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Electric Bike Adoption as a Pathway to Sustainable Mobility: Empirical Evidence from Survey Data

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Abstract: *The transition towards sustainable urban mobility has gained prominence in recent years due to rising environmental concerns, traffic congestion, and dependence on fossil fuels. Electric bikes (e-bikes) have emerged as a viable alternative to conventional petrol-powered two-wheelers, particularly in developing economies where affordability and accessibility play a crucial role. This study examines the role of demographic and socio-economic factors in shaping electric bike adoption and usage behaviour, with a focus on sustainability-oriented consumer choices.*

Using primary survey data, the study analyses respondents' demographic profile, income levels, ownership patterns, usage behaviour, and satisfaction with various attributes of electric bikes. Descriptive statistics are employed to summarise the demographic and socio-economic characteristics of the respondents. The Chi-square test of association is used to examine the relationship between selected demographic variables and electric bike ownership. The results indicate a young and economically diverse respondent base, reflecting the growing acceptance of electric bikes among cost-conscious and environmentally aware consumers. The findings further reveal that electric bike ownership is not significantly associated with gender, suggesting inclusive adoption patterns.

By linking sustainable mobility adoption with socio-economic characteristics, the study contributes to the literature on green consumer behaviour and sustainable transport planning. The findings offer important policy insights for promoting electric mobility through targeted awareness programmes, infrastructure development, and affordability-driven incentives. The study underscores the potential of electric bikes as an accessible and inclusive pathway towards achieving sustainability goals in urban transportation systems..

Keywords*: urban mobility*

I. INTRODUCTION

Background of the Study

The pressures of the growing population in developing economies on personal mobility are one of the most pressing needs due to the rapid urbanisation, the growth of income and the alteration of the lifestyle mode. Although motorisation has made accessibility easier and economical, it has also given rise to severe problems including air pollution, green house gas emissions, traffic congestion, and increased fuel consumption. The transport sector has now been identified as among the biggest contributors of environmental degradation hence the need to change towards sustainable mobility solutions.

In this respect, electric bikes and especially electric vehicles (EVs) have become a topic of interest as an ecologically friendly and rather affordable option to petrol-powered two-wheelers. Electric bikes are especially appropriate in the short distance urban travel as they are affordable in their operations, less emitting and user friendly. They have also been found to be especially relevant during the post-pandemic period as people favor using their personal transportation over public transportation because of the safety needs.

Rationale for the Study

Although the level of electric mobility mobility is becoming a priority of the policy, there is still an unequal rate of adoption among population groups. According to the existing literature, age, income, education, and occupation are some of the demographic and socio-economic characteristics that play a major role in determining sustainable consumption and mobility choices. Nevertheless, there is little empirical study on the impact of these variables on the uptake of electric bikes at the micro level especially in the emerging economies.

The demographic and socio-economic population of the electric bikes users is essential in determining the inclusion and effectiveness of the sustainability policies. Electric bikes tend to be presented as relatively cheap alternatives, but they still might not be able to be adopted due to income barriers, unawareness, or infrastructure deficiencies. Besides, it is important to explore the study of whether sustainable mobility transitions are more or less inclined to adoption based on gender and age groups.

The necessity to conduct the empirical study of the electric bike adoption in the context of sustainability, as well as the role of demographic and socio-economic traits, is what prompts the given study. Through the survey-based evidence and association testing, the study aims at closing the gap between the sustainability policy objectives and the real consumer behaviour.

Objectives of the Study

The objectives of the study are specific and they are:

- To analyze demographic picture of respondents with the help of descriptive statistics.
- To examine the socio-economic traits of the respondents, especially income and occupation.
- To determine the ownership and usage pattern of the electric bikes among the respondents.
- To confirm the relationship between the chosen demographic variables and the ownership of an electric bike with the help of the Chi-square test.
- To assess the place of the electric bikes as a sustainable and non-discriminating mobility solution.

Hypotheses of the Study

According to the purposes, the hypothesis is as follows:

H 01: Gender does not have any significant relationship with ownership of electric bikes.

H 1 1: Gender has a significant relationship with electric bike ownership.

H 0 2: age group is not significantly related to electric bike ownership.

H 12: The relationship between age group and ownership of electric bikes is significant.

H 0 3: Income level does not have a significant relationship with electric bikes ownership.

H 1 3: Income level and ownership of electric bikes have a strong linkage.

These hypotheses can be systematically tested to find out whether demographic neutrality or disparity in sustainable mobility adoption exists or not.

