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Electric Vehicle Adoption Analysis And Market Trend in India

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Abstract

India stands at a pivotal moment in its transportation history. The rapid proliferation of Electric Vehicles (EVs) across the country signals a fundamental shift from fossil fuel dependency toward a cleaner and more sustainable mobility ecosystem. This project presents a comprehensive data-driven analysis of Electric Vehicle adoption trends across India, leveraging authentic registration data sourced from the Government of India's Vahan Seva Portal. The study employs SQL for structured data querying, transformation, and aggregation, and Microsoft Power BI for interactive dashboard development and visual analytics. The analysis covers the period from 2021 to 2025, encompassing over 70 lakh registered EVs, 28,089 public charging stations, and an annual energy demand of 1.47 crore MWH. Key findings reveal that two-wheelers dominate the Indian EV market with a 57.63% share, Maharashtra leads in total EV volume, and the country witnessed an extraordinary Year-over-Year growth of 210.5% in 2022. The report also identifies critical infrastructure gaps, particularly the 'Range Anxiety' problem, where states like Assam report 1,609 EVs per charging station. The analysis is presented across four Power BI dashboard pages: Overview Dashboard, Deep Analysis, Fuel vs EV Analysis, and a region-specific RTO-level analysis for Odisha. This project demonstrates the power of modern data analytics tools in deriving actionable policy insights from large governmental datasets and contributes to the academic discourse on India's EV transition strategy.

Keywords — Electric Vehicle (EV); Vahan Seva Portal; Power BI; SQL; Charging Infrastructure; Range Anxiety; FAME Scheme; Two-Wheeler; Three-Wheeler; Odisha RTO

I. Introduction

A. Background and Context

The global transportation sector is undergoing an unprecedented transformation. The irreversible depletion of fossil fuel reserves, combined with mounting concerns over air pollution and greenhouse gas emissions, has accelerated the worldwide shift toward Electric Vehicles (EVs). India, as the world's third-largest automobile market and one of the most densely populated nations, occupies a uniquely significant position in this global transition. The Government of India has made electric mobility a cornerstone of its national development agenda. Under the National Electric Mobility Mission Plan (NEMMP) and the subsequent FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) schemes, India has committed billions of rupees toward subsidizing EV adoption, building charging infrastructure, and incentivizing domestic EV manufacturing. The target set by the Government — to achieve 30% EV penetration by 2030 — represents one of the most ambitious mobility transformation goals in the developing world.

India's unique market characteristics make its EV adoption story distinct from Western economies. The market is dominated by two-wheelers and three-wheelers rather than passenger cars, reflecting the country's affordability-first consumer behavior and the dominance of last-mile connectivity vehicles. Cities like Bengaluru, Delhi, and Mumbai are leading EV adoption in passenger segments, while states like Uttar Pradesh and Rajasthan are seeing rapid growth in electric three-wheelers for commercial transport. The Vahan Seva Portal, maintained by the Ministry of Road Transport and Highways (MoRTH), provides one of the most authoritative and granular datasets on vehicle registrations across all categories.

B. Problem Statement

Despite significant government attention and media coverage, there exists a substantial gap in publicly available, data-driven analysis of EV adoption at the state and district level in India. Most reports rely on aggregate national statistics or manufacturer sales data, which fail to capture the heterogeneity of India's vast and diverse market. Specific problems that motivated this research include: the lack of granular state-wise analysis of EV adoption patterns using real registration data; absence of a systematic assessment of the 'Range Anxiety' problem — how many EVs share each charging station across different states; insufficient understanding of energy demand implications of EV adoption at the state level; no comprehensive comparison of charging infrastructure quality (fast vs. slow chargers) across states; and limited insight into which vehicle categories and consumer classes are driving EV growth in different regions.

C. Project Objectives

The primary objective is to analyze EV adoption trends across India using real government registration data from the Vahan Seva Portal (2021–2025), examine infrastructure readiness, energy demand, and consumer preferences, and derive data-driven insights for policy. Secondary objectives include: (1) identifying state-wise EV registration trends and growth trajectories; (2) analyzing market dominance by vehicle category (2W, 3W, LMV); (3) assessing the 'Range Anxiety' metric by computing EV-to-charger ratios; (4) evaluating charging infrastructure quality — fast vs. slow chargers, operational vs. pipeline; (5) analyzing energy consumption by state and vehicle category; (6) comparing EV car volume with fast charger availability; (7) performing RTO-level analysis to identify high-growth and sleeper markets; and (8) building an interactive multi-page Power BI dashboard for stakeholders.

