

DESIGNING INCLUSIVE AND SUSTAINABLE TRANSPORT IN DELHI: PATTERNS, CHALLENGES, AND POLICY REFLECTIONS

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Abstract: Delhi, the capital of India, is witnessing rapid urbanization accompanied by critical transportation challenges that threaten its social inclusivity, economic productivity, and environmental sustainability. This paper provides a comprehensive review of Delhi's urban transport system by examining its major components, infrastructure, travel patterns, and policy framework. It evaluates both private and public transportation systems, including the Delhi Metro, Delhi Transport Corporation (DTC), feeder services, non-motorized transport, and emerging mobility trends such as electric vehicles. The study critically assesses structural inefficiencies like poor multimodal connectivity, institutional fragmentation, growing private vehicle dependence, and limited access to safe and affordable transport for marginalized groups, particularly women and low-income communities. Despite the existence of ambitious policies such as the Delhi Electric Vehicle Policy and the National Urban Transport Policy, implementation challenges persist due to overlapping institutional responsibilities, data gaps, and inadequate stakeholder engagement. The analysis emphasizes the importance of aligning local transport planning with the Sustainable Development Goals (SDGs), especially SDG 11 (Sustainable Cities and Communities), SDG 3 (Good Health and Well-being), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action). Ultimately, this review lays the groundwork for designing a sustainable, inclusive, and data-driven transportation framework tailored to Delhi's unique urban context.

Keywords: Urban Transport System, Sustainable Mobility, Delhi Transportation, Public Transit Infrastructure, Travel Behaviour, Non-Motorized Transport (NMT), Smart Urban Mobility, Inclusive Transportation

Introduction

The economic, social, and environmental dynamics of cities are significantly shaped by urban transportation. In countries that are urbanizing quickly, like India, transportation systems play a crucial role in inclusive access, public health, climate resilience, and sustainable urban development (Pojani & Stead, 2015). Delhi, the national capital territory, is unique among Indian cities in terms of its size, population, infrastructural complexity, and policy prominence.

Transportation in Delhi, which is used by more than 30 million people in national capital region is an admiring example of urban India. Its historical planning, population growth, economic

liberalization and political advancements the city's transportation system has undergone various significant changes over the years. The city faces the traffic congestion, air-pollution, road safety concerns, social inequality in order to transportation despite of being significant amount of investment in infrastructure like, Delhi Metro, Expressways and growing fleet of electrical vehicles (MoHUA, 2021). Delhi has complicated governance environment, which having number of overlapping institute, policy framework and jurisdictions, exacerbates these difficulties (UTTIPEC, 2019).

The base cause of these problem is misalignment between transport planning and goals. Inefficiencies are caused by many factors, including huge growing reliance on private vehicles, poor last mile connectivity, very less investment in non-motorized (NMT) infrastructure. And having a failure to adequately land use and transport planning. Total no. of vehicle registered in Delhi is 13 Million as on 2023, with two-wheelers and cars for the majority of urban travel (Transport Department, GNCTD, 2023)

The increase in motorization has resulted in worsening air quality; Delhi is frequently one of the most polluted cities in the world, with up to 40% of PM_{2.5} levels coming from transportation emissions (CPCB, 2022).

In order to be considered sustainable, transportation needs to be viewed as a multifaceted socio-technical system that interacts with the economy, governance, equity, urban form, and environmental health. Sustainable, inclusive, and effective transport systems are essential for achieving the Sustainable Development Goals (SDGs), especially SDG 11 (Sustainable Cities and Communities), SDG 3 (Good Health and Well-Being), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 13 (Climate Action) (United Nations, 2015). However, putting these objectives into practice locally calls for a thorough comprehension of the current transportation systems, including their shortcomings, user experiences, and structural obstacles.

The coexistence of a top-notch metro system, a congested road system, erratic public transportation, and a sizable unofficial transportation industry that includes shared cars, e-rickshaws, and cycle rickshaws makes Delhi an exceptional case study. It is crucial to assess the system from a people-centred and equity-oriented perspective because the city also has significant mobility disparities based on location, gender, and income. For instance, travel trends indicate that women in Delhi are more likely to walk and take public transportation, but they encounter obstacles with regard to accessibility, safety, and dependability (Borker, 2018).

In addition, Delhi transport governance is deviated, with various stakeholder overseeing land use, traffic management, air-quality, road network, and metro-operations, with the very few integrase co-ordination, organization like Delhi Metro Rail Corporation (DMRC), Delhi Transport Corporation (DTC), Delhi Development Authority (DDA), and Unified Traffic and Transportation Infrastructure (Planning and Engineering) Centre (UTTIPEC) are function independently. In multi-mode transport planning, these institutional fragmentation cause implementational delays, and doubling the efforts (Jain & Tiwari, 2018).

After introduction of various policies and programs to cater these issues, including the Delhi Electric Vehicle Policy (2020), National Urban Transport Policy (2006), Smart Cities Mission,

and Gati Sakti Master Plan, their effectiveness lies on strategies to implement, Stakeholder involvement and local adaption (NITI Aayog, 2021). One major problem to attain for the long term improvement in Delhi's mobilities landscape in the absence of a cohesive framework that include sustainability, inclusivity and efficiency.

One of the major drawback on sharing the data of transport planning and technology. The very promising impact of intelligent transport systems (ITS), mapping based on GIS, and real time vehicle tracking has been very limited in cities due to unavailability of mobility data and dashboard, it make more difficult to make demand forecasting, planning and real time policy interventions.

Sustainability of the environment is also at risk. Noise pollution, the urban heat island effect, and greenhouse gas emissions are all significantly influenced by Delhi's transportation system. Low-emission zones, bike sharing schemes, and the switch to electric buses are still in their infancy. Nevertheless, there are ways to incorporate climate goals into transportation reforms, such as by encouraging green mobility corridors, mapping emissions, and creating carbon budgets (TERI, 2022).

In light of this, it is essential to perform a thorough and multifaceted evaluation of Delhi's transportation system as the initial stage of creating a modified sustainable transportation framework for the city. In addition to infrastructure, such a review should look at gendered mobility, modal share, travel behaviour, stakeholder roles, policy effectiveness, and technology applications. The foundation for creating an assistive system that is in line with the SDGs and the realities of urban India can be laid by doing this, as well as by identifying important leverage points for intervention.

By evaluating Delhi's transportation system critically, pointing out its advantages and disadvantages, and investigating potential reforms, this article seeks to close that knowledge gap. The results will aid in the larger endeavour to create a framework for sustainable urban transportation in Delhi that is contextual, evidence-based, and pertinent to policy. Such a framework could eventually be used as a template for other Indian cities facing comparable difficulties, furthering the country's goal of inclusive and sustainable urban mobility.

Components of Delhi's Transport System

Public transportation, private automobiles, and non-motorized transportation are just a few of the modes that make up Delhi's transportation network, which is a hybrid of formal and informal systems. Although the capital city serves as a transportation hub for the National Capital Region (NCR), it faces difficulties with equity, sustainability, and integration in the delivery of mobility services.

Delhi Metro

One of India's most important public transportation initiatives is the Delhi Metro, which is run by the Delhi Metro Rail Corporation (DMRC). The metro system has significantly increased intercity connectivity, particularly between residential and commercial zones, with more than 390 km of operational network distributed across 12 lines and more than 285 stations (DMRC, 2023) as

shown below in Figure 1. The metro is an essential component of the urban transit system, carrying more than 6 million passengers every day. Additionally, by encouraging densification along corridors, its expansion has aided Transit-Oriented Development (TOD) (MoHUA, 2021).

