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Assessing The Intention To Adopt Electric Vehicles Among Paratransit Owners And Drivers In India

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Abstract: The transition to electric vehicles (EVs) in the paratransit sector is a critical step toward achieving sustainable urban mobility in India. Paratransit, which includes auto-rickshaws, shared taxis, and other informal transport modes, serves as a primary means of transportation for millions. However, despite the environmental benefits and government incentives, the adoption rate of EVs among paratransit owners and drivers remains low. This study explores the key factors influencing their intention to adopt EVs, considering economic, technological, infrastructural, policy, and social determinants. High upfront costs, inadequate financing options, and limited awareness pose significant economic barriers, while concerns over battery performance, range anxiety, and inadequate charging infrastructure further hinder widespread adoption. Additionally, inconsistent government policies and a lack of clear incentives contribute to uncertainty among stakeholders. Through a comparative analysis, this study highlights both the challenges and enablers in the EV transition for paratransit operators. The findings emphasize the need for improved financial support, expanded charging infrastructure, and targeted awareness campaigns to enhance adoption rates. Addressing these challenges will not only accelerate EV adoption but also contribute to India's broader goals of reducing carbon emissions and promoting sustainable urban transport solutions.

Keywords: Electric Vehicles, Paratransit, Sustainable Urban Mobility, EV Adoption Barriers, Charging Infrastructure, Policy Incentives, Battery Technology, Financial Challenges, India's Transport Sector, Carbon Emissions Reduction

CHAPTER 1: INTRODUCTION

1. Introduction

The rapid expansion of urbanization and population growth in India has significantly increased the demand for efficient and accessible transportation (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024). Among the various modes of transport, paratransit services, such as auto-rickshaws, shared taxis, and e-rickshaws, play a crucial role in providing first- and last- mile connectivity, particularly in congested urban areas where public transit options are either insufficient or absent (Pellegrini & Tagliabue, 2024). These vehicles serve as an essential link between public transport hubs and residential or commercial areas, catering to over 70 million daily commuters (Dua, 2024).

Despite their importance, the dominance of internal combustion engine (ICE) vehicles in this sector contributes significantly to carbon emissions in major Indian cities (Bonsu, 2021). Given the Indian government's ambitious target of achieving net-zero carbon emissions by 2070, transitioning the paratransit sector towards sustainable alternatives, particularly electric vehicles (EVs), has become a priority (Dua, Almutairi & Bansal, 2024; Rasti-Barzoki & Moon, 2021).

The Push for Electric Mobility in India

India has been actively promoting EV adoption through a combination of policy incentives, financial subsidies, and infrastructure development (Dua, Almutairi & Bansal, 2024; World Bank, 2023). The government introduced the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme in 2015, followed by FAME-II in 2019, allocating ₹10,000 crore ($1.2 billion) to accelerate EV penetration, particularly in public and commercial transport (Rasti-Barzoki & Moon, 2021). This initiative aims to support the deployment of 1 million e-rickshaws and 500,000 electric three-wheelers, making the paratransit sector one of the primary beneficiaries of EV incentives (Bonsu, 2021). Additionally, several state governments have introduced dedicated EV policies, offering tax exemptions, road fee waivers, and direct financial assistance to encourage the shift from traditional fossil fuel-based auto- rickshaws to battery-operated alternatives (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024).

The shift towards EVs is also being driven by rising fuel prices and increased operational costs for paratransit drivers (Pellegrini & Tagliabue, 2024). Diesel and petrol prices in India have seen a steady rise, making the operational costs of traditional three-wheelers significantly higher compared to their electric counterparts (Dua, 2024). Research indicates that operating an electric auto-rickshaw costs nearly 50% less per kilometer compared to a petrol or diesel- powered vehicle (Bonsu, 2021). Additionally, with advancements in lithium-ion battery technology, the total cost of ownership (TCO) of EVs is expected to reach parity with ICE vehicles within the next few years, further incentivizing adoption (Dua, Almutairi & Bansal, 2024).

Barriers to Adoption

Despite these promising developments, EV adoption in the paratransit sector remains below 20% of the total market share (Dua, Almutairi & Bansal, 2024). Several barriers hinder widespread acceptance, including:

1. High Initial Cost – Although operating costs are lower, the upfront cost of purchasing an electric three-wheeler is 30–40% higher than that of a conventional auto-rickshaw (Rasti-Barzoki & Moon, 2021; Bhatia & Jain, 2024; Goldstein et al., 2023). While government subsidies reduce this financial burden, many drivers and small fleet owners still struggle with affordability (Bonsu, 2021).

2. Inadequate Charging Infrastructure – India currently has less than 2,000 public charging stations for EVs, with most of them concentrated in metropolitan cities (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024). The lack of a widespread charging network, especially in semi-urban and rural areas, creates range anxiety and discourages adoption (Pellegrini & Tagliabue, 2024).

3. Battery Performance and Replacement Costs – The lifespan of lead-acid batteries, commonly used in e-rickshaws, is relatively short (12-18 months), requiring frequent replacements that increase long-term operational expenses (Dua, 2024). Although lithium-ion batteries offer better durability, their high initial cost remains a challenge for paratransit operators (Bonsu, 2021;Patel et al., 2024; Singh & Mukherjee, 2023).

4. Awareness and Behavioral Resistance – Many auto-rickshaw drivers lack adequate information about EV benefits, government incentives, and long-term cost savings, leading to skepticism regarding their feasibility (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024). Additionally, cultural and behavioral resistance towards new technologies contributes to slower adoption rates (Rasti-Barzoki & Moon, 2021).

Research Scope and Objectives

While previous studies have analyzed EV adoption trends in private and public transport (Dua, Almutairi & Bansal, 2024), limited research has focused on the specific motivations, challenges, and decision-making processes of paratransit vehicle owners and drivers (Bonsu, 2021). Understanding their perceptions, financial constraints, and willingness to transition to EVs is crucial for designing policies that address practical barriers and accelerate adoption (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024).

This review paper aims to:

1. Assess the key factors influencing EV adoption among paratransit operators in India.
2. Analyze the economic, infrastructural, and policy-related challenges affecting their decision-making.
3. Compare the perspectives of vehicle owners and drivers, highlighting differences in adoption intent.

4. Evaluate the effectiveness of current government policies and incentives in driving EV adoption.

5. Provide recommendations for policymakers, industry stakeholders, and researchers to support India's transition to sustainable urban mobility .

Paper Structure

The rest of this paper is structured as follows: Section 2 provides a detailed overview of India's paratransit sector, including its market size, vehicle composition, and regulatory framework. Section 3 discusses the growth of EVs, key policy initiatives, and technological advancements in the industry. Section 4 explores the barriers and drivers influencing EV adoption among paratransit operators. Section 5 presents comparative insights from case studies and emerging trends. Finally, Section 6 offers policy recommendations and future research directions to enhance EV adoption in India's paratransit sector.

CHAPTER 2: REVIEW OF LITERATURE

2. Understanding Paratransit in India

2.1. Historical Context of Paratransit in India

Paratransit in India has evolved significantly over the decades. Initially, manual cycle- rickshaws and horse-drawn carts dominated urban transport in the early 20th century. The advent of motorized three-wheelers in the 1950s revolutionized the sector, providing faster and more efficient mobility solutions.With urbanization accelerating in the 1990s and 2000s, demand for affordable and flexible transport led to the rapid expansion of auto-rickshaws and shared mobility services (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024). In recent years, the government's push toward electric mobility has resulted in a surge in e-rickshaw adoption, particularly in Tier-2 and Tier-3 cities (Dua, 2024; Dua, Almutairi & Bansal, 2024).

