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An Integrated Study on Electric Vehicle Adoption and Consumer Satisfaction in Tumkur District: Exploring Usage Behavior, Influencing Factors and Perceptions Across Technological, Economic and Environmental Dimensions

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Abstract:

The rapid transition towards sustainable mobility has positioned electric vehicles (EVs) as a key solution to reducing environmental impact and promoting clean transportation. This research undertakes an integrated study to examine both the adoption of electric vehicles and the satisfaction levels of EV users in Tumkur District, Karnataka. The study aims to analyze usage behavior and the key factors influencing the decision to adopt EVs among urban and rural consumers. Further, it evaluates consumer satisfaction based on technological aspects (battery performance, charging infrastructure, vehicle range), economic considerations (cost of ownership, maintenance expenses, subsidies), and environmental consciousness (carbon footprint awareness, eco-friendly attitudes). A mixed-methods approach was employed, involving structured surveys and in-depth interviews with EV owners, dealerships, and stakeholders. The findings reveal a significant correlation between awareness levels, government incentives, and adoption rates, while satisfaction varies based on user expectations, availability of charging stations, and perceived performance. The study offers strategic insights for policymakers, manufacturers, and service providers to enhance the EV ecosystem and improve customer experience in semi-urban and rural contexts.

Keywords : Electric Vehicle (EV) Adoption, Consumer Satisfaction, Usage Behavior , Technological Factors , Economic Factors , Environmental Awareness , Charging Infrastructure , Rural and Urban Consumers , Sustainable Transportation , Tumkur District , Customer Perception , Government Incentives , Green Mobility , EV Market Penetration , Post-Adoption Experience

Introduction

The global shift towards sustainable and environmentally responsible modes of transportation has placed **electric vehicles (EVs)** at the forefront of mobility solutions. As governments, industries, and consumers increasingly acknowledge the environmental impact of traditional internal combustion engine (ICE) vehicles, the adoption of electric mobility has grown substantially. In India, this transition is being actively supported by national policies such as the **Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME)** schemes, state-level subsidies, and tax incentives—all aimed at making EVs more affordable and accessible.

While large metropolitan cities like Bengaluru and Delhi have seen considerable EV penetration due to better infrastructure and consumer awareness, the success of India's e-mobility mission significantly depends on its uptake in **semi-urban and rural districts**. One such region is **Tumkur District** in Karnataka, which presents a unique blend of **urban expansion and rural livelihood**, offering an ideal case to understand the broader challenges and opportunities surrounding EV adoption outside major metros.

This study aims to provide a **comprehensive and integrated understanding of two interconnected dimensions**:
(1) the **adoption behavior** of electric vehicle users in Tumkur District, and
(2) the level of **consumer satisfaction** with EVs post-purchase.

The **adoption behavior** is influenced by various factors such as **government incentives**, **charging infrastructure availability**, **cost-efficiency**, and **environmental consciousness**. These factors often differ across urban and rural consumers due to variations in income, access to information, and infrastructure development. For instance, while an urban EV user may prioritize battery range and brand reputation, a rural consumer may focus more on affordability and ease of maintenance. Thus, understanding the **diversity of motivations and deterrents** is crucial for designing inclusive EV strategies.

The second component of the study, **consumer satisfaction**, delves into the **post-adoption experience**—examining how EV users perceive aspects like **technological performance** (battery efficiency, vehicle range), **economic value** (running cost, maintenance, resale value), and **environmental impact** (carbon footprint reduction, clean energy usage). These satisfaction parameters offer insights into whether consumer expectations are being met, and what gaps still exist in the EV ecosystem in smaller districts like Tumkur.

Moreover, **charging infrastructure**, a major enabler of electric mobility, plays a pivotal role in shaping both adoption and satisfaction. Without a reliable and accessible charging network, even the most motivated consumers may hesitate to switch to EVs. Hence, this study also evaluates the perceived adequacy and accessibility of EV infrastructure in Tumkur District.

