BEYOND TRADITIONAL TRAFFIC SOLUTIONS: Exploring the feasibility and impact of E-micro-mobility adoption

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Abstract - *Rapid urbanization and population growth in Indian cities have led to increased traffic congestion and environmental issues, prompting a need for sustainable mobility solutions. This study explores the feasibility of e-micromobility, including e-bikes and e-scooters, as a viable alternative to traditional transport methods. Using a mixed-methods approach, the research includes a literature review and a comparative analysis of case studies from cities like San Francisco, Paris, Bengaluru, and Ahmedabad. Findings indicate that successful e-micromobility deployment relies on strong policies, sufficient charging infrastructure, geofencing, and public acceptance, with challenges such as infrastructure limitations and regulatory inconsistencies.*

The study proposes a framework for integrating e-micromobility into Indian urban transport systems, focusing on multimodal connectivity, equitable access, and sustainability. It serves as a foundation for policymakers and urban planners, with recommendations for further research to enhance the framework's applicability across various Indian cities.

Key Words: *Atal Setu, Sea Bridge, Traffic congestion, Longevity, Sustainable Infrastructure*

1. INTRODUCTION

E-mobility refers to the use of electric-powered transportation modes, including e-bikes, e-scooters, e-cars, and electric buses, as sustainable alternatives to conventional fuel-based vehicles. This shift is driven by the urgent need to reduce greenhouse gas emissions, mitigate air pollution, and enhance energy efficiency in urban transport systems. E-micro-mobility refers to the use of small, lightweight electric-powered vehicles designed for short-distance travel, typically in urban areas.

1.1 Active Govt. schemes in India

- National Electric Mobility Mission Plan (NEMMP): Launched in 2012 to promote hybrid and electric vehicles in the country.
- Faster Adoption and Manufacturing of hybrid and Electric vehicles (FAME): Phase 1: 2015-2019 ; Phase 2: 2019-2022
- PM Electric Drive Revolution in Innovative Vehicle Enhancement (PM E-DRIVE) Scheme
- Electric Mobility Promotion Scheme 2024 (EMPS 2024): By Ministry of Heavy Industries

2. Research Design

2.1 Aim

To develop a framework for integrating e-micromobility with Aligarh's urban transport system to enhance connectivity, reduce congestion, and promote sustainable mobility.

2.2 Objectives:

1. Assessing feasibility by evaluating parameters necessary for the integration of e-micromobility solutions.
2. To identify challenges and key barriers such as regulatory constraints, economic limitations and infrastructural gaps.
3. Developing Strategic Interventions by formulating a structured framework with policy recommendations and design interventions for seamless e-micromobility integration into the city's transport systems.
4. Analyzing Impact by examining the potential benefits of e-micromobility on traffic congestion, accessibility and environmental sustainability.

2.3 Need of Study:

With the pressing need for environmental sustainability and the shift towards changing mobility trends, e-micromobility offers a promising solution. Technological advancements have made electric vehicles more efficient and accessible, enabling their integration with existing urban infrastructure. These solutions are particularly relevant for developing regions, where cost-effective and scalable transportation options are essential to accommodate future urban growth.