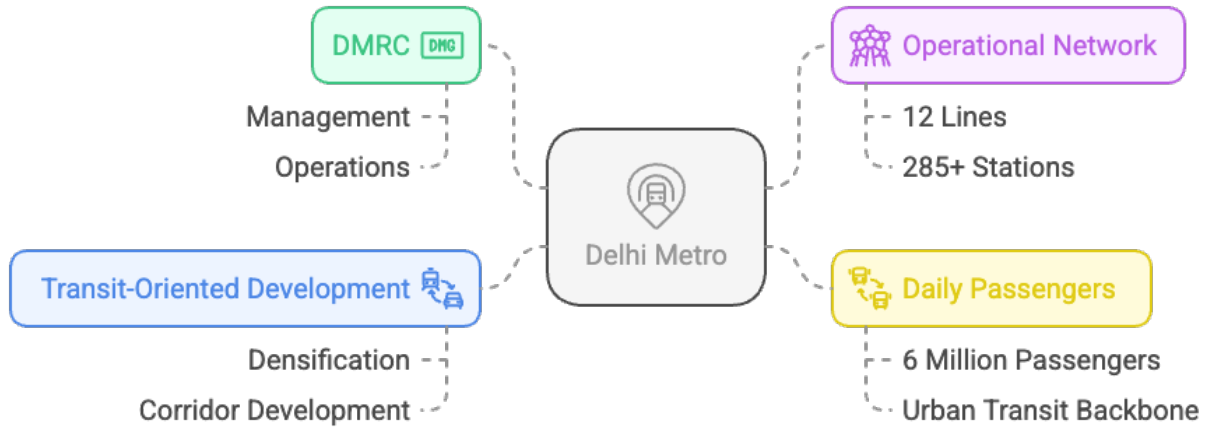


Figure 1: Delhi Metro: Urban Transit and Development.

Delhi Transport Corporation (DTC) and Cluster Buses

About 3,800 low-floor buses make up the DTC's fleet, which is one of the biggest in India. The Cluster Scheme, which is run by the Delhi Integrated Multi-Modal Transit System (DIMTS), adds about 3,000 additional buses through a variety of public-private partnership (PPP) models (Transport Department GNCTD, 2022). Because of their limited route rationalization, overcrowding, poor maintenance, and irregular frequency, these services experience declining ridership despite their reach. Figure 2 shows the cause and effect analysis for the decline of Delhi bus services.

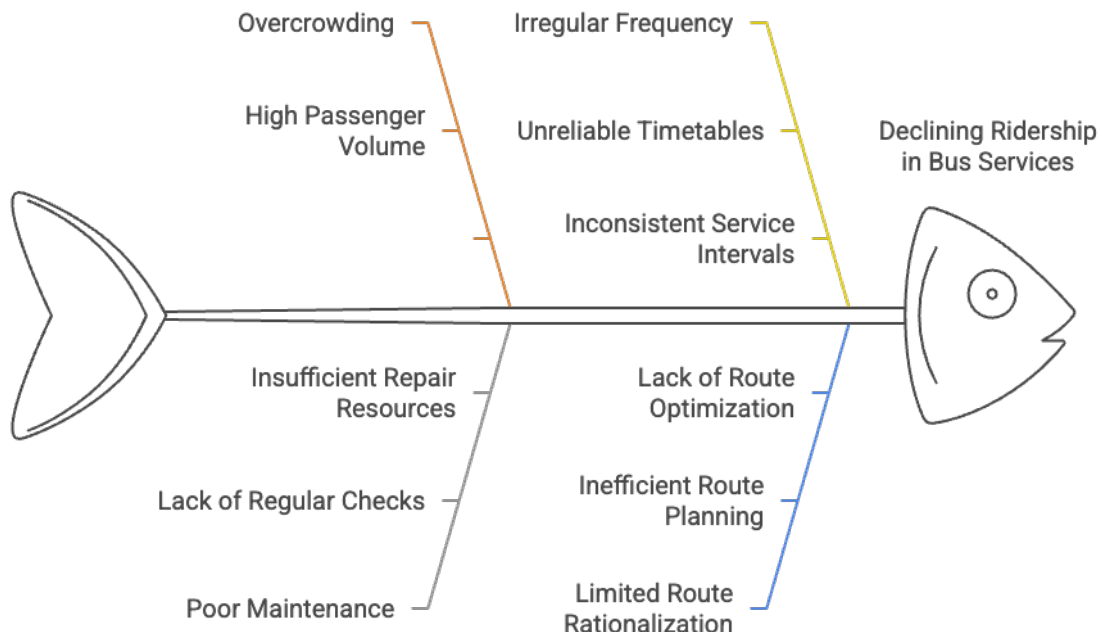


Figure 2: Analysing Declining Ridership in Delhi's Bus Services.

Feeder Services and Last-Mile Connectivity

Last-mile connectivity is provided by feeder buses, autorickshaws, and increasingly electric rickshaws (e-rickshaws), especially in places that are not directly served by mainline or metro bus routes as shown below in Figure 3. Over 100,000 e-rickshaws are in operation throughout Delhi, according to UTTIPEC (2020), but the industry is still primarily unregulated and informal. Low utilization rates in outlying areas are caused by the fact that many metro stations still lack efficient first- and last-mile connections.

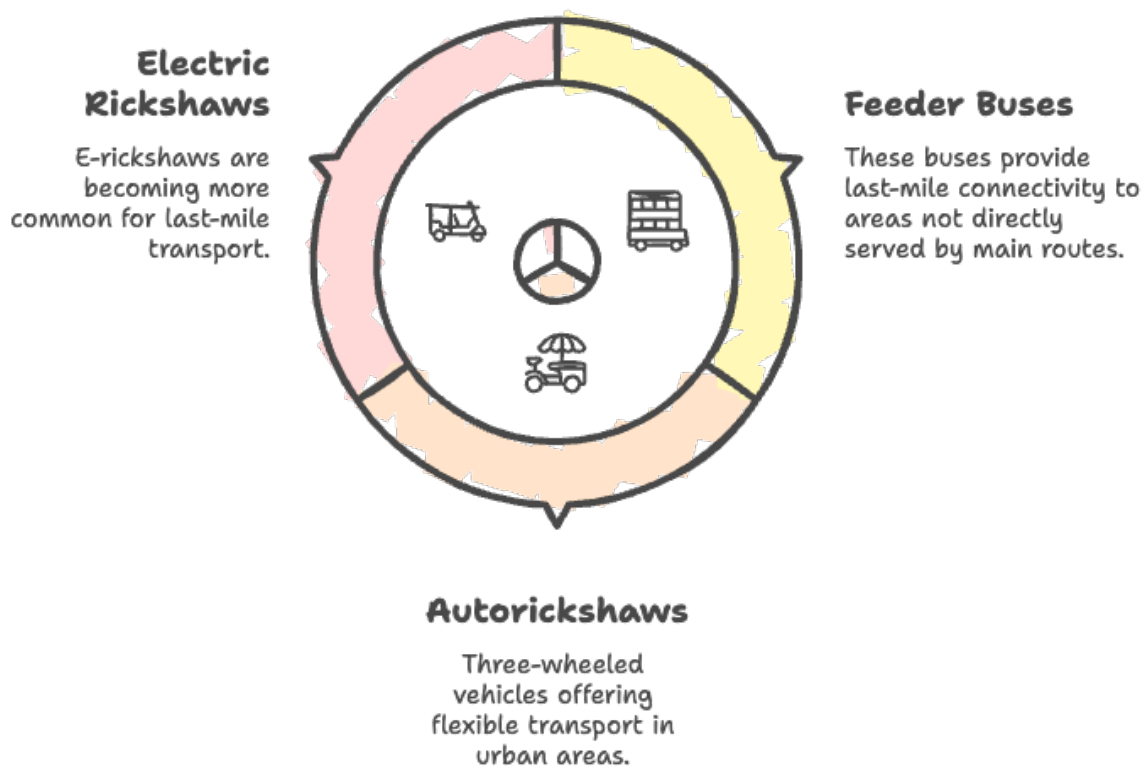


Figure 3: Last-mile connectivity options

Private and Intermediate Transport

Private vehicle ownership in Delhi has skyrocketed, surpassing 13 million registered vehicles in 2022, with two-wheelers making up more than 65% of the fleet (Transport Department GNCTD, 2022). Perceptions of convenience, the unreliability of public transportation, and the social standing that comes with owning a car have all contributed to the high ownership rate.

