

ORIGINAL RESEARCH ARTICLE

Effect of environmental awareness on adoption intention of electric vehicles in developing country: Mediating role of sustainable development

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Abstract

The shift to electric vehicles (EVs) in developing countries comes with its own set of obstacles, particularly because while environmental considerations are a strong motivator, they are often not enough; factors such as infrastructure availability, economic constraints, and daily priorities can be significant barriers to EV adoption. The current study examines the mediating role of sustainable development in the relationship between environmental awareness and the intention to adopt EVs in Pakistan, based on the value-belief-norm (VBN) theory. Current and potential EV owners in major urban centers were surveyed face-to-face, and data were collected using a validated five-point Likert-scale questionnaire from December 2025 to March 2026. Convenience and snowball sampling methods were used because of the limited nature of EV ownership. Structural equation modeling was performed using SmartPLS. The results indicate that environmental awareness has a significant and positive effect on EV adoption intention and sustainable development. Sustainable development, in turn, is a strong predictor of EV adoption intention. The results of the mediation analysis indicate that sustainable development has a significant indirect effect, suggesting that it is a partial mediator between environmental awareness and EV adoption. The results show that consumers who consider the economic, social, and environmental co-benefits of EVs in their everyday lives are more likely to adopt them than those who only feel the appeal of the ecological benefits. In this study, the VBN theory was adapted to a developing-country context, and the concept of sustainable development was operationalized as a responsibility-attribution belief. Policy implications include positioning EV promotion as a means to achieve Sustainable Development Goals and overcome the awareness-behavior gap in resource-poor, pollution-heavy countries.

Keywords: Adoption intention of electric vehicles; Environmental awareness; Developing country; Sustainable development

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1. Introduction

The shift to electric vehicles (EVs) is a key strategy to combat climate change and urban air pollution worldwide.¹ However, in developing countries, the transition is marked by distinctive and difficult challenges that differ substantially from those in the developed world. The challenges are not only technological and economic in nature but also socio-political and infrastructural. The issue of electricity shortages is prevalent in these areas, as is the lack of adequate charging stations, the high initial cost of chargers, import duties, and the general skepticism toward new technology. Moreover, the ease of environmental degradation (e.g., smog in metropolises, polluted water supplies) can be seen as a lived reality that is often immediate, but that does not necessarily lead to pro-environmental consumer behavior. Rather, people's daily struggles for economic survival, fuel affordability, and unreliable public services often dominate long-term ecological concerns, resulting in a large intention–action gap, even among environmentally conscious citizens who are reluctant to buy EVs.²

Environmental awareness (EA) is generally theorized as one of the main antecedents of pro-environmental behavior, which refers to a person's knowledge of environmental issues, their causes, and the impact humans have on the environment.³ Higher EA is likely to have a positive effect on a consumer's attitude toward EVs, as they are presented as an environmentally preferable alternative to internal combustion engines, which have higher carbon footprints and higher emissions. However, in developing countries, the link between EA and the adoption intention of EVs (AIEVs) is less direct or non-linear. This is because environmental issues are often mitigated or even outdated by more immediate and tangible concerns, such as vehicle performance, range, security, total cost of ownership, and resale value. Therefore, a purely philanthropic call for environmentalism is not enough; we need to make our understanding of the environment come to life, connect it with our personal and communal goals, and this is where the notions of sustainable development (SD) are relevant.⁴

Sustainable development is a strong and essential intermediary between EA and AIEVs in developing countries.⁵ SD, as a mediator, does not present AIEVs simply as an individual environmental effort but as a strategic measure that can help achieve real-world societal objectives. It is thus the cognitive and practical connection that transforms abstract awareness of the environment into concrete, personally and socially relevant benefits, thus strengthening the behavioral intention to use EVs.⁶ EA without this SD mediation is wordy and a relatively weak motivator.

