Science World Journal Vol. 20(No 2) 2025 https://dx.doi.org/10.4314/swj.v20i2.27
www.scienceworldjournal.org
ISSN: 1597-6343 (Online), ISSN: 2756-391X (Print)
Published by Faculty of Science, Kaduna State University

Full Length Research Article

ASSESSING SUSTAINABLE ENVIRONMENTAL PRACTICES AND CARBON FOOTPRINT AWARENESS AMONG URBAN DWELLERS IN KADUNA METROPOLIS

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ABSTRACT
Climate change is one of the most pressing global challenges of the twenty-first century, with far-reaching implications for environmental, social, and economic systems. Central to climate discourse is the concept of carbon footprint, which quantifies the total greenhouse gas emissions associated with individual, organizational, or activity-based actions. This study investigates the level of awareness, attitude, and behavioural practices related to carbon footprint reduction among residents of Kaduna Metropolis, Nigeria. Utilizing a quantitative approach, data were randomly collected through structured questionnaires administered to 365 respondents across key urban districts. The study examines factors influencing residents' knowledge of carbon emissions, their willingness to adopt eco-friendly practices, and the socio-demographic variables shaping sustainable behavior (age, education, and income). The data were analyzed using descriptive and inferential statistics. The results reveal a moderate level of awareness of the concept of carbon footprint, with significant variations based on education level, income, and age. While many respondents express positive attitudes toward environmental sustainability, the actual adoption of low-carbon practices, such as waste segregation, energy conservation, and use of public transport, remains limited due to infrastructural and institutional barriers. The findings of this study reveal that education was a significant predictor ($p < 0.001$) of both awareness, attitudes, and behaviors. Gender and education were found to have a significant influence on attitudes toward carbon footprint reduction ($p < 0.001$). Male individuals with higher education levels were more likely to hold positive attitudes and demonstrate greater awareness. The study recommends promoting sustainable urban living and increasing carbon literacy through community workshops and targeted campaigns among residents.

Keywords: Carbon footprint, Climate change, environmental sustainability, greenhouse gas, climate change mitigation.

INTRODUCTION

Climate change remains a major global challenge with profound environmental, economic, and social implications. A critical contributor to this crisis is the increasing emission of greenhouse gases (GHGs), largely from human activities such as energy consumption, transportation, and waste generation (Chuvieco et al., 2021; Holka et al., 2022). The concept of the carbon footprint, defined as the total greenhouse gases (GHGs) emissions directly and indirectly associated with individual or collective actions, has gained prominence as a key metric in climate change discourse (Purwanto et al., 2019). The concept originates from the broader ecological footprint but focuses specifically on carbon emissions rather than overall resource consumption (Ji et al., 2024). Carbon footprint accounting can be implemented at multiple levels, ranging from individual items and families to cities and nations (Han et al., 2022).

Understanding and managing carbon footprints are critical for mitigating climate change, as reducing these emissions can significantly contribute to global efforts aimed at limiting temperature rise and preventing severe environmental disruptions (Labaran et al., 2022). Similarly, awareness and understanding of carbon footprints are pivotal in fostering environmentally responsible behaviors (Wongsaichia et al., 2025). Positive attitudes can drive proactive measures, while negative or indifferent attitudes may hinder efforts to implement effective climate strategies (Attari et al., 2019). Furthermore, the awareness and concern surrounding climate change and its consequences can influence household decision-making, prompting the adoption of more climate-friendly practices. This, in turn, contributes to progress towards building a low-carbon society (Dash et al., 2023).

In developing countries like Nigeria, rapid urbanization and a continued reliance on fossil fuels are major contributors to the rising levels of greenhouse gas (GHG) emissions (Alege et al., 2016; Robert, 2015). As of 2016, Nigeria emitted over 82 million tonnes of CO_2, with a per capita emission of 0.44 tonnes (Oguntade et al., 2023). Studies revealed that household income, size, vehicle ownership, literacy, and the gender of the household head are significant predictors of household carbon emissions (Sulaimon, 2018). Nigeria has pledged to cut its GHG emissions by 20% unconditionally and 45% conditionally by 2030 as a signatory to the Paris Agreement (Federal Government of Nigeria, 2021).