Theoretical Foundation of the Research.

The theoretical basis of the research is sustainable consumption and green mobility publications. It presupposes that demographic (age, gender) and socio-economic (income, occupation) variables drive the electric bike ownership and usage behaviour, which, in its turn, will lead to the sustainable urban mobility results.

Demographic Factors →Socio-Economic Factors→Ownership and Usage of the Electric Bikes

→ Sustainable Mobility Results (Less emission, affordability, accessibility)

The framework emphasizes that the choices of adoption are influenced by personal traits and economic ability, which eventually influence the end results of sustainability at the urban level.

II. REVIEW OF LITERATURE

Sustainable urban mobility has become one of the primary policy priorities due to the rapid urbanisation and the growth of motorisation, which have exacerbated the issues of air pollution, traffic congestion, and fossil fuel reliance (Winslott Hiselius and Svensson, 2017). In this context, electric bikes (e-bikes) have also become an efficient and low-emission option of transportation in the short distance in the city, especially in the densely populated ones.

A considerable amount of literature has made the environmental advantages of switching to e-bikes by replacing personal vehicles. According to McQueen et al. (2020), it is estimated that a shift in favor of e-bikes rather than cars in commutative travel can potentially decrease the amount of carbon dioxide emitted per capita, particularly when traveling less than 10 km. Phillips et al. (2022) also note the same findings by asserting that e-bikes have a great potential to reduce urban transport emissions, in the case that proper policies are set in place to support the shift to e-bikes. The same life-cycle assessment research confirms that even after taking into consideration the production of a battery and the consumption of electricity, e-bikes have a significantly smaller environmental footprint than a conventional vehicle (Elliot et al., 2018; Liu et al., 2021).

Socio-demographic variables that affect the adoption of e-bikes have also received a lot of research. Research on the topic in Europe suggests that age and income are major factors, and younger and working-age people are more likely to adopt it (Sun et al., 2020; de Haas et al., 2021). But according to recent empirical data, there are signs that gender differences in the ownership of e-bikes are decreasing, which points to a shift in the trends toward the more inclusive patterns of sustainable mobility adoption (Di Gangi et al., 2022). This trend highlights the increased acceptance of e-bikes among different groups of people.

Another significant branch of the literature is usage behaviour and user satisfaction. GPS-tracked pilot studies indicate that home-work-home e-bikes are mostly used, the frequency of their use is high on working days, and the average distance of the trips is between 5 and 8 km (McQueen et al., 2020; Di Gangi et al., 2022). It has been found that regular e-bike riding is related to higher levels of travel comfort, decreased levels of commuting stress, and good psycho-physical well-being (Langford et al., 2017; World Health Organization, 2018).

Although these are the benefits, infrastructure and safety issues are some of the major deterring factors to mainstream adoption. Some of the studies highlight that the absence of special cycling infrastructure, risk of safety, and absence of enough parking areas limit the use of e-bikes (Haustein and Moller, 2016; Panwinkler and Holz-Rau, 2021). The literature therefore makes emphasis on integrated urban transport planning, enabling infrastructure and the use of incentives based policies to uphold compliance in the long term.

On the whole, current literature confirms that the e-bike adoption is increasingly influenced by factors of economic efficiency, usability, and sustainability rather than exclusive features of demographics. Nonetheless, part of the empirical findings is related to developed economies and interventions conducted by pilots. This underscores the importance of a micro-level survey based research of emerging urban settings to gain a deeper insight on inclusive adoption trends as well as sustainability performance.

Generally, the literature indicates that there is a transition between the demographic determinism and behavioural explanations of online purchasing. Although digital marketing increases the access and efficiency, platform and message design dictate the sustainability results of digital marketing. This is in line with the necessity to promote accountable digital marketing efforts in accordance with the Sustainable Development Goal 12, especially concerning fast-urbanising economies.

Research Gaps Identified

According to the literature review, a number of gaps in the research are still present. To start with, the majority of the research is based on the impact of digital marketing on online buying without explicitly considering the outcome of sustainability, especially responsible and restrained consumption. Second, there are still few empirical studies of emerging urban economies such as India and the ones that exist have been mainly based on developed countries. Third, the prevailing use of cross sectional designs limits the knowledge concerning the changing behaviour of digital consumption with time. Fourth, little is paid to such behavioural mechanisms as impulse control, digital nudging and ethical marketing practices. Lastly, the relationship between the intensity of the digital marketing and the Sustainable

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Development Goal 12 remains under-researched; therefore, policy-based, behaviour-centred research paradigms are necessary.