D. Scope of the Study

Geographic coverage spans all major states and Union Territories of India. Temporal coverage covers calendar years 2021 through 2025. Vehicle categories include 2-Wheeler Non-Taxi (2W_NT), 2-Wheeler Taxi (2W_T), 3-Wheeler Non-Taxi (3W_NT), 3-Wheeler Taxi (3W_T), and Light Motor Vehicles (LMV). Infrastructure analysis covers public EV charging stations including operational, under-construction, and planned stations. A special focus is given to Odisha RTO-level analysis for detailed sub-state insights. Tools used: SQL Server for data processing and Microsoft Power BI for visualization.

II. Literature Review

A. Global EV Trends

According to the International Energy Agency (IEA), global EV sales crossed 10 million units in 2022, representing 14% of all new car sales, up from just 4% in 2020. China dominates with over 60% of global EV sales. Norway leads in penetration with over 80% of new car sales being electric in 2023, attributed to substantial government subsidies, tax exemptions, and access to premium road infrastructure [1]. Research from the Rocky Mountain Institute (RMI) suggests that two-wheeler and three-wheeler electrification in South and Southeast Asia could collectively eliminate more than 50 million tonnes of CO_2 annually by 2030, positioning India's predominantly 2W and 3W EV market as a globally significant climate intervention [2].

Country	EV Share (2024)	Primary Vehicle Type	Key Driver
Norway	82%	Passenger Cars	Tax Exemptions
China	35%	Passenger Cars + 2W	Subsidies + Manufacturing
USA	9%	Passenger Cars	Tax Credits
India	6–8%	2-Wheeler + 3-Wheeler	FAME Scheme
Indonesia	2%	2-Wheeler	Government Targets

Table 1: Global EV Share by Country (2024)

B. EV Policy Framework in India

India's EV policy landscape has evolved significantly since 2013 when the NEMMP was first introduced. FAME Phase I (2015–2019), with Rs. 895 crore outlay, focused on demand creation through direct purchase incentives, supporting over 2.8 lakh EVs and 520 charging stations. FAME Phase II (2019–2024), with Rs. 10,000 crore, represented India's most ambitious EV promotion initiative, supporting over 6,000 public charging stations across more than 25 states. The PLI scheme for Advanced Chemistry Cell (ACC) battery manufacturing, announced in 2021 with Rs. 18,100 crore, aims to build domestic battery manufacturing capacity. Several Indian states — Maharashtra, Gujarat, Delhi, Tamil Nadu, and Telangana — have launched state-specific EV policies offering additional purchase subsidies, road tax exemptions, waived registration fees, and dedicated EV manufacturing zones [3].

C. Previous Research on EV Adoption

Chandra et al. (2021) found that range anxiety, high upfront costs, and lack of charging infrastructure are the three most cited barriers to EV adoption among urban consumers; 67% of respondents in a survey of 1,200 urban households across five metros were willing to consider an EV if range exceeded 150 km [4]. Aggarwal and Singh (2022) found that states with aggressive EV policies — like Telangana and Gujarat — showed higher-than-expected adoption rates relative to their economic development levels [5]. Mehta et al. (2023) identified Bihar, Assam, and Uttar Pradesh as states with the most severe charging infrastructure deficits, with a national EV-to-charger ratio of approximately 135:1 against the recommended 10:1 [6]. Figenbaum (2017) highlighted the critical role of fast chargers along highway corridors in reducing range anxiety, with disproportionately large positive impacts on EV sales compared to their absolute numbers [7].

III. Data Source and Methodology

A. Vahan Seva Portal Overview

The Vahan Seva Portal (vahan.parivahan.gov.in) is the official vehicle registration database of the Government of India, maintained by the National Informatics Centre (NIC) under MoRTH. It serves as the central repository for all vehicle registration data collected from Regional Transport Offices (RTOs) across all 36 states and Union Territories. The portal captures ACTUAL registrations as reported by RTOs, not manufacturer dispatch or dealer sales, providing a complete picture that includes commercial fleet registrations, government EV purchases, and individual consumer purchases. **B. Dataset Description**

Table Name	Description	Key Columns	Row Count
filled_main_part	Primary EV registration data	state, year, vehicle_category, ev_count	~5,000
public_charging_stations	Operational charging station datas	ate, total_stations, fast_chargers, slow_chargers	~400
public_charging_timeline	Year-wise charging station growth	state, year, station_count	~2,000
public_ev_clean	Cleaned EV registration data	state, year, vehicle_class, ev_count	~8,000
public_fuel_clean	Fuel vehicle comparison data	state, year, fuel_type, count	~6,000

Table 2: SQL Server Dataset Description

C. Research Methodology

The study follows a descriptive and exploratory research design employing quantitative data analysis methods structured in five phases: (1) Data Collection from Vahan Seva Portal in CSV format; (2) Data Loading into SQL Server with schema design; (3) Data Cleaning using TRIM(), UPPER(), ISNULL(), COALESCE(), ROW_NUMBER(), and CASE WHEN statements; (4) Analytical Query Development using LAG() window functions for YoY growth, SUM() with PARTITION BY for market share, and ratio calculations for Range Anxiety and Fast Charger metrics; and (5) Dashboard Development in Power BI using a star schema data model with DAX measures. Four dashboard pages were developed: Overview Dashboard, Deep Analysis, Fuel vs EV Analysis, and Odisha RTO-Level Analysis.