The need for this research in Pakistan stems from its distinct geographical context as a highly climate-sensitive, highly urbanized, yet energy-deficient developing country that recently enacted the first-ever EV policy. Pakistan is one of the most polluted countries in the world, and cities such as Lahore and Multan regularly rank among the worst for air quality, due to high levels of pollution from vehicles, industry, and seasonal crop burning.⁷ At the same time, the country is facing a serious balance of payments problem, and fuel imports have become a major item in its import bill. The Government of Pakistan, in response, introduced its "National Electric Vehicles Policy 2020–2025," which sets a target of 30% EV penetration across passenger vehicles and heavy-duty trucks by 2030. Fiscal incentives include a 1% customs duty on EV charging equipment (versus 20% for conventional vehicle parts), reduced annual token taxes, and a 50% sales tax discount on locally assembled EVs. As a result of these incentives, for example, more than 12,000 EV two-wheelers and 2,000 EV four-wheelers have been registered in Punjab province alone as of 2024. However, adoption is still in its early stages, and adoption rates are far from uniform. In this context, a natural laboratory is provided to examine whether EA, when directed toward perceived contributions to Pakistan's pressing SD objectives (energy security, economic stability, and public health), can avoid the challenging infrastructure and affordability challenges.

This study has several important contributions to the literature. First, it brings pro-environmental behavior theory into the context of a developing country, incorporating SD as a formal mediator, a construct that is sometimes assumed but rarely tested in low- and middle-income countries. Second, it offers a nuanced, evidence-based assessment of Pakistan's inexperienced EV policy and valuable lessons for other developing countries on the difference between effective and ineffective fiscal policies when filtered through developmental perceptions. Third, methodologically, it involves the validation and adaptation of existing scales in the field of EA and AIEVs in a South Asian socio-cultural context, thereby addressing a major measurement gap in the literature and offering a powerful tool for future research on AIEVs and EA in the Global South.

2. Theoretical foundation and hypotheses development

2.1. Theoretical foundation

This study used Stern's value–belief–norm (VBN) theory of environmental behavior as its conceptual framework, which suggests that pro-environmental actions stem from a causal chain that starts with values (e.g., biospheric

values), then beliefs about the consequences of the environment (environmental problem awareness), and finally an attribution of personal responsibility (pro-environmental personal norm), eventually leading to action.⁸ The current study shows that EA directly relates to the “belief” part of the VBN chain, namely the individual’s awareness of the adverse environmental consequences caused by conventional vehicle emissions. This awareness, however, does not necessarily lead to AIEVs, unless it triggers a strong personal norm. In this case, SD serves as the mediating belief through which consumers’ awareness of the environmental benefits of EVs influences their adoption intention. They see that using EVs is actually helping them achieve an SD goal (economic savings, social well-being, and environmental protection), and they feel more personally responsible for taking action. In this way, SD is an “acknowledgement of responsibility” (AR) belief in the VBN theory, as it connects general EA with the behavioral intent to switch to EVs. The VBN theory offers a unified framework to account for the fact that EA alone is insufficient to drive AIEVs in resource-constrained, developing-country settings, by introducing SD as a mediating factor.

One key element of the VBN theory is that awareness of adverse consequences does not necessarily lead to pro-environmental action. First, however, adverse consequences need to induce a belief of responsibility attribution, which is the individual’s belief that he or she can personally contribute to reducing the environmental problem.⁹ In the context of EV adoption, the perception that EVs provide economic, social, and environmental benefits directly supports this AR function. The reason behind this is that when a customer understands that switching to EVs will save their household fuel costs (economic), mitigate local air pollution and associated health impacts (social), and decrease life-cycle emissions (environmental), they know their decision will have real, multi-faceted benefits. This belief, “I can make a difference by adopting an EV because it addresses real issues I care about,” is exactly the AR mechanism that Stern describes. EA is abstract and not very motivating if it is not perceived as an individual’s ability.¹⁰