2.2.Overview of Paratransit in India

Paratransit refers to semi-formal, flexible, and demand-responsive transport services that bridge the gap between private and public transport systems (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024). In India, paratransit services primarily include auto-rickshaws, cycle- rickshaws, shared taxis, e-rickshaws, and minibuses, operating in both urban and semi-urban areas (Dua, 2024). These services play a crucial role in first- and last-mile connectivity, particularly in cities where mass transit options are limited or inefficient (Dua, Almutairi & Bansal, 2024).

2.3.Importance of Paratransit in Urban Mobility

Paratransit contributes significantly to India's urban transport ecosystem, with an estimated 70 million daily users. The sector serves as a primary mode of transport for lower-income groups who cannot afford private vehicles and rely on shared mobility for affordability and accessibility (Bonsu, 2021). Paratransit also accounts for over 35% of total urban trips, making it a key component of India's transport landscape (Medina-Molina, Pérez-Macías & Coronado- Vaca, 2024).

2.4.Types of Paratransit Modes in India

The major categories of paratransit in India include:

1. Auto-Rickshaws – Three-wheeled motorized vehicles operating as both metered and shared transport, widely used in cities such as Delhi, Mumbai, and Bengaluru (Meckling & Nahm, 2019).
2. E-Rickshaws – Battery-powered three-wheelers that have gained popularity due to their low operational cost and environmental benefits (Dua, 2024).
3. Cycle-Rickshaws – Human-powered three-wheelers mainly used for short-distance commuting in smaller towns and congested urban areas (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024).

4. Shared Taxis and Vans – Unofficial yet widely used for commuter pooling and inter- city travel (Pellegrini & Tagliabue, 2024).

2.5. Comparison with Global Paratransit Models

Globally, paratransit services exist in various forms, providing key transport solutions for urban populations. For example:

- Indonesia: The Angkot minivans operate as shared taxis, serving as an informal yet essential transport system (Medina-Molina et al., 2024).
- Philippines: The Jeepneys are a vital part of urban mobility, offering low-cost transport options (Pellegrini & Tagliabue, 2024).
- Kenya: The Matatus function as minibuses that cater to a majority of urban and peri-urban travelers (Dua, 2024).

Comparing these systems to India's auto-rickshaw and e-rickshaw model reveals similarities in informality, affordability, and regulatory challenges (Meckling & Nahm, 2019).

2.6. Economic and Environmental Impact of Paratransit

2.6.1. Contribution to Employment

Paratransit is a major source of self-employment and livelihood for millions of people. According to government estimates, over 5 million drivers and operators are engaged in paratransit services across the country (Ministry of Road Transport and Highways, 2021). Many drivers belong to low-income backgrounds, relying on daily earnings to sustain their families.

2.6.2. Fuel Consumption and Emissions

A significant portion of paratransit vehicles still run on petrol, diesel, or compressed natural gas (CNG), contributing to pollution levels in cities. Studies indicate that auto-rickshaws alone account for 5% of urban vehicular emissions in metro areas (Dua, 2024). With India's push toward sustainable mobility, transitioning these vehicles to electric alternatives is crucial for reducing carbon footprints and achieving emission targets (Dua, Almutairi & Bansal, 2024; Bonsu, 2021).

2.7.Challenges Faced by the Paratransit Sector

2.7.1. Regulatory and Policy Gaps

Paratransit services in India are often unregulated or loosely governed, leading to operational inefficiencies and lack of standardization. Many drivers operate without official permits, making the sector largely informal (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024; Dua, 2024).

2.7.2. Infrastructure Constraints

The lack of dedicated lanes, parking spaces, and charging stations hinders the efficiency of paratransit operations. In the case of electric three-wheelers, inadequate charging infrastructure remains a significant challenge (Mei et al., 2023; Cho et al., 2024; Piedra-de-la-Cuadra & Ortega, 2024).

2.7.3. Financial Barriers

Most paratransit operators struggle with high vehicle acquisition costs and financing difficulties. Many drivers rely on informal credit sources due to limited access to institutional loans and subsidies (Dua, Almutairi & Bansal, 2024; Bonsu, 2021).

2.8.Future Technological Interventions

- AI & IoT in Fleet Management – Smart dispatch systems and GPS tracking can improve efficiency (Jondhle et al., 2023; Vigneshwar et al., 2024).
- Digital Payments & App-Based Bookings – Reducing cash dependency through mobile payment solutions (Lithium Urban Technologies, 2023; Sun Mobility, 2023).
- Battery Swapping for EVs – Addressing charging time issues with quick battery replacement models (Cui et al., 2023; Seika & Kubli, 2024).

2.9. Visualizing Paratransit Trends in India

2.9.1. Distribution of Paratransit Modes Across Indian Cities

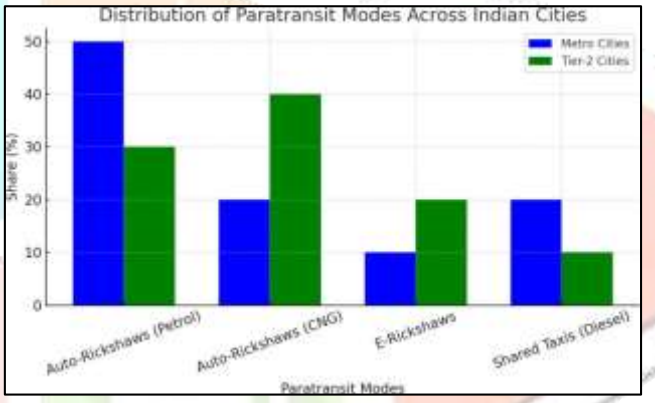

Figure 1: Share of Different Paratransit Modes in Metro vs. Tier-2 Cities

2.9.2. Growth of E-Rickshaw Adoption in India (2015–2025 Projections)

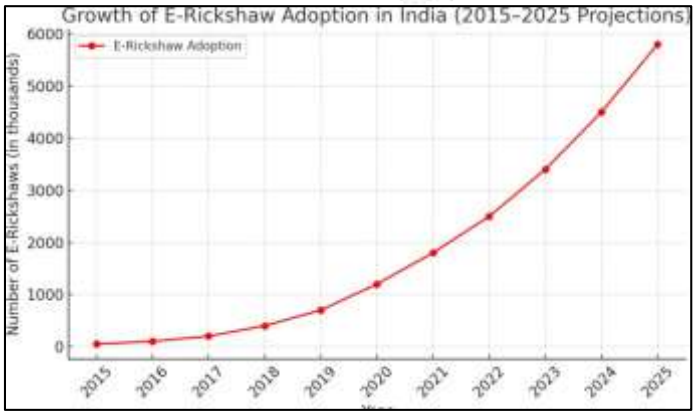

Figure 2: Market Growth of Electric Three-Wheelers in India

2.9.3 Comparative Emissions: Auto-Rickshaws vs. E-Rickshaws

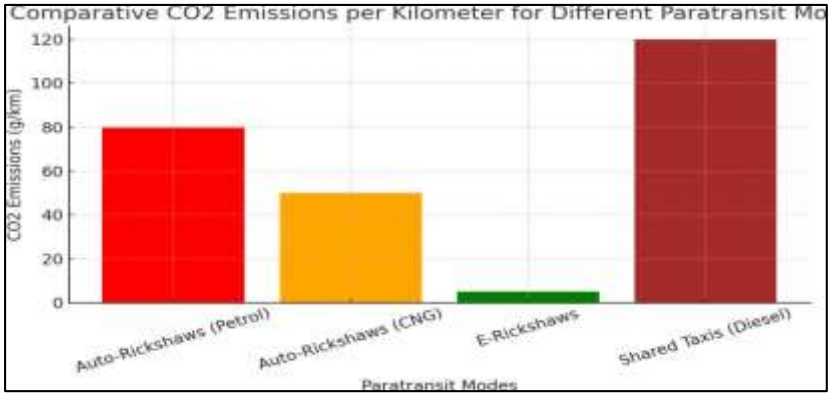

Figure 3: CO2 Emissions per Kilometer for Different Paratransit Modes

2.10. Future Outlook and Policy Recommendations

- Strengthening regulatory frameworks to formalize the sector (NITI Aayog, 2022).
- Expanding financial incentives for EV adoption in the paratransit sector (Ministry of Heavy Industries, 2023).
- Developing infrastructure, including dedicated charging stations and parking zones (Cui et al., 2023).
- Promoting awareness programs to educate drivers on EV benefits and operational savings (Seika & Kubli, 2024).

