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Green Transport Transition: A Comparative Analysis of Kerala with Other Selected States

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ABSTRACT

The transportation sector in India is a significant contributor to environmental pollution, primarily due to its reliance on fossil fuels. With growing awareness of climate change, the adoption of green transportation has emerged as a vital strategy for reducing carbon emissions. This research paper based on secondary data, investigates the penetration of green transport in greenery state, Kerala relative to other Indian states. It analyses key factors such as green vehicle registration trends, the development of charging infrastructure, government policies, and green initiatives in public transport. The study also explores the adoption of green vehicles, the policy measures driving the shift, and the challenges hindering the transition. This study reveals that while Kerala has achieved relatively good annual growth in green transport, it still lags behind some of the larger states. It found that limited charging infrastructure, low consumer green awareness and modest government incentives are hampering green transition. So there may be some room for more policies, incentives and support for the EV ecosystem. The findings offer valuable insights into Kerala's comparative performance in promoting sustainable transportation, highlighting best practices and areas for improvement.

INTRODUCTION

The transport sector in India comprises 13% of the total emissions and is a major contributor to carbon emissions in the country. As to the proportional source of pollution, the fossil fuel powered vehicle seems to be a greater menace. Considering the above-mentioned facts and figures due to climatic changes, the Government of India is planning and implementing different policies to go green transport solutions such as electric vehicles and bio fuelled vehicles and hybrid public transport systems run by renewable energies. Being often acclaimed as one of the most eco-friendly states in India to govern, Kerala hurries to green transport. However, its penetration rate is still comparatively low to states such as Maharashtra, Karnataka, and Delhi. This research aims to evaluate the extent to which the selected transport implementing green practices in the region especially in Kerala with respect to the advanced adopting states in India. Resource friendly transport is a prerequisite to sustainable economic growth and sustainable development and a green economy which offers favourable replacements to resource energy-intensive typical vehicles thought to be responsible for greenhouse gases and air pollution (Salihin *et al.*, 2020; Abbas *et al.*, 2021). Therefore, the use of electric cars is relevant in global reductions in the use of fossil energy, improved quality of the air, and optimal utilisation of generated energy stock Saniyah, 92024). But matters such as lack of charging points and high taxes should be addressed by measures such as giving of tax credits and sensitisation (Saniyah, 2024). They are auto manufacturers such as nano/micro filler epoxy resin and lithium plate technology for increasing the storage capacities and reductions in emission level (Rahman *et al.*, 2020). Further, there is hydrogen-based technology in the HHO generators that give possible solutions to enhance and reduce the fuel and emissions system in normal automobiles (Karthik and Ganesh, 2012, Rahman *et al.*, 2020).

Kerala is a prominent state in India which is less in terms of land area but higher in vehicle population. So, for Kerala, green transportation is of significant relevance. This study compares the level of green transport adoption in the enlightened state of Kerala with other states. It also examines the level of support of government policies and infrastructure for green transport transition.

LITERATURE REVIEW

Sustainable and Green Transportation: A Conceptual Perspective

Today, sustainable and green transport is an integral part of the transport policy and urban development agenda globally. Green transport is about sustainable transport systems that reduce fossil fuel consumption, carbon emissions and support public and private transport to be energy efficient. The demand for sustainable mobility has grown significantly in India, particularly due to the high density of the urban environment and the growing number of vehicles on the roads. The need for sustainable mobility in India has only been compounded by the increasing number of vehicles on the roads and the dense urban environment. Geetam Tiwari (2019) stated that the sustainable transport systems play a very crucial role in the social inclusion, economic efficiency, and in environmental protection. The shift towards

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green mobility in India is increasingly on the axis of electric vehicles (EVs), integrated public transport and low carbon infrastructure. Green transportation can be described as the sustainable systems of transport that is meant to lessen the effects of pollution within transport by enacting laws on reducing greenhouse gas emissions and energy consumption, encouraging the use of environmentally friendly commodities like electric cars, using public transports and cycling and walking. In the world, the transportation sector accounts for 24% of CO2 emissions from the combustion of fuel hence green transports plays a crucial role in combating climate change (IEA, 2020). Kerala, one of the southern states of India with abundant green land has realised that implementing green transport policies and measures are highly needed in order to seek solution to many environmental challenges and to enhance the potential of the state towards the achievement of the global Sustainable Development Goals (SDGs).