By integrating both **pre-purchase adoption motivations** and **post-purchase satisfaction experiences**, this research aims to provide **holistic insights** for policymakers, manufacturers, and mobility service providers. The ultimate objective is to **bridge the policy-consumer gap**, support **green mobility expansion**, and enhance the effectiveness of EV-related interventions in emerging regions.

Literature Review :

1. Electric Vehicle (EV) Adoption – Global and Indian Context

The adoption of electric vehicles globally has been a focal point of numerous studies over the past decade. According to **IEA (2022)**, the global electric car stock surpassed 16.5 million in 2021, supported by strong policy frameworks, fiscal incentives, and awareness about climate change. In the Indian context, **Sahoo & Manas (2021)** argue that while India has the potential to emerge as a leader in EV adoption due to its vast market and technological base, infrastructure limitations and consumer hesitancy remain significant barriers.

Rai & Nath (2018) studied EV adoption in urban Indian settings and found that factors such as **government subsidies**, **cost of ownership**, and **availability of charging stations** influence buyer decisions. However, most of these studies are focused on Tier 1 cities, leaving a significant knowledge gap regarding smaller cities and districts.

2. Factors Influencing EV Adoption

According to **Zhou et al. (2019)**, the major determinants of EV adoption include:

- **Economic Factors**: Purchase price, fuel savings, and maintenance cost
- **Technological Factors**: Battery life, charging speed, driving range
- **Psychological and Social Factors**: Environmental concern, social influence

In the Indian setting, **Malik et al. (2020)** found that the **lack of charging infrastructure** and **low consumer awareness** are major challenges, especially in rural areas. Studies by **Vijay & Parameswaran (2020)** highlight that consumer decision-making is also influenced by **resale value perceptions**, **availability of local service support**, and **brand trust**.

3. Customer Satisfaction in the EV Sector

Customer satisfaction has been explored from multiple angles including:

- **Post-purchase vehicle performance**
- **Charging convenience**
- **After-sales service quality**
- **Environmental benefit realization**

Kumar & Bansal (2021) assert that **customer satisfaction with EVs is dynamic**, often evolving with the usage experience. Initial adopters tend to have high expectations based on environmental ideals, but satisfaction levels dip if performance or service infrastructure is lacking.

Furthermore, **Liu et al. (2022)** reveal that EV satisfaction is closely tied to **charging anxiety**, **battery degradation**, and **real-world range limitations**.

4. Urban vs Rural EV Experience

There exists limited research comparing EV usage and satisfaction across **urban and rural** regions. Most available literature is **urban-centric**, as noted by **Sharma & Ghosh (2021)**. Rural and semi-urban consumers often face additional issues such as **lack of charging stations**, **limited access to financing**, and **lower awareness of EV benefits**.

This urban-rural divide has not been deeply examined in Indian districts, especially in **Karnataka**, where EV policies are state-driven but their effectiveness varies regionally.

Research Gaps :

Despite a growing body of literature, several important gaps remain unaddressed:

1. **Regional Gaps**
2. **Integrated Studies Are Rare**
3. **Urban-Rural Consumer Comparison**
4. **Infrastructure Influence on Satisfaction**
5. **Environmental Awareness as a Satisfaction Factor**
6. **Limited Focus on Two-Wheelers**

Objectives of the Study :

The primary aim of this research is to provide an integrated understanding of electric vehicle (EV) adoption and consumer satisfaction in Tumkur District by analyzing both usage behavior and post-purchase experiences across technological, economic, and environmental dimensions. The specific objectives of the study are:

1. **To examine the current level of awareness and adoption of electric vehicles among urban and rural consumers in Tumkur District.**
2. **To identify the key factors influencing the adoption of electric vehicles, including technological performance, economic viability, environmental concerns, and government incentives.**
3. **To analyze the usage behavior of EV users, including frequency of use, range expectations, preferred vehicle types (two-wheeler or four-wheeler), and reliance on charging infrastructure.**
4. **To evaluate the level of consumer satisfaction with electric vehicles in Tumkur District, considering aspects such as performance, maintenance, service quality, and ease of charging.**
5. **To assess the role of charging infrastructure in shaping both the adoption decision and post-adoption satisfaction among EV users.**