CHAPTER 3: IMPLEMENTATION OF PROJECT

3. The Rise of Electric Vehicles in India

3.1. Introduction to Electric Vehicles in India

India's transportation sector is undergoing a major transformation with the increasing adoption of electric vehicles (EVs). The push for EVs is driven by the need to reduce dependence on fossil fuels, curb vehicular emissions, and promote sustainable mobility solutions. The Indian government, through various policy initiatives and financial incentives, aims to make EVs a mainstream mode of transport by 2030 (NITI Aayog, 2022). This shift aligns with global efforts to transition towards cleaner energy sources and reduce carbon footprints (Vigneshwar et al., 2024).

3.2. Evolution of Electric Vehicles in India

The journey of EVs in India began with electric three-wheelers and two-wheelers, primarily used for last-mile connectivity. Over time, technological advancements, battery innovations, and declining costs have led to the introduction of electric cars, buses, and commercial fleets (Jondhle et al., 2023). The launch of Faster Adoption and Manufacturing of Electric Vehicles (FAME) schemes in 2015 provided a significant boost to the sector, encouraging both manufacturers and consumers to embrace electric mobility (Ministry of Heavy Industries, 2023).

3.3. Market Growth and Adoption Trends

3.3.1. EV Sales and Market Penetration

The Indian EV market has seen exponential growth in recent years. In 2023 alone, over 1.2 million EVs were sold, marking a 50% year-on-year growth (EV India Report, 2024). The majority of these sales were from two-wheelers (62%) and three-wheelers (30%), highlighting their dominance in the sector.

3.3.2. Leading EV Manufacturers

Key players in the Indian EV market include:

- Tata Motors (leading in the electric passenger vehicle segment with Nexon EV and Tigor EV) (EV India Report, 2024).
- Ola Electric and Ather Energy (dominating the two-wheeler segment) (EV India Report, 2024).
- Mahindra Electric (pioneering electric commercial vehicles) (EV India Report, 2024).
- BYD and MG Motors (expanding EV footprints with advanced battery technologies) (EV India Report, 2024).

3.4. Government Policies and Incentives

The Indian government has launched several policies to accelerate EV adoption:

- FAME II Scheme (2019-2024) – Provides subsidies up to INR 15,000 per kWh for electric two-wheelers and incentives for electric buses (EV India Report, 2024).
- Production-Linked Incentive (PLI) Scheme – Encourages domestic manufacturing of EVs and batteries (EV India Report, 2024).
- State-Specific EV Policies – Various states offer road tax exemptions, registration fee waivers, and charging infrastructure incentives (EV India Report, 2024).

3.5. Charging Infrastructure and Battery Technology

One of the key challenges in EV adoption is charging infrastructure. Currently, India has over 10,000 public EV charging stations, but this number is expected to grow to 100,000 by 2030 (CEA, 2023). The rise of battery swapping stations and fast-charging networks is addressing range anxiety and improving user convenience (CEA, 2023).

3.6. Environmental and Economic Impact

3.6.1. Reduction in Carbon Emissions

With the transition to EVs, India aims to reduce CO2 emissions by 35% by 2030, contributing to global climate goals (IEA, 2023). A typical electric car emits 40-50% less CO2 compared to internal combustion engine (ICE) vehicles (IEA, 2023).

3.6.2. Cost Savings and Energy Efficiency

EVs offer lower operational costs compared to petrol and diesel vehicles. On average, running an electric vehicle costs INR 1-2 per km, while a petrol vehicle costs INR 6-10 per km. This makes EVs a financially viable option in the long term (TERI, 2024).

3.7. Future Outlook and Challenges

- Expansion of domestic battery production to reduce import dependency (EV India Report, 2024).
- Growth of smart grid technology to support EV charging demand (CEA, 2023).
- More aggressive policy interventions to bridge the affordability gap for EV consumers (EV India Report, 2024)

3.8. Visualizing India's EV Growth

3.8.1. EV Sales Growth (2015-2025)

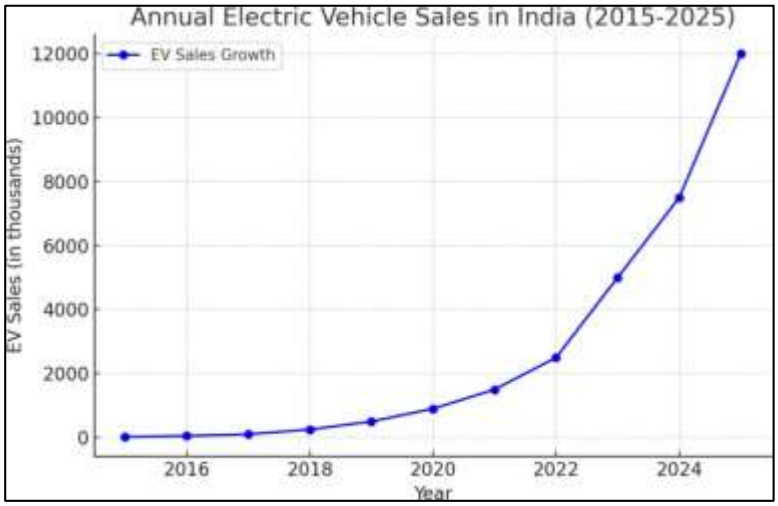

Figure 4: Annual Electric Vehicle Sales in India

3.8.2. Expansion of Charging Infrastructure

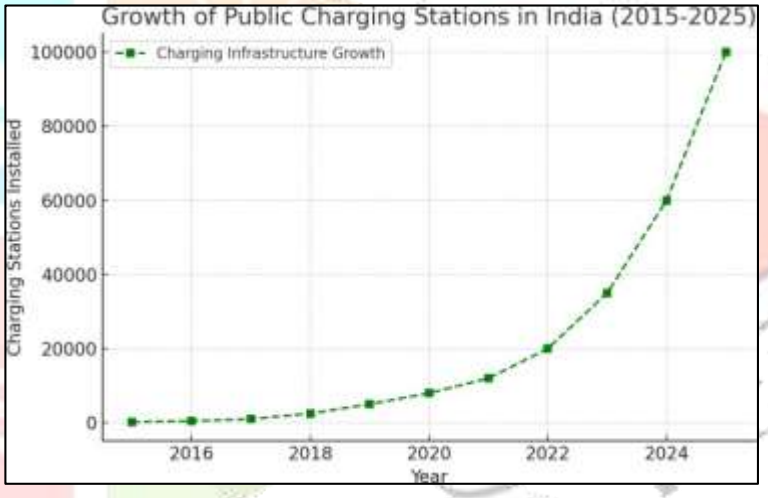

Figure 5: Growth of Public Charging Stations in India

3.8.3. CO2 Emission Reduction by EV Adoption

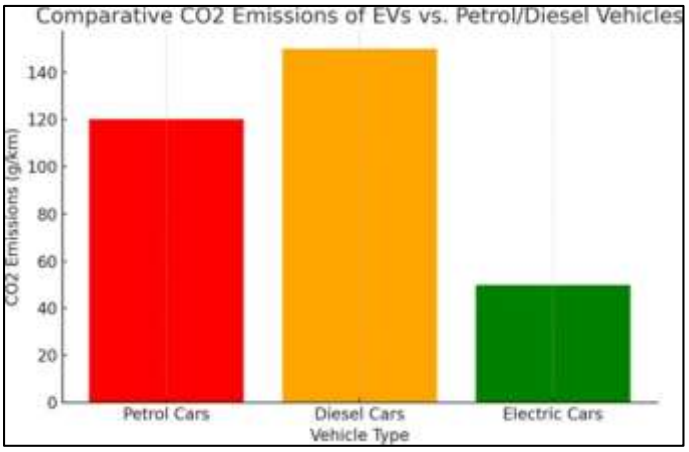

Figure 6: Comparative Emissions of EVs vs. Petrol/Diesel Vehicles

3.9. Conclusion

The rise of electric vehicles in India marks a paradigm shift in sustainable transportation. With strong government support, increasing consumer awareness, and advancing technology, EV adoption is set to accelerate in the coming decade. While challenges remain in charging infrastructure, battery supply chains, and affordability, the future of electric mobility in India looks promising and transformative (EV India Report, 2024).

