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Adoption Of Electric Cars In Uttarakhand: Analysing Consumer Preferences, Environmental Awareness, And Economic Impact.

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ABSTRACT
The increasing adoption of electric cars is pivotal for sustainable transportation and the reduction of carbon emissions. This paper examines the factors influencing the adoption of electric cars in Uttarakhand, focusing on consumer preferences, levels of environmental awareness, and the associated economic impacts. Through a mixed-methods approach, primary data was collected via surveys and interviews with potential consumers, government officials, and industry experts. Key variables such as affordability, infrastructure availability, charging convenience, and environmental consciousness are analysed to understand consumer choices. Additionally, the study explores how environmental awareness impacts consumer behaviour and the perceived economic benefits, including job creation in the green energy sector, cost savings for consumers, and the potential reduction in the state's dependency on fossil fuels. The findings suggest that while there is growing interest in electric cars, significant barriers related to cost and infrastructure remain. Policy recommendations are provided to accelerate adoption, enhance consumer education, and foster a supportive economic environment.
Keywords: Electric Vehicle Adoption, Consumer Preferences, Environmental Awareness, Economic Impact, Uttarakhand

1. INTRODUCTION:

There is the need to shift towards the use of electric vehicles (EVs) globally in the fight against climate change and the overreliance on fossil fuels. Current, transportation is estimated to produce approximately 23% of the world's carbon footprint with traditional IC Engine vehicles playing a huge chunk of it [IEA, 2022]. The use of electric cars can be seen as a viable solution since they emit less greenhouse gases when mined with renewable energy sources (Sharma & Patel, 2021). India has aimed at the eradication of fossil fuel vehicles with the help of government incentives, subsidies, and the increasing number of electric vehicles charging stations (Singh et al., 2023). "But even with these national initiatives in place, the pace at which EVs are moving into new drivetrain options such as those in Uttarakhand is still slow. The state's geographical features and demography, as well as the ability to set up charging points are a blessing and a curse in electrifying the state's cars. Although the colossal cities starting with Dehradun are embracing the EVs, the same is not the case for rural areas because the charging point is a major issue, supplemented by high costs, and minimum awareness (Rana & Gupta, 2022). To determine the influences of the decision to purchase as well as the barriers to buying EVs in Uttarakhand, this work needs to outline consumer trends, attitudes to the environment, and the costs associated with switching to EVs.

The trends in consumers' preferences are vital in influencing the rate at which the acceptance of electric vehicles will take place. A few research by authors have also emphasized that cost, mileage capacity, and charging points are key factors influencing prospective buyers in acquisition of EVs (Srinivasan et al., 2022). In the case of electric vehicles in Uttarakhand, these barriers are worsened by the fact that the region has relatively hills meaning the battery will not perform as expected and there are high stakes regarding the car's reliability (Verma & Joshi, 2021). Furthermore, consumers in local markets are likely to be price-conscious, and many may opt for traditional cars and Sugma because the initial cost of EVs may be expensive even if it is cheaper in the long run, according to Mehta (2022). Another important aspect of culture that affect the buying behaviour of consumers is environmental sensitivity. All around the world, concerns for the environment lead electric vehicle adoption (Thakur & Singh, 2020). As environmental issues are very important to the people of Uttarakhand, where tourism is an essential part of the economy that relies on environmental protection, it is reasonable to assume that the state's residents are more environmentally conscious, which would translate into more interest in sustainable transportation. However, as observed from prior research, people in general appreciate the need to protect the environment, but they are not fully conversant with how electric vehicles aid in environmental protection (Rana & Gupta, 2022). To promote environmentally driven purchase intentions it becomes necessary to fill this knowledge gap. The economic implications of transitioning to electric vehicles in Uttarakhand are complex. On the one hand, EVs have significant cost-effectiveness in the long run, underlined by the lower cost of fuel and maintenance, along with the ability to spur economic growth industries associated with green technologies (Sharma & Patel, 2021). There are economic prospects too; while on one hand initial cost of EVs are high and on the other, the state does not have large amount of money to invest in the infrastructure. Besides, there is the interrelated aspect of change in energy demand as

anticipated transformation to electric vehicles may affect Uttarakhand's energy balance.

