Original Article

Promoting Sustainable Development: Elements Affecting Electric Vehicle Adoption and Theoretical Approaches

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Abstract

The study aims to explore interdisciplinary strategies for sustainable development, focusing on sustainable transport, particularly electric vehicles (EVs). It will explore the evolution of EV technology, various types, and factors influencing their adoption, including demographic, technical, economic, psychological, and environmental factors. Additionally, the study provides a comprehensive review of theoretical frameworks such as the Theory of Planned Behaviour, Diffusion of Innovation, and Technology Acceptance Model to gain insight into consumer behaviour when adopting electric vehicles. The conclusion will emphasise the necessity of collaboration among policymakers, industry stakeholders, and consumers to drive mass adoption of EVs and promote sustainable development. The study will employ a thorough and methodical secondary data analysis technique to evaluate interdisciplinary approaches to sustainability, aiming to enhance our understanding of the complex dynamics and potential pathways to achieve sustainability goals by incorporating previous information and concepts.

Keywords- *climate change, worldwide issue, sustainable development, green ideas, policies, electric vehicle adoption, interdisciplinary approach*

Introduction

The word 'Sustainable development' is the combination of two words 'Sustainability' and 'development'. The concept of sustainability, according to (Ben-Eli, 2018) is a dynamic equilibrium in which the population grows to realise its full potential while preventing irreversible negative effects on the environment's carrying capacity, which is its primary source of sustenance and, (Mensah, 2019) defines development in their study as a transformative process, development is described as "a rise in the human capacity to establish new structures, manage with challenges, adapt to perpetual change, and endeavour intentionally and creatively towards achieving novel goals. according to the report of the World Commission on Environment and Development, "Humanity can make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs."(WCED, 1988)

(Commonwealth Secretariat, 2011) Globally, a lot of companies strive for sustainable development, which calls for a multidisciplinary strategy that takes into account social, economic, and environmental aspects. A comprehensive plan is needed to address both social disparity and environmental deterioration. From concept to implementation, multidisciplinary cooperation may produce a wide range of answers and creative strategies for promoting sustainable development.(Hou et al., 2020)

Green ideas for sustainable development

Many ideas support to promotion of sustainable development like investing and promoting clean sources of energy such as solar, wind, hydropower, and geothermal power. (Yuksel & Kaygusuz, 2011) , The process of composting saves soil and water while reducing waste materials. (Hou et al., 2020), The clothing industry also fosters sustainable development since natural fabrics are biodegradable and use a lesser amount of water and energy to produce them.(Neumann et al., 2021) and Sustainable transport also contributes to promoting sustainable development. The use of electric vehicles is very helpful for reducing air pollution.(Lazzeroni et al., 2021).

The adoption of electric cars, air pollution, climate change, and sustainable transportation are the main topics of this article. It covers air pollution, the effects of climate change on human health, and the advantages of electric cars for the environment.

The evolution of electric vehicles promotes sustainable development

The climate catastrophe is intensifying as greenhouse gas emissions increase. According to the most recent Intergovernmental Panel on Climate Change study

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global temperatures are presently 1.1 °C higher than pre-industrial levels and are on track to approach or exceed the key 1.5 °C threshold by 2035. Catastrophic and worsening heat waves, droughts, flooding, and wildfires are much too common.(UN DESA, 2023) On every continent of the world, the rate of natural resource depletion has accelerated in recent years. (Gilal et al., 2020)Air pollution, particularly from the transportation industry, contributes significantly to the present climate emergency, underscoring the rising concern over climate change on a worldwide scale that has emerged over the past 20 years.(Press Trust of India, 2023) Air pollution and climate change are mostly caused by the transportation industry, especially in metropolitan areas. Electrification is required to solve this issue and achieve sustainability as road transportation grows, substituting electric vehicles for internal combustion ones..(Franke et al., 2012).