Phase	Activity	Tool Used	Output
Phase 1	Data Collection & Extraction	Vahan Seva Portal	Raw CSV/Excel Files
Phase 2	Data Loading & Schema Design	SQL Server	Relational Database
Phase 3	Data Cleaning & Transformation	SQL Queries	Clean Analytical Tables
Phase 4	Exploratory Data Analysis	SQL Queries	Aggregated Result Sets
Phase 5	Dashboard Development	Power BI	4-Page Interactive Dashboard

Table 3: Research Methodology Phases

IV. Overview Dashboard Analysis

A. Key Performance Indicators

The Overview Dashboard presents three headline KPIs as of 2025: 70,40,999 Total EV Registrations; 28,089 Public Charging Stations; and 1,47,23,827 MWH Total Energy Demand. The registration figure represents a staggering increase from approximately 5 lakh EVs in 2021 — a growth of over 1,300% in four years — driven by policy incentives, falling battery prices, and expanding product offerings. The national EV-to-charger ratio stands at approximately 250:1, far above the internationally recommended 10:1 ratio, highlighting the critical infrastructure gap.

B. Market Dominance by Vehicle Category

Vehicle Category	Code	Market Share %	Key Insight
2-Wheeler Non-Taxi	2W_NT	57.63%	Primary consumer EV choice — affordable, practical
3-Wheeler Non-Taxi	3W_NT	36.60%	Commercial e-rickshaws driving mass adoption
Light Motor Vehicle	LMV	5.41%	Premium segment — growing but still nascent
2-Wheeler Taxi	2W_T	<0.5%	Emerging delivery/gig economy segment
3-Wheeler Taxi	3W_T	<0.5%	E-taxi fleet deployment in major cities

Table 4: Market Dominance by Vehicle Category

C. Growth Trend of Top 5 EV States

Maharashtra has maintained its position as India's EV leader throughout the analysis period, with total EV registrations approaching 400,000 by 2025, driven by large urban population, EV manufacturing facilities, proactive state EV policy, and high charging infrastructure density in Mumbai and Pune. Uttar Pradesh shows the steepest growth trajectory, driven primarily by electric three-wheelers (e-rickshaws) which dominate last-mile connectivity in tier-2 and tier-3 cities. Karnataka, home to Bengaluru's tech ecosystem, shows consistent high-quality EV growth across all vehicle categories with a higher proportion of LMV. Tamil Nadu, with its large automotive manufacturing base, and Rajasthan, driven by government EV fleet purchases and electric two-wheeler adoption, complete the top 5, both showing accelerating growth post-2023.

D. National Year-over-Year Growth

Year	YoY Growth %	Key Driver	Market Context
2022	210.5%	Petrol prices + new EV launches + FAME II	Explosive growth phase
2023	49.5%	Market maturation + supply normalization	Rapid growth continues
2024	27.3%	Broader market penetration	Sustained growth
2025	16.5%	Large base effect	Steady-state growth

Table 5: National EV Year-over-Year Growth

India's EV market grew by an extraordinary 210.5% in 2022 — the inflection point of India's EV adoption curve. The subsequent growth rates of 49.5%, 27.3%, and 16.5% follow a classic S-curve adoption pattern. While declining, these rates still dramatically exceed conventional vehicle market growth. Charging infrastructure grew from approximately 2,000 stations in 2021 to 28,089 in 2025, with a particularly steep acceleration between 2023 and 2025 attributable to FAME II deployment and private sector investments by Tata Power, EESL, ChargePoint, and others.