III. METHODOLOGY

Research Design

The research design used is a descriptive and analytical study. It integrates both descriptive and inferential statistics to characterize the respondents and experiment with inferential statistics to establish relationships among the variables.

Data Source

It is grounded on a primary data that is going to be gathered with the help of a structured questionnaire. The questionnaire was aimed at eliciting data on demographic features, socio-economic, possession of electric bikes, their usage patterns, satisfaction, and attitude towards electric bikes.

Sampling Design

The convenience sampling technique was adopted because of time and accessibility factors. The respondents were sampled on the urban areas where the use of electric bikes is slowly rising. Analysis was done on 105 valid responses after cleaning the data.

- Sample Size : 105
- Variables Used in the Study
- Demographic Variables: gender, age.
- Socio-Economic Variables: wages/month, Profession.
- Adoption Variable: The ownership of electric bike (Yes/No)
- Sustainability Measures: price effectiveness, frequency of use, satisfaction.

Tools and Techniques of Analysis

Descriptive Statistics: Demographic and socio-economic profiles were crushed in frequencies and percentages.

Chi-Square Association Test: Used to test the relationship between demographic factors (e.g. gender) and the ownership of electric bikes.

Rule of decision: p less than 0.05 signifies that there is a significant association.

Tabular Presentation: A presentation of results is made through the use of tables in order to make them understandable.

Ethical Considerations : The survey was conducted on a voluntary basis and the purpose of the study was explained to the respondents as an academic purpose. Respondent confidentiality was guaranteed and no personal identification information was provided.

Scope and Limitations

The research concentrates on a small sample of study and people in cities, which can act as a limitation to generalisation. Nevertheless, the results are very promising in terms of the investigations of the new sustainable trends in mobility and can be utilized in the future in terms of large-scale research.

Table 1 Demographic and Socio-Economic Profile of the Respondents

Gender	Frequency	Percentage (%)
Female	54	51.43
Male	51	48.57
Total	105	100.00

Table 1, above shows a nearly balanced gender composition, ensuring adequate representation of both male and female respondents in analysing sustainable mobility adoption.

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Age Group	Frequency	Percentage (%)
Below 20 years	35	33.33
21–30 years	48	45.71
31–40 years	12	11.43
41–50 years	8	7.62
Above 50 years	2	1.90
Total	105	100.00

Table 2 above reveals, a majority of respondents fall in the below 30 years age group, indicating stronger participation of younger cohorts, who are typically more receptive to sustainable transport alternatives such as electric bikes.

Table 3 Monthly Income of the Respondents

Monthly Income	Frequency	Percentage (%)
Below ₹10,000	43	43.43
₹10,001 – ₹20,000	24	24.24
₹20,001 – ₹30,000	23	23.23
₹30,001 – ₹50,000	6	6.06
Above ₹50,000	3	3.03
Total	99*	100.00

*Income responses exclude missing values.

The income profile indicates dominance of low- and middle-income groups, highlighting the relevance of cost efficiency in sustainable mobility adoption.

Chi-Square Test of Association

Gender and Ownership of Electric Bike

Gender	Own Electric Bike – Yes	Own Electric Bike – No	Total
Female	41	13	54
Male	42	9	51
Total	83	22	105

Chi-Square Test Results : χ^2 value = 0.324, Degrees of freedom = 1, p-value = 0.569

According to the Chi-square test, the relationship between sex and the possession of electric bikes is not significant ($p > 0.05$). This implies that the use of electric bikes is gender-neutral, which supports the idea of the sustainable mobility solutions being inclusive.

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Overall Analytical Insight

The descriptive analysis indicates that it was a young, economically diverse sample, which is highly appropriate to investigate sustainability-oriented transport behaviour. The Chi-square findings also suggest that demographic neutrality in ownership holds policy narratives of electric mobility as an inclusive and sustainable alternative among the population groups.

Structural Equation Modelling (SEM)

SEM is a multivariate method that is of advanced level and estimates relation among both latent and observed variables combining factor analysis and regression.