Due to their ability to provide middle-class and upper-class individuals with flexible mobility, ride-hailing services like Ola, Uber, and Rapido have become increasingly popular. Their contribution to traffic, road space occupation, and carbon emissions is controversial, despite the fact that they are convenient and ease parking pressure (ITDP, 2021). These aggregators frequently function outside of the current frameworks governing urban transportation, creating governance gaps.

Non-Motorized Transport (NMT)

For lower-income groups and short-distance commuters especially, walking and cycling account for a sizable portion of daily mobility in Delhi. The Comprehensive Mobility Plan (CMP) claims that, especially in unauthorised colonies and resettlement areas (UTTIPEC, 2020), around 34% of trips are completed by walking and 11% by cycling.

NMT infrastructure still lags behind, even with the high modal share. Often, they are poorly planned, encroached upon, or discontinuous. Along some main roads, dedicated cycle tracks exist but suffer from disuse, discontinuity, or conversion into parking spaces. Though these are still to scale city-wide (MoHUA, 2021), the Smart Cities Mission and the Cycle4Change Challenge have started pilot improvements in some areas, including Connaught Place and Lutyens' Delhi.

Intermodal Integration and Infrastructure

The absence of intermodal integration is a significant issue for Delhi's transportation system. Despite initiatives like the One Delhi Card, commuters frequently have to change between modes (for example, from metro to bus or e-rickshaw). As a result, there isn't a single mobility card that is accepted by all modes. Peripheral areas frequently lack the infrastructure necessary for a smooth interchange, such as integrated terminals and wayfinding signage (DIMTS, 2022).

Furthermore, parking management is still a controversial topic. Uncontrolled or free on-street parking degrades road space efficiency and causes congestion in the majority of urban areas, particularly in commercial and residential colonies. (NIUA, 2020).

Travel Behaviour and Modal Share

Developing sustainable transportation strategies in Delhi requires an understanding of travel behaviour and modal share. The city's mobility pattern is varied and frequently dispersed, influenced by distance, gender, socioeconomic status, and the availability of dependable infrastructure. Most travel in Delhi takes place in the urban periphery, and because of traffic and inefficient infrastructure, a significant percentage of trips are short in distance but take a long time. Nearly 60% of daily trips are under 5 km, according to Delhi's Comprehensive Mobility Plan (CMP) (2021), but non-motorized transport (NMT) infrastructure, such as secure bike lanes and walking trails, is still lacking. Figure 4 shows that the percentage of walking trips has dropped from 34% in 2008 to about 25% in 2021, suggesting a trend towards more motorised modes of transportation, partially due to urban sprawl and safety concerns (UTTIPEC, 2021).

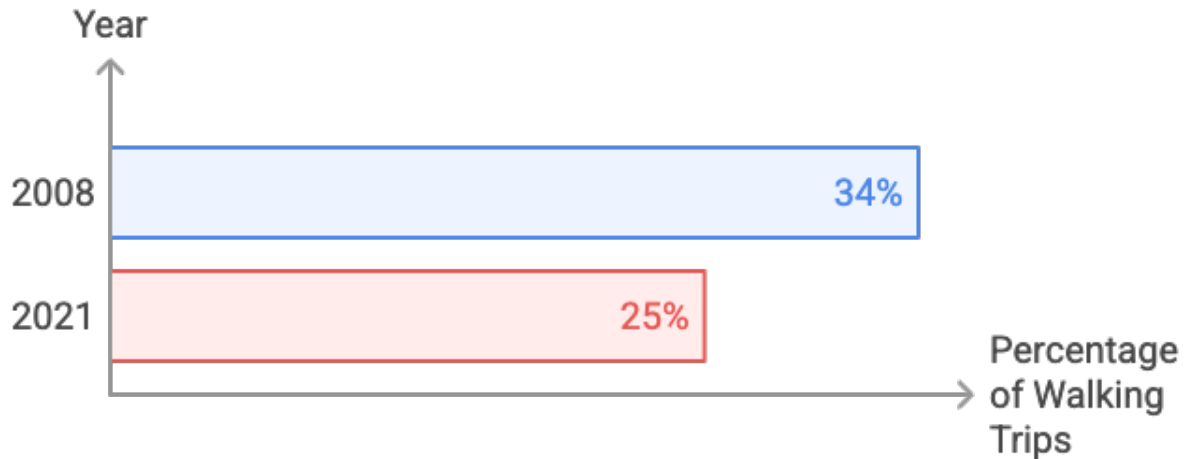


Figure 4: Trends in Walking Trips in Delhi.

The percentage of people using public transport has been trending downward. Compared to the 60% target set by the National Urban Transport Policy, the estimated 2020 modal share of public transport (including Delhi Metro and buses combined) was less than 40% (MoHUA, 2014). Poor last-mile connectivity, disparities in service quality, and the growing inclination towards private vehicles and intermediate public transport have all been blamed for this decline (RITES, 2020). The Delhi Metro also has accessibility issues because of its distance from homes and lack of feeder services, even with its extensive coverage and high daily ridership of over 5 million before COVID (DMRC, 2022).

The use of private vehicles, especially two-wheelers, has taken over. Two-wheelers account for more than 65% of registered vehicles, with cars coming in second at about 25%, according to the Delhi Statistical Handbook (2022). Figure 5 below visualizes how vehicle types in Delhi can be ranked based on the degree of regulation and formality. Road safety, emissions, and congestion are all directly impacted by this trend of motorisation. Particularly in low-income and peri-urban areas, paratransit modes like shared autorickshaws and e-rickshaws are crucial in fulfilling last-mile demand. But these are still mostly unregulated and informal, with inadequate integration with the official transit system (TERI, 2021).

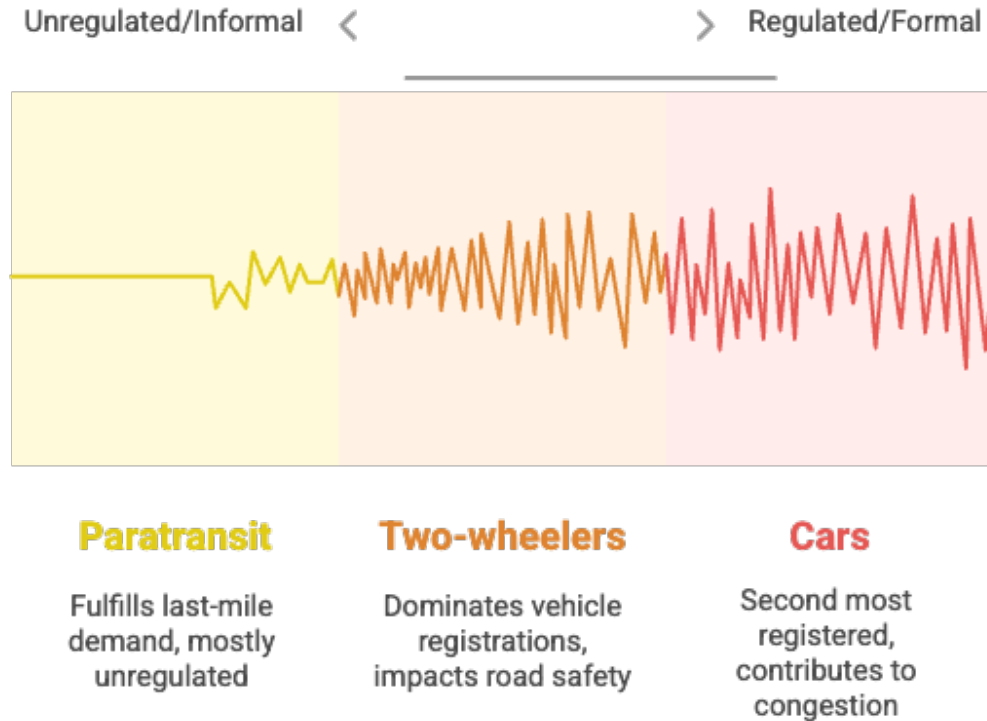


Figure 5: Vehicle types ranked by regulation and formality.