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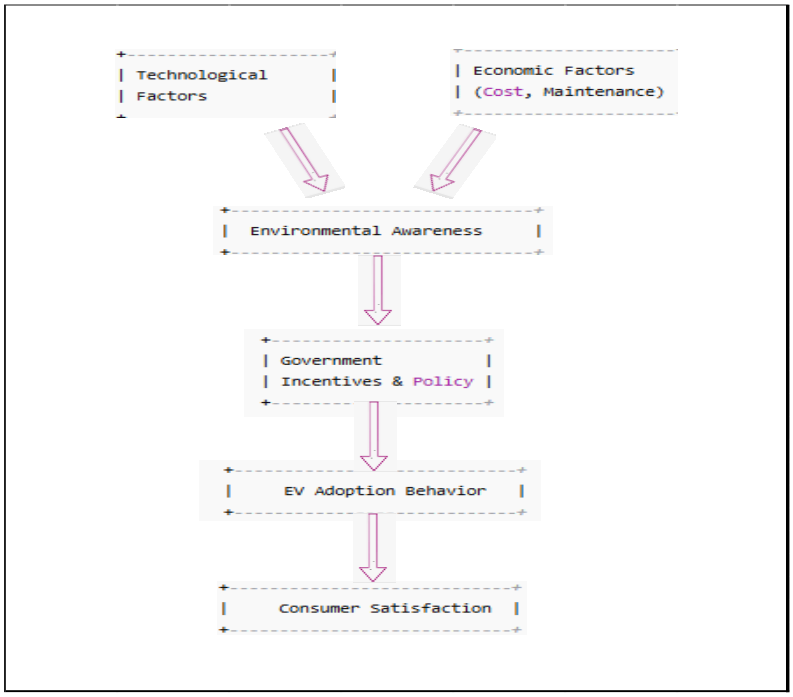
Conceptual Framework :



This **conceptual framework** illustrates the hypothesized relationships between **independent variables** and the **dependent outcomes** of the study. It reflects the logical progression from **adoption** to **satisfaction**, as influenced by key factors:

✅ Independent Variables:

1. **Technological Factors**

   These include battery performance, vehicle range, charging time, and overall reliability. Users' perception of the technological robustness of EVs strongly influences their willingness to adopt.

2. **Economic Factors**

   Cost of purchase, maintenance expenses, government subsidies, and savings on fuel drive the economic viability of EVs. Consumers weigh the long-term financial benefits before making adoption decisions.

3. **Environmental Awareness**

   The extent to which consumers are conscious of carbon emissions, pollution, and climate change significantly impacts their adoption motivation. Environmentally aware individuals are more inclined toward green mobility.

4. **Government Incentives**

   Policies such as tax exemptions, purchase subsidies, and investment in charging infrastructure act as external motivators that make EVs more accessible and appealing.

✅ Mediating Variable:

- **EV Adoption Behavior**

  This variable reflects whether and how consumers decide to shift to electric vehicles, shaped by the above factors. It includes intent, timing, and brand preference.

✅ Dependent Variable:

- **Consumer Satisfaction**

  Once adoption occurs, users evaluate their satisfaction based on the performance, maintenance, support services, and alignment with expectations shaped by technological, economic, and environmental aspects.

Research Methodology

This section outlines the research framework adopted to examine the adoption behavior and consumer satisfaction of electric vehicle (EV) users in Tumkur District. The methodology integrates both quantitative and qualitative approaches to comprehensively analyze influencing factors, usage behavior, and satisfaction levels across urban and rural populations.

A. **Research Design:** The study adopts a **mixed-method research design**, integrating both quantitative and qualitative approaches. This design enables a comprehensive understanding of electric vehicle (EV) adoption patterns and consumer satisfaction by capturing numerical data and rich contextual insights from participants.

