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ELECTRIC VEHICLE ADOPTION FOR SUSTAINABLE DEVELOPMENT IN PALAKKAD: CUSTOMER AWARENESS, SATISFACTION POLICY, AND MANUFACTURING STRATEGY

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ABSTRACT

This research investigates the increasing usage of electric vehicles (EVs) in Palakkad, emphasizing customer awareness, satisfaction, government policy, and manufacturing strategies, with a focus on advancing sustainable development. Due to increased environmental worries and a shift towards more sustainable transportation, electric vehicles provide a green option compared to conventional gasoline-powered cars. The research is focused on evaluating how well customers understand the advantages and drawbacks of electric vehicles, their contentment with current EV options and infrastructure, and the impact of government policies on promoting EV usage. Moreover, the study investigates the production methodologies of both local and national car manufacturers, pointing out the obstacles and chances of expanding the EV manufacturing strategy to keep up with increasing demand. Data is gathered from urban and suburban areas of Palakkad to gain a thorough understanding of consumer behavior and market dynamics. This study also explores the strategies to boost EV adoption, such as rewards, financial support, and improving infrastructure such as charging points. The results seek to enhance knowledge on how EV adoption can be boosted in semi-urban areas such as Palakkad to promote environmental sustainability and economic growth in the long run.

Keywords: Sustainability, Infrastructure, Environment, Demand, Strategy

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1. INTRODUCTION

India's EV industry is experiencing rapid growth! What is the reason behind it? Thanks to assistance from the government, growing concerns about the environment, and advancements in technology. Initiatives such as FAME, which stands for Faster Adoption and Manufacturing of Hybrid and Electric Vehicles, are strongly advocating for an increase in EVs. The nation's ambitious target is to ensure that by 2030, 30% of private vehicle sales are electric vehicles, as well as 70% for commercial vehicles, 40% for buses, and a staggering 80% for two- and three-wheelers. This implies that there may be around 80 million EVs on the streets of India in the near future. Furthermore, they aim to produce these electric vehicles domestically through the 'Make in India' campaign.

In 2023, the global market for EVs was worth around $255.54 billion. Amazing, right? That amount is expected to soar above $2 trillion by 2033! In India alone, there has been a huge bump in sales—up by 49.25% in 2023—with 1.52 million units sold. Experts think the market value could climb from $3.21 billion in 2022 to about $114 billion by 2029 and charging stations are rising too! By February 2024, around more than 12,146 public charging stations located throughout the nation. Maharashtra & Delhi are leading this charge—no pun intended—as companies like Hyundai & Ola work on expanding things for EV drivers. Different states have set unique goals too; for instance, Maharashtra wants about 10% of new vehicle registrations to be EVs by 2025 while Karnataka aims to switch all cargo vehicles to electric by 2030! Partnerships are forming as well; like BM Electric Vehicles teaming up with MUON India & Uno Minda connecting with Suzhou Inovance showing how rapidly things are speeding up. Oh! And Ola Electric just launched its new electric autorickshaw (Electric Vehicle Industry Report, 2024)

The government isn't stopping there either. They are giving customs duty exemptions for lithium-ion battery production and have invested $1.43 billion through the FAME II scheme to help out further. Plus, they're planning to convert around 800,000 diesel buses into electric ones—how cool is that? The Electric Mobility Promotion Scheme is starting with a budget of about $60.18 million aimed at boosting sales of electric two- & three-wheelers as well. Altogether these efforts are in line with that awesome goal: reaching 30% electric mobility by 2030 and showing the world how India can lead in green transportation.

Sustainable consumption and Production (SCP), which matches SDG (Sustainable Development Goal) 12, matters big time since we're using resources faster than we should (Wang et al., 2019). Between 2010 and 2017, the global material footprint jumped from about 73 billion tons to nearly 86 billion tons by 2050 if we keep going this way—oh no—we might need resources from THREE planets just to keep up

China, the United States, and India, the largest sources of greenhouse gas emissions, account for 42.6% of worldwide emissions, while the other 100 countries contribute only 2.9% (World Resource Institute, 2023). Luckily, electric cars provide a positive resolution by decreasing emissions and cutting down on transportation costs as shown by Rezvani et al. (2015) and Tarei et al. (2021). The NEMMP and FAME Indian policies aim to encourage the use of electric vehicles by taking advantage of the country's vast road network and strong position in the automotive sector. Despite the numerous excellent ideas available, the public still lacks high acceptance of electric vehicles. The new goal is to ensure that 33% of total car sales by 2030 consist of electric vehicles (Khurana et al., 2020). Perceptions of electric vehicles and the availability of charging stations are also significant factors in the scenario. More research is required to understand what is dampening the excitement of Indian communities.