Mobility data broken down by gender shows notable differences. Only 18% of Delhi's women commute by private vehicle, according to a study by Jagori and UN Women (2018). A larger percentage use buses and shared transportation. Safety, cost, and trip chaining—the practice of combining work, shopping, and child care into a single trip—have a significant impact on women's travel, underscoring the significance of creating gender-sensitive transportation regulations.

Travel mode choices are also influenced by socioeconomic status. The majority of lower-income groups travel by bus, e-rickshaw, or foot, frequently at the expense of lengthy journeys and exposure to hazardous conditions. Spatial and mobility disparities are made worse by the greater likelihood of private vehicle ownership and use among those with higher incomes (CSE, 2020).

Additionally, COVID-19-induced telecommuting and flexible work arrangements have started to change the frequency and patterns of trips, especially for middle- and upper-class individuals (NITI Aayog, 2021). But because blue-collar and essential workers still depend on overworked public systems, this change hasn't made a big difference in reducing traffic.

Understanding these various travel behaviours and actively influencing mode choices through infrastructure, policy, and service design are essential to the shift to a sustainable transportation future. To improve Delhi's transport results, equitable investments in NMT, improvements to public transport, and multimodal integration—all directed by behavioural insights—will be essential.

Transport Governance in Delhi

The governance of Delhi's transportation system is highly fragmented, involving a multitude of agencies operating at different administrative levels. This institutional complexity has long been

identified as a core challenge in planning and implementing an integrated and sustainable urban transport system in Delhi (RITES, 2021; TERI, 2020).

Key Institutions and Their Roles

- **Transport Department, Government of NCT of Delhi (GNCTD):** This is the nodal agency responsible for regulating public transport, implementing road safety initiatives, issuing vehicle registrations and driving licenses, and framing policies such as the Delhi Electric Vehicle Policy (GNCTD, 2020).
- **Delhi Transport Corporation (DTC):** As the largest public bus operator in Delhi, DTC manages the state-owned bus fleet, servicing millions of daily commuters. However, issues related to fleet modernization, scheduling inefficiencies, and declining ridership have been reported (Delhi Dialogue Commission, 2019).
- **Delhi Metro Rail Corporation (DMRC):** DMRC is a joint venture between the Government of India and GNCTD. It has been praised globally for efficient metro rail operations but faces limited integration with other modes like buses and intermediate public transport (CSE, 2021).
- **Delhi Development Authority (DDA):** Under the Ministry of Housing and Urban Affairs (MoHUA), DDA is responsible for land use planning. However, poor synchronization between transport planning and land development has led to urban sprawl and car-dependent communities (Jain et al., 2018).
- **Unified Traffic and Transportation Infrastructure (Planning & Engineering) Centre (UTTIPEC):** Established under the DDA, UTTIPEC is tasked with creating mobility plans, street design guidelines, and multimodal integration frameworks. Although it proposes progressive plans, their implementation is often delayed due to limited enforcement authority (UTTIPEC, 2019).
- **Municipal Corporations (MCDs and NDMC):** These local bodies are responsible for the maintenance of roads (non-arterial), footpaths, and streetlights. Coordination gaps between municipal authorities and transport departments result in service overlaps or delays in urban mobility projects (MoHUA, 2022).
- **Delhi Traffic Police:** Handles enforcement of traffic regulations, manages congestion hotspots, and works closely with civic authorities. However, limited manpower and outdated enforcement tools hinder its effectiveness (Delhi Traffic Police Annual Report, 2021).

Challenges

The governance framework in Delhi lacks a unified transportation authority, resulting in siloed operations and policy inconsistencies. Each agency often operates with its own set of priorities, mandates, and budgets, leading to coordination gaps in planning, service delivery, and data sharing (TERI, 2020). For instance, metro stations are frequently disconnected from bus terminals, and shared auto stands are often unregulated, creating inconvenience and safety concerns for commuters (RITES, 2021) as shown below in Figure 6.

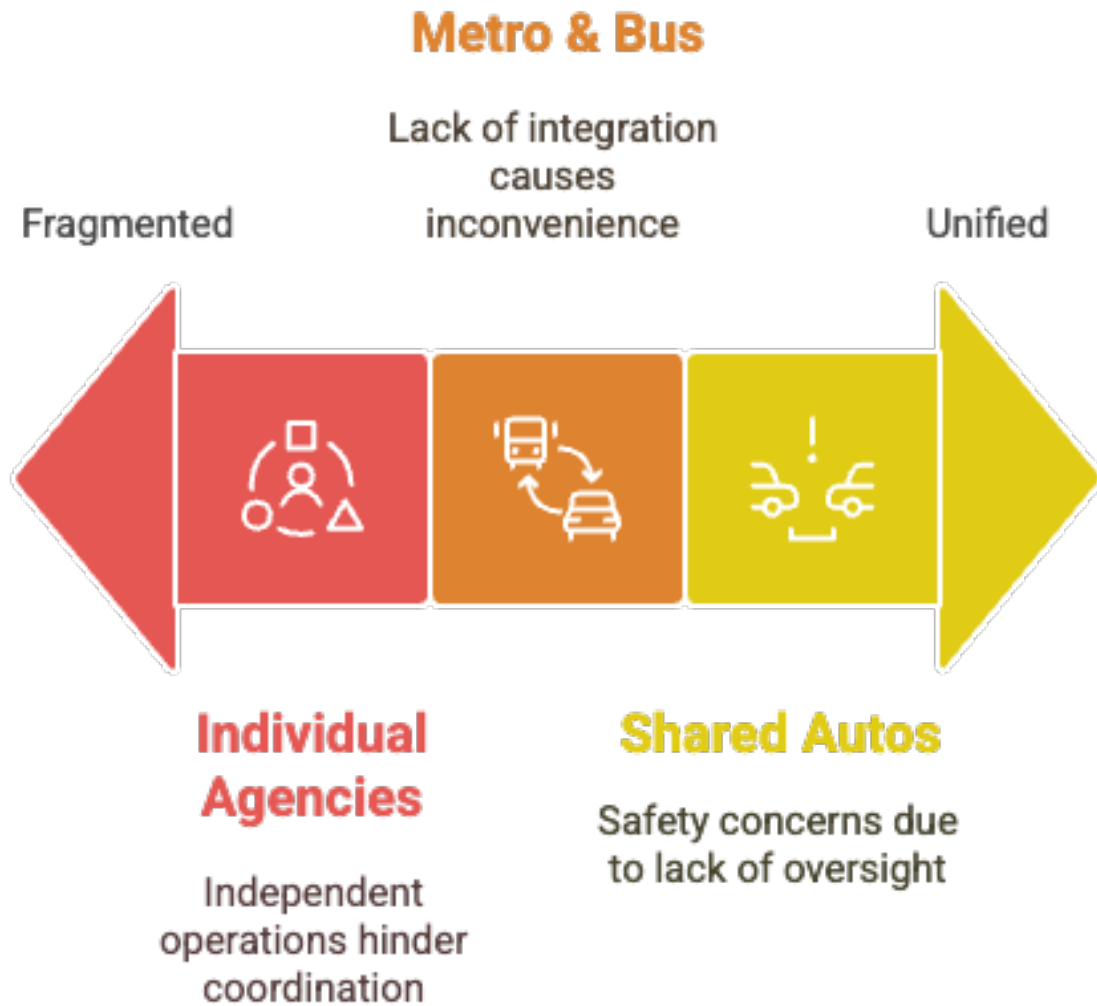


Figure 6: Transportation governance ranges from fragmented to unified control. (self-generated) Additionally, there is no central database or platform for integrated mobility data across agencies, which limits the ability to conduct evidence-based transport planning and monitoring (MoHUA, 2022). The absence of multimodal integration policies—such as common ticketing, synchronized timetables, and unified mobility passes—weakens the user experience and reduces the attractiveness of public transport.