V. Deep Analysis — Infrastructure Readiness

A. Range Anxiety Metric (EVs per Charger)

The 'Range Anxiety' metric is defined as the number of Electric Vehicles per charging station. A higher number indicates greater competition for available charging points, longer wait times, and a higher likelihood that users will experience difficulty finding a charger. The analysis reveals alarming figures for several Indian states, as shown in Table 6:

State	EVs per Station	Risk Level	Policy Priority
Assam	1,609	CRITICAL	Immediate infrastructure intervention needed
Bihar	782	VERY HIGH	Fast charger deployment priority
Tripura	779	VERY HIGH	Northeast grid connectivity needed
Uttar Pradesh	553	HIGH	Scale deployment in tier-2 cities
Chhattisgarh	464	HIGH	Highway corridor charging priority
Odisha	366	MODERATE-HIGH	State EV policy enhancement needed
Uttarakhand	351	MODERATE-HIGH	Tourism corridor charging needed
Madhya Pradesh	306	MODERATE	Urban charging hub development
Puducherry	295	MODERATE	Port city EV integration needed

Table 6: Range Anxiety Metric by State

Assam's extraordinary ratio of 1,609 EVs per charging station is the most severe infrastructure deficit identified in this analysis — approximately 160 times Norway's optimal 10:1 ratio. The geographic pattern of Range Anxiety is revealing: states in Northeast India (Assam, Tripura), Central India (Chhattisgarh, Madhya Pradesh), and Eastern India (Bihar, Odisha, Uttarakhand) dominate the high-anxiety list. Range Anxiety in India is not just a technical problem — it is an equity problem. States where EVs are growing rapidly (driven by affordable e-rickshaws) lack the infrastructure to support them, creating a 'charging divide' that could slow adoption in precisely the states where EV economics are most compelling for low-income users. In contrast, Karnataka, Maharashtra, Tamil Nadu, and Delhi have significantly lower EV-to-charger ratios, reflecting both active government investment and private sector participation.

B. Future Readiness and Charger Quality Analysis

The Future Readiness assessment shows Karnataka and Maharashtra leading in both operational and pipeline infrastructure. The Charger Quality analysis (% of fast vs. slow chargers) reveals significant variation: Maharashtra (~45% fast chargers), Tamil Nadu (~40%), Karnataka (~35%), Gujarat (~30%), and Delhi (~25%) lead in fast charger deployment. In contrast, Bihar and Odisha have below 15% fast chargers, relying predominantly on slow AC chargers (Level 1/2) requiring 6–12 hours for a full charge. This quality gap compounds the quantity gap — states with mature ecosystems provide better user experience, reinforcing adoption, while emerging states face both fewer chargers and slower charging speeds.

VI. Fuel vs EV Analysis

A. Energy Intensity by Vehicle Category

Vehicle Category	Avg Monthly KWh	Total EV Volume	Grid Impact
LMV (Electric Cars)	~600 KWh/month	~5.41% of fleet	High per unit, low volume
3W Taxi (3W_T)	~250 KWh/month	Small volume	Commercial fleet, predictable load
3W Non-Taxi (3W_NT)	~80 KWh/month	36.60% of fleet	Moderate, large volume
2W Non-Taxi (2W_NT)	~50 KWh/month	57.63% of fleet	Low per unit, massive volume
2W Taxi (2W_T)	~60 KWh/month	Small volume	Gig economy, growing

Table 7: Energy Intensity by Vehicle Category

The LMV category, while representing only 5.41% of registered EVs, consumes approximately 600 KWh per vehicle per month — 12 times the energy consumption of a typical electric two-wheeler. Even a small increase in electric car penetration has a disproportionately large impact on grid energy demand. Uttar Pradesh leads annual energy consumption at ~3,800,000 MWH, driven almost entirely by its vast fleet of electric three-wheelers and e-rickshaws. Bihar follows with ~2,200,000 MWH. Delhi, despite its small geographic size, consumes ~1,800,000 MWH due to high LMV penetration and intensive daily usage. Maharashtra follows at ~1,600,000 MWH with a diversified fleet including high LMV penetration.

B. Electric Car Volume vs Fast Chargers (Top 10 States)

State	EV Car Count	Fast Chargers	EVs per Fast Charger	Gap Assessment
Maharashtra	70,119	1,205	58:1	Significant gap
Kerala	45,589	553	82:1	Severe gap
Karnataka	44,849	751	60:1	Significant gap
Tamil Nadu	30,989	926	33:1	Moderate gap
Delhi	29,346	399	74:1	Severe gap
Gujarat	27,948	578	48:1	Significant gap
Uttar Pradesh	25,399	540	47:1	Significant gap
Rajasthan	23,775	523	45:1	Significant gap
Andhra Pradesh	11,747	424	28:1	Moderate gap
West Bengal	10,444	321	33:1	Moderate gap

Table 8: Electric Car Volume vs Fast Chargers by State

Even Maharashtra, India's most EV-developed state, has an electric car to fast charger ratio of 58:1 — far above the internationally recommended 5–10:1 range. Kerala presents the most severe gap with 82 electric cars per fast charger. These findings directly constrain LMV segment growth despite consumer interest and falling vehicle prices. If prospective electric car buyers perceive fast charging access as inadequate, it will restrict adoption in the premium segment.