The advancement of green transportation in developing nations offers distinct opportunities and challenges. As developed countries concentrate on upgrading current infrastructures, emerging cities have the opportunity to establish low-carbon transportation systems from the outset, fostering inclusive and sustainable development (Alves *et al.*, 2023). Essential strategies involve focusing on public transportation, promoting walking and biking, limiting automobile usage, and adopting compact, mixed-use urban planning (Chen & Lu, 2015; Alves *et al.*, 2023). These methods not only cut down on emissions but also enhance liveability and accessibility to vital services (Alves *et al.*, 2023). Smaller and medium-sized cities present unique opportunities for sustainable changes because of their adaptability, although they might encounter limitations in resources (Pojani & Stead, 2015). Effective execution demands visionary leadership, coordinated land use and transport plans, agency collaboration, domestic skill development, sufficient cost recovery, and involvement from the private sector (Vandycke & Wright, 2012). By concentrating on these factors, developing nations can establish transportation systems that promote both developmental objectives and ecological sustainability

Green Transport Initiatives in India

India's Government has adopted strategies in regard to the green transport; the Faster Adoption and Manufacturing of Electric Vehicles (FAME) scheme, the National Electric Mobility Mission Plan (NEMMP). Delhi and Maharashtra have further evolved state-level policies that introduce incentives such as subsidies along with incentives to undertake taxes and charge structures for dispersing EV (Mishra, 2021). Indian policy-making efforts for green transport are outlined in this section. This section presents an overview of Indian policy initiatives for green transport. The Government of India has introduced various governance mechanisms and policy initiatives at the national level to expedite the transition towards green transport. The National Electric Mobility Mission Plan (NEMMP) and the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) Scheme are key policy measures in the drive to electric mobility adoption at a national level. The financial support for the public transport electrification and charging infrastructure development is a specific feature of the FAME-II scheme and is being given by the Ministry of Heavy Industries. In parallel, the National Urban Transport Policy (NUTP) calls for sustainable urban transport, focusing on public and non-mechanised transport. Kumar & Alok (2020) noted that the push for green mobility in India is growing more influenced by enabling government policies, technological advances, and citizens' environmental consciousness.

Green Transport Infrastructure Development in India

There has been a significant development of the green transport infrastructure in India over the last decade too. Indian cities are introducing metro rail, electric bus services, EV charging stations and smart mobility systems under various schemes like Smart Cities Mission and PM e-Bus Sewa. Sharma & Singh (2022) argue that the institutional coordination, integration of transport planning, and digital infrastructure support have contributed to sustainable urban mobility governance in Indian smart cities. The disparities in the Indian states, however, remain a factor in the rate and success of green transport adoption.

State-level Green Transport Transition: Kerala and Fellow States

The section provides details of green transport transition at the state level in Kerala and other fellow states. Several Indian states have drawn up unique green transport plans, taking into account the economic priorities and administrative capacity. Kerala, known as the "Greenery State," has become a significant example in the field of sustainable mobility, thanks to its eco-friendly outlook and socially inclusive development strategy. The Kerala State Road Transport Corporation (KSRTC) has introduced electric buses, promoted EV charging infrastructure and implemented the Kochi Water Metro project, which are all areas where the State has been committed to green transportation. Nair & Menon (2023) pointed out that the Kochi Water Metro is an innovative and environment-friendly urban transport system that combines water-based transportation with the modern public transportation system. Other States in India have also made significant strides in green mobility transition. Karnataka is now a hub for electro mobility manufacturing and innovations, and Tamil Nadu has pushed for electro mobility initiatives with industrial policy incentives and green industrial corridors. State of Maharashtra and Delhi have come out with comprehensive EV policies for promotion of EV, public transport electrification and charging infrastructure development. Bhattacharya & Thamby

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(2021) observed that policy support, infrastructural preparedness, investment climate, and governance quality are all important factors that affect the spread of green transport policies among states in India.

State-wise Comparison of Green Transport Adoption

Some previous research has highlighted that the states like Delhi and Karnataka are among the leaders implementing green transport, while EVs are densely spread in these regions (Das & Sinha, 2022). Still, there are few scholarly articles that can highlight the case of Kerala. Kerala's elaborate public transport trendy agenda and its strive to launch electric buses prove the readiness of this state to become the pioneer of green transport (Radhakrishnan, 2023).

Barriers to Green Transport Adoption

Telecommunication challenges that surround green transport in India include high cost of electric cars, absence of charging stations and public awareness (Raj & Singh, 2022). Similarity regional disparities regarding economic development also contribute, as higher literacy states with higher per capital income and industrial development like Maharashtra & Karnataka have a higher EV penetration.

Research Gap

Although the extent of green transport in the state of Kerala with reference to the other states in India with regards to adoption, policies and issues have been discussed to some extent, but still there is inadequate knowledge about the socio-economic and psychological factors which may affect consumers' decision on green transport. Furthermore, research about the importance of localised renewable energy infrastructure in the development of green vehicles in different states is scarce. Most previous longitudinal research has only examined consumer knowledge gaps, perceptions, and costs of green transportation technologies in addition to overall policy initiatives and adoption rates. The differences between regions in terms of infrastructure that facilitates the electric cars, charging stations and integration of renewable energy like the solar electric charging station for cars, the popular ideas in the green transport concept still lack in-depth discussion.

This study could address:

- What are the trends in EV registration rates per state?
- How do infrastructure facilities like charging stations support the adoption rate of green transport?
- To what extent the policy framework and public transport initiatives strengthen green transport?