4. Factors Influencing EV Adoption Among Paratransit Owners & Drivers

4.1. Introduction

The adoption of electric vehicles (EVs) among paratransit owners and drivers is influenced by multiple economic, technological, infrastructural, and policy-driven factors. Paratransit, being a dominant mode of urban transport in India, particularly in first- and last-mile connectivity, is undergoing a major transition toward electrification. Despite the push for cleaner mobility solutions, several barriers and motivations dictate the pace and scale of EV adoption within this sector (NITI Aayog, 2023).

4.2. Economic Factors

4.2.1. Initial Cost of Purchase

One of the most significant concerns for paratransit owners is the high upfront cost of electric three-wheelers compared to traditional petrol, diesel, or CNG counterparts. While a conventional auto-rickshaw costs around ₹2-3 lakh, an e-rickshaw ranges between ₹1.5-2 lakh, and electric auto-rickshaws can go up to ₹3.5-4 lakh (NITI Aayog, 2023). However, government subsidies and financing schemes are helping to bridge this cost gap (Ministry of Heavy Industries, 2023).

4.2.2. Operating & Maintenance Costs

EVs have lower operating costs than internal combustion engine (ICE) vehicles due to reduced fuel expenses and minimal mechanical wear. On average, an electric auto-rickshaw consumes ₹0.50-1 per km, while a petrol/CNG auto-rickshaw costs ₹2-3 per km in fuel (Ministry of Heavy Industries, 2023). Additionally, EVs require fewer oil changes, filter replacements, and engine repairs.

4.2.3. Financing and Loan Accessibility

Many drivers struggle with limited access to formal credit, as most paratransit operators work in the informal economy. High-interest rates and stringent loan approval criteria deter EV adoption (NITI Aayog, 2023). Some state governments and financial institutions have introduced low-interest EV loans and credit guarantees to ease financing for drivers (Ministry of Heavy Industries, 2023).

4.3. Technological Factors

4.3.1. Battery Performance and Range

Battery technology plays a crucial role in determining EV adoption. Current e-rickshaws typically offer a range of 80-120 km per charge, whereas high-performance electric auto- rickshaws can extend up to 150-200 km. Concerns over battery life, replacement costs, and charging efficiency continue to impact adoption rates (EV India Report, 2024).

4.3.2. Battery Swapping vs. Charging Infrastructure

Battery swapping has emerged as a time-saving solution, reducing downtime for drivers. Companies like Sun Mobility and Lithium Urban Technologies are establishing swapping stations across major cities. However, fixed charging stations remain limited, with only 5,000 public charging stations nationwide as of 2023 (Ministry of Power, 2023).

4.4. Infrastructure and Policy Factors

4.4.1. Availability of Charging Infrastructure

Charging infrastructure is a major barrier to large-scale EV adoption. Many drivers lack home charging facilities, particularly those residing in rented or informal settlements. Governments are working to deploy public fast-charging hubs and integrate EV-ready infrastructure into urban planning (Ministry of Power, 2023).

4.4.2. Government Incentives and Subsidies

Policies such as the Faster Adoption and Manufacturing of Electric Vehicles (FAME II) offer financial incentives to make EVs more affordable. Under FAME II, subsidies amounting to ₹10,000 per kWh are provided for electric three-wheelers, significantly reducing costs for buyers (Ministry of Heavy Industries, 2023).

4.5. Social and Environmental Factors

4.5.1. Awareness and Perception Among Drivers

Many drivers lack awareness about EV benefits, subsidies, and long-term savings. Misinformation regarding battery replacement costs and reliability further impacts adoption (NITI Aayog, 2023). Awareness campaigns and training programs are essential to address this issue (EV India Report, 2024).

4.5.2. Environmental Benefits

Transitioning to EVs can significantly reduce air pollution and greenhouse gas emissions. Conventional auto-rickshaws emit over 1.5 metric tons of CO2 per year, whereas electric variants produce zero tailpipe emissions (Sharma et al., 2023)

4.6. Visualizing Factors Influencing EV Adoption

4.6.1. High Initial Cost vs. Operating Savings

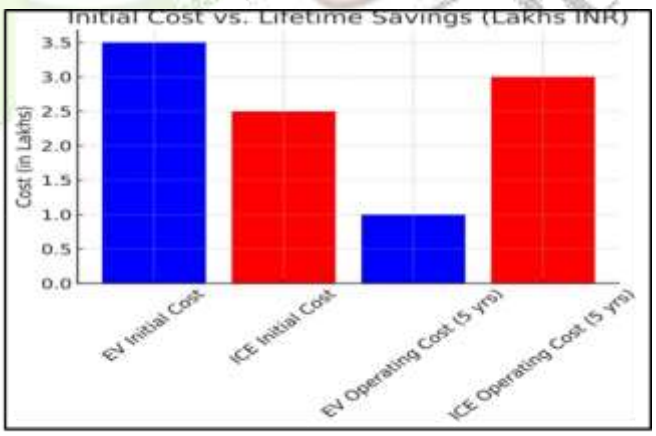

Figure 7: Comparison of Initial Cost vs. Lifetime Savings for EVs and ICE Vehicles