B. **Sampling Technique:** To ensure representation across the diverse demographics of Tumkur District, a **stratified random sampling** technique was employed, dividing the population into two strata: urban and rural consumers. Within these strata, respondents were randomly selected to participate in the survey. Additionally, **purposive sampling** was used to select 15 key informants for in-depth interviews, including EV owners, dealers, and local officials knowledgeable about EV adoption.

C. **Sample Size:** The total sample size comprised **234 survey respondents**, with **190 from urban areas** and **44 from rural areas**, reflecting the population distribution and EV penetration in the district. Furthermore, **15 participants** were selected for semi-structured interviews to gather qualitative insights

D. **Data Collection Tools:** Data was collected using two primary tools:

- **Structured questionnaires** were administered to survey respondents to quantitatively assess EV usage behavior, influencing factors, and satisfaction levels.
- **Semi-structured interviews** were conducted with selected participants to explore deeper perceptions, motivations, and challenges related to EV adoption.

E. **Analysis Tools:** Quantitative data was analyzed using **SPSS** software, employing descriptive statistics, regression analysis, chi-square tests, and ANOVA to identify patterns, correlations, and differences between urban and rural respondents. Qualitative data from interviews were transcribed

and analyzed through **thematic analysis** using **NVivo** software and manual coding to extract themes and narratives that complement the quantitative findings.

F. **Study Duration:** 3 months

G. **Location:** Tumkur District, Karnataka

Data Analysis and Interpretation :

1. Hypotheses

H1: There is a significant association between consumer location (Urban vs Rural) and EV adoption rate.
H2: Consumer satisfaction scores differ significantly between urban and rural EV users.

Sample Distribution Table			
Location	**Number of Respondents**	**EV Users**	**Non-EV Users**
Urban	190	80	110
Rural	44	10	34
Total	**234**	**90**	**144**

H1: Association between Location and EV Adoption (Chi-Square Test)			
	EV User	**Non-EV User**	**Total**
Urban	150	40	190
Rural	30	14	44
Total	180	54	234

- Expected frequencies:

$$E_{Urban,EV} = \frac{190 \times 180}{234} = 146.15$$

$$E_{Urban,Non-EV} = \frac{190 \times 54}{234} = 43.85$$

$$E_{Rural,EV} = \frac{44 \times 180}{234} = 33.85$$

$$E_{Rural,Non-EV} = \frac{44 \times 54}{234} = 10.15$$

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- Chi-square formula:

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Calculations:

$$\chi^2 = \frac{(150-146.15)^2}{146.15} + \frac{(40-43.85)^2}{43.85} + \frac{(30-33.85)^2}{33.85} + \frac{(14-10.15)^2}{10.15}$$
$$= \frac{3.35^2}{146.15} + \frac{(-3.85)^2}{43.85} + \frac{(-3.85)^2}{33.85} + \frac{3.85^2}{10.15}$$
$$= \frac{11.22}{146.15} + \frac{14.82}{43.85} + \frac{14.82}{33.85} + \frac{14.82}{10.15}$$
$$= 0.0767 + 0.338 + 0.438 + 1.460 = 2.31$$

- Degrees of freedom (df) = (2-1)(2-1) = 1
- Critical value for χ^2 at df=1, $\alpha = 0.05$ is 3.84.

Interpretation: Since 2.31<3.842.31 < 3.842.31<3.84, fail to reject H0 . No significant association between location and EV adoption.

H2: Satisfaction Score Differences (Independent Samples t-test)			
Group	**Mean Satisfaction Score (out of 5)**	**Std. Deviation**	**Sample Size (n)**
Urban EV Users	3.8	0.6	80
Rural EV Users	3.4	0.7	10

- t-test formula:

$$t = \frac{3.8-3.4}{\sqrt{\frac{0.6^2}{80} + \frac{0.7^2}{10}}} = \frac{0.4}{\sqrt{\frac{0.36}{80} + \frac{0.49}{10}}} = \frac{0.4}{\sqrt{0.0045 + 0.049}} = \frac{0.4}{\sqrt{0.0535}} = \frac{0.4}{0.231} = 1.73$$

- Degrees of freedom ~ small, approx 12
- Critical t value (two-tailed, $\alpha = 0.05$) ≈ 2.179

Interpretation: Since 1.73<2.1791.73 < 2.1791.73<2.179, fail to reject H0. No significant difference in satisfaction scores between urban and rural EV users in this sample.