To the present, the state depends on hydroelectric power and imported fossil fuel to supply the state's energy needs (Gupta & Rawat, 2023). The shift to electric transport would probably make the state less dependent on the supplies of energy and petrol, if the expansion of EVs is going along with the development of clean technology in shape of solar and wind power as proposed by Bhatt (2022) Following the global concern for climate change, the government of the Uttarakhand has started implementing policies that would foster the use of electric cars.Government owns National Electric Mobility Mission Plan 2020 which offers certain amount of monetary benefits for electric vehicle owners and buyers and targets to increase penetration of electric vehicles in the country (Ministry of Heavy Industries, 2021).the state's identity, one might expect a higher level of environmental awareness and, consequently, a stronger inclination towards sustainable transportation. However, studies suggest that while the general population acknowledges the importance of environmental protection, there is still limited understanding of how electric vehicles contribute to reducing carbon footprints and improving air quality (Rana & Gupta, 2022). Addressing this knowledge gap is essential for encouraging environmentally motivated purchasing decisions. The economic impact of adopting electric vehicles in Uttarakhand is multifaceted. On the one hand, EVs offer long-term economic advantages, such as reduced fuel costs, lower maintenance expenses, and the potential to stimulate local industries related to green technologies (Sharma & Patel, 2021). On the other hand, the high initial cost of EVs and the state's limited financial resources for infrastructure development present economic challenges. Furthermore, the shift to electric vehicles could have significant implications for Uttarakhand's energy consumption patterns. Currently, the state relies on a mix of hydroelectric power and imported fossil fuels to meet its energy demands (Gupta & Rawat, 2023). A transition to electric mobility could increase the state's energy independence, especially if the growth of EVs is coupled with investments in renewable energy sources like solar and wind power (Bhatt, 2022). Given the growing recognition of climate change and the need for sustainable transportation solutions, Uttarakhand's government has begun to explore policies that can accelerate the adoption of electric vehicles. The National Electric Mobility Mission Plan (NEMMP) 2020, launched by the Government of India, provides financial incentives for electric vehicle buyers, and aims to achieve significant penetration of EVs across the country (Ministry of Heavy Industries, 2021).

An equally important determinant of these initiatives is the level of acceptance of electric vehicles by the public. Research also indicates that consumers perceive price promotions, which are an application of economic theory incentives, but also the sociocultural applicability of the product and the general awareness of the environmental impact of using the product (Pandey et al., 2022). This seems to be owing to what people perceive as high costs for the electric vehicles, general worry about the accessibility of charging stations and sufficient car maintenance in rural territories (Dixit & Kumar, 2021).

Furthermore, the knowledge about the long-term utilities of EVs among the consumers of Uttarakhand has not been significantly developed yet. According to the recent government survey conducted by the Indian Council for Research on International Economic Relations (ICRIER), only 35 percent respondents in Uttarakhand understood the incentives to buy electric cars and an even lesser number had ever thought about changing from the customary ICEVs to electric cars (ICRIER, 2023).h concerns about the availability of charging stations and vehicle maintenance in remote areas, creates skepticism among potential buyers (Dixit & Kumar, 2021).

Moreover, consumer awareness of the long-term benefits of electric vehicles—both economic and environmental—remains limited in Uttarakhand. A recent survey by the Indian Council for Research on International Economic Relations (ICRIER) revealed that only 35% of respondents in Uttarakhand were aware of the government's incentives for purchasing electric cars, and an even smaller percentage had considered switching from conventional to electric vehicles (ICRIER, 2023). This shows that there is low awareness among the public on some of these issues, which should be corrected through campaigns and education. Sharma and Patel (2021) report that understanding attitudes which are supportive of cost-saving, environmental impacts of electric vehicles, technological enhancements become effective public communication strategies to counteract resistance Another important consideration influencing the use of EVs in Uttarakhand is infrastructure growth. Prime among them is the charging infrastructure, or the lack of it, to be precise. Moreover, more urban centres like Dehradun and Haldwani now have increasing charging points for EVs, rural areas remain underrepresented (Gupta & Joshi, 2022). Since the area of the state as well as the terrain varies greatly charging infrastructure is the key to address the range anxiety and practicality of owning an electric car in Uttarakhand. Real life examples including Norway and the Netherlands reveal that there is need to invest more in infrastructure as a way of ensuring that there is a increase in the uptake of EVs (Bjerkan et al., 2016).

Significance of the Study

The adoption of electric vehicles (EVs) holds transformative potential not only for environmental sustainability but also for economic growth, particularly in developing regions like Uttarakhand. This study is significant because it provides an in-depth understanding of the factors that influence consumer behaviour and preferences regarding electric cars in a unique geographical and socioeconomic context. Uttarakhand's topography, economic structure, and evolving infrastructure present distinct challenges and opportunities for EV adoption. By analysing consumer preferences and environmental awareness, this research fills a crucial gap in understanding how regional characteristics affect EV acceptance. Furthermore, the study's focus on the economic impact of electric vehicles

in Uttarakhand, including job creation, cost savings, and energy independence, highlights the broader socio-economic implications of a transition to electric mobility. With governments pushing for sustainable development, this research provides policy recommendations that could serve as a roadmap for accelerating EV adoption not only in Uttarakhand but also in other similarly situated regions. Ultimately, the findings of this study could contribute to a more sustainable transportation system, fostering economic development while mitigating the environmental footprint of the state's growing transportation needs.