2.4 Methodology

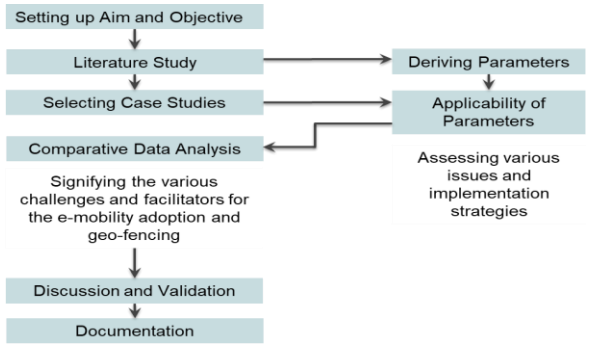

Fig -1: Methodology

3. Literature study

Table -1: Literature Study

S. No	Title	Year	Summary	Inferences	Parameters
1	Review on electric mobility: Trends, challenges and opportunities	2024	• Advancements in EV components • the environmental benefits of Evs • outlines the growing popularity of Evs • Government initiatives worldwide aimed at promoting EV adoption	• Growing Adoption • Environmental Benefits • Need for Infrastructure	• Infrastructure Availability • Technological advancement • Policies
2	A shift towards e-mobility in india: challenges and innovations	2023	• Need to reduce greenhouse gas emissions • Lack of infrastructure • Consumer perception and awareness • Current trends in e-mobility	India is making strides towards adopting electric mobility, significant barriers remain that must be addressed	• Affordability • Inadequate infrastructure • Range Anxiety • Consumer preference
3	Developing micromobility in urban areas: network planning criteria for e-scooters and electric micromobility devices	2022	• Urban Planning challenges • Regulatory framework • Criteria for infrastructure planning • The concept of geofencing • Case study of Palermo	• The adoption of e-scooters is seen as a potential solution to urban mobility challenges • Key planning criterias	Safety and Security Accessibility Intermodality Vehicle cap Population Stats Consumer preference
4	Shared E-Scooters: A Review of Uses, Health and Environmental Impacts, and Policy Implications of a New Micro-Mobility Service	2021	• need for sustainable transportation solutions • Key Stakeholders	• Environmental Impact • Economic Factors • Consumer Acceptance • Future Outlook	• Consumer Acceptance • Policy and Regulation • Market Dynamics • Population Stats
5	E-mobility solutions for urban transportation: User needs across four continents	2023	• User Needs Analysis • correlations between user perceptions of e-mobility and external factors • Challenges in Market Penetration • Stakeholder Engagement	• E-mobility as a Solution to address urban transport challenges • Importance of Local Context	• stakeholder priorities • External Environment • Infrastructure Development
6	The method of route optimization of electric vehicle	2022	• Route optimization of electric vehicle • Effective trip planning that incorporates the locations of charging stations • A travel route in poland, aiming to minimize the distance traveled.	• Importance of charging stations • Genetic algorithms • Simulation and testing • Aims to enhance the environmental conditions	• Vehicle Range • Charging Station Types • Population Stats • Charging Times • Environmental Impact
7	Identification of Potential Locations of Electric Vehicle Supply Equipment	2015	• Vehicle Usage Patterns • Factors Influencing Charging Needs • Data Utilization • Destination Analysis • Charging Preferences	• Strategic Planning • Behavioral Insights • Diverse Charging Solutions • Data-Driven Decisions	• Usage Patterns • Destination Types • Population Stats • Topography • User Group
8	Geofencing in location-based behavioral research: Methodology, challenges, and implementation	2023	• Geofencing Methodology • Empirical Studies • Recommendations for researchers on how to optimize geofencing studies • Behavioral Research	• Privacy and Data Security • User Behavior and Engagement • Cross-Platform Considerations	• User-Centric Design • accuracy and reliability • Environment • Distance
9	Analyzing the Potential of Geofencing for Electric Bicycles and Scooters in the Public Right of Way	2020	• Background study • Geofencing Applications • Survey of Practices • Levels of success with geofencing technology • Challenges due to GPS inaccuracies and user behavior	• Safety and Regulation • Technology Limitations • Collaboration is Key • User Behavior	• Safety Regulations • User Group • Population Stats • Continuous Improvement • Collaboration with stakeholders

4. Case Study

4.1 San Francisco

The San Francisco Municipal Transportation Agency (SFMTA) implemented an e-micromobility program (2017–2019) with an $80 billion budget, covering 76 sq. km. Key strategies included a permit system, geofencing for parking and usage, and community engagement to address concerns. Challenges such as geofence limitations, community opposition, and vehicle caps impacted effectiveness. Despite these, the initiative improved mobility, reduced congestion, and promoted sustainability. The government prioritized EV adoption, integrated charging infrastructure, and enhanced public transit connectivity. Post-implementation adjustments focused on refining regulations, addressing spatial inequities, and strengthening operational strategies to ensure long-term feasibility and environmental benefits.