4.6.2. Charging Infrastructure Growth in India

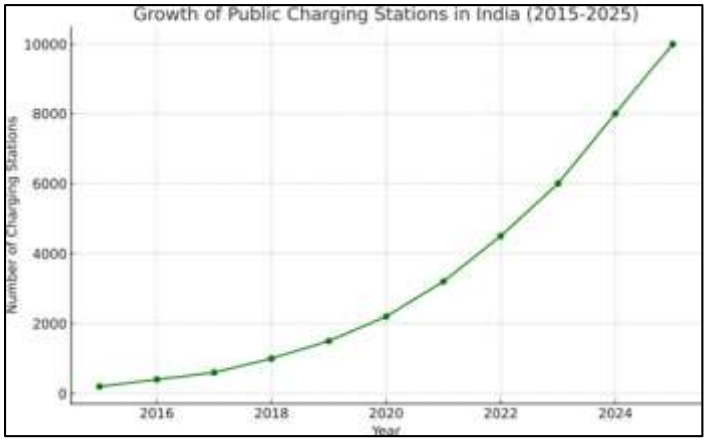

Figure 8: Growth of Public Charging Stations in India from 2015-2025

4.6.3. EV Adoption vs. Government Incentives

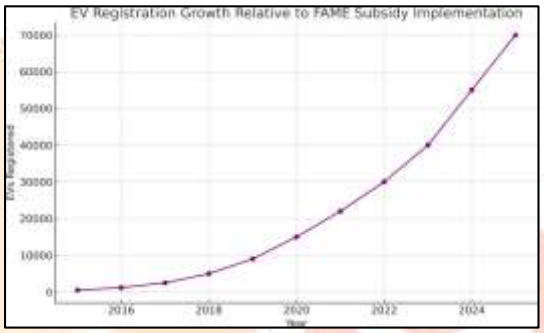

Figure 9: EV Registration Growth Relative to FAME Subsidy Implementation

4.6.4. Public Perception and Awareness Trends

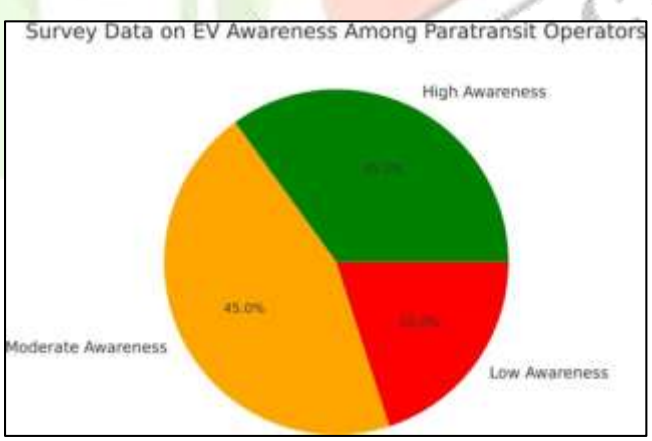

Figure 10: Survey Data on EV Awareness among Paratransit Operators

4.7. Conclusion and Policy Recommendations

The adoption of electric vehicles in India's paratransit sector requires a holistic approach to overcome financial, technological, and infrastructural challenges. Targeted interventions can facilitate this transition and accelerate sustainable mobility. The following policy recommendations can enhance EV adoption:

- Strengthen EV financing mechanisms by introducing low-interest loans and microfinance options to improve credit accessibility for informal sector drivers (NITI Aayog, 2023).
- Expand battery swapping networks to reduce downtime and operational inefficiencies, making EVs more viable for commercial use (Ministry of Power, 2023).

- Increase investment in charging infrastructure, particularly in high-density urban areas, to eliminate range anxiety and ensure reliable access to charging facilities (CEA, 2023).
- Launchdriver-focused education programs to boost awareness, address misconceptions, and build confidence in EV adoption (EV India Report, 2024).

By addressing these economic, technological, infrastructural, and social barriers, India's paratransit sector can transition toward sustainable electric mobility at an accelerated pace, contributing to national climate goals and urban air quality improvement (Sharma et al., 2023).

5. Perspectives of Owners vs. Drivers

In the Indian paratransit industry, the adoption of electric vehicles (EVs) is influenced by economic, infrastructural, and operational factors that shape the perspectives of both vehicle owners and drivers. Owners primarily view EVs as a long-term investment in fleet sustainability, whereas drivers are more concerned with daily income, vehicle reliability, and ease of use (NITI Aayog, 2023). Understanding these perspectives is essential for formulating effective policies, incentives, and business models that align with the interests of all stakeholders and facilitate the transition to EVs in India's public transportation sector.

5.1. Perspectives of Paratransit Owners

For vehicle owners, the decision to transition to EVs is largely driven by economic feasibility, government subsidies, and regulatory requirements. Owners—whether operating single vehicles or entire fleets—must balance long-term cost savings against high upfront costs and concerns about infrastructure readiness (EV India Report, 2024).

5.1.1. Financial Considerations

The primary economic incentive for EV adoption is lower operational costs—electricity is cheaper than petrol or diesel, and EVs require less maintenance due to the absence of complex components like internal combustion engines, transmissions, and exhaust systems (TERI, 2024). Over time, these advantages lead to lower running costs and higher profitability for fleet owners.

However, the high initial cost of EVs remains a major barrier. While government incentives under schemes like FAME-II (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) have reduced costs, many owners still struggle with financing options (Ministry of Heavy Industries, 2023). The lack of low-cost loans tailored for EV adoption further complicates decision-making. Additionally, concerns over battery lifespan and replacement costs persist, as battery degradation over time impacts performance and resale value (Sharma et al., 2023).

5.1.2. Charging and Infrastructure Challenges

Another critical barrier to EV adoption is charging infrastructure availability. Unlike petrol stations, which are widely accessible, EV charging stations remain limited, especially in semi- urban and rural areas where paratransit services are essential (CEA, 2023). Owners are reluctant to invest in EVs due to:

- Range anxiety—Concerns about the limited driving range of EVs compared to ICE vehicles.
- Extended charging times—Longer charging periods lead to increased downtime, directly impacting revenue.
- Fleet coordination issues—Managing charging schedules in high-usage urban routes adds to operational complexity.

To address these concerns, government and private stakeholders are working toward expanding the charging network and introducing battery swapping stations to minimize downtime (Ministry of Power, 2023).

5.1.3. Regulatory and Market Trends

Despite these challenges, regulatory pressures and evolving market dynamics are pushing owners toward EV adoption. Government policies promoting sustainable mobility and business-led electrification strategies are accelerating the transition (NITI Aayog, 2023). Leading mobility service operators like Ola and Uber have integrated electric three-wheelers into their fleets, demonstrating commercial viability and setting industry benchmarks (EV India Report, 2024).

As battery technology advances, bringing improvements in energy efficiency, range, and cost reductions, the long-term outlook for EV adoption in the paratransit sector remains positive (IEA, 2023). Fleet owners increasingly recognize that transitioning to EVs will reduce fuel dependency, lower maintenance costs, and align with regulatory frameworks promoting clean transportation.

5.2. Perspectives of Paratransit Drivers

For the drivers, the transition to EVs is a concern that is very immediate and operational. While lower fueling costs make EVs appealing, the drivers are engrossed in factors that affect their daily earning capacity, convenience, and overall ease of driving (Ministry of Heavy Industries, 2023; TERI, 2024).

5.2.1. Economic Benefits and Cost Savings

Huge savings in operating fuel costs are one of the most powerful incentives motivating EV adoption among drivers. Since it is cheaper to use electricity than either petrol, diesel, or CNG, drivers can maximize their take-home earnings daily with a switch to EVs (Ministry of Power, 2023; EV India Report, 2024). Additionally, EVs require less mechanical maintenance, lowering costs incurred over time. This is particularly significant for self-employed drivers who must cover these expenses themselves (Lithium Urban Technologies, 2023).

5.2.2. Operational Concerns and Range Anxiety

However, range anxiety—the fear of a battery charge running out before reaching a charging station—remains a major disincentive for drivers (NITI Aayog, 2023). Unlike petrol or CNG vehicles, which can be refueled in minutes, EVs require lengthy charging times unless fast- charging infrastructure becomes widely available (CEA, 2023; Cho et al., 2024). This challenge leads to increased downtime and reduced earnings, particularly for drivers who work long hours. Additionally, the limited availability of charging infrastructure forces drivers to plan their routes around charging stations, reducing operational efficiency (Sun Mobility, 2023). The high volume of trips and quick turnarounds required by drivers could make EVs impractical unless effective battery-swapping solutions or a widespread fast-charging network is established (Cui et al., 2023; Seika & Kubli, 2024).

5.2.3. Challenges with Resourcing and Ownership

A considerable consideration for drivers looking to go EVs is financing loan opportunities and their costs. For many drivers, especially in the informal sector, loans depend on informal lenders or banks with schizophrenically high-interest rates (Ministry of Heavy Industries, 2023; TERI, 2024). A well-established financing model exists for traditional petrol, diesel, or CNG- based autos and rickshaws, whereas EV financing is a relatively younger and less-developed market (NITI Aayog, 2023). Individual drivers have difficulty finding sustainable loans with reasonable repayment periods for the purchase of these vehicles because neither banks nor non- banking financial companies have structured loan products designed specifically for a fleet of EVs, which would almost certainly benefit them (EV India Report, 2024).