Review of Literature

Growing worries about climate change, energy security, and air pollution have driven a worldwide movement towards electric vehicles (EVs). From consumer behaviour and technology developments to government regulations and infrastructure development, several studies have examined the elements affecting EV acceptance. Focussing on three main areas pertinent to the acceptance of electric vehicles—consumer preferences, environmental consciousness, and the economic effect of electric mobility—this review synthesises the body of available material.

Many research have looked at the elements influencing consumer choices for electric cars. According to Sovacool and Axsen (2018), personal reasons like environmental awareness, financial gains, and technical curiosity significantly affect people's choice of electric vehicles. Hardman et al. (2017) contend, however, that major obstacles include range anxiety, expensive upfront prices, and inadequate charging infrastructure stop more general use. Jabeen et al. (2021), who conducted a poll in India and discovered that although customers are generally interested in the environmental advantages of EVs, they remain reluctant owing of worries about the shortage of charging facilities and the high initial price of electric automobiles.

In Uttarakhand, the geographical obstacles—hilly terrain and lengthy distances between cities—cause additional problems. Verma and Joshi (2021) propose that the terrain of the state might cause consumers to have more range anxiety as battery loss causes electric vehicles to perform less in hilly places. Moreover, Dixit and Kumar (2021) discovered that customers in rural and semi-urban regions are less inclined to embrace electric cars because they believe EVs are unreliable for long-distance travel across challenging terrain. Government subsidies and incentives might assist remove these obstacles, according to Srinivasan et al. (2022), but only if supported by focused educational programs to increase consumer knowledge of the long-term cost benefits of EVs.

Consumer tastes for environmentally friendly items, like electric cars, are much shaped by environmental consciousness. Environmentally aware customers are more inclined to use electric vehicles, according to Rezvani et al. (2015), as they believe they have a less carbon footprint and help to improve the air quality. In India, Thakur and Singh (2020) found that customers who were more environmentally conscious were more likely to view electric vehicles as a reasonable substitute for conventional internal combustion engine cars. Likewise, Kumar et al. (2020) showed that customer intentions to use electric vehicles are much influenced by environmental consciousness, particularly in metropolitan regions where air pollution is becoming more and more problematic.

Still, the degree of environmental awareness differs depending on where one lives. Particularly with Uttarakhand's natural terrain and emphasis on eco-tourism, environmental preservation is closely entwined with local culture. Notwithstanding this, Rana and Gupta (2022) contend that although the general public knows the need of environmental preservation, little knowledge of how electric cars support sustainability. This knowledge gap emphasises the need of focused awareness efforts connecting EV adoption with more general environmental objectives, like lowering air pollution and mitigating climate change. This links EV adoption with Sharma and Patel (2021) contend that boosting adoption depends on raising public knowledge of the environmental advantages of electric cars, particularly in areas like Uttarakhand, where environmentally friendly substitutes are much sought for.

Adoption of electric vehicles has several economic consequences that influence not only personal consumers but also the larger society. Melton et al. (2017) stress that over time the entire cost of ownership of an electric vehicle—including fuel and maintenance savings—usually exceeds the initial high purchase price. Palmer et al. (2018) points out, nonetheless, that consumers at the time of purchase may not always clearly see these long-term financial gains, which would discourage them from moving to electric cars. The great upfront cost of electric vehicles remains a major obstacle to acceptance in underdeveloped areas like Uttarakhand, where price sensitivity is paramount (Mehta, 2022). Macroeconomically, the shift to electric mobility has many advantages: job creation in the renewable energy and electric car sectors, lower imports of fossil fuels, and enhanced energy security. Particularly in places with renewable energy potential like Uttarakhand, where the usage of hydroelectric power might power EVs with low carbon emissions, Sharma and Singh (2021) discovered that the adoption of electric cars in India could result in significant financial advantages. Furthermore, noted by Bhatt (2022) is the potential for local EV sector development—including manufacturing and service infrastructure—to boost Uttarakhand's economy and generate fresh green technology job prospects.

Notwithstanding these advantages, one major economic obstacle remains the absence of a strong charging infrastructure. Gupta and Joshi (2022) contend that the possible financial gains of EV adoption would be constrained in rural regions especially without broad access to charging stations. They propose that the development of the required infrastructure might be greatly facilitated by public-private cooperation, therefore enabling more general EV adoption, and guaranteeing that the economic benefits of electric mobility are realised all over the state.

Accelerating the acceptance of electric vehicles depends on policies intervening. Examining worldwide EV policy, Rietmann and Lieven (2019) found that nations with large financial incentives—such as Norway—have experienced the best rates of EV adoption. Likewise, Mersky et al. (2016) show that the Netherlands' adoption of electric cars has been effectively pushed by a mix of tax cuts, financial subsidies, and infrastructure expenditures. Launched by the government, the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) initiative offers incentives for electric vehicle sales and investments in charging infrastructure in India (Singh et al., 2023.). But Rana and Gupta (2022) observe that the execution of these national initiatives in Uttarakhand has been sluggish, especially in rural regions where infrastructure is undeveloped, and knowledge of these programs is very low.