Electric cars (EVs) are becoming more and more popular since they are quiet, practical, and consume very little gasoline, which makes them perfect for city environments. They contribute to cleaner air by consuming no energy, producing no emissions, and without requiring petrol stations.(Un-Noor et al., 2017).

The Mechanism of Battery Electric Vehicle

This article discusses the benefits of electric vehicles but lacks knowledge about their types and technology. There are four categories: hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), battery electric vehicles, and fuel cell electric vehicles.
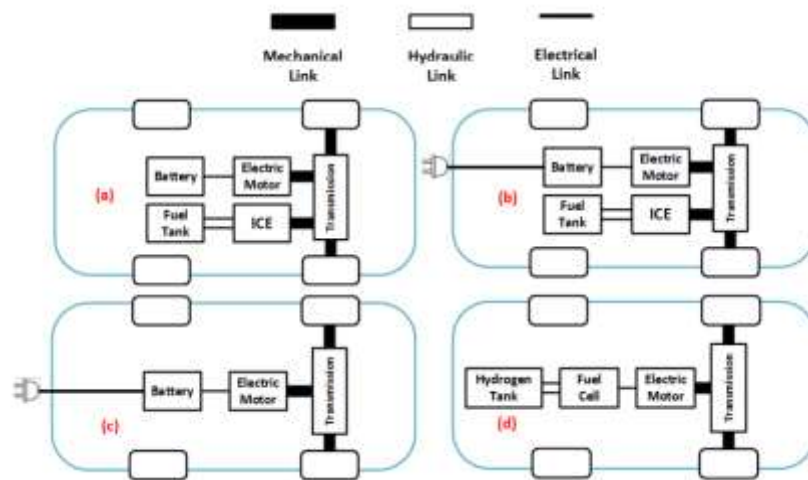

fig.1 Source:(Nour et al., 2020)

Hybrid electric vehicle (HEV)

Hybrid electric vehicles are powered by an internal combustion engine and one or more electric motors, which use energy stored in batteries. A hybrid electric vehicle cannot be plugged in to charge the battery. Instead, the battery is charged through regenerative braking and by the internal combustion engine. (Nour et al., 2020)

Plug-in hybrid electric vehicle (PHEV)

PHEVs run on alternative or traditional fuels, as well as electric power stored in a battery. The internal combustion engine, regenerative brakes, or hooking the battery onto an external power source can all be used to charge it. (Adnan et al., 2017)

Battery electric vehicle (BEV)

Battery electric vehicles (BEVs) are less complicated and more effective than typical internal combustion engine (ICE) cars because they include a high-voltage battery, an electric engine with a power electronics controller, and a single-speed transmission. They are gaining popularity in the business as a viable alternative. (Faraz et al., 2021)

Fuel Cell Electric Vehicle (FCEV)

The fuel cell generates the electricity. The chemical reaction occurs between the lead electrode and the battery. The essential fuels, namely hydrogen and oxygen, are required to create electricity with little greenhouse gas emissions.(Muthukumar et al., 2021)

Comprehensive Review Based on Influencing factors of Adoption of Electric Vehicles

There are many factors which influencing factors that can be categorised into five categories shown in Table 1

Table 1: Categorization and Influencing factors of electric vehicle

S.N.	Factors	Related factors	References
1.	Demographic factors	Age, gender, income, education, employment status, residential status, family size	(C. fei Chen et al., 2020; Globisch et al., 2018; Mohamed et al., 2016; Sovacool et al., 2018; Westin et al., 2018; Yakup & Sevil, 2011)
2.	Technical factor	Driving range, charging time, battery life, charging infrastructure, performance, speed,	(Bobeth & Matthies, 2018; Ledna et al., 2022; Saxena et al., 2014; Tran et al., 2013; Wu et al., 2015)
3.	Economic factor	Purchase cost, energy efficiency, fuel cost, government incentives, tax benefits	(Larson et al., 2015; Peters & Dütschke, 2014; S. Wang et al., 2017; Yadav et al., 2024; Yuksel & Kaygusuz, 2011; Q. Zhang et al., 2013; X. Zhang et al., 2013; Zhou et al., 2021)
4.	Psychological factor	Social influence, driving experience,	(Axsen et al., 2013; Hasan & Simsekoglu,