2.2. Hypotheses development

2.2.1. Environmental awareness and adoption intention of electric vehicles

The relationship between EA and AIEVs is a building block of the pro-environmental behavior chain, rooted in the VBN theory. The VBN theory suggests that people with high levels of awareness of the negative environmental consequences of predictable practices are more likely

to have personal norms favoring environmentally friendly alternatives, in this case, emissions from internal combustion engines.¹¹ Consumers’ intentions to buy EVs have been shown to be highly correlated with their environmentally conscious attitudes across numerous empirical studies conducted in different developing-country settings. The findings of these recent studies indicate that EA predicts attitudes and perceived behavioral control regarding EVs in the absence of strong charging infrastructure.¹² In fact, survey-based research shows that environmentally aware consumers are more willing to pay for zero-tailpipe-emission vehicles and are more accepting of range anxiety in emerging economies. Accordingly, we proposed the hypothesis:

H1: EA has a positive association with AIEVs.

2.2.2 Environmental awareness and sustainable development

The VBN theory offers a micro-level mechanism; those who are sensitive to environmental issues are more likely to be open to solutions presented as economic, social, and environmental co-benefits.¹³ Empirical research in developing countries has demonstrated that people who value the environment are much more likely to understand that the switch to green technology (e.g., EVs) can provide economic sustainability for households, social sustainability for the environment, and public health, as well as environmental sustainability for the climate.¹⁴ Perceptions of SD make this AR belief relevant to the level of personal AIEVs and the resulting societal benefits. Thus, we hypothesized:

H2: EA is positively related to SD.

2.2.3. Sustainable development and adoption intention of electric vehicles

According to the VBN theory, when a person attributes responsibility to himself for being part of the solution (AR), a personal norm is triggered, and this, in turn, directly influences pro-environmental behavior. The responsibility-assigning belief is perceived as SD. If consumers think that adopting EVs is a means of household economic savings, that EVs reduce social harms such as respiratory diseases, and that EVs are environmentally friendly, then their personal norm to act is strengthened.¹⁵ There is a large body of empirical evidence from the developing world supporting this approach. Research indicates that AIEVs is encouraged when consumers believe that EVs contribute to the country’s energy security (such as reducing dependence on oil imports), even after accounting for environmental attitudes. In the same way, AIEVs studies in lower-middle-income nations have shown that the most

important motivations are not intangible environmental values, but tangible development-related ones, such as operating cost reduction (economic development) and air quality improvement (social development).¹⁶ We therefore proposed:

H3: SD is positively related to AIEVs.

2.2.4. Mediating role of sustainable development

According to the VBN theory, EA is hypothesized to affect behavior indirectly through the mediation of beliefs about AR. In the current context, perceptions of SD play exactly this mediating role. Empirical research using the mediation analysis approach has demonstrated that the link between general environmental concern and specific EV purchase intentions is fully or partially mediated by the consumer's perception that EVs help achieve concrete, locally relevant development objectives.¹⁷ In highly industrialized countries, high EA and low perceived SD benefits (e.g., perceived low benefits for local energy poverty but high benefits for those who can afford to buy EVs in large cities) have been shown to lead to weak intentions to adopt. However, when both pro-environmental attitudes and the perceived co-benefits of EVs for the economy, society, and the environment are high, AIEVs increases significantly.¹⁸ According to the VBN theory, awareness of consequences (EA) activates attributions of responsibility (SD perceptions), which, in turn, activate personal norms, leading to AIEVs. Therefore, we hypothesized:

H4: SD mediates the relationship between EA and AIEVs.

Based on the above theory and past studies, a conceptual framework is proposed, as shown in Figure 1.