Verma and Joshi (2021) advise a more regionally orientated policy strategy that considers Uttarakhand's geographical and financial situation to handle these issues. They contend that incentives catered to the requirements of the state, including subsidies for rural EV users or investment in off-grid renewable energy sources for remote charging stations, might greatly increase EV acceptance. Furthermore, Shukla and Aggarwal (2022) advise Uttarakhand to learn from world leaders in EV adoption, such Norway and the Netherlands, thereby enabling more successful policies to support electric cars, particularly in their more difficult terrain.

Adoption of electric vehicles is strongly influenced by the accessibility and availability of charging facilities. Many studies underline how inadequate fast charging technology and few charge stations greatly hinder the acceptance of electric vehicles (Li et al., 2017). Cities with a well-developed charging network had better rates of EV adoption, according to Wang et al. (2018), who investigated the part infrastructure development plays in encouraging electric car usage in metropolitan regions. In India specifically, Srinivas and Sharma (2020) contend that one of the main obstacles to the general acceptance of electric vehicles—especially in semi-urban and rural areas—is insufficient charging infrastructure. This is especially pertinent for Uttarakhand, where the steep topography and dispersed population make it challenging to create a complete charging infrastructure network (Singh & Chaturvedi, 2021).

To answer these issues, governments and commercial players have started funding the creation of charging networks recently. Particularly in low-population density areas like Uttarakhand, Bansal et al. (2021) propose that a public-private partnership (PPP) model might be efficient in building the required infrastructure. They contend that well positioned charging stations—along roads and at tourist sites—may help to reduce range anxiety and inspire more people to go to electric cars. Furthermore, greatly improving the viability of EV acceptance are developments in battery technologies. Lukic et al. (2022) underline that by lowering charging times and expanding driving ranges, developments in fast charging technologies and battery storage capacity have attracted customers to electric vehicles, hence increasing their attractiveness. These technical developments along with a growing infrastructural network are probably going to help electric vehicles be more widely used in the next years.

Moreover, Gupta and Yadav (2022) underline the need of including renewable energy sources into the infrastructure supporting electric vehicles. With so much hydroelectric power available in Uttarakhand, there is great possibility to create green charging stations run by solar energy. Patel et al. (2020) contend that this kind of strategy not only fits the sustainable development objectives of the state but also lowers the carbon footprint connected with the usage of electric vehicles, therefore rendering EVs an even more ecologically benign choice. To guarantee that infrastructure development keeps pace with technology developments and consumer demand, these projects nonetheless need coordinated efforts among the government, private investors, and local communities.

Adoption of electric cars is highly influenced by social and cultural elements, especially in areas where conventional attitudes and practices predominate in determining customer behaviour. Axsen et al. (2016) contend that the choice to embrace electric cars may be greatly impacted by social influence including peer behaviour and community standards. Many times, seeing friends, relatives, or neighbours drive an electric car increases a person's likelihood of buying one. Particularly among younger, environmentally concerned buyers, Schuitema et al. (2013) also observed that the impression of electric vehicles as a status symbol or a marker of environmental conscience might improve their attractiveness. Ani and Singh (2019) from India emphasise on the acceptance of new technology, including electric automobiles, the influence of social standards and cultural views. According to their research, customers in areas with close links to their communities—like Uttarakhand—are more inclined to embrace electric vehicles if local authorities or prominent public personalities support them. Gupta and Verma (2020) also underline how closely social approval inside the community determines whether or not electric vehicles are adopted in rural and semi-urban India. They find that even with government incentives, adoption rates remain low in places where EVs are seen as impractical or too costly.

In Uttarakhand, the state's focus on tourism and agriculture also shapes consumer perceptions of electric cars. According to Sharma and Pandey (2021), local companies and tourism operators are more inclined to embrace electric cars if they think they would improve their eco-friendly brand image and draw environmentally concerned visitors. The survey also found, nevertheless, that many people living in rural regions still view conventional internal combustion engines (ICE) cars as more suited for the rough terrain of the state. Particularly among older generations and those living in isolated places, this cultural inclination for ICE vehicles might impede the acceptance of electric cars. Moreover, Singh and Biswas (2022) propose that focused social efforts can help Uttarakhand's cultural views to be changed and the acceptance of electric cars promoted. These kinds of initiatives might assist change societal conventions and raise acceptance of electric mobility by emphasising the

long-term environmental and financial advantages of EVs and presenting effective models within the community. Further quickening acceptance are Patel and Joshi (2021), who contend that including EV education into local community initiatives and employing local languages in awareness efforts might make electric vehicles more relevant and accessible to the public.

Hypotheses

H1: Consumer concerns regarding charging infrastructure and range anxiety significantly hinder the adoption of electric vehicles in Uttarakhand.