		emotions, values and beliefs, social status	2020; Higueras-Castillo et al., 2019; Kim et al., 2014; Rezvani et al., 2018; Sahoo et al., 2022; H. Singh et al., 2023; Xu et al., 2020, 2021; Yang & Chen, 2021)
5.	Environmental factor	Environment protection, air pollution, environmental sustainability, green electricity	(Buhmann et al., 2024; Z. Chen et al., 2021; Hackbarth & Madlener, 2016; Higueras-Castillo et al., 2023; B. Kumar et al., 2017; Lai et al., 2015; Y. Wang et al., 2022; Xie et al., 2022)

Electric vehicles (EVs) have become known as an achievable option to mitigate the environmental effect of transportation and dependency on fossil fuels. Despite breakthroughs in EV technology and government incentives, broad EV adoption continues to be complicated phenomenon driven by a variety of variables. Understanding these aspects is critical for politicians, manufacturers, and academics to speed up the transition to sustainable transportation. The purpose of this review is to investigate and analyze the many elements that influence electric car adoption.(V. Singh et al., 2020)

Demographic factors

Adoption of electric cars is heavily influenced by demographic considerations, with higher-income people frequently being early adopters owing to affordability. Age, housing, work, education, and cultural considerations are other variables..(Yakup & Sevil, 2011) Some related studies show how demographic factors affect the adoption of electric vehicles.(Ahmadi et al., 2015) conclude that when we talk about gender in the adoption of electric vehicles men are more interested than women the reason is that men are more driven and more inclined to invest in EVs.(Plötz et al., 2014) shows that age is also a significant predictor in influencing factors for adopting an EV.(Westin et al., 2018) Even after adjusting for sociodemographic characteristics and geographic factors, the study finds that personal norms are the most important factor influencing the ownership of electric vehicles (EVs). Age, education, and home location also have an impact on EV ownership.(Sovacool et al., 2018) counselled that largely men, those with higher levels of education in full-time work, notably in positions in civil society or academia, and those under middle age are the most likely to buy them.(C. fei Chen et al., 2020) their findings reveal that younger guys with a higher income, more children, EV expertise, and a general commitment to sustainability are more likely to embrace EVs.

Technical factors

Technical variables have a considerable impact on EV adoption, including performance, range, charging infrastructure, and user experience. Battery technology, which improves performance and attractiveness; range anxiety; charging infrastructure; charging speed; and compatibility are all important considerations. (Ledna et al., 2022; Lee & Brown, 2021) Even after adjusting for sociodemographic characteristics and geographic factors, the study finds that personal norms are the most important factor influencing the ownership of electric vehicles (EVs). Age, education, and home location also have an impact on EV ownership..(Hossain et al., 2022) Collaboration among industry stakeholders, politicians, and researchers is essential for developing EV technology and infrastructure to match customer demands and preferences.(Dixit & Singh, 2022; Sankaran et al., 2020) identify that improved driving range is a strong influencing factor for the development of electric vehicles.(Junquera et al., 2016) concluded that electric car demand may rise due to battery life improvements, shorter charging times, increased autonomy, and lower prices, with manufacturers aiming to lower EV prices.

Economic factors

The adoption of electric cars is greatly influenced by economic considerations such purchase price, total cost of ownership (TCO), gasoline and energy expenses, infrastructure costs associated with charging, resale value, depreciation rates, government subsidies, and infrastructure investment.(Yadav et al., 2024; Yuksel & Kaygusuz, 2011) The purchase price is an important consideration, with higher-end EVs often costing more than ICE vehicles. Government incentives, tax credits, and subsidies can assist lower the cost of electric vehicles and increase their financial competitiveness.(Sierzchula et al., 2014) concluded that a nation's market share of electric vehicles is positively correlated with its financial incentives, charging infrastructure, and local production facilities. High adoption rates were not guaranteed by either, although charging infrastructure was more closely associated with adoption.(Huang & Ge, 2019) The study demonstrates that attitudes, behaviour control, cognitive status, product perception, and financial incentives all have a favourable impact on customers' inclinations to purchase electric automobiles.

