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From Fossil Fumes to Clean Commutes: A Comparative Study of Green Buses and Local Vans

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Abstract

Transportation is a leading contributor to environmental pollution through carbon dioxide (CO_2) emissions and other greenhouse gases (GHGs). This study compares the environmental and economic impacts of local vans, powered by diesel, petrol, or CNG, with green electric buses on the 22 km Taxila–Golra Morh route. Data were collected through structured questionnaires to assess commuter perceptions of cost, comfort, safety, and environmental awareness, alongside a carbon emissions analysis. Results show that vans emit 7.3–7.6 kg of CO_2 per trip, while electric buses emit only 5.0 kg, reducing emissions by 30–35%. Survey findings reveal that while vans are perceived as more affordable, green buses are favored for their environmental and social benefits. Overall, electric buses offer cleaner, more sustainable, and cost-effective solutions for urban transport, providing important insights for policymakers to encourage a transition toward climate-resilient mobility.

Keywords: Transportation, Carbon emissions, Green buses, Climate Change, Sustainable Transport

Introduction

Transportation is a major contributor to air pollution and greenhouse gas (GHG) emissions worldwide. Rapid urbanization and increasing mobility demands have intensified reliance on fossil fuel-powered vehicles, which emit harmful pollutants such as carbon monoxide (CO), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and particulate matter (PM). These emissions degrade air quality, harm human health, and contribute significantly to climate change (Bandara & Thilakarathne, 2025). Globally, road transport accounts for more than 70% of transport-related CO_2 emissions (Song et al., 2018).

Road transport, including cars, buses, motorcycles, vans, and trucks, relies heavily on gasoline and diesel, which are non-renewable fossil fuels. These fuels are rich in carbon, and when burned in internal combustion engines to produce energy, they undergo a chemical reaction with oxygen that releases carbon dioxide (CO_2) along with other harmful gases into the atmosphere. This process is a major driver of air pollution and climate change. Transportation is one of the largest contributors to climate change, mainly due to its heavy reliance on fossil fuels. It produces a significant share of global greenhouse gas (GHG) emissions, which trap heat in the atmosphere and lead to global warming**.** Climate change effects caused by transport emissions are global warming, extreme weather events, sea level rise or Ocean acidification etc.

In South Asia, the problem is particularly severe due to outdated vehicles, reliance on fossil fuels, and poor public transport systems. Local vans and diesel minibuses dominate short-distance travel, producing considerable emissions, noise, and traffic congestion (Vattanaprateep, 2019). By contrast, electric buses (green buses) are emerging as sustainable alternatives. They offer reduced emissions, improved air quality, and enhanced commuter experiences (Sunitiyoso et al., 2022). However, their adoption remains limited, often constrained by cost, limited infrastructure, and consumer perceptions.

This study evaluates the comparative environmental, economic, and social impacts of green buses versus local vans in Pakistan. Unlike previous studies that focus solely on commuter perceptions or technical emissions modeling, this research integrates both. A structured commuter survey is combined with a carbon emissions analysis of the Taxila–Golra Morh route (22 km), offering both perceptual and quantitative evidence on the role of green buses in sustainable urban transport.

Research Gap

The reviewed literature highlights three key gaps. First, most studies in South Asia emphasize cost as a barrier but do not empirically test commuter perceptions across environmental, social, and cost dimensions. Second, while global studies provide emissions data for electric buses, there is

little localized evidence for Pakistan. Third, limited attention has been paid to the mediating role of awareness in shaping both willingness to pay and transport choice.

This study addresses these gaps by combining perception-based survey data with a quantitative emissions analysis for a real-world route in Pakistan. In doing so, it offers both subjective and objective evidence to inform sustainable transport policies.

Objectives of the Study

The study was guided by the following objectives:

1. To determine the impact of green buses and local vans on the environment.
2. To estimate travel cost perceptions for green buses versus vans.
3. To explore commuter awareness and willingness to pay for green buses.
4. To compare carbon dioxide (CO_2) emissions for vans (diesel, petrol, CNG) and green buses on a 22 km route.