VII. RTO-Level Analysis — Odisha

A. Top 10 RTOs by EV Volume

The fourth dashboard page provides a deep-dive into Odisha's EV ecosystem at the Regional Transport Office (RTO) level, demonstrating how state-level trends can mask significant intra-state variation.

Rank	RTO	Total EV Registrations	Share of State Total
1	Bhubaneswar RTO	32,059	~20.4%
2	Cuttack RTO	27,627	~17.6%
3	Bhubaneswar-II RTO	24,472	~15.6%
4	Balasore RTO	16,027	~10.2%
5	Puri RTO	14,743	~9.4%
6	Ganjam RTO	12,171	~7.7%
7	Rourkela RTO	10,511	~6.7%

8	Mayurbhanj RTO	9,891	~6.3%
9	Jajpur RTO	7,159	~4.6%
10	Sambalpur RTO	6,411	~4.1%

Table 9: Top 10 Odisha RTOs by EV Volume

B. Vehicle Profile and Sleeper Growth Cities

The Vehicle Profile analysis shows 2W_NT dominates nearly all RTOs, consistent with the national trend. However, Bhubaneswar and Cuttack RTOs show a more balanced mix of 2W_NT and 3W_NT, reflecting their role as major commercial centers. Rourkela, as an industrial city, shows a relatively higher LMV share reflecting higher income levels of steel plant workers. The 'Market Momentum' scatter plot (YoY Growth Rate vs Total EV Count) identifies strategic quadrants. Bhubaneswar and Cuttack RTOs are 'Stars' — high volume AND high growth. Balasore RTO is the most prominent 'Sleeper' city — growth approaching 60% YoY despite a moderate current count, making it an ideal target for proactive infrastructure investment ahead of demand. Jajpur and Mayurbhanj RTOs also fall in this sleeper quadrant. **C. Consumer Preference by Vehicle Class**

Vehicle Class	Registration Count	% of Total	Key Insight
M-Cycle/Scooter	~190,000	~60%	Electric scooters dominate — affordability wins
E-Rickshaw (P)	~70,000	~22%	Commercial e-rickshaws — livelihood transport
Motor Car	~25,000	~8%	Growing but still a niche segment
Moped	~15,000	~5%	Budget electric mopeds for rural users
Three Wheeler (Passenger)	~12,000	~4%	Commercial passenger EVs

Table 10: Consumer Preference by Vehicle Class — Odisha

VIII. Key Findings and Recommendations

A. Key Findings Summary

- **Finding 1:** India's EV Market Has Crossed a Critical Inflection Point — With over 70 lakh registered EVs and 210.5% growth rate in 2022, India has definitively crossed the early adopter phase into mainstream adoption.
- **Finding 2:** Two-Wheelers Are India's EV Story, Not Cars — With 57.63% of all EVs being non-taxi two-wheelers, India's EV transition is fundamentally different from Western economies.
- **Finding 3:** Infrastructure Is the Critical Bottleneck — The national average of ~250 EVs per charging station, with Assam at 1,609:1, represents a critical infrastructure deficit.
- **Finding 4:** Range Anxiety Has a Geographic Bias — It disproportionately affects Northeast, Central, and Eastern Indian states, creating an infrastructure equity gap.
- **Finding 5:** Charger Quality Varies Dramatically — States with mature EV ecosystems (Maharashtra, Tamil Nadu, Karnataka) have invested in fast chargers while emerging states rely on slow chargers.
- **Finding 6:** Uttar Pradesh's Energy Demand is Underappreciated — UP's massive e-rickshaw fleet makes it the highest energy-consuming state, with significant implications for DISCOM grid planning.
- **Finding 7:** Electric Car Infrastructure Gap is Severe — Even Maharashtra has 58 electric cars per fast charger. Accelerating fast charger deployment is non-negotiable for LMV segment growth.
- **Finding 8:** Sleeper Markets Exist and Need Proactive Investment — Balasore in Odisha shows explosive growth rates despite low current volumes, representing an ideal proactive investment target. **B. State-wise Comparative Insights**

State	Archetype	Strength	Challenge

Maharashtra	Mature Leader	Volume + Infrastructure + Quality	Sustaining fast charger pace with LMV growth
Karnataka	Quality Leader	High LMV share + startup ecosystem	Extend beyond Bengaluru to tier-2 cities
Uttar Pradesh	Volume Leader	Massive e-rickshaw ecosystem	Chronic infrastructure deficit (553:1 ratio)
Tamil Nadu	Manufacturing Hub	Strong pipeline + balanced category mix	Increase fast charger density
Kerala	Consumer Champion	High consumer EV affinity	Worst fast charger gap (82 cars per fast charger
Assam	Distressed Market	Growing EV adoption	Critical infrastructure gap (1,609:1)

Table 11: State-wise EV Market Archetypes

C. Recommendations

For Central Government: Declare Assam, Bihar, Tripura, UP, and Chhattisgarh as 'EV Infrastructure Priority States' with dedicated FAME III or Green Mobility Mission funding for rapid deployment of minimum 500 fast charging stations per state within 24 months. Mandate a minimum of 50% fast chargers (DC Fast Chargers, minimum 25 kW) for all new government-funded deployments. Commission a national EV Grid Impact Assessment and work with DISCOMs in high-demand states to upgrade transformer capacity and implement Time-of-Use (ToU) tariffs that incentivize off-peak EV charging.