There is a growing consensus among urban mobility experts and policymakers that Delhi needs a single unified transport authority, modelled on global examples such as Transport for London (TfL). This body could coordinate planning, operations, budgeting, and data systems across all modes and agencies. The National Urban Transport Policy (NUTP, 2006) and the Smart Cities Mission have both emphasized the importance of integrated urban transport governance (MoHUA, 2015), yet Delhi has yet to institutionalize such mechanisms.

Challenges in Delhi's Transport System

Delhi's transport ecosystem, though extensive, is riddled with structural, operational, and environmental challenges that hinder its journey towards sustainable mobility. These challenges

manifest across multiple dimensions, including congestion, pollution, safety, infrastructure inadequacy, and institutional fragmentation.

Traffic Congestion and Vehicle Growth

One of the most persistent issues is severe traffic congestion. Delhi has witnessed exponential growth in vehicle ownership. As per the **Economic Survey of Delhi (2022-23)**, the city registered over 13.9 million vehicles, accounting for nearly 10% of India's total vehicle population (Government of NCT of Delhi, 2023). The increased vehicle-to-population ratio has strained the limited road infrastructure. According to the **TomTom Traffic Index (2022)**, Delhi is one of the most congested cities in the world, with commuters spending over 60% extra time in traffic during peak hours. Road space availability remains skewed, with private vehicles occupying over 75% of road space while carrying less than 20% of passengers (MoHUA, 2021). **Figure 7** illustrates the paradox of Delhi's vehicle-centric transport system. Although Delhi holds **10% of India's vehicles**, these vehicles consume an estimated **75% of road space** while carrying only **20% of the city's total passengers**. Moreover, congestion causes an **average of 60% extra travel time during peak hours**, severely impacting productivity, fuel consumption, and public health.

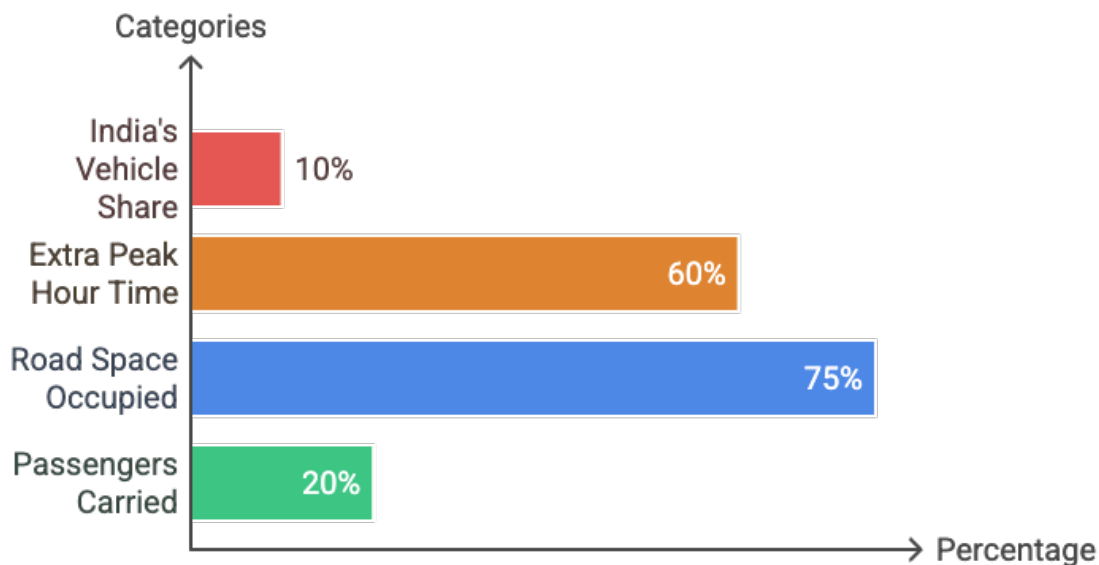


Figure 7: Traffic Congestion and Vehicle Distribution in Delhi.

Air Pollution and Environmental Impact

Transport is a major contributor to Delhi's air pollution crisis. According to the **Central Pollution Control Board (CPCB, 2022)**, vehicular emissions account for 30–40% of PM_{2.5} levels during peak pollution seasons, as shown below in Figure 8. The prevalence of diesel-powered vehicles, older engines, poor fuel quality, and traffic idling exacerbates the emission levels (Guttikunda & Jawahar, 2018). Despite the transition to CNG for public buses and the expansion of the Delhi Metro, the sheer volume of private vehicles continues to offset these gains. Furthermore, the burning of fossil fuels in transportation directly contributes to carbon emissions, countering India's commitments under the Paris Agreement.

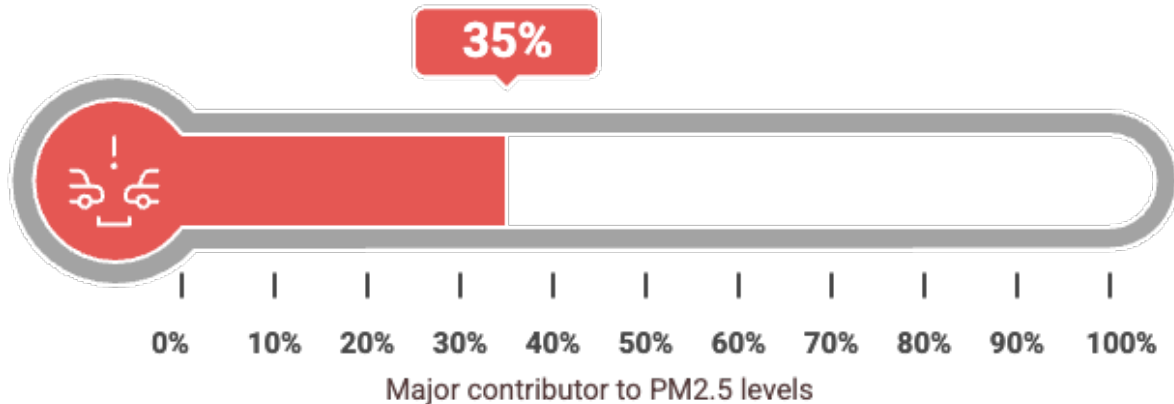


Figure 8: Contribution of Transport to Delhi's Air Pollution.

Public Transport Infrastructure

Even though the Delhi Metro is a world-class example of effective mass transit, the ecosystem of public transportation as a whole is still uneven and underutilised. DTC and Cluster services run the bus system, which is outdated, badly maintained, and not big enough to handle demand. The bus fleet per capita in Delhi is significantly less than the standard established by the Ministry of Urban Development, according to the Comprehensive Mobility Plan (CMP) for Delhi (2020).

Many organizations like Transport Department, DMRC, UTTIPEC, DTC, PWD and municipal co-operations, is stakeholder in governance in Delhi's transport sector. Delhi's Transport system has a crucial gap in multimodal integration. Having a high level metro connectivity, shared mobility, e-rickshaw and buses are not well co-ordinated. In a study conducted by ITDP in 2019, that Delhi doesn't have real-time information systems or uniform smart ticketing, which makes it hard to transfer and makes public transportation less appealing. Also, physical infrastructure sometimes doesn't have universal design, which makes it hard for kids, seniors, and people with impairments to use the system.

Safety and Gender Sensitivity

The transport system is still beset by safety issues, especially for female commuters and pedestrians. Among Indian cities, Delhi has one of the highest rates of fatal traffic accidents. According to data from the Ministry of Road Transport and Highways (2022), 1,213 people died on the roads in Delhi alone. Low non-motorized transport (NMT) uptake is also a result of unsafe cycling conditions, dimly lit bus stops, and a lack of pedestrian crossings. In Delhi, more than 90% of women reported having been harassed in some capacity while using public transport, according to a survey conducted by Jagori and UN Women (2018). This suggests that there have been significant shortcomings in safety and inclusivity.