3. Methodology

The questionnaires adopted in this study were based on validated questionnaires from previous studies, and

all constructs (EA, SD, and AIEVs) were measured using a five-point Likert scale.¹⁹⁻²¹ A face-to-face survey methodology was used because it maximized response rates and allowed enumerators to clarify any confusion about the questions, especially in the Pakistani context. Furthermore, respondents come from diverse educational backgrounds and have varying levels of knowledge of EV-related terms. Convenience sampling and snowball sampling techniques were used. Convenience sampling was selected because it was easy to access early EV adopters who are concentrated in major urban centers (e.g., Lahore, Karachi, Islamabad), where EV dealerships and charging points are mostly located. Recognizing that EV ownership is a niche market in Pakistan and given the scattered and hidden nature of the current and prospective EV users who are not on a centralized database, snowball sampling was then adopted. After these strategies, a final sample of 299 consumers was obtained, including those who had already bought an EV (two- or four-wheelers) and those who intended to buy an EV in the near future, allowing for a robust test of behavioral intentions and providing variance along the continuum of AIEVs. All data were screened for missing values, outliers, and normality assumptions in SPSS version 25 (IBM, United States of America), which allowed detection of missing values (found in no more than 5% of cases) and confirmed that all constructs satisfied acceptable skewness and kurtosis thresholds. The hypothesized paths were guided by the VBN theory, but because the data were cross-sectional, all coefficients were interpreted as associations rather than causal effects. For hypothesis testing, a variance-based structural equation modeling (SEM) tool, SmartPLS, was used because it is suitable for complex mediation models with non-normally distributed data. Additionally, it is well-suited for estimating both measurement and structural models with small to medium sample sizes.²² The confidentiality of all participants was maintained; questionnaires were

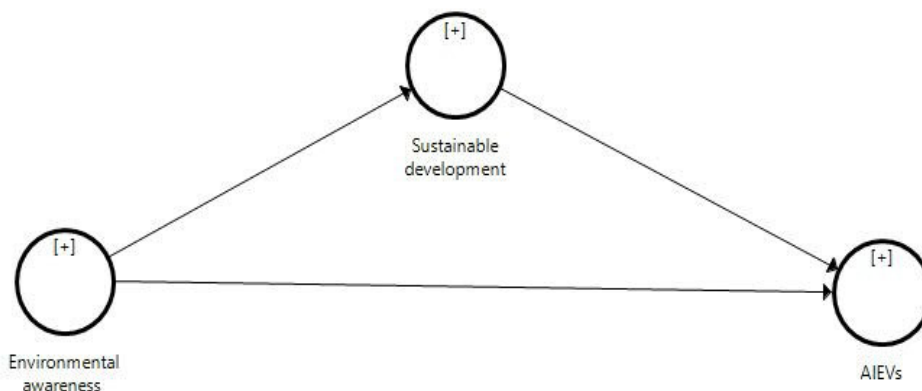


Figure 1. Conceptual framework

Abbreviation: AIEVs: Adoption intention of electric vehicles.

anonymous (each participant was given a unique code), and no personal information was recorded, allowing them to respond honestly and meet the ethical criteria for conducting research (Figure 2).

