case-study/transmilenio#:~:text=In%20the%20areas%20where%20TransMilenio,have%20decreased%20by%2040%20percent.

Urban Design lab Educations Pvt. Ltd. (2023, August 29). Qualitative Research Methods in Urban Planning & Design. *Urban Design lab*. https://urbandesignlab.in/qualitative-research-methods-in-urban-planning-design/?srsltid=AfmBOoqrxyZ0ZI2z558xg6C9lcTsAXojbryCgbADk2ZUPSatPfwH4Zp_

Urban Growth: Ministry of Housing and Urban Affairs, Government of India. (2011.). https://mohua.gov.in/cms/urban-growth.php

Urban population (% of total population) – India. United Nations Population Division. World Urbanization Prospects: 2018 Revision. *World Bank Open Data*. https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=IN

Van Renswouw, L., Lallemand, C., Van Wesemael, P., & Vos, S. (2022). Creating active urban environments: insights from expert interviews. *Cities & Health*, *7*(3), 463–479. https://doi.org/10.1080/23748834.2022.2132585

Verma, A., Harsha, V., & Subramanian, G. H. (2021). Evolution of urban transportation policies in India: A review and analysis. *Transportation in Developing Economies, 7*(2). https://doi.org/10.1007/s40890-021-00136-1

Vivek, R., Nanthagopan, Y., & Piriyatharshan, S. (2023). Beyond methodology: Theoretical foundations of triangulation in qualitative and multi-method research: A literature review. *Scientific Studios on Social and Political Psychology*, *29*(2), 53–62. https://doi.org/10.61727/sssppj/2.2023.53

Voß J-P (2007) Designs on Governance: Development of Policy Instruments and Dynamics in Governance. Twente, Netherlands: University of Twente.

Xue, C., Zhou, H., Wu, Q., Wu, X., & Xu, X. (2021). Impact of Incentive Policies and Other Socio-Economic Factors on Electric Vehicle Market Share: A Panel Data Analysis from the 20 Countries. *Sustainability*, *13*(5), 2928. https://doi.org/10.3390/su13052928

Vyas, A. R., & Patel, P. J. (2024). *A review of public road transport in India: Challenges, innovations, and policy recommendations*. Grenze International Journal of Engineering and Technology, 10(1), 45-58.

Yang, S., Ahmad, A., Park, P. Y., Sohn, G., & Krygsman, J. (2020). Public Transit Service Reliability Assessment using Two-Fluid Model. *Transportation Research Record*, *2674*(4), 89-100. https://doi.org/10.1177/0361198119896783

Annexure 1 - Consent Form

Title of the study: Enhancing Multi-Modal Public Transportation in Hyderabad focusing on City's Metro Rail

Researcher's Name: Subhash Gottumukkala

Affiliation: Student of Master's Program in Public Policy, Kautilya School of Public Policy.

Contact Information: sgottumu25@kautiya.org.in, +919492924766

This research project is to explore the integration of metro, bus, and surface rail (Local train) services in Hyderabad's public transportation system. This is to identify barriers to an effective urban mobility and then propose solutions to improve the efficiency and accessibility of the city's transport network.

Participants for this study were selected based on their expertise in transportation planning, urban development, and public policy. Their insights are important to understand the current challenges, perspectives and opportunities to integrate the three modes of transport in Hyderabad.

Recording Method:

The semi structured interviews will be recorded by audio recordings as well as written notes. This data will be securely stored on password-protected devices to ensure confidentiality. The storage device are Subhash's personal phone and laptop

Annexure 2 - Semi Structured Interview- Questionnaire

1. What do you perceive as the primary barriers to effective last-mile connectivity in Hyderabad's public transportation system?
2. In your experience, what are the most significant barriers to effective coordination between the Hyderabad Metro Rail and the TGSRTC bus services?
3. How do you think the integration of metro, bus, and surface rail services can be improved to enhance overall public transport efficiency?
4. How do you think public transportation in Hyderabad serves all socio-economic groups equally? If not, what changes would you recommend?
5. In your opinion, what role does socio-economic status play in commuters' choices between public and private transportation in Hyderabad?
6. How can the transition from internal combustion engine (ICE) vehicles to electric vehicles (EVs) be leveraged to promote the use of public transportation in Hyderabad?
7. What specific policies or practices would you recommend to enhance the operational efficiency of TGSRTC buses in relation to the existing metro system?