The above insights would assist in establishing niche policy frameworks and strategies in green transport uptake whereas; addressing region and socio-economic factors. Hence, this study aims to fill this gap by making a comparative analysis of the transition of green transportation in Kerala and its neighbouring states of India from the governance, policy and green transportation infrastructure point of view.

MATERIALS AND METHODS

The methodology of the study is aligned with sustainable transportation theory and the concept of green transition governance, which focus on the importance of policy measures, technology uptake and infrastructure readiness for the promotion of environmentally sustainable transportation systems. The study uses comparative analytical approach to analyse the status of green transport transition in Kerala and selected Indian states. The study is predominantly based on secondary data and a critical review and synthesis of relevant empirical literature.

.Major quantitative indicators are the number of electric vehicles registered in the respective states, availability of the charging stations for EVs, trends in EV registrations and extent of public transport electrification including electric buses and metro system. The data is gathered from real-time sources like the Ministry of Road Transport and Highways, NITI Aayog, state transport departments, policy documents concerning electric mobility and green infrastructure. The theoretical underpinning of the study is based on sustainability transition theory, which highlights the interaction between technological innovation, governance support, and infrastructural development to shape the transition from traditional transportation to environmentally friendly and low-carbon alternatives.

The key variables analysed include:

- Number of electric vehicles registered per state
- Number of charging stations available
- Government policies and incentives
- Public transport initiatives (electric buses, metro systems, etc.)
- EV registration trends in Kerala and neighbouring states
- Initiatives taken by private as well as public transport operators in Kerala and selected states to strengthen green transportation.
- The impact of green transport policy initiatives on transport management efficiency in selected Indian states

The analysis is focused on the period from 2018 to 2023 to provide a current perspective on the penetration rate of green transport.

RESULTS AND DISCUSSION

Green Transport Penetration in Kerala

Kerala has performed a moderate trend in green transport transition. Current statistics reveal that there are 15,000 EVs registered in the state of Kerala and constituting about 1.2 per cent of total registered vehicle stock in the state by the beginning of this year, 2023. Currently, the state has around 250 public accessible EV charging stations and institutions are planning to develop these to 500 by the year 2025 (Government of Kerala, 2023). The state's attention has been more towards the usage of electricity for the public transport system, which has brought into the 200 electric KSRTC buses. Also, Kochi Metro Rail, which is partly being operated through solar power, is the sustainable introduction of a public

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transport system.

The table presents information about EV stocks, charging points, electric bus deployment, and total vehicle stock in the years 2018 through 2023. Here's a breakdown of each column:

Table 1: Green Transport Penetration in Kerala (2018-2023)

Year	EV Registrations**	Charging Stations**	Electric Buses**	Total Vehicle Population (in lakhs)
2018	2,000	50	50	106.5
2019	4,000	80	100	110.2
2020	6,500	120	120	115.0
2021	9,000	160	150	119.8
2022	12,000	200	180	124.3
2023	15,000	250	200	128.6

*Source: (TERI Annual reports 2018-19 to 2023-24) **nearest rounded figures*

1. **Year:** Significant changes occurred between 2018 and 2023.
2. **EV Registrations:** EV registrations grew from 2,000 in 2018 to 15,000 in 2023, reflecting a steady rise in popularity.
3. **Charging Stations:** The number of charging stations increased from 50 in 2018 to 250 in 2023, keeping pace with the growing EV population.
4. **Electric Buses:** The number of electric buses rose from 50 in 2018 to 200 in 2023, indicating a gradual shift toward electric public transport.
5. **Total Vehicle Population:** The total number of vehicles increased from 106.5 lakh in 2018 to 128.6 lakh in 2023, with EVs contributing to this growth.

Discussion

Year-on-year EV registrations display an upward trend, this could imply that consumers are showing an increasing interest in electric vehicles or that electric mobility has been encouraged through policies. More EV charging points mean more support for the growth of EV registration levels. Increased public transport infrastructure hence shows a commitment to the growth of environmentally-friendly transport. The total vehicle population is gradually increasing each year, indicating an overall rise in vehicle usage, although EVs represent a small but growing proportion of this total. This data corresponds to the general utilitarian trend of electrification in the vehicle segment, progressive infrastructure advancements and favourable policies to support sustainable public transport.

Comparison with Other Indian States

From Kerala green transport penetration is relatively low compared to states like Delhi, Maharashtra, Karnataka and others that have initiated more aggressive policies and higher implementation index. From the analysis in Table 2, Delhi takes the lead with 30,000 and Karnataka follows with 28,000 electric vehicle registrations by 2023. They enjoy strong polices, incentive and infrastructure support mechanisms, and infrastructure investment (Das & Sinha, 2022).