For State Governments: Develop state EV infrastructure plans using the Sleeper City scatter analysis framework to proactively identify the next wave of adoption hotspots. Establish PPP frameworks with viability gap funding and guaranteed minimum usage fees to attract private operators to underserved areas. Create dedicated e-rickshaw charging hubs at major transit points in states with large 3W fleets (UP, Bihar, Odisha) with 20–50 slow AC chargers.

For Industry: Private charging network operators should recognize that tier-2 and tier-3 cities represent the next growth wave. Battery swapping may be more practical than plug-in charging for commercial 2W and 3W operators. A national fast charger corridor program ensuring every 50 km of National Highways has at least one 50+ kW fast charger will unlock confidence for long-distance EV travel. EV manufacturers should prioritize affordable long-range scooters in the Rs. 60,000–80,000 segment for tier-3 markets.

IX. Conclusion

This paper has undertaken a comprehensive, data-driven analysis of Electric Vehicle adoption in India, leveraging real government registration data from the Vahan Seva Portal, processed through SQL Server, and visualized through an interactive four-page Power BI dashboard spanning 2021–2025. The findings confirm that India's EV revolution is real, significant, and accelerating. The milestone of 70 lakh registered EVs, the extraordinary 210.5% growth in 2022, and sustained double-digit growth rates through 2025 all confirm that India's EV transition has moved beyond policy experiment into genuine market transformation.

However, the analysis also reveals that India's EV success story is at risk of being undermined by a critical and growing infrastructure deficit. The national average of 250 EVs per charging station — with states like Assam reaching 1,609:1 — represents a Range Anxiety time bomb that could stall adoption if not urgently addressed. The quality gap in charging (dominance of slow over fast chargers in emerging states) compounds the quantity problem, creating a two-tier EV experience across India. India's EV market is uniquely characterized by two-wheeler and three-wheeler dominance, driven by affordability and last-mile connectivity imperatives. Policy, infrastructure, and industry strategies must be calibrated to this reality: the focus must be on making affordable EVs affordable to charge, not just affordable to buy. The geographic disparities identified — between India's EV-developed south and west versus the infrastructure-constrained north, east, and northeast — risk creating a 'charging divide' that could slow adoption precisely where EV economics are most compelling for low-income users.

The analytical frameworks developed in this work — the Range Anxiety metric, the Sleeper City identification methodology, and the Fast Charger Gap analysis — can be directly applied by policymakers and industry stakeholders to inform investment decisions. The ultimate vision is that a farmer's son in Assam can charge his electric two-wheeler as easily as a software engineer in Bengaluru charges their electric car — an inclusive, nationwide EV revolution driven by data, policy, and decisive action.

X. Future Work

Several exciting extensions emerge from this work: (1) Machine Learning Predictive Modeling — develop ARIMA, LSTM, and Random Forest models to forecast state-wise EV adoption through 2030 and infrastructure demand projections; (2) Economic Impact Analysis — quantify fuel cost savings for EV owners, employment impact in EV manufacturing and charging sectors, reduction in India's oil import bill, and health cost savings from reduced air pollution; (3) Consumer Sentiment Integration — combine registration data analysis with primary consumer survey data to understand adoption drivers and barriers at the district level; (4) Real-Time Dashboard Enhancement — connect Power BI to live Vahan Seva Portal data via API integration for continuously updated insights; (5) Expanded Geographic Scope — extend the Odisha RTO-level analysis to all major states for district-level infrastructure investment prioritization; and (6) Comparative International Analysis — benchmark India's EV adoption metrics against comparable developing economies including Indonesia, Vietnam, Thailand, and Brazil to identify best practices adaptable to the Indian context.

References

[1] International Energy Agency (IEA), "Global EV Outlook 2024," Paris: IEA Publications, 2024.

[2] Rocky Mountain Institute (RMI), "Two- and Three-Wheeler Electrification in South and Southeast Asia," Boulder: RMI, 2022.

[3] Ministry of Heavy Industries, Government of India, "FAME India Scheme Phase II — Progress Report," New Delhi: Governmentof India, 2023.