Furthermore, urban centers such as Kaduna Metropolis face increasing environmental pressure due to population growth, traffic congestion, and energy use, all of which contribute to a growing carbon footprint (Buhari, 2018; Manzuma et al., 2018). Despite Nigeria's commitment to reducing emissions under the Paris Agreement (Federal Government of Nigeria, 2021), public awareness and sustainable practices remain limited (Lacroix & Gifford, 2018).

Previous studies in Nigeria have focused on climate awareness among farmers, health professionals, and carbon footprint (Adesiji et al., 2013; Aderinoye-Abdulwahab & Abdulbaki, 2021; Kolapo et al., 2022; Maigida et al., 2024). However, there is a lack of data on urban residents' perceptions, attitudes, and behaviors related to carbon footprints. This gap limits the development of effective public policies and environmental interventions. Therefore, this study examines the influence of demographic factors (age, education, income) on individuals' awareness, attitudes, and behaviour related to carbon footprints among residents of Kaduna Metropolis. The findings are expected to inform targeted strategies

for promoting environmental sustainability and supporting Nigeria's transition to a low-carbon economy.

MATERIALS AND METHODS

Study Area

Kaduna State is situated between latitudes 10° 25' 0" N and 10° 40' 0" N and longitudes 7°20' 0" E and 7° 35' 0" E, with an area of 46,053 km^2 (Fig. 1). Kaduna State consists of 23 local government areas. As the state's administrative capital, Kaduna Metropolis is the epicenter of governmental and economic operations, driving activity and development. Kaduna North and Kaduna South Local Government Areas (LGAs), which were formerly part of the Northern Nigerian Territory Board, along with the rapidly expanding urban areas of Igabi and Chikun LGAs (Dantudu, 2014). This study area, bounded by 10°22'00" - 10°40'00" N latitude and 7°20'00" - 7°28'00" E longitude, occupies a central location, fostering easy communication and exchange. The metropolis encompasses 262 km², with elevations between 600 and 650 m above sea level (Samaila & Aderemi, 2022). As of 2022, Kaduna metropolis had an estimated population of nearly 2 million, according to Statista. Ibrahim et al. (2018) estimated the 2016 population of Kaduna and its surrounding areas to be approximately 2,004,282, utilizing a 2.47% annual growth rate.

Kaduna's climate is classified as tropical savanna (*Aw*) under the Köppen system, marked by alternating wet and dry seasons. The dry season extends from October to April of the following year, while the rainy season lasts from April through mid-October, with peak rainfall occurring in August (Abubakar et al., 2024) and with an annual average of 1323 mm (Baba et al., 2020). The underlying geology of Kaduna is mainly metamorphic rocks, which include biotite gneisses and older granites, with mostly ferruginous soils derived from granites, gneisses, and sedimentation (Muhammad & Abubakar, 2025).

Kaduna's fertile agricultural lands, particularly along the Kaduna River, have historically supported urban agriculture. Agriculture is a significant contributor, with the Bank of Agriculture headquartered in Kaduna, exporting cotton, peanuts, sorghum, and ginger (Nigeria Bank of Agriculture [NBA], 2020). However, rapid urbanization and socio-economic development have significantly altered land use patterns, converting much of the area to industrial, commercial, residential, and public uses (Musa & Abubakar, 2024). Kaduna's population expansion can be traced back to colonial times when farmers were encouraged to settle in the area to mitigate food deficiencies, as noted by Shehu (2011).