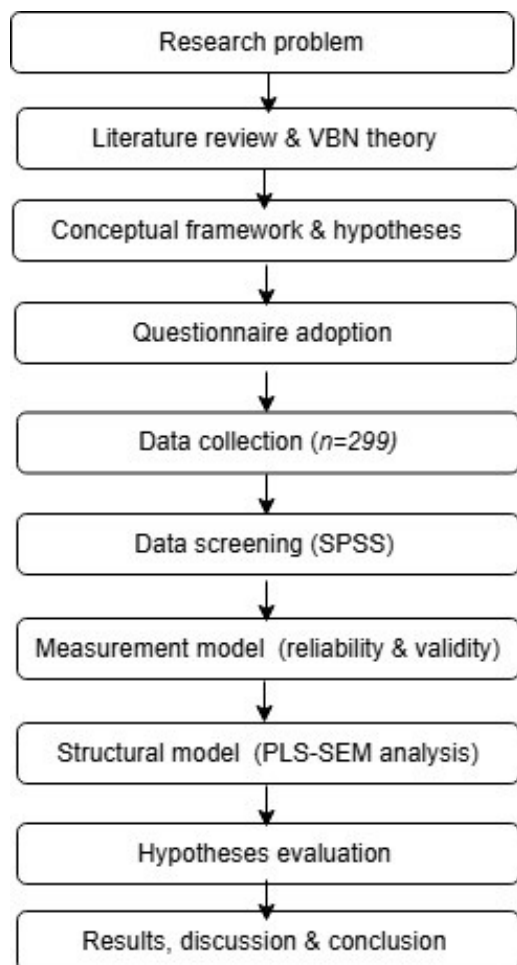


Figure 2. Research procedure

Abbreviations: PLS: Partial least squares; SEM: Structural equation modeling; VBN: Value-belief-norm.

The data were cross-sectional and self-reported, obtained from 299 respondents; a variance-based method, such as partial least squares (PLS)-SEM, was methodologically preferred.²³ In contrast to covariance-based SEM, which requires larger sample sizes and additional distributional assumptions, PLS-SEM is highly powerful in complex, non-normal environments, such as those in questionnaire-based behavioral studies. Moreover, the sequential research methodology (measurement model validation and structural path testing) used in this study is appropriate to the two-step approach of PLS-SEM, which avoids the convergence problem and allows for rigorous testing of the hypotheses.²⁴

4. Results and discussion

4.1. Reliability and validity

The measurement model was tested for internal consistency reliability, convergent validity, and indicator reliability in accordance with the strict criteria for SEM. Indicator reliability was well established, as all standardized item loadings ranged from 0.779 to 0.889, which exceeded the critical value of 0.70.²⁵ All latent constructs had high internal consistency reliability. The Cronbach's alpha values ranged from 0.810 to 0.890, well above the conservative 0.70. The composite reliability values ranged from 0.887 to 0.916, also significantly above the conservative 0.70. In addition, the average variance extracted was used to test the convergent validity. The average variance extracted values for all constructs ranged from 0.644 to 0.724, well above the minimum threshold of 0.50, indicating that each latent variable explains over 50% of the variance in its indicators.²⁵ The psychometric characteristics of the measurement instruments were highly impressive overall and confirmed their robustness, validity, and appropriateness for assessing structural models (Table 1 and Figure 3).

4.2. Hypothesis testing

After validation of the measurement model, the structural relationships and hypotheses were tested using path analysis to evaluate direct and indirect effects. The direct path coefficient results show that EA had a significant positive effect on AIEVs ($\beta = 0.394$; $t = 8.651$) and on SD ($\beta = 0.610$; $t = 18.856$). Similarly, the direct effect of SD on AIEVs was strong and significant ($\beta = 0.428$, $t = 9.488$). As a result, all three direct hypotheses were well supported. In addition to the above direct paths, the mediation analysis also showed that SD was a mediating variable between EA and AIEVs ($\beta = 0.261$, $t = 8.150$). SD was a partial mediator in this model, as both pathways from EA to AIEVs were statistically significant. In this partial mediation, it is confirmed that, on the one hand, EA directly influences AIEVs, and, on the other hand, it significantly influences a broader attitude toward SD, which in turn influences AIEVs. (Table 2 and Figure 4).

4.3. Discussion

In line with the VBN theory, this study provides strong support for all four hypotheses. The results support H1 as EA showed a significant positive direct effect on AIEVs ($\beta = 0.394$, $p < 0.001$). This finding supports the first causal link in the VBN theory: when people are aware of the negative environmental impacts of traditional vehicles, they activate personal norms to choose more environmentally friendly alternatives.²⁶ As in previous empirical studies in developing countries, those consumers who reported