Path analysis model demonstrates the direct and indirect connections between the observed variables with regard to the health outcomes. The variables of exercise (x 1) and hardiness (x 2) are exogenous variables and can covariate, which implies that more active people can also be psychologically harder. Fitness (y 1) and stress levels (y 2) are positively influenced by exercise and hardiness, respectively, which implies that stress can be handled more effectively by resilient people. Fitness has a bad influence on stress, which means that the fitter an individual is, the less stress she or he has. The last outcome variable is illness (y 3), which is affected by several pathways. It depends directly on fitness and stress, which points to both physical and psychological pathways according to which health outcomes are defined. Also, indirect effects of exercise and hardiness on illness are also exerted via fitness and stress respectively. It has the presence of the disturbance terms (ζ 1, ζ 2, ζ 3) which is appreciated as a recognition of unexplained variance in the presence of other unobserved variables. In general, the model shows that lifestyle, psychological resilience, and health outcomes are interconnected.

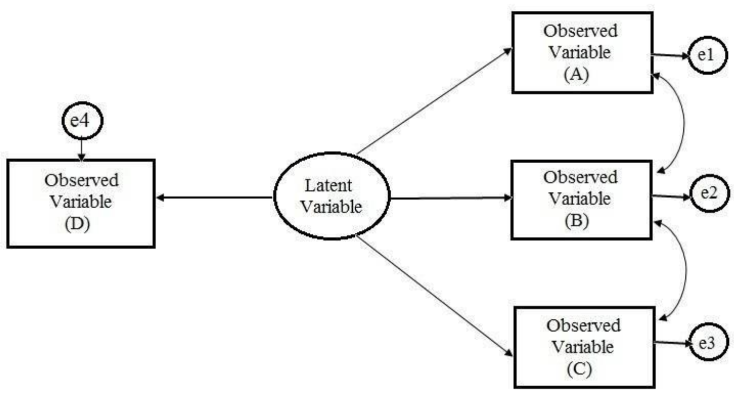

Figure 3.2 : Basic Structural Equation Model
Source: Author's Formulation

The simplistic Structural Equation Model (SEM) demonstrates how a latent construct is related with the indicators of measurement as well as the measurement error. Latent variable is some theoretical construct, which is immeasurable. It is represented by three variables (A, B, and C) observed and each variable is an indicator of the latent construct. The directional arrows between the latent variable and the observed variables depict factor loadings, which mean the intensity and the direction of the relationship between the latent construct and each indicator. These error terms (e1, e2 and e3) of the observed variables include the measurement error and unexplained variance and the fact that we are using observed measures as suboptimal measures of the underlying concept. Also, the model has an observed exogenous variable (D) that has its error term (e4), this is connected to the latent variable, that presupposes the presence of a causal or explanatory relationship. All in all, the model exhibits the way in which SEM combines the measurement and structural elements to examine complex relations with a clear consideration of the error.

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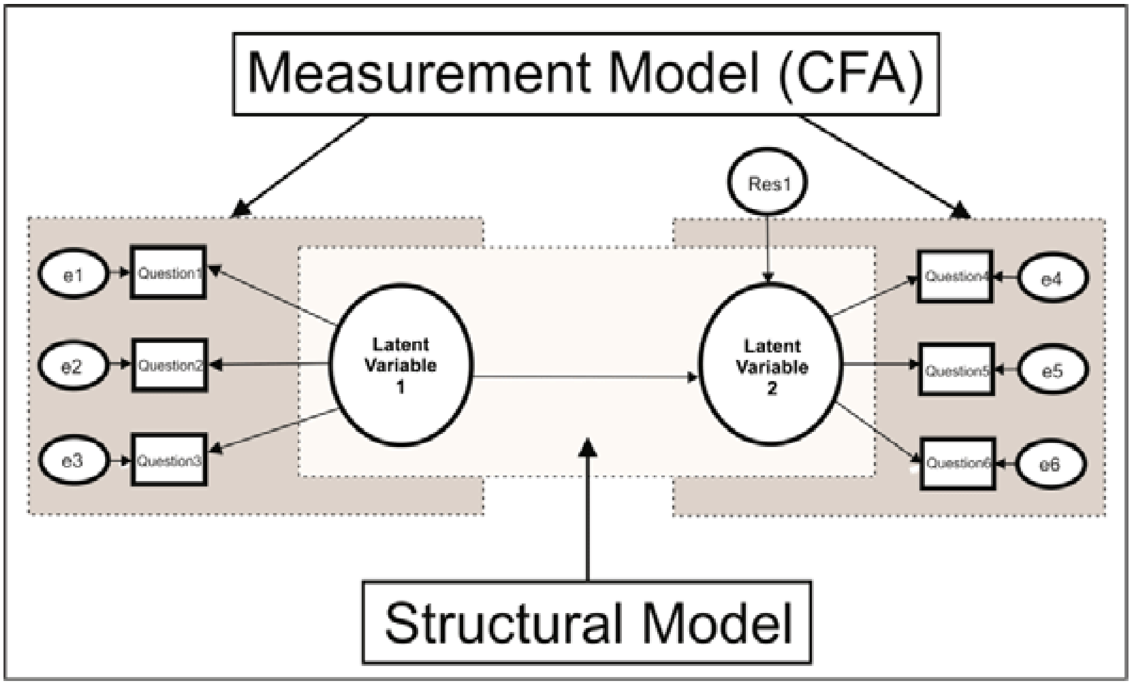