In India where demand keeps rising alongside economic growth -there's hope Evs will play their part nicely in improving sustainability overall while reducing reliance on fossil fuels –we have goals set ambitiously getting us towards extensive use of electricity-powered rides across various niches. Palakkad district especially serves as a prime ground for exploring usage patterns given its growing suburbs populated gradually over time making strides personally achievable together boosting momentum everywhere!

These advantages involve reducing greenhouse gas emissions and enhancing air quality primarily due to higher energy efficiency resulting in savings in repair costs despite budget limitations. While there are still several obstacles, such as upfront expenses for purchasing new technology and concerns about limited range impacting daily commute comfort, the slow progress in infrastructure development also makes potential buyers hesitant (Kempton&Letendre, 1997).

Understanding the benefits is an important factor driving the adoption trends forward, with many individuals nationwide hesitant to fully embrace new materials and technologies due to a lack of comprehension. This can lead to confusion and frustration, as well as a tendency to prioritize style over quality assurance. Awareness of these risks is essential in order to fully appreciate the possible gains brought about by advancements in civilization. (Caperello&Kurani, 2011)

2. LITERATURE REVIEW

Customer satisfaction plays a vital role in the widespread acceptance of electric vehicles (EVs). According to Omahne et al., (2021), key factors such as battery life, charging infrastructure, and after-sales services significantly influence consumer satisfaction. Enhancing these areas, particularly in suburban regions where infrastructure is often underdeveloped, can lead to higher EV adoption rates. Government policies also play an important part in this process.

Tarei, Chand, and Gupta (2021) highlighted that initiatives like India's The goal of the FAME scheme is to encourage the embracing of electric vehicles by offering subsidies and incentives. However, challenges persist, especially with the inadequate development of charging infrastructure and the need for stronger financial incentives. On the manufacturing side, strategic approaches are essential for sustainable growth. Mukherjee and Ryan (2020) emphasized the importance of cost reduction, technological innovation, and the local production of EV components to foster a domestic manufacturing ecosystem. Collaboration between manufacturers and policymakers is critical for overcoming these challenges. Furthermore, Mukherjee and Ryan (2020) pointed out that region-specific studies, particularly in smaller districts like Palakkad, are lacking, which hampers a thorough understanding of local consumer awareness and acceptance of EVs. Rezvani, Jansson, and Bodin (2018) also noted the need for focused research on consumer behavior toward high-end products like EVs, especially in developing countries like India. They suggest that psychological and socio-technical factors influencing EV adoption should be explored, particularly in suburban areas. From an environmental perspective, Jochem, Babrowski, and Fichtner (2015) demonstrated that the adoption of EVs can significantly reduce greenhouse gas emissions, particularly in crowded regions when paired with sustainable energy sources. The significant environmental advantages of combining EVs with clean energy solutions underscore the importance of widespread EV use.

2.1. OBJECTIVES

Evaluate the current level of electric vehicle (EV) usage in Palakkad by analyzing customer awareness, satisfaction, government policy, and manufacturing strategies to identify opportunities for promoting sustainable growth and increasing EV adoption in both urban and suburban areas.

3. METHODS

The main information for this study was gathered via a survey created following discussions with a limited number of EV customers, experts, and marketers. The survey consisted of 81 questions, 7 of which were about demographics while the rest covered topics such as customer awareness, satisfaction, social perception, government policy, and manufacturing strategies for electric vehicles. 135 questionnaires were distributed for the sample size, with 125 returned; 10 were disregarded due to incomplete information, resulting in 115 valid responses. Because the research focused on Palakkad district, the number of participants was limited to 115. The collected data was entered, coded, and grouped for analysis using four key tools: simple percentage for multiple responses, factor analysis, and Structural Equation Modelling (CFA).

4. RESULTS AND DISCUSSION

Table 1 Demographic Profile of the Respondents

S.No	Gender	No. of respondents	Percent
1	Male	64	55.7
2	Female	51	44.3
	Total	115	100.0
S.No	**Age**	**No. of respondents**	**Percent**
1	18-25	36	31.3
2	25-35	31	27.0
3	35-45	27	23.5
4	Above 45	21	18.3
	Total	115	100.0
S.No	**Marital Status**	**No. of respondents**	**Percent**
1	Married	87	75.7
2	Unmarried	28	24.3
	Total	115	100.0
S.No	**Education**	**No. of respondents**	**Percent**
1	Graduate UG/PG	61	53.0
2	Professional	54	47.0
	Total	115	100.0
S.No	**Residing Region**	**No. of respondents**	**Percent**