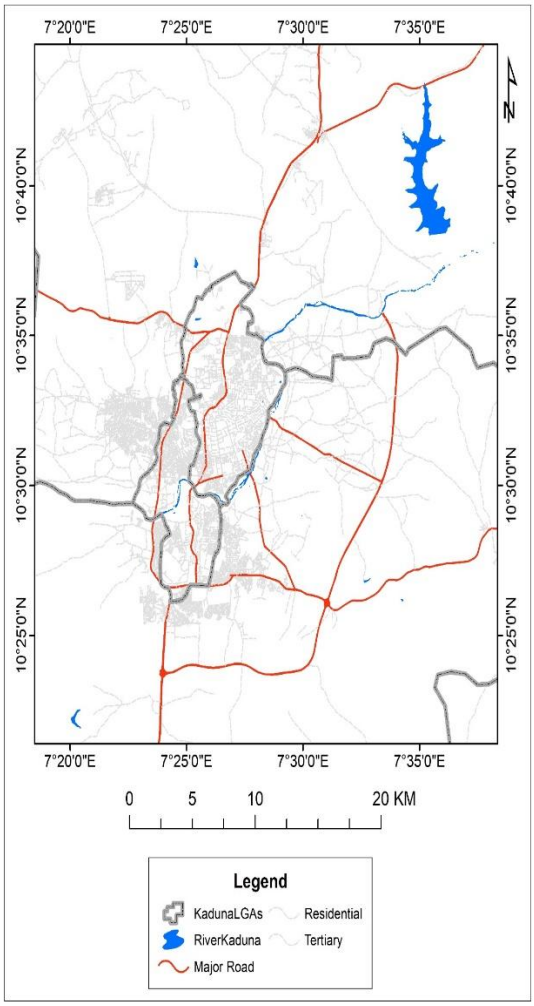

Figure 1: Map of Kaduna Metropolis.
Source: Adopted from GRID^3 Nigeria, 2024

DATA

This study is based on the analysis of quantitative data. Information was gathered from primary sources, which involved designing and distributing questionnaires to the respondents. The selection of wards was carried out using purposive sampling, whereas simple random sampling was applied in selecting the 365 survey respondents.

Data Collection and Analysis

The primary instrument for data collection was a structured questionnaire, comprising binary, multiple-choice, and Likert-scale items, organized into four sections. The first section gathered socio-demographic information from respondents. The second section assessed their awareness and understanding of carbon footprint issues within Kaduna Metropolis. The third section focused on respondents' attitudes toward reducing their carbon footprint, while the fourth section collected data on sustainable practices adopted by residents. The collected data were systematically organized and analyzed using descriptive and inferential statistics. Binary logistic regression was used for

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dependent variables with two categories, and ordinal logistic regression was applied to variables measured with multiple responses. Finally, multinomial logistic regression was utilized for variables on a Likert scale. This approach allowed for appropriate modelling of the different types of response variables and enabled a comprehensive examination of the influence of explanatory factors on residents' awareness, attitudes, and behaviors related to carbon footprint.

RESULTS

Socio-demographic Characteristics of the Respondents

The demographics of the respondents in the study area, including gender, age, occupation, household size, and educational level, are detailed in Table 1.

Table 1: Demographic distribution of respondents

Age	Frequency	Percent
18-24	61	16.7
25-34	146	40.0
35-44	119	32.6
45-54	26	7.1
55 above	13	3.6
Total	**365**	**100.0**
Gender		
Male	203	55.6
Female	162	44.4
Total	**365**	**100.0**
Educational Level		
No formal education	26	7.1
Primary	9	2.5
Secondary	47	12.9
Tertiary	283	77.5
Total	**365**	**100.0**
Occupation		
Student	89	24.4
Employed	112	30.7
Self-employed	137	37.5
Unemployed	18	4.9
Retired	7	1.9
Total	**365**	**100.0**

Table 1 revealed that a significant number of the respondents were between the ages of 25–34 (40%) and 35–44 (32.6%), indicating a youthful adult population in Kaduna Metropolis. According to Long et al. (2023), young individuals are more likely to have a higher carbon footprint than older adults. The table also showed the educational qualification of the respondents, with 77.5% having tertiary education. This demonstrates that the majority of respondents are literate. It has been predicted that a higher level of education is associated with greater awareness of climate-related implications. This high level of education is expected to correlate positively with awareness of complex environmental issues, including carbon footprint (Bello et al., 2025). The result also revealed that the gender was relatively balanced, with a slight male majority (55.6%). In terms of occupation, a large segment of respondents is self-employed (37.5%), followed by those who are employed (30.7%) and students (24.4%). These groups are likely to differ in their access to environmental information and their daily exposure to activities that contribute to carbon emissions (e.g., transport, business operations, etc.). Studies have shown that students' knowledge of carbon footprint varies by their academic discipline. (Dash et al., 2023).