As illustrated in Figure 9, the transportation safety issues in Delhi are widespread and affect various user groups. The limited adoption of non-motorized transport (NMT) options, such as cycling, can be directly attributed to the lack of secure cycling paths. In addition, the occurrence of deadly accidents, particularly at intersections and unregulated crossings, underscores the urgent requirement for traffic calming measures and designs that prioritize pedestrians.



Figure 9: Safety Issues Impact Delhi Transport.

Policy Landscape and Initiatives

Delhi's urban transportation policy landscape is characterized by a vibrant mix of national guidelines, state-level regulations, and experimental projects focused on promoting inclusive and sustainable mobility. Despite some progress, significant challenges persist due to a fragmented governance framework and inconsistent policy execution. This section analyzes the primary regulations that shape Delhi's transport system and their connection to sustainability objectives.

National Urban Transport Policy (NUTP), 2006

The National Urban Transport Policy (NUTP) was created by the Ministry of Housing and Urban Affairs (MoHUA) to serve as a foundational guide for sustainable urban transport within Indian cities. It focuses significantly on "prioritizing people over vehicles," promoting integrated land-use planning, public transit, and non-motorized transport (NMT) (MoHUA, 2006). NUTP recommends the formation of Unified Metropolitan Transport Authorities (UMTAs) to facilitate coordinated planning and also advocates for the development of multimodal transportation systems. In Delhi, UTTIPEC partially implements this recommendation. Despite NUTP providing an ideal framework, cities like Delhi face challenges in consistently applying it due to issues like institutional fragmentation and limited resources (Kumar & Agarwal, 2013).

Delhi Electric Vehicle Policy, 2020

In response to rising vehicular pollution, the Delhi Electric Vehicle Policy (2020) was launched with a goal to make electric vehicles (EVs) account for 25% of new vehicle registrations by 2024 (Government of NCT of Delhi, 2020). The policy offers a comprehensive set of fiscal incentives, scrappage benefits, interest subvention, and a targeted focus on two-wheelers, three-wheelers, and electric buses. Figure 9 below summarizes the main pillars of Delhi's EV policy.

It also promotes the creation of EV charging infrastructure through public-private partnerships and encourages fleet electrification by aggregators and delivery companies. Initial reports suggest significant uptake in electric two-wheelers, but the transition in public transport fleets (e.g., DTC buses) has faced delays due to procurement and infrastructure readiness issues (CEEW, 2021).

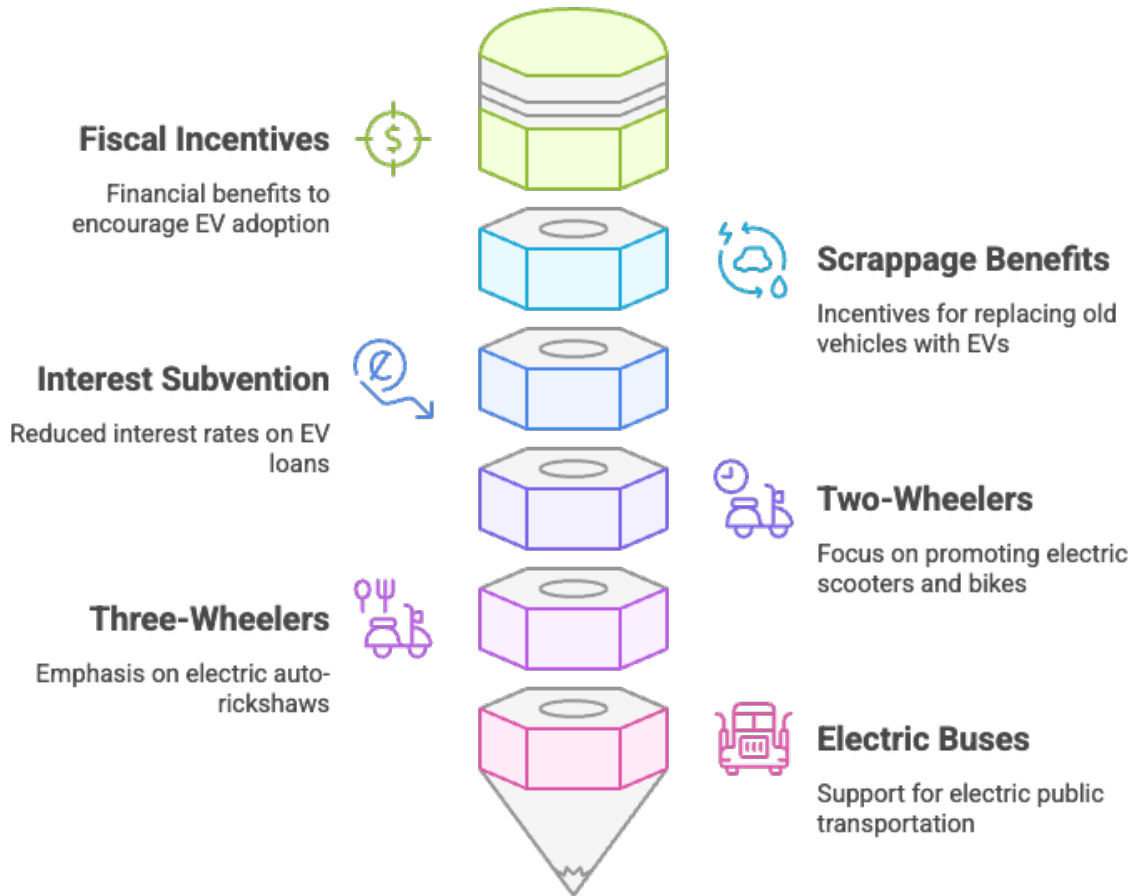


Figure 10: Delhi's Electric Vehicle Policy Overview.

Comprehensive Mobility Plan (CMP) and UTTIPEC Guidelines

The Comprehensive Mobility Plan (CMP) for Delhi, prepared under UTTIPEC's oversight, aims to align transport investments with sustainable development. It integrates land use and transport planning, emphasizing mass transit systems, non-motorized modes, and decongestion strategies (UTTIPEC, 2011). It introduces strategies like Transit-Oriented Development (TOD), congestion pricing, and multimodal integration hubs.

However, many proposed projects under the CMP remain on paper due to delays in approvals, funding challenges, and institutional overlaps (RITES, 2020).

Odd-Even Scheme

Introduced by the Delhi Government in 2016 as a pollution control measure, the Odd-Even scheme restricts private vehicle movement based on registration numbers on alternate days during high-pollution periods (Sharma & Dikshit, 2016). While effective in reducing peak-hour traffic temporarily, its long-term environmental impact has been debated due to insufficient modal alternatives and exemptions for certain vehicle types.

National Electric Mobility Mission Plan (NEMMP) & FAME Scheme

At the national level, the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) scheme under the NEMMP 2020 supports Delhi's EV adoption goals. FAME-II provides subsidies for electric buses, three-wheelers, and two-wheelers, along with support for

charging infrastructure (Ministry of Heavy Industries, 2022). Delhi has been one of the largest beneficiaries under the scheme, although the disbursement and procurement process often lags behind demand.

Street Design and Non-Motorized Transport Initiatives

As part of the Smart Cities Mission and India Cycles4Change Challenge, Delhi initiated Street for People campaigns and redesigned select roads for pedestrian and cycling use. Pilot projects in areas like Chandni Chowk and Connaught Place have demonstrated the potential for low-carbon, walkable spaces, but wide-scale implementation is limited (ITDP India, 2021).

UTTIPEC's Street Design Guidelines also recommend Complete Streets, universal accessibility, and climate-sensitive urban design, but execution across Delhi's road network has been uneven (UTTIPEC, 2019).

Policy Gaps and Challenges

Despite progressive policies, Delhi's transport governance remains fragmented among multiple agencies—DMRC, DTC, PWD, MCDs, UTTIPEC, and the Transport Department—often working in silos. This leads to:

- **Delayed implementation** of schemes like multimodal ticketing and common mobility cards.
- **Conflict in jurisdiction**, especially regarding land use, parking policy, and NMT infrastructure.
- **Lack of integrated data systems**, hindering real-time decision-making.