1	Semi - Urban	74	64.3
2	Urban	41	35.7
	Total	115	100.0
S.No	**Occupation**	**No. of respondents**	**Percent**
1	Student	36	31.3
2	Professional	56	48.7
3	Entrepreneur	23	20.0
	Total	115	100.0
S.No	**Income**	**No. of respondents**	**Percent**
1	Less than 10000	36	31.3
2	10001 - 30000	9	7.8
3	30001 - 50000	47	40.9
4	50001 and above	23	20.0
	Total	115	100.0
S.No	**Currently own or use an electric vehicle**	**No. of respondents**	**Percent**
1	Yes	115	100.0
		115	100.0
S.No	**How Often Use EV**	**No. of respondents**	**Percent**
1	Daily	38	33.0
2	Several times a week	64	55.7
3	Once a week	13	11.3
	Total	115	100.0

Source: Primary Data

The information presented in the Table No 1 sheds light on the demographic distribution of 115 survey participants and provides fascinating insights into their use of electric vehicles (EVs). When it comes to gender, there is 55.7% male, and the rest 44.3% female, showing a fairly even level of involvement. Most of the participants are aged between 18-25 (31.3%) and 25-35 (27%), while the fewest belong to the over 45 age group (18.3%). The majority of participants are married (75.7%), with 53% holding a graduate degree and 47% working as professionals. A significant number of survey participants live in semi-urban regions (64.3%), showing that EV usage is growing outside of cities. In terms of profession, approximately 48.7% are professionals, while students make up 31.3% and entrepreneurs account for 20% of the group. Income distribution varies, with the majority earning between ₹30,001 and ₹50,000 (40.9%), followed by those earning less than ₹10,000 (31.3%). All participants own or use an electric vehicle, with 55.7% using it multiple times per week, and 33% using it each day. This shows a significant reliance on electric vehicles for everyday transportation requirements. The information indicates that people in various age, income, and occupation categories are increasingly embracing electric vehicles, with semi-urban residents and professionals playing a significant role in this trend.

Table 2 Multiple Response for Stimulating factors usage of EV

Stimulating Factors	**Responses**		**% of Cases**	**Rank**
	N	**Percent**		
Environmental concerns	102	10.0%	88.7%	V
Cost savings	104	10.2%	90.4%	III
Convenience	103	10.1%	89.6%	IV
Health benefits	105	10.3%	91.3%	II
Government incentives	103	10.1%	89.6%	IV
Reduced noise pollution	103	10.1%	89.6%	IV
Home charging convenience	115	11.3%	100.0%	I
Long-term sustainability	90	8.8%	78.3%	VIII
Technological innovation	92	9.0%	80.0%	VII
Energy independence	100	9.8%	87.0%	VI
Total	**1017**	**100.0%**	**884.3%**	

Source Primary Data

The data from the above Table No 2 shows something interesting! Home charging convenience is the top reason people choose it, with 100% saying it's important. Right after that, we have Health benefits, which is at 91.3%, and then Cost savings at 90.4%. Other things, like Convenience, Government incentives, & less noise pollution, are equally important too—89.6% of folks felt that way. This shows that practical benefits and how society feels about it matter. Now, let's talk about Environmental concerns. They matter a lot too, at 88.7%, but they're not quite as important as those immediate personal benefits. Energy independence comes next with 87%, and Technological innovation stands at 80%. Both are key in the decision-making process finally, Long-term sustainability is last on the list at 78.3%. It seems like while sustainability is vital, people still focus more on the short-term benefits that they can see and feel right away.

Table 3 Stimulating factor of electric vehicle (EV), Palakkad City KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.854
Bartlett's Test of Sphericity	Approx. Chi-Square	1443.670
	df	78
	Sig.	.000

Table 4 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.823	60.175	60.175	7.823	60.175	60.175	4.085	31.427	31.427
2	1.372	10.556	70.732	1.372	10.556	70.732	3.482	26.787	58.214
3	1.259	9.688	80.419	1.259	9.688	80.419	2.887	22.205	80.419

Extraction Method Principal Component Analysis.

The preceding Tables 3 & 4, illustrate the outcome of factor analysis using principal components analysis with the Varimax rotation technique. The KMO and Bartlett's test indicated that the Kaiser Mayer Olkin measure of sampling adequacy is 0.854 with a significance value below 0.000, indicating the variables are statistically significant and factor reduction can be performed. Based on Table 4, the researcher concluded that 13 variables formed five groups with Eigen values above 1, collectively accounting for approximately 80% of the awareness of electric vehicles in Palakkad City.