Table 2: Comparative Green Transport Penetration across Indian States (2023)

State	EV Registrations**	Charging Stations**	Electric Buses**	Government Incentives (in INR crores)
Delhi	30,000	600	350	500
Maharashtra	28,000	550	300	450
Karnataka	28,000	500	280	400
Kerala	15,000	250	200	200
Gujarat	20,000	350	220	300

*Source: (TERI Annual reports 2018-19 to 2023-24)**nearest rounded figures*

Discussion

In terms of penetration, Delhi tops the list in regards to EV registrations (30,000), number of charging stations (600), and electric buses (350) into its public transport system; backed up by government incentives worth INR 500 crore. Maharashtra and Karnataka share the second position in TEV registration with numbers 28,000 each, charged point 500 and electric buses 50, which could be attributed to the robust state level policy support INR 450 crores for Maharashtra, and INR 400 crores for Karnataka. The chart also reveals that Gujarat and Kerala have made moderate improvement wherein Gujarat excels over Kerala in sales of electric vehicles registration, number of charging stations, and the amount of financial incentives offered. Kerala with a significantly low number of EV registrations (15000) and government incentives (INR 200 crores) manages to have a decent number of electric buses (200) which indicates a moderate, but not extremely aggressive drive towards green mobility .

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Government Policies and Incentives

Kerala has better green transport policies in place but not as competitive as those of states like Delhi where incentives for electric vehicles are provided and major investments in the charging infrastructure have been made. Kerala currently has policy support for EVs with incentives of up to INR 1.5 lakh per electric car as opposed to Delhi's INR 2.5 lakh (Radhakrishnan, 2023). It is with these considerations that financial influences emanating from the private business contribute towards helping explain the penetration differential between the two states, again showing that the penetration is lower in Kerala. Table 3 showing the growth of green transportation (measured by EV registrations) in Kerala and other major states in India from 2018 to 2023:

Table 3: Growth of Green Transportation in terms of EV registration (2018-2023)

State	2018 (EVs in thousands)	2019 (EVs in thousands)	2020 (EVs in thousands)	2021 (EVs in thousands)	2022 (EVs in thousands)	2023 (EVs in thousands)
Kerala	2	4	6.5	9	12	15
Karnataka	5	10	15	20	25	28
Tamil Nadu	3	6	9	12	16	18
Andhra Pradesh	2.5	5	7	10	13	16
Delhi	6	12	18	24	28	30
Maharashtra	4	9	14	19	23	28
Gujarat	3	7	10	14	18	20

Source: (TERI Annual reports 2018-19 to 2023-24)

The table 3 provides a clear comparison of green transport growth, highlighting Kerala's progress alongside other states. States like Karnataka and Delhi show significantly higher adoption rates, driven by more aggressive policies and infrastructure investments. Meanwhile, adoption of EV in Kerala has gradually grown from 2000 in 2018 to 15,000 in 2023 indicating that the adoption is growing every year. But its growth path is less steep compared to states like Delhi, Karnataka, & Maharashtra who anticipate much greater and faster EV adoption, with Delhi expected to have at least 30,000 EVs by 2023. Karnataka and Maharashtra were no different; both states got to 28,000 EVs in 2023. Other states including Tamil Nadu Andhra Pradesh; and Gujarat have also expanded with Gujarat touching 20,000 EVs; Tamil Nadu 18,000; and Andhra Pradesh 16,000. This slow but constant rate of development in Kerala indicates that EV transitions are being implemented at a slower pace compared to the more powerful strategies noted for other bigger states.