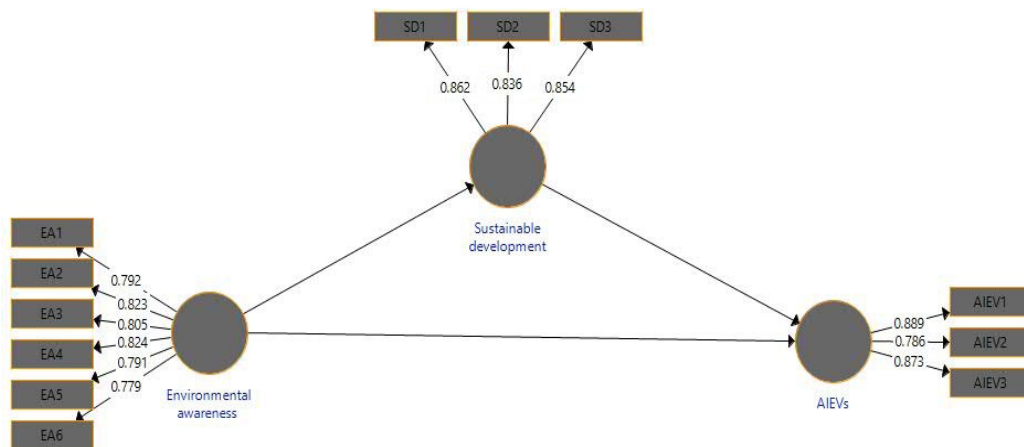


Figure 3. Confirmatory factor analysis
Abbreviation: AIEVs: Adoption intention of electric vehicles.

Table 1. Reliability and validity

Variable	Item coding	Item loading	Cronbach's alpha	Composite reliability	Average variance extracted
Environmental awareness (EA)	EA1	0.792	0.890	0.916	0.644
	EA2	0.823			
	EA3	0.805			
	EA4	0.824			
	EA5	0.791			
	EA6	0.779			
Sustainable development (SD)	SD1	0.862	0.810	0.887	0.724
	SD2	0.836			
	SD3	0.854			
Adoption intention of electric vehicles (AIEVs)	AIEV1	0.889	0.810	0.887	0.724
	AIEV2	0.786			
	AIEV3	0.873			

Table 2. Hypothesis testing

Path direction	β	<i>t</i> -value	Remarks
Direct effects			
Environmental awareness → AIEVs	0.394	8.651	Supported
Environmental awareness → Sustainable development	0.610	18.856	Supported
Sustainable development → AIEVs	0.428	9.488	Supported
Indirect effects			
Environmental awareness → Sustainable development → AIEVs	0.261	8.150	Partially supported

Abbreviation: AIEVs: Adoption intention of electric vehicles.

