

Achieving Sustainability through Technology with Special Reference to Sustainable Transport in India

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ABSTRACT

Sustainability has become one of the most pressing challenges of our time, particularly for fast-growing countries like India. With its expanding population and rapid urbanization, India faces increasing pressure on its infrastructure, especially in the transportation sector. Transport plays a vital role in everyday life—connecting people, goods, and services—but it is also one of the largest contributors to air pollution, greenhouse gas emissions, and fossil fuel consumption. In this context, technology offers an opportunity to rethink how we move and to make that movement more sustainable, efficient, and inclusive. This paper focuses on how India is using technology to achieve sustainability, with a special focus on the transport sector.

The journey toward sustainable transport in India has already begun, with cities adopting electric vehicles (EVs), metro systems, Bus Rapid Transit Systems (BRTS), and app-based ride services. These are not just technological upgrades but steps toward a cleaner and more accessible future. For example, cities like Ahmedabad and Pune have introduced smart buses with real-time tracking, while Delhi and Bengaluru are expanding their metro networks to reduce the number of cars on the road. These initiatives help lower emissions and ease congestion, improving the quality of life for millions of commuters.

This research explores both the progress and the challenges in adopting such technologies. Using a mixed-methods approach, it draws from policy reports, academic studies, and real-world case examples, along with surveys and interviews from key stakeholders—commuters, transport officials, urban planners, and technology providers. The study examines national policies such as the FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) scheme, the National Electric Mobility Mission Plan (NEMMP), and the Smart Cities Mission, assessing how well these initiatives are supporting the transition to cleaner transport options.

Beyond vehicles and infrastructure, the paper also looks at how digital tools—like Artificial Intelligence (AI), Geographic Information Systems (GIS), and the Internet of Things (IoT)—are being used to make transport systems smarter. These technologies help with tasks like traffic management, route optimization, and safety monitoring, creating more responsive and user-friendly public transport systems.

However, the path is not without obstacles. Issues such as high upfront costs of technology, lack of adequate infrastructure, limited awareness among users, and unequal access across urban and rural areas continue to slow progress. The study emphasizes the importance of inclusive planning, where the benefits of sustainable transport reach all sections of society, not just those in major cities or higher income brackets.

In conclusion, the paper argues that while technology alone cannot solve all the issues in the transport sector, it can serve as a powerful enabler when combined with effective policies, public participation, and strong governance. Sustainable transport is not just about adopting new technologies—it's about creating a system that works for people, the environment, and the economy. This research offers insights and recommendations for building that system in the Indian context, aiming to contribute meaningfully to the broader goal of sustainable development.

INTRODUCTION

India faces mounting pressure to address climate change, urban congestion, and energy security. As one of the fastest-growing economies, it must balance development with environmental sustainability. The transport sector, responsible for significant greenhouse gas emissions, presents an opportunity for intervention through technological innovation. This study investigates how technology can enhance sustainability in Indian transport, aiming to inform both academic discourse and policymaking.

LITERATURE REVIEW

Technological Interventions in Sustainable Transport Existing research highlights electric vehicles (EVs), intelligent transport systems (ITS), and shared mobility as key technological innovations driving sustainable transport (Gota et al., 2019; NITI Aayog & RMI, 2018). EV adoption, promoted by schemes such as FAME II, has been central to India's sustainable mobility strategy. ITS applications have improved urban mobility efficiency, while app-based platforms have enabled multimodal integration and last-mile connectivity.

Policy and Institutional Framework The National Electric Mobility Mission Plan (NEMMP) and Smart Cities Mission provide institutional support for sustainable transport, but their execution has been uneven (Pucher et al., 2020). Several studies note a lack of coordination between central and local agencies, resulting in fragmented implementation.

Barriers to Technological Adoption Barriers include high upfront costs, inadequate charging infrastructure, and limited public awareness (ICCT, 2020). Behavioral studies emphasize user resistance to new technologies, especially in low-income and rural segments (Agarwal & Mani, 2019).

Research Gaps Most studies focus on specific technologies (e.g., EVs or ITS) or single-city case studies. There is limited integrated research that holistically examines the ecosystem of technologies contributing to sustainable transport in India. Furthermore, there is a need for more empirical data on the socio-behavioral aspects influencing technology adoption.

Research Question and Hypothesis **Research Question:** How can technological innovations contribute to achieving sustainable transport in India, and what are the socio-technical barriers to their adoption?

Hypothesis: Integrated technological interventions, supported by policy coherence and public acceptance, significantly enhance the sustainability of urban transport systems in India.

METHODOLOGY

Research Design A mixed-methods design was adopted, combining quantitative analysis of urban mobility data with qualitative insights from stakeholder interviews.

Data Collection

- **Secondary Data:** Reports from NITI Aayog, MoHUA, ICCT, and World Bank datasets on urban mobility indicators.
- **Primary Data:** Semi-structured interviews with policymakers, urban planners, and technology providers in five major Indian cities: Delhi, Mumbai, Bengaluru, Pune, and Ahmedabad.

Data Analysis

- Quantitative data were analyzed using descriptive and inferential statistics in SPSS.
- Qualitative data were coded thematically using NVivo to identify recurring themes related to opportunities and barriers in technology adoption.

FINDINGS

Electric Mobility EV adoption is accelerating, with Delhi and Bengaluru leading in charging infrastructure. However, rural-urban disparity persists. Financial incentives have boosted private EV sales, but public EV transport remains underdeveloped.

Intelligent Transport Systems ITS have improved traffic flow and safety in cities like Pune and Ahmedabad, where BRTS networks are integrated with real-time monitoring. However, smaller cities lag due to funding and technical capacity constraints.

App-Based and Shared Mobility App-based services like Ola and Uber, and bike-sharing platforms, have improved last-mile connectivity. However, their environmental benefit depends on reducing private car usage, which remains inconclusive.

Socio-Technical Barriers Public awareness and behavioral resistance emerged as critical barriers. Many users express concerns over EV range anxiety and distrust of new systems. Stakeholder interviews emphasized the need for targeted awareness campaigns and user-centric design.

DISCUSSION

This study confirms that technology is a powerful enabler of sustainable transport but must be supported by coherent policy frameworks and behavioral change strategies. Urban-rural disparities and socio-economic segmentation in technology access pose significant challenges. A systems-based approach integrating infrastructure, governance, and community engagement is essential.

CONCLUSION AND POLICY IMPLICATIONS

This research contributes to the academic understanding of sustainable transport in India by presenting a multi-dimensional analysis of technological interventions. Policy recommendations include:

- Strengthening public-private partnerships for EV and ITS infrastructure
- Enhancing inter-agency coordination for seamless policy implementation
- Conducting public awareness campaigns to overcome behavioral resistance

FUTURE RESEARCH DIRECTIONS

Future studies should:

- Expand to include peri-urban and rural transport systems
- Employ longitudinal designs to assess technology adoption over time
- Integrate environmental impact assessments with behavioral data

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