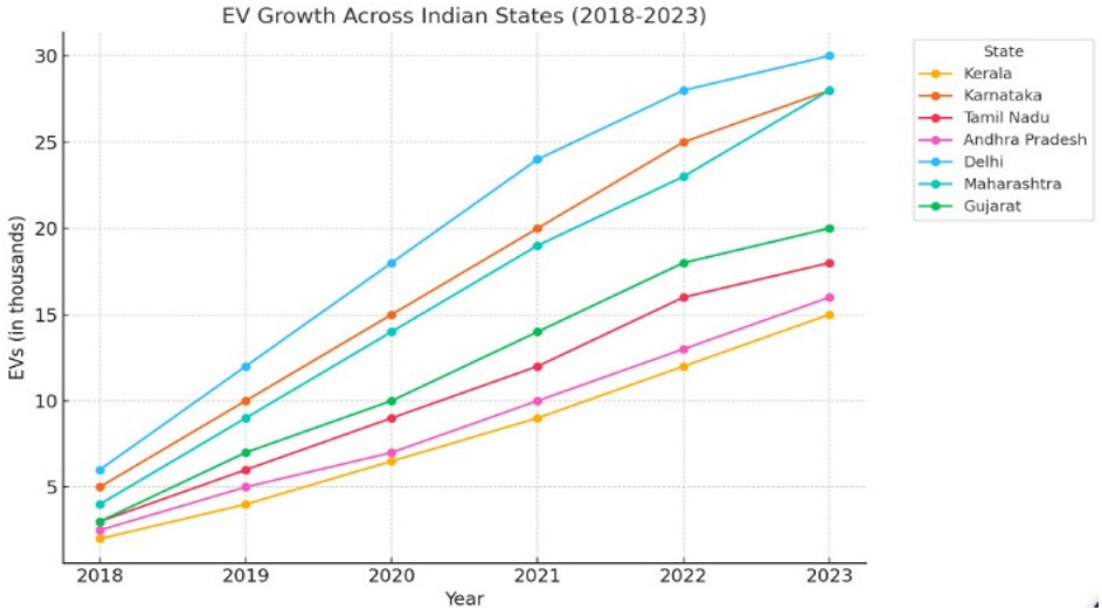


Figure1: Growth trend of E-vehicles across various Indian states

The figure 1 compares the growth of electric vehicle (EV) adoption in Kerala with other Indian states from 2018 to 2023, showing the number of EVs (in thousands) each year. Here is the trend graph showing the growth of green transport (measured by EV registrations) in Kerala and neighbouring states such as Karnataka, Tamil

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Nadu, and Andhra Pradesh from 2018 to 2023. The graph illustrates that while Kerala has seen steady growth, neighbouring states like Karnataka have experienced more rapid increases in EV adoption.

Key Observations

• Kerala's Steady Growth: In Kerala, EV adoption rose consistently from 2,000 in 2018 to 15,000 in 2023. The growth rate is steady but modest compared to larger states like Delhi and Karnataka.

• Delhi as the Leader: Delhi shows the highest adoption among these states, starting at 6,000 EVs in 2018 and reaching 30,000 in 2023. The rapid growth in Delhi may be due to government incentives and urban demand for cleaner transport.

• Karnataka's High Growth: Karnataka saw a significant rise from 5,000 in 2018 to 28,000 in 2023, placing it close to Delhi by the end of the period. This reflects Karnataka's strong focus on green technology and the presence of tech hubs that encourage eco-friendly solutions.

• Consistent Increase in Tamil Nadu and Andhra Pradesh: Both Tamil Nadu and Andhra Pradesh have shown a steady increase, with Tamil Nadu reaching 18,000 and Andhra Pradesh reaching 16,000 EVs by 2023.

• Maharashtra and Gujarat's Competitive Rates: Maharashtra started at 4,000 in 2018 and reached 28,000 in 2023, similar to Karnataka. Gujarat, though starting with a lower baseline, reached 20,000 by 2023, showing steady growth but at a slower pace than Maharashtra.

Table 4: summarising initiatives taken by private transport operators to promote green transportation in Kerala and nearby states (Tamil Nadu, Karnataka, and Andhra Pradesh)

Initiative	Description	States Implemented	Example of Operators
Electric Buses & Vehicles	Adoption of electric buses, autos, and taxis to reduce carbon emissions.	Kerala, Karnataka, Tamil Nadu	KSRTC-Swift (Kerala), Ola Electric, Lithium Urban Technologies
CNG & LNG Fleet Adoption	Shifting from diesel to CNG/LNG for cleaner fuel alternatives.	Kerala, Tamil Nadu, Karnataka	Indira CNG Taxis (Kochi), MTC (Chennai), BMTC (Bengaluru)
Carpooling & Ride-Sharing Services	Encouraging shared rides to reduce congestion and fuel usage.	Kerala, Karnataka, Andhra Pradesh	UberPool, BlaBlaCar, Rapido
Bicycle & E-Scooter Rentals	Promoting last-mile connectivity through shared cycles and e-scooters.	Kerala, Karnataka, Tamil Nadu	Yulu Bikes (Bengaluru), MYBYK (Chennai, Kochi)
Solar-Powered Charging Stations	Installation of solar-based charging hubs for EVs.	Kerala, Tamil Nadu	KSEB EV Charging Hubs, Tata Power EV Charging Stations
Integration with Metro & Rail	Facilitating seamless multimodal transport with metro and rail connectivity.	Kerala, Karnataka	Kochi Metro Feeder Buses, BMTC-Metro Feeder (Bengaluru)
Green Certification for Fleets	Implementing sustainability certifications and incentives for eco-friendly fleets.	Karnataka, Kerala	Smart City Projects (Bengaluru, Kochi)
Paperless Ticketing & Digital Payments	Reducing paper usage through digital ticketing apps.	Kerala, Tamil Nadu, Karnataka	Namma Yatri (Bengaluru), Chalo App (Kochi, Chennai)
Carbon Offset Programs	Partnering with environmental organizations to offset carbon footprints.	Kerala, Karnataka	Private Bus Operators' Green Drive (Mysuru, Thiruvananthapuram)

Source: (Egovelectsonline.com &Reuters, 2025)

Discussion

the measures implemented by private transport providers in Kerala and surrounding regions demonstrate a firm dedication to eco-friendly transport by embracing electric, CNG, and LNG-fuelled vehicles, thereby decreasing dependence on fossil fuels. The combination of ride-sharing, carpooling, and last-mile connectivity options like bicycle and e-scooter rentals additionally helps to alleviate congestion on city roads and reduce emissions. Investing in solar-powered charging stations and integrating multimodal transport options with metro and rail systems improves the sustainability of urban transportation. Moreover, the adoption of digital ticketing and electronic payment methods promotes environmental protection by minimizing paper waste. Operators are promoting environmentally friendly practices by implementing green certifications and carbon offset initiatives, fostering sustainable travel habits. These collective actions signify

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an increasing movement towards more sustainable and efficient transportation options, which correspond with wider environmental objectives and government initiatives focused on minimizing carbon emissions in the area.