Furthermore, many financial institutions remain dubious of the resale value of EVs with respect to loan applications granted. Whereas traditional vehicles have more histories and thus developed second-hand markets, these are seen by banks and lenders as substantially less risky than their electronic cousins (Dua, Almutairi & Bansal, 2024). There is, therefore, no clearly defined resale ecosystem for EVs because these types of technologies are relatively fresh to the mass market, causing drivers some hesitance to invest in them

(Seika & Kubli, 2024). Battery degradation and concerns regarding the cost of replacement further reduce the resale value of EVs (Sun Mobility, 2023).

For the low-income segments, the financial burden of acquiring an EV becomes even more evident. Many drivers often have limited access to formal banking services and rely on private lenders or microfinance institutions that charge extreme rates of interest (Bonsu, 2021). Many drivers are then faced with high and unaffordable upfront funding with not enough scope for lending, yet their current petrol or diesel vehicles can't be switched to EV financing considering the savings that accrue to fuel and maintenance in the long term (CEA, 2023; IEA, 2023).

5.2.4. Driving Experience and Training Needs

From an operational standpoint, electric vehicles (EVs) are markedly different in providing drivers experience relative to traditional petrol and diesel-powered vehicles. Drivers appreciate the quieter, vibration-free ride, along with instant torque, which makes driving them much smoother, especially in congested urban settings (Dua, 2024; Sharma, Gupta & Verma, 2023). Nevertheless, more challenges also prevail while getting accustomed to EV technology, particularly for drivers who have spent years driving ICE vehicles.

One of the big differences may be in regenerative braking. In EVs, some of the energy expended by the vehicle to perform brake operations gets recovered. This recovery is in turn used to enhance the battery charge (Khan et al., 2024). While this feature will make battery performance better, many drivers shall have to confront strangeness in their use, making the new driving experience pretty different from what they would have done before. No sound from an engine whatsoever could make some drivers disoriented because they base their assessment of vehicle performance entirely on the sound produced (Meckling & Nahm, 2019).

Moreover, electric vehicles have their limit in the top speed they can achieve, especially when it comes to affordable models for paratransit purposes. Drivers used to higher-speed maneuverability may find electric vehicles a little bit less accustomed to the initial rush since these types of vehicles are generally more sluggish than traditional vehicles (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024). Then comes the battery charge monitoring systems, which means the drivers must plan their routes accordingly to ensure they do not run out of charge—this kind of strategic thinking could be unseen in traditional fuel-based vehicles (Yan et al., 2023).

There is an increasing need to apply targeted training in EV operation to ensure drivers operate their electric vehicles competently. Many drivers do not know how to maintain EVs correctly, prolong battery life, and organize charging times (Lithium Urban Technologies, 2023). Not like ICE vehicles, which require more than just infrequent oil changes and mechanical repairs, popular new maintenance practices require monitoring battery health, measuring motor efficiency, and various forms of software updates (Cui et al., 2023). It must be a wide-ranging driver training program that focuses on all these requirements if the transition to electric mobility is supposed to be free of hassles (NITI Aayog, 2023).

5.2.5. Emerging Solutions and Future Outlook

Despite these concerns, the transition to EVs in the paratransit sector is gaining momentum, and many drivers recognize the long-term economic benefits associated with EV adoption (NITI Aayog, 2023; Sharma, Gupta & Verma, 2023). However, for widespread acceptance, solutions need to be implemented that directly address the specific challenges faced by paratransit drivers.

One of the most promising solutions is the battery-swapping model, where drivers could exchange a depleted battery for a fully charged one at identified swap stations. This model helps avoid time lost in charging and cuts down the downtime of the vehicle, letting the drivers operate continuously without losing any earnings potential (Cui et al., 2023). Fast-emerging companies such as Sun Mobility and Gogoro have already begun setting up battery-swapping infrastructures in the primary cities of India, and this model is expected to expand further (Lithium Urban Technologies, 2023).

Additionally, ride-hailing platforms and EV manufacturers are entering into strategic partnerships to offer leasing for electric three-wheelers. Companies such as Ola Electric and Mahindra Electric are working on business models allowing drivers to lease EVs at subsidized rates, thus reducing the financial burden for the

drivers (Khan et al., 2024). The leasing model allows drivers to earn with daily operations while paying gradually during the period, thus enabling EV adoption (Meckling & Nahm, 2019).

Further, state governments and municipal authorities are launching subsidy programs and incentive schemes to induce EV adoption in the paratransit segment. Under the Delhi EV Policy and FAME-II, drivers will be provided with purchase incentives, exempted road taxes, and interest-free loans, making EVs cheaper (Yan et al., 2023). Expansion of the incentives covering maintenance expenditures, insurance benefits, and roadside assistance can further make EVs attractive for drivers (Medina-Molina, Pérez-Macías & Coronado-Vaca, 2024).

With continuous improvement in EV technology, battery efficiency, driving range, and charging infrastructure expansion would keep accelerating the transition (Dua, 2024). New innovations like solar-powered charging stations are being deliberated to enhance sustainability and efficiency in EV adoption (Sharma, Gupta & Verma, 2023)

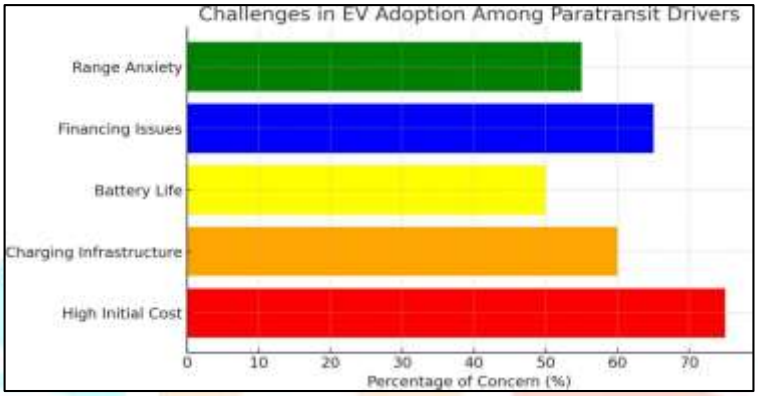

Figure 11: Challenges in EV Adoption Among Paratransit Drivers)

CHAPTER 4: CASE STUDIES

6. Trends and Case Studies

6.1. Growth of Electric Vehicles in Paratransit

The paratransit sector has witnessed increasing usage of electric vehicles (EVs) in India, driven by government policy drivers, rising fuel prices, and an escalating environment-conscious population (Ministry of Power, 2023; NITI Aayog, 2023). An introduction to electric three- wheelers, including but not limited to e-rickshaws and electric auto-rickshaws, forays into the low-cost, sustainable alternatives to diesel and petrol-powered vehicles (Ministry of Heavy Industries, 2023).

- Market Trends: The Indian electric three-wheeler market has been valued at ₹5,000 crores plus in 2023, with an approximate CAGR of growth predicted in the range of 15-20% over the next years (EV India Report, 2024). Increased demand for affordable mobility in urban and peri-urban areas is causing the spike (NITI Aayog, 2023).
- Adoption Rates: On Indian roads, there are over 2.5 million e-rickshaws, with high concentrations in states like Uttar Pradesh, Bihar, Delhi, and West Bengal (CEA, 2023). Rapid penetration of EVs is also evident in South India, where cities like Bengaluru and Chennai are pushing towards shared mobility's electrification (Sun Mobility, 2023).
- Employment Generation: The electric paratransit industry is providing means of livelihood to a large number of drivers, and there are around 1.5 million drivers directly employed as e- rickshaw and e-auto drivers in India (NITI Aayog, 2023).

6.2. Government Policies and Incentives Driving Adoption

Government support is crucial in stimulating EV adoption in the paratransit sector. With various policies at the national and state levels, the transition toward electric mobility receives a momentum push (TERI, 2024).