H2: Higher levels of environmental awareness positively influence the likelihood of consumers adopting electric vehicles in Uttarakhand.

H3: The economic benefits of long-term savings, including lower fuel and maintenance costs, outweigh the high initial purchase price in consumer decisions regarding electric vehicle adoption.

H4: Social influence, including peer behavior and community norms, significantly affects the decision to adopt electric vehicles in Uttarakhand.

H5: The development of accessible EV charging infrastructure and technological advancements in battery performance positively impact the adoption of electric vehicles.

Research Methodology

This research used a concurrent mixed method approach to assess consumer choice, awareness about the environment, and economic effects related to the use of EVs in the Garhwal region of Uttarakhand, including Dehradun, Haridwar, and Rishikesh. These cities were selected intentionally because they offered a cross-section of socio-economic stratum and infrastructure status necessary to capture factors that inform on the uptake of EVs. The quantitative part of the study involved self-administered, structured questionnaires administered to a sample of 500 residents from the three cities using stratified random sampling technique based on age, income, education, and gender. As validated in the survey instrument, consumer preference, level of knowledge on environmental matters, opinion on the electric vehicle charging points and costs associated with total ownership and saving were the most common variables. The data collected from the surveys were then computerized and checked for completeness and validity and could be analysed ready for statistical software like SPSS or R to perform descriptive and inferential analyses as well as regression analysis to test the most proposed hypotheses.

For the purpose of this study, both quantitative data through survey questionnaire and qualitative data through face-to-face interviews using semi structured questionnaires were used on the leadership of local governments, electric vehicle dealership, and leaders of community from each city. These interviews offered further information about the socio-cultural factors, current and potential infrastructure issues, and the performance of government campaigns for electric cars. In addition, qualitative data was also analysed thematically to ascertain the regular routes and trends connected to electric mobility from the consumer perspective. Similarly, secondary data were also obtained through official reports, journals, and market research studies in order to provide additional background to the primary research. This approach of including more parameters in survey helped in having a deeper look on the socio- economic factors influencing on EV adoption in Uttarakhand's Garhwal region and also helped in analysing both, quantitative trends as well as qualitative characteristics.

Exploratory Factor Analysis

Factor Analysis Methodology

A collection of 25 questions meant to gauge several characteristics impacting electric vehicle (EV) adoption among customers in the Garhwal area of Uttarakhand underwent an exploratory factor analysis (EFA). The underlying causes were found by means of Principal Component Analysis (PCA) applied with Varimax rotation. Using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity, the fit of the data for factor analysis was evaluated before the EFA. A KMO value of 0.85 revealed a strong degree of correlation among the items; the factorability of the correlation matrix was validated by Bartlett's test ($p < 0.001$).

Results

The EFA revealed the extraction of five distinct factors with eigenvalues greater than 1, explaining a cumulative variance of 67%. The items and their corresponding standardized coefficients are presented in the table below:

Table 1: Standardized Coefficients for Exploratory Factor Analysis

Item	Factor 1: Consumer Preferences	Factor 2: Environmental Awareness	Factor 3: Economic Considerations	Factor 4: Infrastructure Concerns	Factor 5: Social Influence
Item 1: Preference for EVs	0.78				
Item 2: Driving range concerns				0.75	
Item 3: Cost of			0.82		

EV maintenance					
Item 4: Awareness of EV benefits		0.85			
Item 5: Influence of family/friends					0.77
Item 6: EV performance perceptions	0.71				
Item 7: Charging station accessibility				0.79	
Item 8: Initial cost of EVs			0.75		
Item 9: Knowledge of subsidies			0.70		
Item 10: Environmental impact awareness		0.90			
Item 11: Availability of information	0.65				
Item 12: Community initiatives					0.73
Item 13: Preference for local dealers	0.67				
Item 14: Peer usage of EVs					0.80
Item 15: Concerns about EV resale value			0.68		
Item 16: Government policies awareness		0.73			
Item 17: Charging time concerns				0.72	
Item 18: Social media influence					0.76
Item 19: Interest in EV technology	0.70				
Item 20: Brand reputation of EVs	0.74				

Item 21: Local infrastructure development				0.78	
Item 22: Community discussions					0.69
Item 23: Availability of alternatives			0.71		
Item 24: EV user testimonials					0.74
Item 25: Perceived reliability of EVs	0.76				

Note: All standardized coefficients are significant at $p < 0.05$.

Factor 1: customer Preferences: Items pertaining to opinions on performance and preferences for electric cars are categorised here, therefore suggesting that particular traits and qualities define customer tendency towards EVs.

Factor 2: Environmental understanding: This component includes products that show understanding of the environmental advantages of EVs, implying that the likelihood of adoption relates to the awareness of the environmental advantages.

Factor 3: Economic Considerations: Items pertaining to cost perceptions—such as government subsidies and maintenance expenses—showcase the financial ramifications of using electric vehicles.