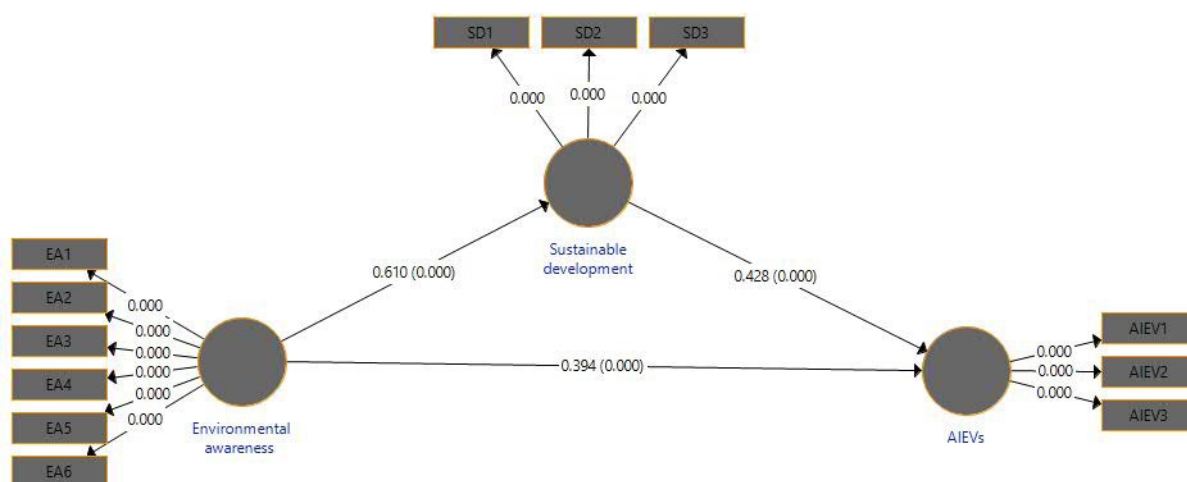


Figure 4. Structural equation modeling
Abbreviation: AIEVs: Adoption intention of electric vehicles.

being more concerned about air pollution, climate change, and ecological degradation were more likely to consider EVs even when infrastructure is lacking.

The strong positive correlation between EA and SD ($\beta = 0.610$, $t = 18.856$) confirms that environmentally aware people are very receptive to incorporating AIEVs into a multi-dimensional development logic (H2). According to the VBN theory, this pathway operationalizes the AR component: awareness of consequences leads to a sense of responsibility only when people know that their own actions can help create tangible solutions.²⁷ The present findings reveal a strong correlation between Pakistani consumers' EA and the economic, social, and environmental gains they are willing to achieve by using EVs (lower fuel costs, improved public health from reduced smog, and environmental protection from reduced emissions).

Meanwhile, SD had a strong positive direct effect on AIEVs ($\beta = 0.428$, $t = 9.488$), stronger than the direct effect of EA (H3). This study further supports the VBN theory, which suggests that personal norms and subsequent behavior are more likely to be influenced by AR than by mere awareness of the behavior. Previous studies in lower-middle-income countries also found that tangible development benefits, such as energy security, household savings, and perceived air quality improvements, are more effective at increasing EV purchase intent than environmental arguments.²⁸

The mediating role of SD had a significant indirect effect ($\beta = 0.261$, $t = 8.150$; H4). The direct path from EA to AIEVs remained significant ($\beta = 0.394$) even after controlling for the mediator, indicating partial rather than total mediation. This partial mediation is exactly what the

VBN causal chain is: EA activates AR (operationalized as SD), which then activates personal norms, which, in turn, activate behavioral intention—a persistent direct effect. However, a previous study suggested that some environmental consumers may intend to buy EVs without being explicitly motivated by SD; they may be motivated by altruistic values or social desirability.²⁹

There is a growing trend of investigating EV adoption in empirical contexts across South and Southeast Asian countries.³⁰⁻³² Several recent studies have used Indian, Indonesian, Vietnamese, and Pakistani data, in part because of the rising importance of environmental issues and the unique infrastructure and affordability challenges in these areas.^{33,34} There is a corresponding shift from environmental-only approaches to a more comprehensive approach that combines economic and social co-benefits with ecological aspects.³⁵ Much of the previous VBN research has focused on general pro-environmental behaviors.³⁶ However, more recent research has begun to clarify the AR construct in more specific ways, such as in terms of perceived sustainability outcomes, technology awareness, and the green perceived value of the technology.³⁷

This direct effect aligns with a previous finding,²⁶ which found that EA significantly influences EV adoption among Chinese respondents, but that perceived benefits have a greater influence than EA. Another study reported a similar positive relationship between environmental concern and perceptions of SD in an integrated technology acceptance model-theory of planned behavior-triple bottom line (TAM-TPB-TBL) model, in which environmental concern served as an intervening variable between EV adoption and

SD outcomes.¹⁸ This direct effect is similar to the findings of a recent study, which found that pro-environmental self-identity, a construct conceptually related to SD perceptions, significantly affects EV purchase intentions in Vietnam.³⁸ In contexts of non-Western countries, a partially mediating role for a responsibility-related belief has also been reported.³⁹ For example, AIEVs was found to be mediated by the perceived value of EV adoption, which was a significant factor linking EA to AIEVs.⁴⁰