6.2.1. National-Level Policies

- FAME-II: This scheme grants subsidies of up to ₹30,000 for electric three-wheelers, which will benefit small operators (Ministry of Heavy Industries, 2023).
- PLI Scheme: Aims at the local manufacturing of EV components and reduces dependence on imports; this could reduce the final cost of the vehicle in the long run (IEA, 2023).
- Scrappage Policy: It aims to formally phase out older petrol and diesel three-wheelers and offers various incentives for replacement with EVs (NITI Aayog, 2023).

6.2.2. State-Level Incentives

Many state governments have announced their own subsidy and policy measures to accelerate EV adoption in paratransit (NITI Aayog, 2023).

- **Delhi:** Offers a purchase incentive of ₹30,000 and waives road tax and registration fees for electric auto-rickshaws. The state has also developed an extensive network of public charging stations (Delhi EV Policy, 2023).
- **Maharashtra:** Provides a subsidy of ₹10,000 per EV, along with additional incentives for fleet operators adopting electric autos (Maharashtra EV Policy, 2023).
- **Karnataka:** Has initiated programs to integrate electric autos with public transport, collaborating with ride-hailing companies to support their adoption (Karnataka Transport Department, 2023).

6.3. Case Examples of EV Adoption in Paratransit

Here are real-world cases highlighting the gradual acceptance of electric vehicles in India's paratransit sector.

6.3.1. Delhi's E-Rickshaw Revolution

Delhi has become the center of India's electric rickshaw movement. The city has integrated more than 100,000 registered e-rickshaws into its public transport system, making it one of the largest electric rickshaw fleets globally (Delhi Transport Department, 2023). The government has also introduced dedicated charging and parking areas to support the growing number of electric three-wheelers (NITI Aayog, 2023).

6.3.2. Bengaluru's Auto-Rickshaw Electrification Drive

The Karnataka government has facilitated the introduction of electric auto-rickshaws across Bengaluru through partnerships with private players. The state has collaborated with companies such as SUN Mobility to develop battery-swapping solutions that minimize downtime for drivers (Sun Mobility, 2023). This initiative has had a positive impact on driver earnings by significantly reducing fuel costs (Karnataka EV Policy, 2023).

6.3.3. Ola's Electric Auto Expansion

Ola, one of India's largest ride-hailing platforms, has launched Mission Electric, an initiative aimed at deploying 10,000 electric auto-rickshaws across multiple cities (Ola Electric, 2023). The company offers lease-to-own options to enable drivers to access EVs without facing high upfront costs, thereby making electric mobility more accessible in the paratransit sector (IEA, 2023).

6.3.4. Hero Electric and Mahindra's Entry into Paratransit EVs

Prominent automakers have introduced EV models into the paratransit sector. Hero Electric has launched an electric auto model aimed at fleet operators, providing a cost-effective and sustainable alternative to

conventional vehicles (Hero Electric, 2023). Mahindra Electric has introduced the Treo, an advanced electric three-wheeler featuring an improved battery and extended driving range (Mahindra Electric, 2023). These developments highlight the growing interest of established manufacturers in the expanding paratransit EV market.

6.4. Future Prospects and New Forms of Business

The future of electric vehicles in the paratransit industry looks promising, driven by advancements in financing models, battery technology, and shared mobility solutions (NITI Aayog, 2023).

- Battery-Swapping Technology: Companies such as SUN Mobility and Amara Raja are deploying battery-swapping stations that enable drivers to replace depleted batteries within minutes, eliminating long charging downtime (Sun Mobility, 2023).
- Ride-Sharing and Fleet Electrification: Ola and Uber are incentivizing drivers to switch to electric auto-rickshaws by offering financial benefits and operational support (IEA, 2023). Collaborations with finance firms allow drivers to lease EVs, spreading their upfront investment over time (Ola Electric, 2023).
- Integration with Renewable Energy: Efforts are underway to develop solar-powered EV charging stations, reducing reliance on grid electricity and enhancing the sustainability of EV operations (MNRE, 2023).

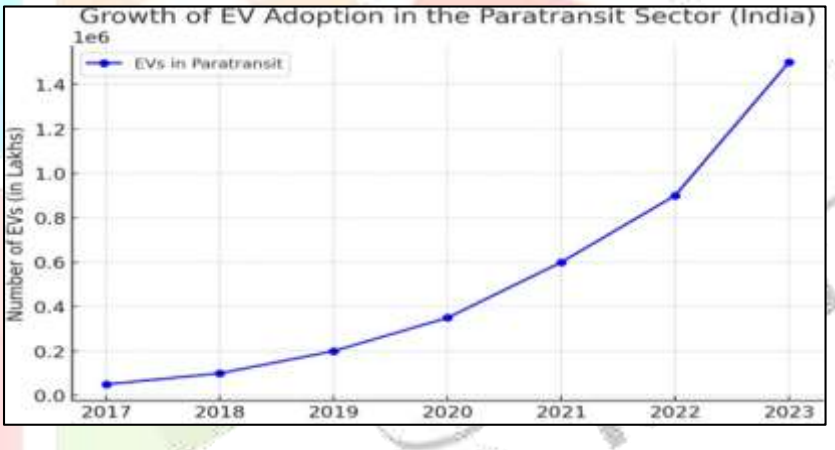

Figure 12: Growth of EV Adoption in the Paratransit Sector (India)

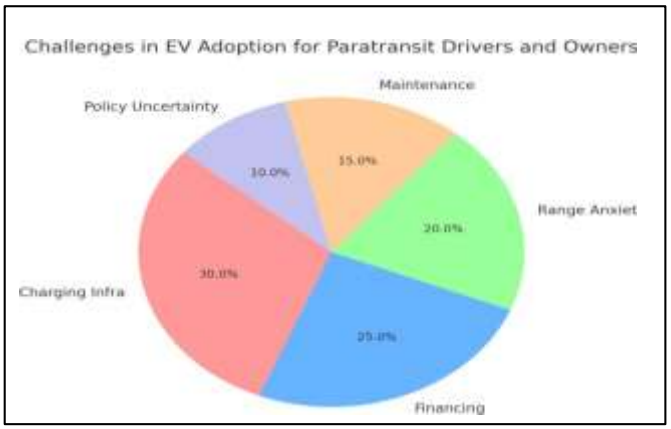

Figure 13: Challenges in EV Adoption for Paratransit Drivers and Owners

CHAPTER 5: RESULTS AND DISCUSSION

7. Road Ahead: Challenges & Opportunities

Paratransit's transition to electric vehicles (EVs) can be described as an arduous challenge. Nonetheless, there is a limitation in the mainstreaming of EV adoption in India's paratransit sector. The systemic impediments that have arisen will shape the future of electric mobility for paratransit owners and drivers (NITI Aayog, 2023).

7.1. Challenges in EV Adoption

While several benefits accrue to the adoption of electric three-wheelers, there exist a disturbing number of indicators at the disposal of the domain that will hinder universal adoption (Ministry of Heavy Industries, 2023).

7.1.1. Limited Charging Infrastructure

The prevalence of fueling stations considerably influences the paratransit EV adoption scenario in India. Unlike standard fuel stations, there are very few charging stations (CEA, 2023; Ministry of Power, 2023). Some additional issues are:

- Very few public charging points: Drivers can hardly find charging stations along their routes, leading to range anxiety (EV India Report, 2024).
- Slow charging speeds: Being in an early stage, fast-charging infrastructure mostly takes considerably longer time than refueling of petrol or CNG autos (Cho et al., 2024).
- Battery-swapping limitations: While swapping technology is being introduced, its adoption has not taken root yet (Sun Mobility, 2023).