4.2 Paris

Paris has implemented a comprehensive e-mobility strategy to promote sustainable urban transport, focusing on non-polluting modes like cycling, electric vehicles, and public transport. Covering 78.05 sq. km with a budget of $273M, key initiatives include over 1,000 km of cycling routes, expanded EV charging stations, and policies like the Ecologic bonus/malus system. The city integrates e-mobility with public transport, supports participatory governance, and aims to phase out diesel by 2024 and petrol by 2030.

Challenges include safety concerns, urban space management, and accessibility disparities. Despite these, Paris has seen improved mobility, reduced congestion, and enhanced environmental sustainability.

4.3 Brisbane

Brisbane's e-mobility strategy, initiated by the Brisbane City Council (BCC), aims to create a sustainable, accessible, and efficient transport network while reducing congestion. Covering 1,100 sq. km with a budget of $66M, the city introduced policies, dedicated infrastructure, and partnerships with companies like Lime and Neuron. Key measures include e-scooter regulations, public charging facilities, and awareness campaigns.

4.4 Bengaluru

Bengaluru has implemented a strategic transition towards electric mobility, aiming for 50% EV adoption by 2030. Covering an area of 290 sq. km with a budget of $300M, key policies such as the Karnataka EV & Energy Storage Policy (2017) and FAME schemes (2015, 2019) have driven progress. Key stakeholders

include government bodies and companies like Ola, Yulu, BMTC, and Uber. Strategies focus on charging infrastructure, battery swapping, metro integration, and corporate engagement. Challenges include inadequate charging stations, high costs, policy gaps, and public transport limitations. The shift to e-mobility is expected to enhance sustainability, economic growth, and urban mobility.

5. Comparative Analysis

Table -1: Literature Study

	San-Francisco (CA)	Paris (France)	Brisbane (Australia)	Bengaluru (India)	Ahmedabad (India)	Bhubaneswar(India)
Scale of Study	76sq. Km.	78.05 sq.km.	1100 sq.km.	300 sq.km.	90.27 sq.km	40.0 sq.km
Issues	• Geographic Coverage Issues • **Community Opposition** • **Operational Challenges**	• Safety Concerns • **Urban Space Management** • **Public Perception** • Environmental Impact	• Regulatory and Legal Framework • **Public Perception** • Diverse User Groups • **Street Clutter**	• **Inadequate Infrastructure** • **High Costs and Economic Viability** • Public Transport Limitations	• **Infrastructure Challenges** • **High initial costs** • Awareness and Edu. • Operational limitations	• **Inadequate infra.** • **Financial Constraints** • Regulatory Challenge • Public Awareness • Market dynamics
Key Features	• Geographic Constraints and Geofencing • Regulatory Framework • **Community Engagement and Opposition** • Integration-Public Transit	• 15 Minute City Concept • **Participatory Governance** • Free-floating electric scooters (FFES) • Equity and Accessibility	• Public-Private Partnerships • CityLink Cycleway (Infrastructure) • **Community Engagement and Education**	• Environmental Benefits • **Integration with Public Transit** • Public Awareness **Participatory Governance**	• **Comprehensive policy framework** • Economic incentive • Data Driven Solutions • Skill development	• Area Based Development (ABD) • Cost effective • Multi-modal integration • Integration with smart city goals
Authorities Involved	• SFCTA • SFMTA	• RATP	• BCC • DTMR	• BMTC • KSRTC	• AMC • GEDA	• (CRUT) • Govt. of Odisha
Environment Impact	• **Reduction in Carbon Emissions** • **Promotion of Active Transportation**	• **Reduction in Emissions** • Improved air quality	• **Reduction in Emissions** • **Sustainable Transport**	• **Reduction in Emissions** • **Sustainable urban development** • Noise pollution reduction	• **Reduction in GGs Emissions(25.1MT)** • Improved Air quality	• **Reduction in GGs Emissions** • Sustainable urban development
Strategies	• Geofencing Strategies • **Regulatory Framework** • **Community Engagement** • PPP model	• Cycling Infrastructure • **Policy and Regulation** • free-floating e-scooters • integration with existing public transport systems	• **Policy Development and Framework** • **dedicated Infrastructure** • **Collaboration with Stakeholders** • Public Awareness Campaigns	• Battery Swapping Facilities • **Policy framework** • Parking Regulations • Integration with Metro Services • **Corporate Engagement**	• **Infrastructure Development** • **Policy and Regulatory Framework** • Awareness and Education Programs • Integration with Existing Transport Systems	• **Infrastructure Development** • Public-Private Partnerships (PPP) • Government Support • Awareness and Community Engagement
Stage of Completion	Completed in 2019 and running	Banned since sept 2023	Completed in 2023 and running	Completed in 2022 and running	Completed in 2023 and running	Running/ Honorable mention at 2023 STA.
Project Benefits	• Enhanced Mobility Options • Reduction in Traffic Congestion • Increased Public Transit Usage	• Enhanced Mobility Options • Reduction in Traffic Congestion • Promotion of Sustainable practices	• Enhanced Mobility Options • Complementary mode of transport to public transit	• Infrastructure Development • Integration with Existing Transport Systems • Support for Local Businesses	• Reduction in Greenhouse Gas Emissions • Investment Attraction • Robust Charging Infrastructure	• Integrated Transport System • User-Centric Approach • Sustainable Urban Development