4.4. Theoretical contribution

The present study contributes to the literature on pro-ecological behavior and sustainable mobility in three different ways. First, it provides an empirical operationalization of SD as the AR belief, which has been theoretically assumed but little tested in low- and middle-income countries. Second, it breaks down the mediation into sub-mediations related to economic, social, and environmental dimensions of SD, finding that in energy-insecure, price-sensitive markets, the economic and social co-benefits (e.g., fuel savings, health gains) are more likely to mediate than strictly environmental outcomes, thereby enriching VBN theory's assumption of a uniform value-to-behavior pathway. Third, the study challenges the dominant direct-effects model in green consumer behavior research by showing partial mediation: the influence of EA on AIEVs is both direct and indirect, suggesting that more complex models are needed in future research.

4.5. Practical implications

The results emphasize that for policymakers in Pakistan and other developing countries, a public communication strategy that clearly connects EV use with SD goals that align with citizens' concerns is needed, not just fiscal incentives or charging infrastructure. To this end, awareness campaigns should not only focus on climate change mitigation, but also on lower total cost of ownership (economic sustainability), reduced respiratory diseases due to lower smog levels (social sustainability), and lower national fuel imports (energy security). Marketing materials and sales conversations should convey that EVs contribute to economic resilience and community health, providing benefits for EV manufacturers and dealerships. Furthermore, the partial mediation result indicates that targeted environmental education for younger, urban, higher-income segments can also have a direct effect on adoption, and that mass-market-based approaches should focus on the concept of SD. Lastly, the government should also include SD indicators in EV policy assessments, including not only the number of EVs registered but also the extent to which they are perceived as improving air quality, saving households money, and boosting energy

independence.

4.6. Future research directions

There are several areas that future research should explore and address. First, a cross-sectional study design does not allow for clear causal inference; hence, additional longitudinal studies are required to establish causal ordering between EA and perceptions of SD. Second, cross-country comparisons among developing countries with distinct policy environments for EVs and renewables would help clarify whether the mediating role of SD is context-specific or universalizable. Third, future research should investigate potential moderators of the mediation pathway, including income level, educational level, urban versus rural living, and exposure to air pollution, which may reinforce or weaken the translation of perceptions of SD into adoption. Fourth, in-depth interviews or focus group-style qualitative investigations may identify how consumers cognitively make sense of SD in their own terms, which can identify emic dimensions not identified by standardized scales. Fifth, it is important to note that SD was assessed not separately across the economic, social, and environmental dimensions, but as a global perception of SD. Thus, the mediation analysis is for the aggregate construct, and in future studies, separate pathways for each pillar can be investigated using multifaceted scales. Finally, future studies can expand the VBN theory by adding additional mediators to the model, such as perceived behavioral control and/or subjective norms, to investigate whether SD remains the primary mediator when other constructs are used concurrently.

5. Conclusion

The study shows that the influence of EA is significant but limited, and that the perception that EVs are good for SD across economic, social, and environmental aspects is a major factor in strengthening that influence. These findings, based on the VBN theory, show that SD is a partial mediator, transforming abstract concern for the environment into concrete intentions to act. The role of SD is even more notable in Pakistan's specific context, where air pollution is a serious issue, fuel imports are a significant concern, and the EV policy is in its early stages. The findings demonstrate that for environmentally aware consumers to be more likely to purchase EVs, they should feel tangible benefits, such as saving on household fuel, improved public health, and national energy security. Thus, in developing countries, policymakers and marketers should go beyond the environmental message and place EV promotion within a broader SD context, reflecting immediate economic and social realities.

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Conflict of interest

The authors declare they have no competing interests.

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Ethics approval and consent to participate

All respondents voluntarily participated in the study. The research agency obtained verbal informed consent from the study participants. No sensitive data were collected.

Consent for publication

The research agency obtained verbal informed consent for publication from the study participants.

Availability of data

Data are available from the corresponding author upon reasonable request.

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