According to the table 4, Karnataka is at the forefront of green transportation initiatives, with the Bengaluru Metropolitan Transport Corporation (BMTC) and private companies such as Yulu Bikes and Namma Yatri spearheading the push for electric vehicle usage, ride-sharing, bicycle rentals, and digital ticketing. Bengaluru, specifically, boasts a robust ecosystem that facilitates multimodal transport integration, solar-powered electric vehicle charging stations, and environmentally friendly certification initiatives.

Nonetheless, Kerala shows significant advancements, particularly in electric buses (KSRTC-Swift), metro feeder services, and LNG/CNG utilization, positioning it as a strong second.

Table 5: Green Transport Initiatives: Government vs. Private Operators in Kerala and Selected states

State	Public Transport Electrification	EV Policy & Subsidies	Metro Expansion	CNG & Alternative Fuels	Private EV Fleets	EV Charging & Infra
Delhi	Electric buses in DTC fleet	Delhi EV Policy 2020 with subsidies	Delhi Metro expansion, e-rickshaws for last-mile	Odd-Even scheme to reduce emissions	BluSmart, Ola, Uber deploying electric taxis	Private charging stations expansion
Maharashtra	Electric buses under BEST in Mumbai	Maharashtra EV Policy 2021	Metro projects in Mumbai, Pune, and Nagpur	CNG auto-rickshaw conversion	Bajaj, Piaggio expanding e-autos; Mahindra electric delivery vehicles	Reliance Jio-BP setting up EV charging
Kerala	KSRTC K-SMART electric bus project	Electric auto-rickshaw subsidies	Kochi Metro solar-powered expansion	Green hydrogen buses in Kochi	Private e-bus services in Thiruvananthapuram	Tata Motors EVs for ride-hailing companies
Karnataka	BMTC electric buses	Karnataka EV Policy 2017 supporting e-mobility	Bengaluru Metro expansion	CNG bus deployment	Yulu, Ather electric scooters; Ola adopting EVs	Private cab operators investing in EV infrastructure
Andhra Pradesh	APSRTC electric buses	Green corridors for EV charging	Vizag Metro project	E-rickshaw promotion in urban areas	Private logistics firms using EVs	Ola, Rapido expanding e-bike services
Tamil Nadu	Electric buses in Chennai & Coimbatore	TN EV Policy 2019 encouraging EV manufacturing Chennai Metro solar-powered expansion	Chennai Metro solar-powered expansion	CNG buses in public transport	TVS electric scooters; Lithium Urban Technologies corporate EV fleets	Private investment in charging infra

Source: (Egovelectsonline.com & Reuters, 2025)

Discussion

Table 5 provides a structured comparison of green transport initiatives by governments and private sector players across the six states. Kerala state has achieved notable progress in eco-friendly transportation, especially with the KSRTC K-SMART electric bus initiative, the incorporation of green hydrogen buses in Kochi, and the solar-powered growth of Kochi Metro. In relation to other states, Kerala's strategy is forward-thinking but still falls short in some aspects.

Comparison with Other States

Delhi and Maharashtra boast a more assertive electric vehicle (EV) policy, featuring larger numbers of electric buses and auto-rickshaws. Delhi's Odd-Even initiative also aids in lowering emissions, a feature missing in Kerala. Karnataka and Tamil Nadu possess more robust EV manufacturing ecosystems, featuring firms such as Ather and TVS at the forefront of e-mobility innovation. Kerala promotes the adoption of electric vehicles but currently lacks significant manufacturing centres for EVs.

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Andhra Pradesh and Tamil Nadu have prioritized private sector-led EV logistics and bike rental services, sectors where Kerala has not yet progressed significantly.

Kerala is outstanding in electrifying public transport and using alternative fuels such as green hydrogen; however, it must enhance private electric vehicle adoption, charging facilities, and EV production. Although it leads in sustainable metro growth, it needs to enhance strategies to keep up with the electric vehicle adoption rate of Delhi, Maharashtra, and Karnataka.

Insights

Regional Variations: South states which have more of the technology supportive environment and higher incentives from the government more growth rates than others.

Kerala's Position: What is important to note is that while Kerala is experiencing annual growth of about 8-9 per cent, it still trails some of the larger states, thus there may be some room to provide further policies and incentives or support for the EV ecosystem in the state.