Black bold: Common parameters in every study

Blue bold: Unique parameters in each study

6. Feasibility Analysis:

	Pop. Density/ stats	Transportation Equity Goals	Environmental Considerations	Public Transport Integration	Infra. Development	Community Engagement	Alignment with transport plans	Economic Consideration	Traffic Congestion
San-Francisco (CA)	✓	✓	✓	✗	✓	✓	✗	✓	✗
Paris (France)	✓	✗	✓	✓	✓	✓	✗	✗	✓
Brisbane (Australia)	✓	✓	✓	✗	✓	✓	✓	✓	✗
Benglauru (India)	✓	✓	✓	✓	✓	✓	✓	✗	✓
Ahemdabad (India)	✓	✗	✓	✗	✓	✓	✓	✓	✗
Bhubaneswar (India)	✓	✓	✓	✓	✓	✓	✗	✓	✓
Impact Percent	100 %	66.67%	100%	50%	100%	100%	50%	66.67 %	50%

Fig -2: Feasibility Analysis

7. Way Forward:

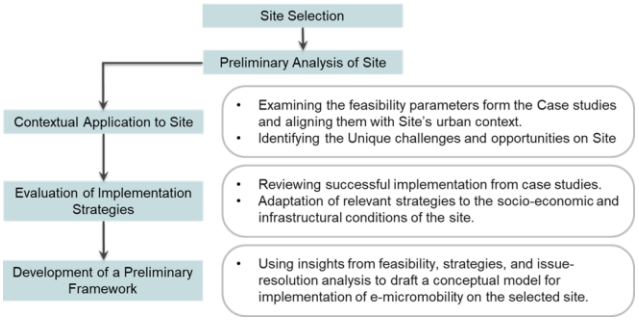

Fig -3: Way forward

This research is supposed to continue with site selection and a preliminary site analysis to align feasibility parameters from case studies with the site's context, identifying unique challenges and opportunities.

8. Conclusion:

In conclusion, the case studies of Paris, Brisbane, San Francisco and Bengaluru provide valuable insights into the evolving landscape of e-micro- mobility and its integration into urban transportation systems. Each city has approached the regulation and implementation of e-scooters and e-bikes with unique strategies that reflect their specific urban contexts and policy goals. Paris exemplifies a proactive approach, leveraging geo- fencing to manage spatial equity and ensure that micro-mobility services align with public policy objectives, such as reducing congestion and enhancing accessibility. Brisbane's experience highlights the importance of collaboration between local government and private operators, emphasizing the need for clear regulations and infrastructure that support safe and efficient e- mobility. Meanwhile, San Francisco's regulatory framework showcases the challenges of managing multiple operators and the

necessity of adapting policies to address safety concerns and public space usage. Collectively, these case studies underscore the critical role of stakeholder engagement, data- driven decision-making, and adaptive governance in fostering a sustainable and equitable e- micro-mobility ecosystem that meets the diverse needs of urban populations. The feasibility analysis also led to the identification parameters that are the most applicable in the current scenarios and would be considered if any site is to be geo-fenced for the implementation of e-mobility.

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