The first factor, labeled "Manufacturing strategy," includes 6 variables: Supply Chain Sustainability (0.824), Advanced Manufacturing Technologies (0.781), Labor Training and Development (0.777), Efficiency Optimization (0.750), Carbon Footprint Reduction (0.739), and Investment in Research and Development (0.724). Factor 2, comprising Incentives for Purchases (0.841), Subsidies for Infrastructure Development (0.825), Emissions Reduction Targets (0.815), and Integration with Renewable Energy (0.787). Were combined and labeled as "Government Strategy". The third component consists of three variables: Environmental Friendliness (0.893), Societal Responsibility (0.851), and Luxury and Status (0.846). Were assembled and labeled as "Social Perception".

Hence, the researcher determined that the primary factor labeled "Manufacturing strategy" with 6 variables is significantly influencing Electric Vehicle awareness in Palakkad City more than the other factors, as displayed in the table above. Because of time constraints, the researcher was unable to conduct additional multivariate analysis to determine the relative importance of each factor.

Table 5 Goodness of Fit test for CFA

Name of category	**Name of index**	**Threshold**	**Index Value**
Absolute Fit measure	CMIN/Df	Between 1 and 3	1.700
	GFI	> 0.90	0.911
	AGFI	> 0.90	0.850
	RMSEA	< 0.10	0.078
	PClose	> 0.50	0.065
Incremental fit measure	NFI	> 0.90	0.926
	CFI	> 0.90	0.967

	TLI	> 0.90	0.953
	IFI	> 0.90	0.968
Parsimonious fit measure	PGFI	> 0.50	0.538
	PCFI	> 0.50	0.674
	PNFI	> 0.50	0.645

From the above Table No 5, It is clearly denoted that the understanding of Electric Vehicles (EVs) is measured in several ways. We examine the complete adequate fit, gradual fit, and concise fit. The results show a nice fit for the model some important numbers are CMIN/Df (1.700), GFI (0.911), and RMSEA (0.078). These all suggest that the model matches the data pretty well. Also, when we check the incremental fit measures like NFI (0.926), CFI (0.967), & TLI (0.953), they are above 0.90, which is great! The parsimonious fit indices—like PGFI (0.538), PCFI (0.674), and PNFI (0.645)—also meet the required levels. This means our model is both good and simple.

Now, let's talk about 15 different variables that relate to EV awareness. They are split into two groups based on how they load onto the factors. Group 1 is called Vehicle Performance & Economic Viability and has eight variables. These include things like being eco-friendly, saving money, how EVs perform compared to regular cars, charging time, maintenance costs, long-term fuel savings, initial costs, & resale value. All these show how much people care about practical and financial stuff when thinking about owning an EV.

Group 2, which we call Infrastructure & Public Perception, includes seven variables too! This group looks at things outside of the cars themselves—like where you can find charging stations, what government incentives exist, feelings about range anxiety, brand awareness, the impact on air quality, general public thoughts on EVs, & how charging infrastructure is growing. It shows that society and facilities play a big part in getting people to accept EVs. So overall? Both inside factors—like performance & cost—and outside factors—like infrastructure & public opinion—are super important in creating awareness and acceptance of electric vehicles.

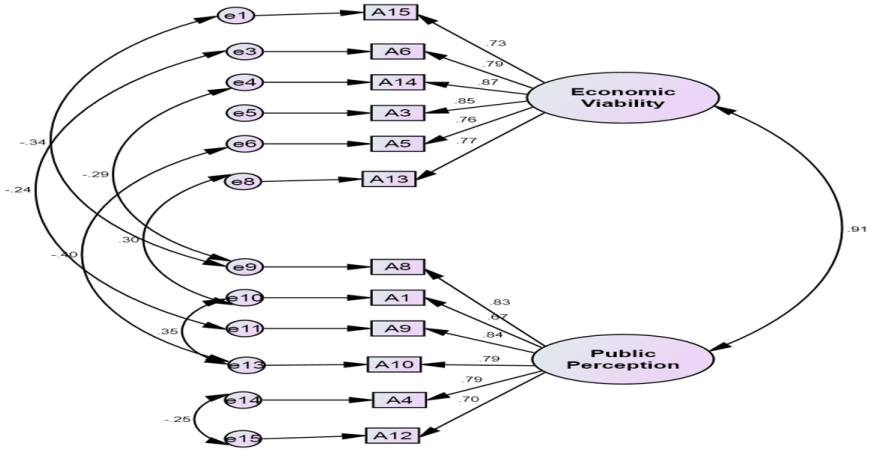

Figure 1 CFA model with standardized factor loading

Table 6 Goodness of Fit test for CFA - Satisfaction level of electric vehicle (EV)