Impact of Green Transport Policies on the Indian Transport Management Efficiency

Indian government initiatives and institutional interventions at National and State levels have been critical to the transition towards sustainable and green transport in the country. These efforts not only expand the use of environmentally friendly transportation systems but are also designed to optimize transport management including by decreasing congestion, optimizing public transport, reducing energy consumption and enhancing commuter services. All major states have adopted various green transport policies, including the introduction of electric vehicle policies, expansion of charging infrastructure, and electrification of public transport, among others. A comparative analysis of selected states has been given below to show the effects of green transport policy initiatives on transport management efficiency.

Table 6: The Impact of Green Transport Policy Initiatives on Transport Management Efficiency in Selected Indian States

State	Major Green Transport Policy Initiatives	Key Infrastructure / Operational Developments	Impact on Transport Management Efficiency	Sources
Kerala	Kerala EV Policy; KSRTC electric bus initiatives; Kochi Water Metro	Expansion of EV charging stations (around 1,300+); electric buses; integrated water-based urban mobility	Improved eco-friendly public mobility, reduced fuel dependency, enhanced multimodal connectivity and urban transport sustainability	(Graphaize, 2025; NITI Aayog, 2023)
Delhi	Delhi EV Policy 2020; PM E-Drive integration; EV corridor development	Nearly 9,000 charging points; large-scale induction of electric buses; fast-charging corridors	Increased charging accessibility, reduced operational emissions, improved last-mile connectivity and fleet management efficiency	(The Times of India, 2025)
Karnataka	Karnataka EV & Energy Storage Policy	India's highest number of charging stations (about 5,800+); Bengaluru EV ecosystem	Improved EV adoption ecosystem, better urban mobility management and stronger public-private transport integration	(Graphaize, 2025)
Tamil Nadu	Tamil Nadu EV Policy; EV manufacturing incentives	Charging infrastructure expansion; EV industrial corridor development	Strengthened sustainable transport supply chain and improved electrified transport operations	(Graphaize, 2025)
Maharashtra	Maharashtra EV Policy 2025	More than 4,000 charging stations; highway charging corridors	Enhanced intercity EV movement, improved charging accessibility and better transport network efficiency	(DIYguru, 2025)

Discussion

The analysis under table 6 implies that the policy efforts towards sustainable and green transport have played a crucial role in enhancing the efficiency of transport management systems in the states of India. As states implement more robust policy frameworks, expand charging infrastructure, and have more active public transport electrification programmes, their performance in terms of operational efficiency, accessibility, and environmental impact is comparatively better in these areas. Delhi has become a beacon of success where the aggressive policy of promoting EVs, deploying electric buses on a large scale and establishing charging corridors have made city mobility easier to manage, and

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cut reliance on conventional fuel-based transport. In a similar manner, Kerala has enhanced the efficiency of multimodal transport with the introduction of electric public transport and forward-looking projects like the Kochi Water Metro. The results also indicate that infrastructural preparedness, policy stability, and institutional coordination are key factors in the speeding up of the transition to green mobility. Nevertheless, the uneven distribution of charging stations and the challenges of implementation efficiency persist, leading to regional imbalances in the development of sustainable transport in India.

Metro Rail System and Green Transport Efficiency

The analysis of metro rail system has added an important dimension of sustainable and green public transport in India to the scope of the present study, which makes it novel and comprehensive. The low carbon emissions, energy-efficient operations, reduced traffic congestion, high commuter carrying capacity of metro rail systems make it one of the most efficient and environmentally friendly methods of urban transportation. By comparing Kerala with other Indian states, a holistic appraisal of the contribution of green transport infrastructure to transport management effectiveness, commuter satisfaction and sustainable urban development is enabled. Hence, the analysis of metro rail enhances the green transport transition study in India in a comprehensive way.

Table 7: Metro Rail Systems and Green Transport Efficiency in Selected Indian States

State/City	Metro Rail Initiative	Green and Sustainable Features	Contribution to Transport Efficiency and Commuter Satisfaction	Sources
Kerala (Kochi)	Kochi Metro	Solar-powered stations, energy-efficient operations, integrated water metro connectivity	Reduced urban congestion, improved multimodal connectivity, and enhanced commuter convenience	(Kochi Metro Rail Ltd., 2024)
Karnataka (Bengaluru)	Namma Metro	Regenerative braking system, solar energy utilisation, reduction in vehicular emissions	Improved urban mobility efficiency and reduced travel time in high-density corridors	(BMRCL, 2024)
Delhi	Delhi Metro	First carbon-credit earning metro system; extensive solar energy adoption; energy-efficient stations	High commuter satisfaction, reduced pollution, and cost-effective mass transportation	(DMRC, 2024)
Tamil Nadu (Chennai)	Chennai Metro	Green building certification, renewable energy integration	Enhanced passenger comfort, lower carbon emissions, and improved public transport reliability	(CMRL, 2024)

Discussion

Table 7 highlights that metro rail plays a significant role in the sustainable and efficient management of urban transportation in India. Delhi, Karnataka, Kerala, and other states are implementing green technologies in their metro rail projects, such as using solar energy, regenerative braking systems, and efficient station designs. They have helped to alleviate traffic congestion, emissions from cars, and reliance on the transport system powered by fossil fuels. Delhi Metro is one of the cases selected, and it is already recognized worldwide as a successful example of sustainable metro system, because of its successful implementation of carbon-credit and wide integration of renewables. Likewise, Kochi Metro also showcases innovation by combining the metro and water mobility networks, enhancing multimodal mobility and the convenience of commuters. The results show that in addition to being time efficient and environmentally sustainable, the implementation of metro rail systems also boosts the satisfaction of commuters with their transportation services as it is safe and reliable. Hence, the development of metro rail has become an important part of strategy for transitioning Indian transport system green.