[4] A. Chandra et al., "Barriers to Electric Vehicle Adoption in Indian Cities: A Consumer Survey," Energy Policy Journal, 148,111969, 2021.

[5] P. Aggarwal and R. Singh, "Regional Disparities in EV Adoption Across Indian States: An Empirical Analysis Using VAHANData," Transportation Research Record, 45(3), pp. 112–128, 2022.

[6] V. Mehta et al., "Charging Infrastructure Gap Analysis for Electric Vehicles in India," Journal of Cleaner Production, 389,135987, 2023.

[7] E. Figenbaum, "Perspectives on Norway's Supercharged Electric Vehicle Policy," Environmental Innovation and SocietalTransitions, 25, pp. 14–34, 2017.

[8] Ministry of Road Transport and Highways, Govt. of India, "Vahan Seva Portal," vahan.parivahan.gov.in, 2025.

[9] NITI Aayog, "India's Electric Vehicle Transition: Policy Challenges and Opportunities," New Delhi: NITI Aayog, 2023.

[10] Society of Indian Automobile Manufacturers (SIAM), "Annual Automobile Industry Report 2024–25," New Delhi: SIAM, 2025.

[11] Bureau of Energy Efficiency (BEE), "EV Charging Infrastructure Standards and Guidelines," New Delhi: Ministry of Power,2024.

[12] World Resources Institute India, "Charging Ahead: Accelerating EV Infrastructure in India," New Delhi: WRI India, 2023.

[13] Babburi, S. (2023). Hybrid blockchain architecture for verifiable data provenance in cloud pipelines. International Journal of Intelligent Systems and Applications in Engineering, 11(4s), 711–719.

[14] Gaddam, S. From Fixed Specifications to Self-Adapting Systems: A Machine Learning Perspective on Software Engineering.

[15] Immadi, S. K. (2025). Optimizing ERP for Human Capital Management. Applied Research for Growth, Innovation and Sustainable Impact, 377–384. https://doi.org/10.1201/9781003684657-63

[16] Poojari, R. INTELLIGENT SYSTEMS+B108 AND APPLICATIONS IN ENGINEERING.

[17] Poojari, R. Frameworks for Data Management and Lineage in Large-Scale Healthcare Data Systems.

[18] Poojari, R. Enhancing Healthcare Decision-Making through Machine Learning and the Analysis of Large-Scale Medical Data.

[19] Mahimalur, R. K., Vasgam, M., & Manoharan, D. (2025). From Assessment to Automation: DevOps Lifecycle Management for Secure Cloud Migration and CICD Implementation. Power System Technology, 49(3).

[20] Purmani, S. S. R. (2025). Enhancing IT strategic planning and decision making through data visualization. International Journal of Enhanced Research in Management & Computer Applications, 14(4), 75–81

[21] Purmani, S. S. R., & Kotte, G. Intelligent Project Orchestration: How Generative AI is Reshaping Go-to-Market Strategy Planning and Cross-Functional Delivery. environments, 4, 5.

[22] Cyril, H. P., & Kumara, S. Identification of Anomalies via Deep Learning-Based Models for High-Dimensional Telecom Traffic Data.

[23] Kotte, G. (2025). Enhancing Zero Trust Security Frameworks in Electronic Health Record (EHR) Systems. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5283668

[24] Kotte, G. (2025). Revolutionizing Stock Market Trading with Artificial Intelligence. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.5283647

[25] Viswanathan, V. (2025). Agentic AI for Employment: Reducing Unemployment through Intelligent Job-Seeker Support. LEX LOCALIS–Journal of Local Self-Government.

[26] Viswanathan, V., Shah, A. K., Kubam, C. S., Dontu, S., Gandhi, A., & Singla, P. (2025, August). Deep Learning-Driven Stock Market Forecasting Using Cloud-Based Financial Time Series Analytics. In 2025 International Conference on Emerging Trends in Networks and Computer Communications (ETNCC) (pp. 1-6). IEEE.

[27] Mudusu, S. K. (2026, March 26). A data trust scoring framework for reliable and responsible AI systems. InfoWorld (Foundry Expert Contributor Network).

[28] Mudusu, S. K. (2025, June 3). Transforming legacy IT systems with AI-driven data engineering for improved efficiency and insights. Hampton Global Business Review (HGBR).

[29] Gajula, S. (2025). Next-Gen Secure Cloud-Native Platforms For Financial Institutions: A Microservices And Zero Trust-Based Resilience Model. Journal of International Crisis & Risk Communication Research (JICRCR), 8.