Psychological factors

The adoption of electric cars is heavily influenced by psychological variables, such as innovativeness, cognitive biases, social influence, perceived benefits, barriers, environmental concerns, and psychological distance.(Ryoung & Wujin, 2021) Environmentally concerned people are more inclined to see EVs as a greener option than conventional automobiles. Benefits such as cost savings, performance improvements, and social prestige all influence EV adoption. (Khurana et al., 2020) Perceived impediments include range anxiety, limited charging infrastructure, and worries about battery life and dependability(Sankaran et al., 2020). Social impact, which includes peer influence and subjective standards, can boost confidence in EV adoption. (White & Sintov, 2017) Risk perception, psychological distance, and innovativeness all impact EV adoption.(Patil et al., 2020) Cognitive biases, including confirmation bias, anchoring bias, and availability prejudice, might influence attitudes and views concerning electric mobility. (Xu et al., 2021) The driving experience has a major influence on customer satisfaction, trust, and adoption intentions for electric cars (EVs), with satisfaction positively impacting trust and trust adversely affecting satisfaction. (Thøgersen & Ebsen, 2019) According to the study, moral duties and attitudes play a role in the social effect on intentions to acquire electric cars; positive views are reinforced and doubt is decreased by personal experience.(Barth et al., 2016) finds that EV professionals and non-experts acknowledged that cost-related issues were far more relevant than psychological processes. (Ryoung & Wujin, 2021) shows in their results that Cultural variations affect motivation, reasons for purchasing, and satisfaction with electric vehicles.

Environmental factors

Environmental variables have a huge impact on the adoption of electric vehicles. Climate change concerns, air quality and pollution, resource depletion and energy security, noise pollution, and ecological damage are all important drivers of EV adoption. (Franke et al., 2012)EVs can help cut carbon emissions and combat climate change while lowering air and noise pollution can result in calmer, more pleasant urban areas.(Adnan & M Vasant, 2016) EVs also have lower environmental consequences across their whole lifespan, including decreased emissions and resource exploitation. Urban planning and sustainability measures, such as incorporating EV infrastructure into urban planning efforts, promote both sustainable transportation and environmental sustainability.(Nordlund et al., 2016) EVs can serve as distributed energy storage devices, facilitating renewable energy integration. Government regulations and incentives, like as emissions rules and charging infrastructure expenditures, are important environmental influences on the EV industry(H. Zhang et al., 2008). By tackling these issues, stakeholders may contribute to a cleaner, healthier, and more sustainable future for mobility.(Degirmenci & Breitner, 2017) concluded that environmental concerns are a very strong predictor compared to purchase price and driving range in the adoption of electric vehicles.(Adnan et al., 2018) identify that Consumer attitudes are strongly impacted by their environmental concerns. (Xie et al., 2022) Environmental consciousness has a substantial impact on the link between technological compatibility and perceived risk.(Okada et al., 2019) The evaluation of EVs demonstrates that environmental awareness has an immediate impact on a non-EV user's purchasing intention, but only a slight impact on an EV user's post-buy satisfaction.(Khurana et al., 2020) environmental concerns have indirect effect on behaviour intention of consumer and a direct effect on the attitude of consumers to adopt electric vehicle.(Flamm, 2009) The family members who knew more about the environmental implications of owning and driving automobiles had more fuel-efficient vehicles,

Comprehensive review based on theoretical framework on the adoption of electric vehicle