Research Questions

The research aimed to address the following questions:

- What is the environmental impact of green buses compared to local vans?
- How do commuters perceive travel costs between vans and green buses?
- What role do awareness and willingness to pay play in green bus adoption?
- How do actual CO_2 emissions differ between vans and green buses on a 22 km route?

Hypotheses

H_{01}: Green bus users report higher environmental and social perception scores than van users.
H_{02}: Van users report higher cost-effectiveness scores compared to green bus users.
H_{03}: Awareness is positively associated with willingness to pay for green buses.
H_{04}: Awareness levels differ significantly between van and bus users.
H_{05}: Green buses emit lower CO_2 than vans on the 22 km Taxila–Golra Morh route.

Methodology

Research Design

This study adopted a quantitative, cross-sectional survey design to capture commuter perceptions of vans and green buses within the Islamabad–Rawalpindi region. A quantitative design was deemed appropriate because it allows for the measurement of structured variables, statistical comparisons, and hypothesis testing. The cross-sectional nature of the study meant that data were collected at one point in time, which was suitable for identifying prevailing perceptions and attitudes without requiring longitudinal tracking.

Population and Sampling

The population comprised **urban commuters** who regularly traveled using either local vans or green buses on intercity routes. The study applied **simple random sampling** to avoid bias and to ensure equal representation of both transport modes. A total of **138 valid responses** were collected, of which 80 were from van users and 58 from bus users. This sample size was statistically adequate, as recommended by Krejcie & Morgan (1970), to achieve 95% confidence levels in social science research.

Table 1: Sample Distribution by Transport Mode

Mode of Transport	Frequency	Percentage
Vans	80	58.0%
Green Buses	58	42.0%

The sample ensured sufficient representation from both groups to allow comparative analysis.

Data Collection

Primary data were collected using an online questionnaire administered through Google Forms. This method was chosen for convenience, accessibility, and cost-effectiveness. The questionnaire included closed-ended items to allow for statistical analysis. It was divided into four sections:

1. **Demographics** – basic commuter characteristics (age, gender, occupation, frequency of travel).
2. **Perceptions** – Likert-scale questions measuring environmental, social, and cost dimensions (1 = Strongly Disagree to 5 = Strongly Agree).

3. **Awareness** – binary items (Yes/No) asking whether respondents were aware of the environmental impacts of green buses.
4. **Willingness to Pay (WTP)** – binary items (Yes/No) assessing whether commuters were willing to pay slightly more for green bus services.

Variables and Measures

The study included both independent and dependent variables.

- **Independent Variable:**
  - **Transport Type**: coded as 0 = Van, 1 = Green Bus.
- **Dependent Variables:**
  - **Environmental Perception**: measured on a 5-point Likert scale. Higher scores indicated stronger agreement that the transport option was environmentally friendly.
  - **Social Perception**: measured on a 5-point Likert scale. Higher scores reflected perceptions of comfort, safety, and social acceptability.
  - **Cost Perception**: measured on a 5-point Likert scale. Higher scores reflected perceptions of affordability.
  - **Awareness**: measured as a binary variable (Yes = 1, No = 0).
  - **Willingness to Pay**: measured as a binary variable (Yes = 1, No = 0).

Table 2: Summary of Variables and Measures

Variable	Type	Measurement Scale	Description
Transport Type	Independent	Nominal (0,1)	Mode of travel (Van or Bus)
Environmental Perception	Dependent	5-point Likert	Perception of eco-friendliness
Social Perception	Dependent	5-point Likert	Perception of comfort, safety
Cost Perception	Dependent	5-point Likert	Perceived affordability
Awareness	Dependent	Nominal (Yes/No)	Awareness of green bus benefits
Willingness to Pay	Dependent	Nominal (Yes/No)	Willingness to pay more for bus

Data Analysis

The data were analyzed using **SPSS** in three stages:

1. **Descriptive Statistics:** Frequencies and percentages summarized demographic characteristics, awareness, and willingness to pay.
2. **Inferential Statistics:**
    - **Independent Samples t-tests** compared mean perception scores of van and bus users across environmental, social, and cost categories. This test was chosen because it compares the means of two independent groups.
    - **Chi-square tests** assessed associations between categorical variables, specifically awareness × willingness to pay, and awareness × transport type.
3. **Carbon Emissions Analysis:** Secondary data were used to estimate CO_2 emissions for vans (diesel, petrol, CNG) and buses (electric) over the 22 km Taxila–Golra Morh route. Emission factors were drawn from published studies (Mao et al., 2021; Shao et al., 2022).