Recommendations

Based on the tables' data and observations, following are the targeted recommendations for Kerala to accelerate green transport growth and catch up with higher-adopting states like Delhi and Karnataka:

1. Strengthen Government Incentives and Subsidies:

• Increase Financial Incentives: Provide additional subsidies for EV purchases to reduce upfront costs, especially for two-wheelers and public transport vehicles. This could encourage more adoption among the general population.

• Tax Breaks for EV Infrastructure: Offer tax incentives for businesses and housing societies to set up EV charging stations, fostering a supportive infrastructure.

2. Expand EV Infrastructure:

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• Develop More Charging Stations: Increase the density of EV charging stations across urban and semi-urban areas to reduce range anxiety. Partner with private firms for a PPP (public-private partnership) model.

• Battery Swapping Facilities: Introduce battery-swapping stations in cities to minimise charging wait times and support EV adoption among commercial vehicles.

3. Promote Public EV Transport:

• Electrify Public Bus and Taxi Fleets: Develop policies encouraging the adoption of electric buses and incentivise EVs for cab aggregators and local taxis. This can significantly reduce emissions and showcase EVs to a larger audience.

• Discounted EV Public Transport Fares: Provide discounted rates on public EV transport options, making them an affordable and preferred choice.

4. Awareness and Education Campaigns:

• Launch Awareness Programs: Inform the public about the economic and environmental benefits of EVs. Highlight the long-term savings on fuel and maintenance compared to conventional vehicles.

• Workshops for Businesses: Educate local businesses about the benefits of fleet electrification and government schemes, which could motivate them to transition their logistics to EVs.

5. Collaborate with Private Sector and Technology Hubs:

• Attract EV Start-ups and Manufacturing Units: Encourage EV-related start-ups to set up R&D and manufacturing units in Kerala by providing subsidies and land incentives, following Karnataka's example.

• EV Skill Development: Partner with educational institutions to offer EV-focused training programs, creating a skilled workforce in green technology and reinforcing local EV manufacturing.

6. Special Focus on Rural and Semi-Urban Areas:

• Subsidised Rural EV Transport: Pilot EV public transport schemes in rural areas, making it easier for rural communities to access affordable and sustainable transportation.

• Promote Two-Wheeler EVs: Target the two-wheeler segment for rural and semi-urban areas, as it's both cost-effective and practical for daily short-distance travel.

By implementing these strategies, Kerala could see accelerated growth in green transport, contributing to a more sustainable transportation ecosystem and improved air quality across the state.

CONCLUSION

Drawing on systematically compiled secondary evidence from authoritative sources, the present study provides important insights into the green transport transition of Kerala as compared with other competing states in India. The study establishes that Kerala has made tremendous strides towards sustainable and green mobility, especially in the areas of public transport electrification, development of metro rail, integrated water-based mobility and "green" transport governance. Initiatives like Kochi Metro and Kochi Water Metro, as well as the growing promotion of electric buses by the Kerala State Road Transport Corporation, reflect the state's efforts towards low-carbon and sustainable transportation. Kerala has made significant strides in consolidating green transport in the public transport system than several states in the country. The study also shows that EV penetration and charging infrastructure in Kerala is comparatively lower than the top states like Delhi, Karnataka and Maharashtra. The analysis also indicates that sustainable transport policy measures, metro rail, expansion of charging infrastructure, and public-private participation have a significant impact on the efficiency of transport management systems by alleviating congestion, increasing commuter satisfaction, boosting operational efficiency and reducing environmental pollution. However, issues like lack of charging infrastructure in semi-urban and rural areas, lower awareness among consumers, high costs of EVs to begin with and implementation differences still play a role in the progress of the green transport transition in Kerala. Overall, the prospects of sustainable and green public transport transition in Kerala are promising. The state has a highly developed institutional framework for supporting green mobility, high social development indicators, environmental awareness, and an economy that is increasingly geared towards tourism, which give it great potential as a national model for sustainable mobility. The potential for further growth and expansion in electric public transport, metro systems, renewable energy infrastructure, and multimodal mobility networks can significantly bolster Kerala's green transportation sector. This transition needs to be accelerated through greater policy support, targeted financial incentives, modernisation of rural transport and more private sector involvement. Further studies can be conducted in the future to explore the socio-economic consequences of the implementation of green mobility, the behaviour change of commuters, and the sustainability results in the long term of integrated public transport systems in Kerala and other Indian States.

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