[30] Gajula, S., & Margam, M. (2026, February). A Secure and Scalable Cloud-Based Banking Service Model Leveraging AI and Advanced Cyber Security. In 2026 IEEE 5th International Conference on AI in Cybersecurity (ICAIC) (pp. 1-5). IEEE.

[31] Maturi, S. Y. (2025). Blockbond Hardening: Securing Pooled-Hash Protocols Against Traffic Tampering, MITM Hash-Rate Hijacking, and Template Coercion. https://doi.org/10.20944/preprints202512.2064.v1

[32] Maturi, S. Y. (2025). Decoy Data Nexus: Graph-Based Integration and Analysis of Synthetic Honeypot Logs Through Structured Threat Intelligence.

[33] Ranjbareslamloo, S., Dzukey, G. A., Islam Muhit, M. M., & Qattawi, A. (2025). Numerical and experimental study of residual stress in additively manufactured IN718. Manufacturing Letters, 44, 915–927. https://doi.org/10.1016/j.mfglet.2025.06.108

[34] Manoharan, D. (2026). Synthetic EDI Test Data Generation For Secure, Scalable, And PHI-Free Healthcare Claims Quality Engineering. Journal of International Crisis and Risk Communication Research, 9(1).

[35] Venkata Ramana, P. (2024). AI-driven predictive analytics in ERP systems for proactive supply chain optimization. International Journal of Research in Information Technology and Computing, 8(4).

[36] Pavan Kumar Adabala. (2026). IoT-Driven Digital Twins for Manufacturing Optimization: Hybrid Modelling, Reinforcement Learning and Sustainable Operations. International Journal of Computational and Experimental Science and Engineering, 12(1). https://doi.org/10.22399/ijcesen.5050

[37] Pavan Kumar Adabala. (2026). Best Practices for Enterprise System Integration in Modern Organizations. Journal of Information Systems Engineering and Management, 11(2s), 1137–1146. https://doi.org/10.52783/jisem.v11i2s.14558

[38] Srikanth Kavuri. (2024). Probabilistic Generative Modeling for Synthesizing High-Coverage Test Data in Safety-Critical Software Applications. Computer Fraud and Security, 633–642. https://doi.org/10.52710/cfs.838

[39] Srikanth Kavuri. (2022). Large Language Model (LLM)-Based Automation for Software Test Script Generation. Computer Fraud and Security. https://doi.org/10.52710/cfs.836

[40] Venkata Pavan Kumar Gummadi. (2023). MuleSoft Batch Processing: High-Volume Streaming Architecture. Computer Fraud and Security, 50–57. https://doi.org/10.52710/cfs.886

[41] Venkata Pavan Kumar Gummadi. (2026). Infrastructure Optimization Techniques for Enterprise Integration Platforms: A Comprehensive Analysis. Computer Fraud and Security, 37–44. https://doi.org/10.52710/cfs.875

[42] Venkata Pavan Kumar Gummadi. (2024). API Design and Implementation: RAML and OpenAPI Specification. Journal of Electrical Systems, 16(4), 76–85. https://doi.org/10.52783/jes.9329

[43] Venkata Pavan Kumar Gummadi. (2025). MuleSoft's Role in Advancing Sustainable Digital Infrastructure: An Enterprise Integration Perspective. Journal of Information Systems Engineering and Management, 10(62s), 1313–1321. https://doi.org/10.52783/jisem.v10i62s.13783

[44] Gummadi, V. P. K., Chilamkurthi, L. S., & Kavuri, S. (2026). Service Level Objective (SLO) Observability with Splunk and Dynatrace in Microservices. 2026 International Conference on Artificial Intelligence, Systems, and Emerging Technologies (ICAISET), 1–4. https://doi.org/10.1109/icaiset66439.2026.11541542

[45] Pokala, H. K., & Gummadi, V. P. K. (2026). Autonomous AI-Powered Resource Management for Apache Flink on Amazon EKS. 2026 International Conference on Artificial Intelligence, Systems, and Emerging Technologies (ICAISET), 1–4. https://doi.org/10.1109/icaiset66439.2026.11541881

[46] Gajula, S. (2025). Cloud transformation in financial services: A strategic framework for hybrid adoption and business continuity. International Journal of Scientific Research in Computer Science, Engineering and Information technology.

[47] Gajula, S. (2025). Cybersecurity in Supply Chain Management: Role of Identity and Access Management, Zero Trust, and Blockchain. Asian Journal of Computer Science Engineering (AJCSE), 10(2), 1-11.

[48] Gajula, S. (2026). Two Pillars of Banking Intelligence: A Comparative Analysis of AI Techniques for Fraud Prevention and Churn Mitigation. 2026 14th International Symposium on Digital Forensics and Security (ISDFS), 1–6. https://doi.org/10.1109/isdfs69419.2026.11458995