Source: Author's formulation based on primary data collected

The figure is a Structural Equation Modelling (SEM) modeling that includes the measurement model (Confirmatory Factor Analysis) and the structural model. The measurement model defines the way in which every latent variable is operationalised by the use of various observed indicators. Latent Variable1 refers to three observed items (Questions 13), whereas Latent Variable2 refers to another group of observed items (Questions 56). The related error terms (e1–e6) represent the measurement error along with the careless variance, as observed indicators are of imperfect nature. This is in line with construct validity because it verifies that each set of indicators is loading on corresponding latent construct. The structural model shows the postulated causal relationship between the two latent variables and it shows that Latent Variable 1 has a directional causal relationship with Latent Variable 2. Res1 is the unexplained variance of the endogenous latent construct. In general, the model illustrates that SEM is able to establish both validation of measurement properties and test theoretical relationships as a potent approach in the analysis of complex behavioural and socio-economic phenomena.

Components

- Measurement Model: Links observed variables to latent constructs (via CFA)
- Structural Model: Tests causal relationships among constructs

Advantages

- Tests direct and indirect effects
- Accounts for measurement error
- Suitable for complex behavioural and policy models

Model Fit Indices

CFI, TLI (≥ 0.90)
RMSEA (≤ 0.08)
SRMR (≤ 0.08)

Analysis of the effect of income, education and household size on food, health and leisure spending using latent social economic status.

IV. CONCLUSION

The paper has investigated how demographic and socio-economic variables can influence the adoption and satisfaction of electric bikes in a sustainability-based mobility system. Based on descriptive statistics, association testing, and structural equation viewpoint, the results reveal that the adoption of electric bikes is becoming more practical with the consideration of cost-effectiveness, usability, and perceived benefits than demographic exclusivity. Nearly no gender-based discrepancies in the sphere of ownership help emphasize the nature of inclusivity of electric mobility. The findings also indicate that latent factors that are generated based on satisfaction and use factors are key determinants of sustainable transport behaviour. Altogether, the research proves that the electric bikes are a potential, affordable and eco-friendly substitute of the traditional two-wheelers. The research connects individual traits to more general sustainability findings, which adds the empirical data to the emerging body of green mobility transitions in developing economies.

Policy Recommendations

The conclusions present a number of policy implications to facilitate sustainable mobility. To start with, incentives that are affordability based such as targeted subsidies, low-interest financing and tax subsidies should be reinforced to attract adoption among the low- and middle-income groups. Second, charging infrastructure should be invested in, especially in residential and workplace locations, to enhance the convenience of the user and decrease range anxiety. Third, more acceptance can be achieved among demographic groups by making them aware of long-term cost savings and environmental benefits of the initiative. Considering the gender-neutral adoption trends, the adoption policies must be oriented towards inclusivity and not targeting towards particular groups. Also, the user satisfaction and long-term usage could be increased by the improvement of the after-sales service networks and by the battery replacement facilities. The inclusion of electric bikes in the city transportation planning, last-mile connectivity, and shared mobility systems will also contribute to the sustainable city development objectives.

Scope for Future Research

The current study is very informative but it also leaves a number of opportunities to conduct further research. First, bigger and more geographically dispersed samples are able to enhance the generalisability of results. Second, longitudinal research would assist in capturing change in adoption behaviour over time, especially when infrastructure and policy support changes. Third, structural equation model can be expanded in the future research by including attitudinal variables like environmental awareness, risk perception, and technology readiness. The comparative analysis of electric bikes and other electric vehicles could also provide more significant insights into the mode choice in dynamic mobility systems. Also, the sustainability assessment could be enhanced by including objective environmental measures, including emission reductions. Lastly, mixed-method designs that would integrate survey data with qualitative interviews would have more detailed information on consumer motivations and adoption barriers.

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