Annexure 3 - Gerund and In-Vivo Codes for thematic analysis

Gerund Codes	In-Vivo Codes
• Investing in Metro Expansion • Reducing RTC Bus Fleet • Walking to Metro Stations • Using Shared Autos for Last-Mile Connectivity • Calculating Last-Mile Costs • Competing for Public Transport Ridership • Lacking Coordination Between Agencies • Optimizing Bus-Metro Integration • Funding Last-Mile Services • Introducing Fare Integration • Developing Institutional Coordination • Building Multimodal Hubs • Prioritizing Bus Route Optimization • Standardizing Fare Structures • Enhancing First-Mile Connectivity • Integrating Electric Vehicles in Public Transport • Improving Accessibility for Women and Disabled Commuters • Providing Reliable Public Transport • Expanding Bus Services to Growing Areas • Addressing Socioeconomic Barriers in Public Transport • Promoting Non-Motorized Transport • Encouraging Public Transport Use Through Awareness • Utilizing Data for Route Planning • Funding Public Transport Through CSR and PPP Models • Developing Real-Time Bus Tracking Systems • Addressing Infrastructure Challenges for Last-Mile Connectivity • Implementing Single-Ticketing	• "Metro hasn't reached its capacity" • "People just accept that shared auto is a thing" • "No door-to-door time savings" • "Last mile cost may be higher for some people" • "Metro and RTC are competing with each other" • "Public transport should not be looked at that way" • "Angkots are a very good example" • "We have crossed that stage where you have to provide bus service and both will be full" • "People who can afford private vehicles will continue using them" • "Public transport is funded by a sales tax measure" • "Metro is such a powerful system" • "Hyderabad’s bus system is well-integrated with the metro" • "We need a cheaper last-mile option" • "They are not acting as a feeder, basically" • "If you build a flyover, you attract more cars" • "Developing an app will increase transparency, accountability, and efficiency" • "We are running enough feeder buses for Metro already" • "We just need a body to regulate, understand, and optimize" • "People won’t use public transport unless it competes with private transport on time" • "Multimodal integration should be seamless"

Systems • Enhancing Metro Station Parking Facilities • Managing Public Transport Operational Costs • Regulating Informal Transit Modes	• "People don't walk because they are unable to walk" • "We are not going to places where the new city is growing" • "Farebox recovery is low, so we will always have a funding gap" • "Parking becomes an attraction for success" • "We have to prepare a framework and a long-term vision" • "You cannot just propose a policy without understanding the implications for each organization" • "Hyderabad is lucky to have shared autos, even though they are not legal" • "Our bus ticket fares are ridiculously high" • "Buses run efficiently, but we need more of them" • "Technology will take care of integration, we will take care of operations"

Annexure 4 - Data Log Table

No.	Date	Location	Pseudonym	File name	File deletion date
1	24/02/2025	Zoom - Online	GSRC	First_2402	28/02/2025
2	07/03/2025	Begumpet – In person	AN1	Second_0703	10/03/2025
3	19/03/2025	RTC X Roads – In person	AN2	Third_1903	24/03/2025
4	23/03/2025	Zoom - Online	ND	Fourth_2303	24/03/2025

Annexure 5 - Data Handling Procedure

Participants were informed about the research process and their rights through the consent forms. To protect participants' privacy, their identities and responses are anonymized using pseudonyms, ensuring they cannot be personally identified. All data collected during the research is securely stored, with encryption or password protection, to prevent unauthorized access. Only authorized researchers directly involved in the study have access to the transcripts. Transcripts of interviews are sent to each participant through email for their review. These transcripts will be stored in password-protected cloud storage for three years, while the original recordings will be destroyed to further safeguard confidentiality.

Annexure 6 - Positionality Statement

Hyderabad is my home, it's my city. My connection to the city is personal and experiential, having seen its transformation from childhood. I viewed urban development as wider roads, fast-moving vehicles, tall skyrises, and mostly infrastructural growth. However, my perspective has changed over the years through my academics and lived experience to see development as social equity, accessibility to services, and mobility.

I've experienced the challenges of going through the city's disintegrated public transportation System. Though I like riding a car and bike in my city, this may not be a privilege for everyone. I had first-hand observations of commuters struggling with last-mile connectivity and the lack of integration of the three public transport modes, depending on commute options.

My research on this topic is driven partly by my frustration of being unable to rely on public transportation in my city despite my willingness. My understanding of urban mobility has evolved from just a mobility point of view to one that affects social equity, environmental sustainability, and opportunities for the underserved, making my research not only the physical integration of transportation modes but also their social implications.

My experience as someone with access to private transport options may differ from the people who are only dependent on public transport. I will balance this by incorporating diverse perspectives from various groups of commuters. My ultimate goal is to contribute to developing an integrated multi-modal transport system for all the residents of Hyderabad, irrespective of economic status or location disparities.