7.1.2. High Ceilings & Financing Issues

- Initial vehicle costs: Electric auto-rickshaws have considerably higher initial costs than petrol or CNG auto-rickshaws, making them inaccessible to most independent drivers (IEA, 2023).
- Less financing available: Most drivers depend on informal loans or high-interest loans because EV financing is still an emerging field (TERI, 2024).
- Lack of resale value: The volatility of the resale market for EVs discourages drivers from investing in EVs, as conventional autos offered a more consistent second-hand return (Dua et al., 2024).

7.1.3. Battery Performance & Replacement Issues

- Concerns on battery lifetimes: As EV batteries age, their deterioration reduces vehicle mileage and performance; hence, the frequent replacement of a battery may eventually offset any savings made in fuel (Cui et al., 2023).
- High replacement cost of batteries: Replacement costs tend to hover around 40% of the car price, posing a heavy burden upon most drivers (Yi et al., 2024).
- Recycling and Disposal Problems: No concrete legislation is yet in place regarding EV batteries on recycling and disposal in India, which brings about environmental and operational issues (Seika & Kubli, 2024; Meckling & Nahm, 2019).

7.1.4. Maintenance Skill Gaps

- Lack of trained mechanics: Unlike conventional vehicles, EVs require specialized knowledge for servicing and repairing. The existing workforce is largely untrained in EV maintenance (Jondhle et al., 2023).
- Limited availability of spare parts: The EV market is still in development, so spare parts are not as easily accessible as conventional vehicle parts (Gong et al., 2024).

7.2. Opportunities for Growth and Expansion

Even with these daunting challenges, several possibilities could fast-track EV adoption in India's paratransit sector:

7.2.1. Expansion of Charging and Battery-Swapping Infrastructure

- Fast-charging networks: Charging stations along major transit routes may help alleviate range anxiety (Ministry of Power, 2023).
- Battery-swapping stations: Sun Mobility and Ola Electric are building battery- swapping solutions that minimize a driver's downtime (Sun Mobility, 2023).
- Integrating renewable energy: Solar charging stations may offer a cost-effective and sustainable means of support in rural areas (Campos et al., 2024).

7.2.2. Green Financing and Other Fair-Lending Programs

- Microfinance and low-interest loans: Financial institutions could custom-design loan products to bring EVs within the reach of individual drivers (Dua et al., 2024).
- Battery leasing models: This would dramatically cut down on upfront costs, as battery ownership would be disconnected from instant vehicle purchase (EV India Report, 2024).
- Government financing: The expansion of subsidy and tax policies over time should be geared toward further encouraging drivers to transition to EVs (NITI Aayog, 2023).

7.2.3. Technical Improvements and Smart Mobility

- Improved battery technology: New discoveries in solid-state and lithium-iron- phosphate batteries will mean extended operational time, resulting in cheaper systems for energy storage (Fan et al., 2024).
- Connected vehicle technology: Internet of Things-enabled electric vehicles can seamlessly optimize their route, battery usage, and fleet management, enhancing efficiency (Wu et al., 2024).
- Electrification of ride-sharing and fleets: Companies such as Ola, Uber, and Rapido investing in electric fleets are setting industry trends that spur independent uptake (Dua, 2024).

7.2.4. Policy Support and Industry Collaboration

- State-level EV policies: States like Delhi and Maharashtra support aggressive EV policies based on some expanded frameworks to act as models for other regions (Ministry of Heavy Industries, 2023).
- Public-private partnerships: The involvement of the government sector in innovation or infrastructure development can greatly help (IEA, 2023).
- Scrappage and trade-in programs: Incentives to scrap older gasoline/diesel vehicles for EVs can hasten the transition (Seika & Kubli, 2024).

7.2.5. Local Manufacturing and Job Creation

- Boosting indigenous manufacturing: Expanding EV manufacturing in the country can lessen dependence on imports and thus cut costs (Lithium Urban Technologies, 2023).
- Job opportunities in EV servicing: Training programs for mechanics and service technicians could fill the skill gap and help develop the EV ecosystem (Rajesh et al., 2025).

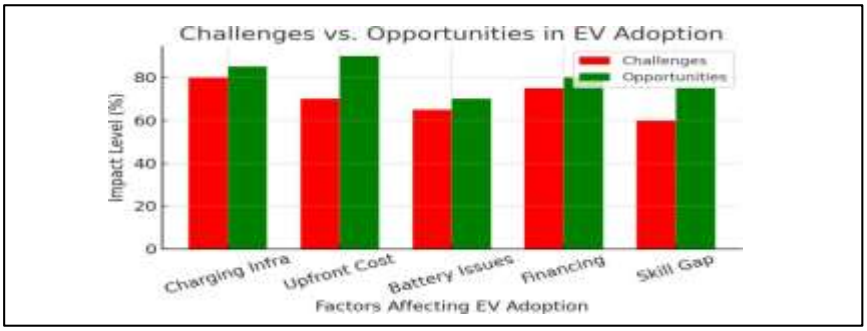

Figure 14: challenges VS opportunities in EV Adoption

FINAL CHAPTER: CONCLUSION & FUTURE RESEARCH RECOMMENDATIONS

Conclusion

The adoption of electric vehicles (EVs) in India's paratransit sector is a vital step toward achieving a more sustainable urban transport system. This study has explored the economic, infrastructural, regulatory, and technological factors influencing EV adoption among vehicle owners and drivers. While government policies such as FAME-II, state subsidies, and private sector investments have played a significant role in promoting EVs, challenges such as high initial costs, inadequate charging facilities, financial constraints, and battery-related concerns continue to impede large-scale implementation.

Our findings indicate that paratransit vehicle owners recognize the long-term financial benefits of EVs, along with regulatory support that encourages their adoption. However, drivers remain apprehensive due to immediate operational difficulties, including concerns over range limitations, charging time, and the availability of financing options. Emerging trends suggest that battery-swapping models, green financing strategies, and collaborations between government and private entities can help overcome these obstacles. Successful case studies from Delhi, Bengaluru, and corporate initiatives like Ola Electric highlight that a well-structured approach to policy and infrastructure development can accelerate EV adoption in the paratransit sector.

To ensure a seamless transition to electric mobility, a coordinated effort involving policymakers, financial institutions, technology developers, and industry stakeholders is essential. Expanding the charging network, introducing innovative financial models, and equipping drivers with the necessary knowledge and skills will be crucial to making EVs a practical choice for India’s paratransit industry.

Future Research Recommendations

While this research provides an overview of key factors influencing EV adoption in India’s paratransit sector, further studies are required to explore specific areas in greater depth:

1. Economic Feasibility & Cost Analysis
   - A comprehensive Total Cost of Ownership (TCO) study comparing electric and internal combustion engine (ICE) three-wheelers over an extended period.
   - Examination of battery replacement costs and their impact on driver profitability over time.

2. Understanding Driver & Consumer Behavior

- Identifying psychological and social factors that contribute to drivers' reluctance to switch to EVs.
- Evaluating the effectiveness of awareness campaigns, training programs, and incentives in encouraging adoption.

3. Infrastructure & Energy Demand Assessment
   - Investigating the scalability of battery-swapping technology as an alternative to fixed charging stations.
   - Analyzing the impact of increased EV charging demand on urban electricity grids and the feasibility of integrating renewable energy-powered charging solutions.

4. Financial & Policy Innovations
   - Evaluating the effectiveness of current financing schemes and identifying obstacles preventing drivers from accessing loans for EV purchases.
   - Benchmarking India's EV policy framework against global best practices in promoting commercial EV adoption.

5. Environmental & Socioeconomic Impact
   - Measuring the reduction in greenhouse gas emissions and air pollution with the adoption of EVs in the paratransit sector.
   - Assessing the impact of EV adoption on driver income, employment opportunities, and overall livelihood security.

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