This paper examines many theoretical frameworks for researching the uptake of electric cars and emphasizes how crucial it is to comprehend consumer considerations in order to minimize environmental problems and promote sustainable mobility.Some studies and their theoretical framework are shown in Table 2

Theory of planned behaviour (TPB)

(Ajzen, 1991) The Theory of Planned Behaviour (TPB) is a framework for analyzing and forecasting human behaviour. It suggests that an individual's behaviour is driven by their desire to do that behaviour, influenced by three factors: attitude, subjective norm, and perceived behavioural control. Attitude affects the likelihood of adopting electric vehicles, while subjective norms refer to perceived societal pressure. Perceived behavioral control, intention, and societal standards also impact adoption. (Shalender & Sharma, 2021)(Huang & Ge, 2019)(Adnan et al., 2017) (Thøgersen & Ebsen, 2019)

Diffusion of innovation (DOI)

(rogers everett M., 2003) Five primary adopter types are identified by Everett Rogers' Diffusion of Innovation theory: innovators, early adopters, early majority, late majority, laggards, and traditionalists. Risk-takers are innovators; early majority is achievable; late majority is crucial; laggards embrace innovations with reluctance.

Technology Acceptance Model (TAM)

(Davis, 1987) Fred Davis created the Technology acceptance Model (TAM), a theoretical framework in the 1980s to forecast information technology user acceptance. It implies that attitudes toward use, behavioral intention to use, and perceived utility and simplicity of use all have an impact on motivation.

Norm activation theory (NAT)

(Schwartz, 1977) According to Schwartz's Norm Activation Theory (NAT), pro-social behaviors like environmental activism and sustainable consumerism are impacted by personal experiences, cultural factors, and socialization of one's own norms. Emotional arousal and antecedent situations initiate these norms.

Unified theory of acceptance and use of technology (UTAUT)

The Unified Theory of Adoption and Use of Technology (UTAUT) is an approach created by (Venkatesh et al., 2003) The UTAUT model predicts people's adoption of information technology using factors like performance expectations, effort, and social influence. It considers facilitating conditions like technical assistance, training, infrastructure, and policies, and actual usage behavior.(Venkatesh v, 2012) which is the continuation model of UTAUT with some updation. To explain individual consumer behaviour, the researcher eliminates one moderator (volunteer to use) and adds three more independent components (hedonic motivation, price value, and habit). The only difference between UTAUT and UTAUT2 in this work was consumer context.

Table: 2- Studies and Theoretical Framework

	Reference	Theoretical framework	Methodology for data collection	Findings
	(Buhmann et al., 2024)	Extended theory of planned behavior	Online survey	Attitude, perceived behavioral control, subjective norm, and moral norm significantly influence customer adoption intentions, with environmentally conscientious customers potentially supporting BEV adoption due to favorable sentiments.
	(H. Singh et al., 2023)	UTAUT 2 NAM model	Questionnaire survey	Performance expectation, enabling conditions, hedonic motivation, price value, and personal norms positively influence customers' intentions to adopt electric vehicles, while effort expectancy and social influence do not.