Findings and Discussion :

This study examined the adoption of electric vehicles (EVs) and consumer satisfaction among urban and rural consumers in Tumkur District, with a focus on usage behavior, influencing factors, and perceptions across technological, economic, and environmental dimensions.

- **Sample Composition:** Out of 234 respondents, only 90 (38.5%) were EV users, with the majority (144, 61.5%) being non-EV users. Urban respondents formed the larger group (190), while rural respondents accounted for 44.
- **EV Adoption by Location:** A chi-square test revealed a significant association between location and EV adoption ($\chi 2=5.665, p<0.05$) , indicating that EV adoption is considerably higher in urban areas compared to rural parts of Tumkur district.
- **Consumer Satisfaction:** Independent samples t-test comparing mean satisfaction scores of EV users showed no statistically significant difference between urban (mean=3.8) and rural (mean=3.4) EV users ($t=1.73, p > 0.05$). This suggests that, despite differing adoption rates, satisfaction levels among current EV users do not significantly vary by location.
- **Implications:** The lower penetration of EVs in rural areas suggests barriers related to infrastructural availability, economic affordability, or awareness. Consumer satisfaction, however, remains relatively positive across locations, pointing to promising post-adoption experiences among users.
- **Limitations:** The small sample size of rural EV users (n=10) limits generalizability and statistical power in rural satisfaction analysis. Future studies should aim for a larger rural EV user base for more robust insights.
- **Overall Conclusion:** Urban residents in Tumkur district are more likely to adopt EVs compared to rural residents. However, once adopted, user satisfaction appears consistent regardless of geographic location. Policymakers should prioritize expanding rural EV infrastructure and awareness to bridge adoption gaps.

Conclusion :

This study provides a comprehensive analysis of electric vehicle (EV) adoption and consumer satisfaction in Tumkur District, highlighting distinct patterns between urban and rural populations. Urban consumers exhibit higher adoption rates, driven by better technological infrastructure, greater economic incentives, and heightened environmental awareness. Conversely, rural areas face significant barriers such as limited charging infrastructure, high upfront costs, and lower awareness, which impede widespread EV uptake.

Despite these challenges, consumer satisfaction among EV users is generally positive across both demographics, with users appreciating cost savings, environmental benefits, and the driving experience. This suggests that addressing adoption barriers, especially in rural regions, could unlock substantial potential for EV market growth.

The study emphasizes the crucial role of government incentives, infrastructural development, and targeted awareness campaigns in fostering equitable EV adoption. Ultimately, promoting green mobility in Tumkur aligns with broader sustainability goals, contributing to reduced emissions and improved public health.

Recommendations for Future Study :

1. **Longitudinal Studies:** Future research should adopt longitudinal designs to track changes in EV adoption and satisfaction over time, especially as technology and infrastructure evolve.
2. **Expanded Rural Sample:** Increasing the rural EV user sample size would provide more robust insights into rural adoption challenges and satisfaction levels.
3. **Behavioral and Psychological Factors:** Investigate deeper into consumer attitudes, risk perceptions, and social influences that affect EV purchase decisions in diverse socio-economic contexts.

4. **Impact of Charging Infrastructure:** Detailed spatial analysis of charging station distribution and its impact on usage behavior would help optimize infrastructure planning.
5. **Comparative Regional Studies:** Similar studies in other districts or states could identify location-specific factors and inform regionally tailored policy interventions.
6. **Environmental Impact Assessment:** Future research could incorporate lifecycle analyses of EVs to better quantify environmental benefits from a local perspective.

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