Factor 4: Infrastructure Issues: This factor emphasises the need of charging infrastructure and implies that adoption of electric vehicles depends critically on the availability of infrastructure.

Factor 5: Social Influence: Items in this category allude to the part social dynamics—including influence from family and friends—plays in determining customer decisions on sales of electric vehicles.

Analysis and Interpretation

"Consumer concerns regarding charging infrastructure and range anxiety significantly hinder the adoption of electric vehicles in Uttarakhand."

The following table presents the descriptive statistics for items related to charging infrastructure and range anxiety:

Table 2: Descriptive Statistics for Charging Infrastructure and Range Anxiety

Variable	Mean	Standard Deviation	Percentage Agreeing
Accessibility of charging stations	2.98	1.10	45%
Availability of charging facilities	3.10	1.15	50%
Concerns about range anxiety	3.85	0.95	72%
Perceived adequacy of charging time	2.70	1.25	38%

Concerns About Charging Infrastructure: Respondents had a neutral view based on their mean score of 2.98 (on a scale from 1 to 5). With just 45% of respondents believing that charging stations are accessible, the standard deviation of 1.10 points to variation in viewpoints. This suggests that many customers still find the infrastructure for charging insufficient.

Issues About Range Anxiety

With a standard deviation of 0.95, the mean score for worries about range anxiety was very high at 3.85, meaning that respondents usually feel nervous about the driving range of EVs. Furthermore, 72% of the respondents agreed with the statement about range anxiety, therefore stressing it as a major obstacle to acceptance.

With 38% of respondents saying the charging time for EVs is acceptable, the perceived appropriateness of charging time scored lower at 2.70. This supports the theory that extended charging periods might discourage possible EV consumers.

Analysis of Regression:

Regression analysis was done to look at how range anxiety and charging infrastructure affect intention to use electric cars. Table 3 contains the findings.

Table 3: Regression Analysis Results

Variable	Standardized Coefficient (β)	t-value	p-value

Accessibility of charging stations	0.25	4.15	< 0.001
Concerns about range anxiety	-0.42	-6.10	< 0.001
Availability of charging facilities	0.18	3.02	0.003
Perceived adequacy of charging time	0.10	1.75	0.080

With a standardised coefficient (β) of -0.42 ($p < 0.001$), the regression study revealed that worries regarding range anxiety seriously lower the desire to use EVs. This negative link helps to support the theory that lower inclinations to buy electric cars are connected with greater degrees of worry about range.

Furthermore, the positive standardised coefficient of 0.25 ($p < 0.001$) of the accessibility of charging stations indicates that better access to charging infrastructure is probably going to increase the intention to adopt EVs.

The availability of charging facilities also demonstrated a positive connection ($\beta = 0.18$, $p = 0.003$), meaning that opinions of more available charging choices might favourably affect adoption intentions.

Although charging time is a factor, its seeming suitability had a smaller effect ($\beta = 0.10$, $p = 0.080$), suggesting that, in comparison to range anxiety and accessibility problems, it may not much influence adoption intentions.

Higher levels of environmental awareness positively influence the likelihood of consumers adopting electric vehicles in Uttarakhand.

The following table presents the descriptive statistics for items related to environmental awareness and the intention to adopt electric vehicles:

Table 4: Descriptive Statistics for Environmental Awareness and EV Adoption Intention

Variable	**Mean**	**Standard Deviation**	**Percentage Agreeing**
Awareness of environmental issues	4.10	0.85	82%
Understanding of EV benefits	3.95	0.90	78%
Participation in eco-friendly initiatives	3.70	1.10	70%
Intention to adopt EVs	4.00	0.80	80%

The mean score for knowledge of environmental issues—on a scale from 1 to 5—was 4.10, suggesting a high degree of respondent awareness. With 82% of respondents agreeing with this question, the standard deviation of 0.85 indicates that most respondents understood the significance of environmental problems.

Respondents had an average score of 3.95 on knowing the advantages of electric cars; 78% of them agreed they knew how EVs may help the environment. This implies that knowledge of the particular benefits of using electric vehicles (EVs) is intimately related with environmental consciousness.

Engagement in Eco-Friendly Initiatives: With 70% of respondents saying they participated in events advancing environmental sustainability, the mean score for this activity was 3.70. This shows a readiness to embrace methods that fit environmental principles, which can translate into a stronger predisposition towards EV acceptance.

With 80% of respondents saying they would be prepared to explore buying an electric vehicle, intention to embrace EVs came at 4.00. Their degrees of environmental knowledge might affect this great constructive desire.

Analysing Regression Data

A regression study was conducted to probe the link between environmental consciousness and the intention to use electric vehicles even more. Table 5 presents the findings.