Therefore, strengthening institutional coordination, enabling robust financing mechanisms, and fostering citizen participation are key to bridging the policy-practice gap in Delhi's transport sector.

Opportunities for Sustainable Transition

Achieving sustainable urban mobility in Delhi necessitates a paradigm shift from a vehicle-centric to a people-centric approach, aligning with national and global sustainability goals. Several critical opportunities exist for transitioning the current transport system into a more sustainable and inclusive framework.

Electrification of Public and Intermediate Transport

Delhi's push for electric mobility under the **Delhi Electric Vehicle Policy 2020** presents a significant opportunity for decarbonizing urban transport. The policy aims to ensure that **25% of all new vehicle registrations by 2024 are electric**, targeting both public and private transport modes (Government of NCT Delhi, 2020). Electrification of buses, particularly the DTC and Cluster fleets, can drastically reduce particulate emissions and noise pollution, which are major concerns in Delhi's congested urban fabric.

Additionally, electrifying **three-wheelers and e-rickshaws**, which form the core of Delhi's last-mile and para-transit systems, can create widespread environmental and social benefits. Studies show that electric three-wheelers emit up to **60% fewer greenhouse gases** compared to petrol counterparts (IEA, 2022). Deployment of **charging infrastructure**—especially battery swapping stations at high-density nodes—remains a critical enabler for this transition.

Integrated and Inclusive Public Transport

Despite the success of the **Delhi Metro Rail**, public transport's overall modal share is declining due to poor integration between metro, buses, and last-mile services (UTTIPEC, 2021). A major opportunity lies in **developing a seamlessly integrated public transport system** through unified ticketing, synchronized schedules, and multimodal hubs.

Moreover, improving the **coverage and reliability of buses** remains key. According to the **Comprehensive Mobility Plan (2019)**, over **30% of Delhi's population lacks access to reliable bus services** within 500 meters. Reviving bus connectivity in underserved and peripheral areas can enhance accessibility for low-income groups and reduce private vehicle dependence.

Integration must also consider the needs of **women, the elderly, and differently-abled individuals**. Gender-sensitive design (e.g., better lighting, surveillance, safe waiting areas) can increase women's confidence in using public transit, contributing to a more inclusive system (Tiwari & Jain, 2021).

Strengthening Non-Motorized Transport (NMT)

NMT—including walking and cycling—remains the most sustainable mode of travel, especially for short urban trips. Yet, Delhi has **limited infrastructure** for NMT despite high latent demand. Currently, **more than 30% of trips are under 5 km**, making them ideal for walking or cycling (MoHUA, 2020).

The **Streets for People Challenge** and **Cycle4Change** under the Smart Cities Mission are promising steps, but require institutional scaling and enforcement. Dedicated and safe **pedestrian paths and cycle tracks**, traffic calming measures, and integration with public transport nodes can significantly increase the mode share of NMT. A World Bank study (2020) notes that protected cycle lanes can **increase ridership by 35–50%**, especially if linked with employment and education hubs.

Transit-Oriented Development (TOD)

Delhi's land use and transport systems have traditionally evolved in isolation. The **National TOD Policy** offers a framework to densify and develop mixed-use communities around public transport corridors. Delhi has already notified TOD regulations around the Metro Phase-III corridors, aiming to promote **compact, walkable urban form** (DDA, 2021).

TOD not only improves access to public transport but also reduces the need for long-distance motorized travel, thereby lowering emissions and congestion. Incentivizing affordable housing within TOD zones can ensure that the benefits of improved transport access reach all income groups.

Use of Technology and Data-Driven Planning

Smart technologies can greatly enhance the efficiency, transparency, and responsiveness of Delhi's transport system. The development of **Integrated Command and Control Centres (ICCCs)** can enable **real-time monitoring of traffic, buses, and incidents**, aiding in prompt decision-making and system optimization (NIUA, 2022).

Apps and digital dashboards can help users plan trips more efficiently, track buses in real time, and provide feedback. On the planning side, big data analytics—based on mobile phone data, GPS,

and smart card usage—can assist policymakers in identifying demand clusters, designing dynamic routes, and optimizing resource allocation (ITDP, 2021).

Behaviour Change and Public Engagement

Sustainable transport is not just an infrastructure issue—it also demands behavioural change. Programs like **Raahgiri Day** and **Car-Free Zones** have successfully demonstrated how awareness, experience, and public participation can influence modal shift. Such participatory events should be institutionalized and expanded across all districts to create a culture of sustainability (Jain & Agarwal, 2019).

Public engagement also builds accountability and trust, which are essential for long-term success. Tools like **mobility satisfaction surveys**, **citizen transport forums**, and **inclusive planning workshops** can help bridge the gap between policy and practice.

Conclusion

The larger mobility problems of megacities of the developing world resonate in the transport system of Delhi. A knotted dialectic prevails in the interaction between the public and private transport modes: an over-reliance on private cars, scarce infrastructure for non-motorised mobility, last-mile connectivity, and social and environmental issues. The city has an excellent metro system, reputed as one of the best in India, and an enormous fleet of buses. However, its transport system suffers due to fragmentation in planning and implementation, affecting its sustainability, accessibility, and efficiency.

This study reveals that regulation of the transport system in Delhi is carried out by an overlapping, which tend to hinder integrated decision-making and thereby freeze improvements to the system. The prevalent modal split is worrying, with steady declines in public transport use and commensurate rises in private vehicle ownership. This implies routine traffic congestion, increased travel times, increased fuel consumption, and poor air quality. Would such issues be technical or infrastructural in nature? They represent major issues that are, respectively, public health, social equity, and urban planning. From the sustainability side, Delhi's transport systems have extreme environmental concerns. The poor air quality situation is near-unique in having vehicular emissions as the chief source while also being aided by the high dependency on fossil fuels for mobility.

Yet, there are still issues that, in many cases, remain unaddressed: one is pedestrian and cyclist safety, which is vital for short-distance travel. Secondly, an unprecedented social equity vacuum exists in the entire mobility sector, which stands as a principal impediment to safe, reliable, and affordable mobility for disadvantaged groups such as women, the elderly, and economically disadvantaged persons. The policy framework for Delhi includes three key components: the Delhi Electric Vehicle Policy, transit-oriented development rules and transport integration initiative measures. Real-world implementation faces serious constraints because of institutional vulnerability, inadequate enforcement structures, and systemic deficiencies. The situation becomes

worse because of inadequate data exchange protocols and minimal participation of public-level stakeholders in the transport planning process.

The comprehensive evaluation of Delhi's complex transport system enables the identification of widespread inefficiencies, which serve as a basis for creating an inclusive, sustainable urban mobility system. The sustainability features have been highlighted to focus mainly on the transport model which is going to be implemented in Delhi.

The principles of the sustainability features are universal accessibility, deep reduction of environmental footprints, and optimization of cross-modal interconnectivity. Moreover, the implementation of the utilization of digital technologies, infrastructures for real-time data, and governance with participatory feature that includes all stakeholders, from individuals to private mobility providers, and government, is still very significant.

The analysis provides a background reference to choose the necessary intervention strategies and to rework the present transportation system. It will serve as a strategic plan for the next stages of research aimed at optimizing mobility outcomes and making the transportation infrastructure of Delhi more compatible with the Sustainable Development Goals (SDGs), a data-driven, user-centric, and assistive sustainable transportation model being the final goal, which is also fitting the urban layout of the city.