Name of category	Name of index	Threshold	Index Value
Absolute Fit measure	CMIN/Df	Between 1 and 3	1.929
	GFI	> 0.90	0.938
	AGFI	> 0.90	0.854
	RMSEA	< 0.10	0.090
	PClose	> 0.50	0.069
Incremental fit measure	NFI	> 0.90	0.954
	CFI	> 0.90	0.977
	TLI	> 0.90	0.956
	IFI	> 0.90	0.956
Parsimonious fit measure	PGFI	> 0.50	0.515
	PCFI	> 0.50	0.396
	PNFI	> 0.50	0.503

The Above Table No 6 examined the CFA level of satisfaction among users of electric vehicles (EVs). The findings were obtained from a Goodness of Fit test that employed various measures. The fit metrics indicated that the model is performing quite effectively. The reason for the 1.929 CMIN/df ratio being considered good is because it falls within the acceptable range of 1 to 3.

Afterward, the Goodness of Fit Index (GFI) was measured at 0.938. This exceeds the 0.90 threshold, indicating a robust match. Nonetheless, the AGFI was slightly low at 0.854, suggesting that small adjustments could enhance the situation. The RMSEA was 0.090, suggesting a reasonable fit, however, the PClose was at 0.069, slightly below the acceptable threshold. Now, let's examine the incremental fit metrics - they returned with excellent results! The NFI achieved a score of 0.954. The CFI showed an even improved performance with a value of 0.977 Furthermore, the Tucker-Lewis Index (TLI) and Incremental Fit Index (IFI) both exceeded 0.90, reaching 0.956. This indicates that the model has a strong fit with the data in comparison to a null model. Transitioning to measures of a tight fit, we discovered that the Parsimony Goodness of Fit Index (PGFI) landed perfectly at 0.515, indicating that the model is sufficiently straightforward. However, the Parsimony Comparative Fit Index (PCFI) of 0.396 and Parsimony Normed Fit Index (PNFI) of 0.503 fell slightly below our desired levels, indicating that although it is relatively simple, some modifications could enhance its performance.

The analysis covered 15 variables split into two groups! Group 1 is called "Vehicle Performance and Usability." It includes things like Battery Life, Charging Station Availability, Range per Charge, Charging Speed, Performance, Comfort, and Handling. These factors play a big role in how well EVs work and how happy users feel about them. Group 2 goes by "Customer Satisfaction and Value." It has Interior Space, Exterior Design, Technology Features, Reliability, Safety Features, Price, Resale Value, and Environmental Impact included in this group! These factors reflect what customers think about their EV's overall value and how it matches their hopes regarding usefulness, design, cost & sustainability.

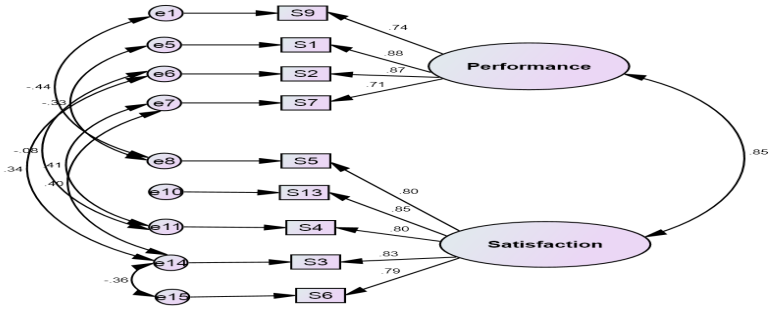

Figure 2 CFA model with standardized factor loading

5. CONCLUSION

In conclusion, the study reveals that electric vehicle (EV) adoption in Palakkad is driven primarily by practical benefits such as home charging convenience, health advantages, and cost savings, with environmental concerns and sustainability playing a slightly secondary role. The findings highlight that while EV usage is growing significantly in semi-urban areas, customer satisfaction is largely influenced by vehicle performance, infrastructure availability, and economic viability. Manufacturing strategies focusing on sustainability, advanced technologies, and labor development, alongside supportive government policies like incentives and infrastructure subsidies, are critical to fostering EV adoption. Although societal perception of EVs as eco-friendly and socially responsible is important, the focus remains on tangible benefits like affordability, performance, and convenience. To enhance EV adoption in semi-urban regions like Palakkad, improvements in public infrastructure, further government incentives, and addressing customer satisfaction are essential for promoting sustainable development and long-term economic growth.

CONFLICT OF INTERESTS

None.

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