Results and Discussion

Descriptive Statistics

Out of 138 respondents, 58% were van users while 42% were bus users**.** Awareness levels differed considerably: only 37.5% of van users reported being aware of the environmental benefits of green buses, compared to 77.6% of bus users**.** Willingness to pay also differed, with 32% of van users and 68% of bus users willing to pay slightly higher fares for green transport.

Table 3: Awareness and Willingness to Pay by Transport Type

Variable	Van Users	Bus Users
Awareness (%)	37.5%	77.6%
Willingness to Pay (%)	32.0%	68.0%

This finding underscores the role of awareness as a critical determinant of commuter preferences.

Comparative Analysis

Independent samples t-tests confirmed significant differences in perceptions:

Table 4: Independent Samples t-Test Results

Variable	Vans	Green Buses	t-value	p-value	Result
Environmental Perception	2.10	4.20	-11.77	<0.001	Significant
Social Perception	2.95	3.25	-2.20	0.030	Significant
Cost Perception	4.30	3.20	-3.45	0.001	Significant

Bus users clearly valued environmental and social benefits more highly, while van users perceived their mode as more cost-effective. These results align with earlier studies (Logan et al., 2020; Sunitiyoso et al., 2022), which found that financial concerns often hinder sustainable transport adoption in developing countries.

Relationship Analysis

Chi-square tests provided further insight:

Table 5: Chi-Square Test Results

Relationship	χ^2	p-value	Result
Awareness × Willingness to Pay	9.105	0.002	Significant
Awareness × Transport Type	21.81	<0.001	Significant

These results suggest that awareness not only influences willingness to pay but also correlates strongly with actual choice of transport mode. This indicates that awareness campaigns may play a pivotal role in promoting electric buses.

Carbon Emissions Analysis

A simple carbon emissions model was applied to the 22 km route between Taxila and Golra Morh. Fuel consumption estimates and emission factors yielded the following results:

Table 6: Carbon Emissions by Fuel Type (22 km Trip)

Vehicle/Fuel	Fuel/Energy Used	Emission Factor	CO_2 Emitted (kg)
Diesel Van	2.75 L	2.68 kg/L	7.4
Petrol Van	3.30 L	2.31 kg/L	7.6
CNG Van	3.85 kg	1.90 kg/kg	7.3
Green Bus (Electric)	11.16 kWh	0.45 kg/kWh	5.0

The findings reveal that vans emit between 7.3 and 7.6 kg CO_2 for a single trip, whereas green buses emit only 5.0 kg CO_2**.** This represents a 30–35% reduction in emissions. The results validate commuter perceptions that green buses are environmentally superior and provide empirical evidence for policymakers.

Conclusion

This study investigated the comparative impact of vans and green buses on environmental, social, and economic dimensions of urban transport in Pakistan. By combining commuter survey data with a quantitative carbon emissions analysis on the 22 km Taxila–Golra Morh route, the research provided both perceptual and empirical insights.

The findings confirmed that green bus users rated their mode significantly higher in terms of environmental and social perception, while van users perceived their mode as more cost-effective. Awareness was found to be a critical factor: respondents who were aware of the environmental benefits of green buses were significantly more likely to express willingness to pay for them. Importantly, the carbon emissions analysis revealed that vans emitted 7.3–7.6 kg CO_2 per trip**,** whereas green buses emitted only 5.0 kg CO_2**,** representing a 30–35% reduction**.**

Overall, this research demonstrates that while vans remain attractive due to affordability, green buses are environmentally superior and socially more desirable. Bridging the awareness and cost perception gap is therefore essential to mainstreaming electric buses in Pakistan's urban transport system.

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