(Upadhyay & Kamble, 2023)	Stimulus organism response model	Questionnaire survey	The study finds that pro-environment responsibility has a substantial impact on pro-environment value and attitude, which in turn effects pro-environment purchase intention of electric cars, with a pro-environment attitude mediating the link.
(D. Wang et al., 2023)	UTAUT	Online survey	performance expectations, social influence, and price value favourably influence EV adoption intention, however, perceived risk has a negative impact. Furthermore, age and gender were found to strongly influence adoption intention.
(Xie et al., 2022)	Innovation diffusion theory and theory of planned behaviour	Questionnaire survey	Purchase intention is influenced by innovation features, with perceived risk playing a mediating role. Fashion consciousness balances relative advantage and perceived danger, whereas environmental consciousness impacts technology compatibility and perceived risk.
(Gunawan et al., 2022)	UTAUT2 and theory of planned behaviour	Questionnaire survey	The study reveals that electric car desire is influenced by factors such as attitude towards usage, subjective norm, and perceived behavioral control.
(Cui et al., 2021)	Maslow hierarchy of needs model	Online survey	environmental concern is the most powerful predictor of EV purchase motivation, followed by price consciousness, openness to experience, social influence, and self-esteem.
(Jaiswal et al., 2021)	Extended technology acceptance model	Online survey	the determinants of attitude, perceived utility, perceived ease of use, and perceived risk impact EV adoption intention both directly and indirectly, with financial incentives policies playing a moderating role.
(Shalender & Sharma, 2021)	Extended Theory of planned behaviour	Questionnaire survey	The adoption intention of customers is positively correlated with attitude, subjective norm, perceived behavioural control, moral norm, and environmental concern.
(C. fei Chen et al., 2020)	Diffusion of innovation	Large scale survey	Younger males with higher income, children, and sustainability values are more likely to adopt electric vehicles, with factors like vehicle-to-grid capability, charging time, fuel economy, financial savings, and environmental value.
(Huang & Ge, 2019)	Theory of planned behaviour	Questionnaire survey	attitudes, behaviour control, cognitive status, product perception, and financial incentives all have a favourable impact on customers' inclinations to purchase electric automobiles in Beijing.
(Thøgersen & Ebsen, 2019)	Theory of planned behaviour and technology acceptance model	Depth interview	Car owners' intention to purchase an eco-friendly vehicle improves with attitude and moral duty, while decreases with perceived difficulties and ambiguity. Personal experience and social influence both have a favorable impact on purchase intentions.

(Adnan et al., 2018)	Extended theory of planned behaviour	Online survey through email	Subjective norms, personal moral norms, perceived behavioural control, and attitude are all highly influenced by environmental concerns.
(Nordlund et al., 2016)	NAT, VBN, theory of environmentalism	Online survey	A comparison between CV, AFV, and HEV/PHEV/EV owners. • HEV, PHEV, and EV owners are more open to change. • Less conservative. • Increased problem awareness, self-efficacy, and a stronger personal norm.
(Mohamed et al., 2016)	Extended Theory of planned behavior	Online survey	Attitudes perceived behavioural control, and norms all have a direct impact on behavioral intention, whereas environmental concerns have an indirect affect. Adoption intention is also influenced by age, work level, and status.
(Peters & Dütschke, 2014)	diffusion of innovation	Large online survey	Early middle-aged male EV adopters with a higher Willingness to buy, impacted by perceived compatibility with personal requirements. Promotion, environmental benefits, and financial incentives are key indicators, but performance aspects are less relevant.
(Plötz et al., 2014)	Diffusion of innovation	Public survey	Middle-aged males from rural and suburban cities who have families should be the primary target audience for EV-promoting transportation policies.

Conclusion

To summarise, the use of electric vehicles (EVs) for sustainable development is impacted by a variety of factors that interact in complicated ways. Consumer decisions are heavily influenced by economic variables such as purchase price, operation expenses, and government incentives. (Degirmenci & Breitner, 2017; Peters & Dütschke, 2014) Technological breakthroughs, such as improvements in battery technology and charging infrastructure, are critical for increasing the ease and attractiveness of electric vehicles.(Ledna et al., 2022; Y. Wang et al., 2022) The adoption of electric vehicles (EVs) is influenced by social factors, environmental consciousness, and regulatory measures. Therefore, in order to accomplish sustainable development goals, these aspects must be fully addressed.(R. R. Kumar & Alok, 2020) Policymakers, industry stakeholders, and the general public must work together to eliminate impediments and speed the transition to a more sustainable transportation environment.

The dynamics of EV adoption are better understood by utilizing economic theories, technological frameworks, sociocultural theories, and policy-oriented frameworks that emphasize cost, technological breakthroughs, societal norms, environmental views, and government actions.

Conflicts of interest
The authors declare that there are no conflicts of interest regarding the publication of this paper.

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