Summary of Study in points:

1. Transport Paradox: Despite having world-class systems like the Delhi Metro and a large bus fleet, Delhi suffers from a heavy dependence on private vehicles and inadequate last-mile infrastructure.
2. Governance Gap: Transport governance is fragmented across multiple agencies, resulting in poor coordination, inefficient implementation, and inconsistent planning.
3. Environmental Concerns: Vehicular emissions are a major contributor to Delhi's air pollution, which raises serious public health and climate-related concerns.
4. Equity and Accessibility Issues: Marginalized groups, including women, the elderly, and low-income residents, face disproportionate barriers in accessing safe and reliable transport.
5. Infrastructure Shortcomings: The lack of Non-Motorized Transport (NMT) infrastructure, poor intermodal connectivity, and outdated public bus systems hinder overall mobility efficiency.
6. Policy-Practice Discrepancy: While several policies exist, their implementation is weak due to institutional vulnerability, poor data-sharing mechanisms, and limited citizen engagement.
7. Sustainability Imperative: The future transport model should prioritize: Universal accessibility, Environmental impact mitigation, Integrated multimodal transport, Technology adoption (e.g., real-time data, smart ticketing), Stakeholder-inclusive governance.
8. Framework Proposal: The paper lays the foundation for a user-centric, data-driven, assistive transport model that aligns with the SDGs and can serve as a blueprint for other Indian cities.

9. Strategic Vision: It calls for systemic reforms in planning, institutional coordination, investment in electric and NMT infrastructure, and behavioural change campaigns for a sustainable urban future.

References:

1. Borker, G. (2018). *Safety first: Perceived risk of sexual harassment and commuting mode choice*. World Bank.
2. CEEW. (2021). *Electric Vehicles in Delhi: Progress and Potential*. Council on Energy, Environment and Water.
3. Central Pollution Control Board (CPCB). (2022). *Air quality monitoring data: National Air Quality Index*.
4. Centre for Science and Environment (CSE). (2021). *The urban commute and how it contributes to pollution and energy consumption*. New Delhi: CSE.
5. CMP for Delhi. (2021). *Comprehensive Mobility Plan for Delhi 2041*. UTTIPEC & DDA.
6. CPCB. (2022). *Air Quality Report for Delhi NCR*. Central Pollution Control Board.
7. CSE. (2020). *Mobility Crisis in Delhi: An Equity Perspective*. Centre for Science and Environment.
8. Delhi Development Authority (2021). *TOD Policy Notification*.
9. Delhi Dialogue Commission. (2019). *Delhi Mobility Report*. GNCTD.
10. Delhi Integrated Multi-Modal Transit System (DIMTS). (2022). *Cluster Bus Scheme and ITS Applications*.
11. Delhi Metro Rail Corporation. (2023). *Operational Network Statistics*. Retrieved from <https://www.delhimetrorail.com>
12. Delhi Statistical Handbook. (2022). *Transport Section*. Directorate of Economics and Statistics, GNCTD.
13. Delhi Traffic Police. (2021). *Annual Report 2021*. Delhi Police Department.
14. DMRC. (2022). *Annual Report 2021–22*. Delhi Metro Rail Corporation.
15. Economic Survey of Delhi. (2022-2023). *Planning Department, Government of NCT of Delhi*.
16. Government of India (2021). *Ministry of Housing and Urban Affairs (MoHUA)*.
17. Government of NCT of Delhi (GNCTD). (2020). *Delhi Electric Vehicle Policy 2020*. Delhi: GNCTD.
18. Guttikunda, S. K., & Jawahar, P. (2018). *Urban transport and air pollution in Indian cities*. Urban Climate.
19. Institute for Transportation and Development Policy (ITDP). (2021). *India Urban Mobility Review*.
20. International Energy Agency (IEA) (2022). *Global EV Outlook*.
21. ITDP India. (2019). *The Role of Multimodal Integration in Improving Transport Systems*.
22. ITDP India. (2021). *India Cycles4Change Challenge – Pilot Learnings*.
23. Jagori & UN Women. (2018). *Safe Cities and Safe Public Spaces for Women and Girls: Delhi Baseline Survey*.
24. Jagori & UN Women. (2018). *Women's Safety Audit in Public Transport in Delhi*.

25. Jain, D., & Tiwari, G. (2018). *Sustainable Transport for Indian Cities: A Review*. Journal of Urban Planning, 145(1), 04018003.
26. Jain, G., Tiwari, G., & Rao, K. (2018). *Land use transport integration for sustainable development: A case of Delhi*. Journal of Transport and Land Use, 11(1), 829–849.
27. Jain, S., & Agarwal, M. (2019). *Public engagement and car-free initiatives: Lessons from Raahgiri Day*. Urban India.
28. Kumar, A., & Agarwal, O. (2013). *Institutional Labyrinth: Designing a Way Out for Improving Urban Transport Services: The Case of Delhi*. World Bank.
29. Ministry of Heavy Industries. (2022). *FAME India Scheme Phase II – Progress Update*.
30. Ministry of Housing and Urban Affairs (MoHUA) (2020). *Urban Mobility India Report*.
31. Ministry of Housing and Urban Affairs (MoHUA). (2015). *Smart Cities Mission Guidelines*. Government of India.
32. Ministry of Housing and Urban Affairs (MoHUA). (2021). *Transit-Oriented Development Policy Guidelines*.
33. Ministry of Housing and Urban Affairs (MoHUA). (2022). *State of Urban Transport in India*. New Delhi: MoHUA.
34. Ministry of Road Transport and Highways. (2022). *Road Accidents in India*.
35. MoHUA. (2006). *National Urban Transport Policy*.
36. MoHUA. (2014). *National Urban Transport Policy*. Ministry of Housing and Urban Affairs, Government of India.
37. MoHUA. (2021). *Review of Urban Transport Projects in India*. Ministry of Housing and Urban Affairs, Government of India.
38. National Institute of Urban Affairs (NIUA) (2022). *Smart Cities Mission Updates*.
39. National Institute of Urban Affairs (NIUA). (2020). *Urban Parking Management in Indian Cities*.
40. NITI Aayog. (2021). *Decarbonizing Transport in India: Pathways and Policies*. Government of India.
41. NITI Aayog. (2021). *Future of Work: The Impact of COVID-19 on Urban Mobility Patterns*.
42. Pojani, D., & Stead, D. (2015). *Sustainable Urban Transport in the Developing World: Beyond Megacities*. Sustainability, 7(6), 7784–7805.
43. RITES. (2020). *Comprehensive Mobility Plan for Delhi – Summary Report*.
44. RITES. (2020). *Transport Demand Forecast Study for Delhi 2041*.
45. RITES. (2021). *Comprehensive Mobility Plan for Delhi 2041*. Submitted to DDA.
46. Sharma, A., & Dikshit, O. (2016). Evaluation of the odd–even scheme of Delhi. *Current Science*, 110(6), 925-926.
47. TERI. (2020). *Urban Transport Governance in India: A Review*. The Energy and Resources Institute.
48. TERI. (2021). *Paratransit in Indian Cities: Role, Challenges and Strategies*.
49. TERI. (2021). *Urban Transport Governance in India: Institutional Coordination and Reform*.

50. TERI. (2022). *Green Mobility for Clean Air in Indian Cities*. The Energy and Resources Institute.
51. Tiwari, G., & Jain, D. (2021). *Gender-sensitive transport planning in Indian cities*. Transportation Research Part A.
52. TomTom Traffic Index. (2022). *TomTom International B.V.*
53. Transport Department, GNCTD. (2023). *Delhi Statistical Abstract on Road Transport*.
54. Transport Department, Government of NCT of Delhi. (2022). *Vehicle Registration Statistics*.
55. Unified Traffic and Transportation Infrastructure (Planning & Engineering) Centre (UTTIPEC). (2019). *Street Design Guidelines*. Delhi Development Authority.
56. United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development*.
57. UTTIPEC (2021). *Comprehensive Mobility Plan for Delhi*.
58. UTTIPEC. (2011). *Comprehensive Mobility Plan – Guidelines and Policies*.
59. UTTIPEC. (2019). *Comprehensive Mobility Plan for Delhi 2041*. Unified Traffic & Transportation Infrastructure (Planning & Engineering) Centre.
60. UTTIPEC. (2019). *Street Design Guidelines*.
61. UTTIPEC. (2020). *Comprehensive Mobility Plan for Delhi*. Delhi Development Authority.