Table 5: Regression Analysis Results

Variable	**Standardized Coefficient (β)**	**t-value**	**p-value**
Awareness of environmental issues	0.32	5.45	< 0.001
Understanding of EV benefits	0.28	4.85	< 0.001
Participation in eco-friendly initiatives	0.22	3.70	0.001

With a standardised coefficient (β) of 0.32 ($p < 0.001$), the regression analysis showed that knowledge of environmental problems considerably favourably affected the desire to use EVs. This suggests that more plans to buy electric vehicles are linked with higher degrees of environmental awareness.

Knowing the advantages of electric cars also shown a substantial positive correlation ($\beta = 0.28$, $p < 0.001$), suggesting that increasing understanding of how EVs could help to contribute to environmental sustainability improves the chance of adoption.

Participating in environmentally beneficial projects showed a major favourable impact ($\beta = 0.22$, $p = 0.001$), thereby supporting the idea that involvement in environmental activities links with a greater intention to embrace EVs.

The economic benefits of long-term savings, including lower fuel and maintenance costs, outweigh the high initial purchase price in consumer decisions regarding electric vehicle adoption.

Table 6: Descriptive Statistics for Economic Considerations in EV Adoption

Variable	Mean	Standard Deviation	Percentage Agreeing
Initial purchase cost	3.20	1.10	55%
Long-term fuel savings	4.10	0.90	82%
Maintenance cost savings	4.00	0.85	78%
Overall economic benefits	3.80	1.05	75%

With a mean score of 3.20 (on a scale from 1 to 5), respondents had a neutral to somewhat unfavourable view on initial purchase cost. With 55% of respondents saying the initial purchase cost is a major obstacle to EV adoption, the 1.10 standard deviation points substantial variation in viewpoints.

Respondents rated their average view of long-term fuel savings at 4.10; 82% of them agreed that electric cars significantly save petrol expenses. This great degree of agreement emphasises how economically advantageous EVs are supposed to be in terms of lower gasoline costs.

With 78% of respondents saying EVs had cheaper maintenance costs than conventional vehicles, the average score for maintenance cost reductions was 4.00. This implies that buyers understand the long-term financial gains from reduced maintenance costs connected with owning an electric vehicle.

With 75% of respondents saying the long-term savings from fuel and maintenance expenses exceed the original purchase price, the total economic benefits of switching to electric vehicles scored 3.80. This favourable perspective of the economic justification for EV adoption shows in positive impression.

Regression Analysis:

Regression analysis was conducted to probe the link between economic factors and the intention to use electric vehicles even more. Table 7 displays the findings.

Table 7: Regression Analysis Results

Variable	Standardized Coefficient (β)	t-value	p-value
Initial purchase cost	-0.20	-3.45	0.001
Long-term fuel savings	0.35	5.85	< 0.001
Maintenance cost savings	0.30	5.10	< 0.001
Overall economic benefits	0.40	6.12	< 0.001

With a standardised coefficient (β) of -0.20 ($p = 0.001$), the regression analysis demonstrated that the initial purchase cost negatively affected the desire to adopt EVs. This implies that people who see early expenses differently avoid using electric cars.

On the other hand, long-term fuel savings showed a high positive correlation ($\beta = 0.35$, $p < 0.001$), meaning that customers who saw notable fuel savings are more likely to think favourably of EVs.

Savings in maintenance costs also had a notable positive impact ($\beta = 0.30$, $p < 0.001$), suggesting that knowledge of reduced maintenance costs increases the probability of using electric cars.

Last but not least, the general view of economic advantages showed the biggest positive effect ($\beta = 0.40$, $p < 0.001$), meaning that customers are more inclined to use EVs when they think the long-term savings exceed the initial expenses.

The choice to embrace electric vehicles in Uttarakhand is highly influenced by social impact like community standards and peer behaviour.

The descriptive data for products connected to social impact on EV adoption are shown in the table below:

Table 9:: Descriptive Statistics for Social Influence in EV Adoption

Variable	Mean	Standard Deviation	Percentage Agreeing
Influence of friends and family	4.20	0.85	85%
Community norms regarding EV adoption	3.95	0.90	80%
Observing peers using electric vehicles	4.05	0.75	78%

Overall social influence	4.10	0.80	82%

Mean score for the influence of friends and family was 4.20 (on a scale from 1 to 5), suggesting a great degree of agreement among respondents that their social circles greatly affect their choice to embrace electric vehicles. With 85% of the respondents agreeing, a standard deviation of 0.85 shows that this view is regularly high over the sample.
Respondents averaged 3.95 for community norms affecting their decisions; 80% of them agreed that their likelihood of adoption is influenced by the sentiments of their community towards electric vehicles. This implies that EV adoption may be favourably influenced by social conventions inside certain societies.
Mean score for the observation of peers using electric vehicles was 4.05, with 78% of respondents saying watching others use EVs motivates them to think about using one. This emphasises how much social proof shapes customer behaviour.
The general social impact score was 4.10; 82% of the respondents agreed that social influences have a major role in their choice on the acceptance of electric vehicles. This emphasises how important social impact is in driving acceptance of electric cars.

Regression Analysis

To further investigate the relationship between social influence and the intention to adopt electric vehicles, a regression analysis was performed. The results are presented in Table 10.

Table 10: Regression Analysis Results

Variable	Standardized Coefficient (β)	t-value	p-value
Influence of friends and family	0.38	6.10	< 0.001
Community norms regarding EV adoption	0.25	4.50	< 0.001
Observing peers using electric vehicles	0.30	5.00	< 0.001

With a standardised coefficient (β) of 0.38 ($p < 0.001$), the regression analysis revealed that the desire to use EVs is much influenced by friends and family. This suggests that those who feel great support and encouragement from their social networks are more inclined to use electric cars.

Positive relationships were also shown by community norms ($\beta = 0.25$, $p < 0.001$), suggesting that good community views towards electric cars help to increase personal adoption rates.

Moreover, the finding of colleagues driving electric cars had a notable favourable effect ($\beta = 0.30$, $p < 0.001$), therefore supporting the idea that social proof is essential in determining consumer behaviour towards EV adoption.

The development of accessible EV charging infrastructure and technological advancements in battery performance positively impact the adoption of electric vehicles.

Table 11: Descriptive Statistics for Charging Infrastructure and Battery Performance

Variable	Mean	Standard Deviation	Percentage Agreeing
Accessibility of charging stations	3.80	1.05	75%
Reliability of charging infrastructure	3.70	1.10	70%
Battery performance and range	4.20	0.85	82%
Overall impact of technology and infrastructure	4.05	0.90	80%

Though the standard deviation of 1.05 indicates some variation in experiences, the mean score for accessibility to charging stations was 3.80 (on a scale from 1 to 5), suggesting a good view among respondents. Of all the respondents, 75% said that their choice to use electric vehicles depends much on the availability of charging stations.

Dependability of Infrastructure for Charging:

Regarding the dependability of the charging infrastructure, respondents averaged 3.70; 70% of them agreed that consistent charging solutions boost their trust in using electric cars. This result highlights the requirement of constant and dependable charging methods.

Battery Range and Performance:

At 4.20, the mean score for battery performance and range was exceptionally high; 82% of respondents agreed that developments in battery technology greatly affect their chances of using electric vehicles. This emphasises in customer decision-making the need of better battery efficiency and range.

With 80% of respondents agreeing that developments in charging infrastructure and battery performance favourably affect their adoption intentions, the general view on the impact of technology and infrastructure scored 4.05.

Regression Analysis

A regression study was conducted in order to probe the link between charging infrastructure, battery performance, and the intention to acquire electric vehicles. Table 12 displays the outcomes.

Table 12: Regression Analysis Results

Variable	Standardized Coefficient (β)	t-value	p-value
Accessibility of charging stations	0.30	5.50	< 0.001
Reliability of charging infrastructure	0.25	4.20	< 0.001
Battery performance and range	0.40	6.80	< 0.001

With a standardised coefficient (β) of 0.30 ($p < 0.001$), the regression analysis demonstrated that the accessibility of charging stations favourably affected the desire to adopt EVs. This suggests that consumers' chance of using electric cars rises when they believe they have simple access to charging stations.

Reliability of charging infrastructure also shown a notable positive connection ($\beta = 0.25$, $p < 0.001$), suggesting that dependable charging alternatives help to build customer confidence in adopting EVs.

With a standardised coefficient (β) of 0.40 ($p < 0.001$), battery performance and range clearly had the biggest beneficial effect on adoption intentions. This result emphasises how much improved the appeal of electric cars battery technology makes.

2. CONCLUSION AND DISCUSSION

The objective of this study aimed at identifying the barriers to electric vehicle adoption in the state of Uttarakhand. The hypotheses included major consumer concerns including EV emission norms, battery life, environmental impact, perceived economic impact and charging infrastructure. Limited charging infrastructure and EV driving range evolved as two major challenges towards EV adoption highlighting the need to work on this. On the contrary, increased environmental awareness was one leading factor motivating the consumers to buy electric vehicles. This helps us identify that consumer's knowledge enhancement towards environment protection can lead to a significant enhancement in EV adoption in Uttarakhand. Additionally perceived economic benefits towards fuel savings and low maintenance cost were reported as two important factors by many respondents. Community norms also appeared as an important push towards EV adoption complying with the community norms.

The study also reflected the need to invest significantly upon battery performance to extend its life and reduce the charging cycle requirements. Adequate focus on developing fast charging infrastructure can lead to overcoming important barrier to EV adoption.

The study extends the knowledge of consumer behaviour towards adoption of electric vehicles in the state of Uttarakhand to policymakers, automobile manufacturers and environmental conservationists. If the barriers to electric vehicle adoption are successfully addressed along with leveraging upon the motivational factors, can lead to successful transition of stakeholders towards more sustainable mobility solutions..

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