Household Size

The household size of residents in Kaduna Metropolis was analyzed and presented in Figure 1.

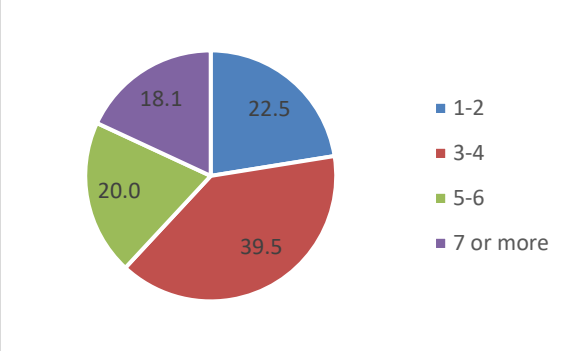

Figure 1: Distribution of Household Size

Figure 1 revealed that the majority of the households consist of 3-4 persons (39.5%), followed by 1-2 persons (22.5%). 5-6 persons (20.0%), and 7 or more persons (18.1%). This distribution indicates a trend towards smaller household sizes in the urban context of Kaduna Metropolis.

Influence of Socio-demographic Factors on Individuals' Awareness, Attitudes, and Behaviors Related to Carbon Footprints

This section examines how sociodemographic factors, particularly gender, income, and educational attainment, influence respondents' awareness, attitudes, and behaviors regarding carbon footprints. Depending on the characteristics of each dependent variable, models for binary logistic regression, ordinal logistic regression, and multinomial logistic regression were utilized.

Influence of socio-demographic variables on Awareness

To determine whether sociodemographic factors significantly influence individuals' awareness of carbon footprints (measured as a binary variable: Yes or No), Binary Logistic Regression was employed. The model assessed the odds of being aware based on gender, education, and income categories, as shown in Tables 2 and 3.

Table 2: Influence of socio-demographic variables on Awareness (Model Summary)

Step	-2 LogLikelihood	Cox & Snell R Square	Nagelkerke R Square
1	387.495[a]	.107	.154

a. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.
Source: (Author's Analysis, 2025).

Table 2 shows that Nagelkerke R^2 = 0.154 indicates that about 15.4% of the variance in awareness of carbon footprints is explained by gender, education, and occupation.

Table 3: Influence of socio-demographic variables on Awareness (Variables in the Equation)

Variables in the Equation

		B	S.E.	Wald	Df	Sig.	Exp(B)
Step 1[a]	Q2. Gender	.053	.252	.044	1	.833	1.055
	Q3. Educational Level	-.866	.146	35.140	1	.000	.420
	Q4. Occupation	-.158	.128	1.512	1	.219	.854
	Constant	2.372	.767	9.549	1	.002	10.714

a. Variable(s) entered on step 1: Q2. Gender, Q3. Educational Level, Q4. Occupation.
Source: (Author's Analysis, 2025).

Table 3 reveals that Education was the only statistically significant variable ($p < 0.001$) with a negative coefficient (B = -0.866) and Exp(B) = 0.420, indicating that individuals with lower education are 58% less likely to be aware of their carbon footprint. While Gender ($p = 0.833$) and occupation ($p = 0.219$) were not statistically significant.

Influence of socio-demographic variables on Attitudes

Respondents' attitudes toward carbon footprint issues were measured using a Likert scale, reflecting ordinal responses (e.g., Strongly Disagree to Strongly Agree). An Ordinal Logistic Regression was conducted to evaluate how gender, education, and income influence the likelihood of holding more positive or negative attitudes, as indicated in Tables 4 and 5.

Table 4: Influence of socio-demographic variables on Attitudes (Model Fitting Information)

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	Df	Sig.
Intercept Only	286.650			
Final	252.187	34.463	9	.000

Link function: Logit.
Source: (Author's Analysis, 2025).

Table 4 shows that attitude is statistically significant, with a Chi-square value of 34.463 ($p < .001$). This indicates that the model significantly explains variation in attitudes toward reducing carbon footprints. Therefore, the predictors included in the model reliably influence respondents' attitudes toward reducing their carbon footprint.

Table 5 Influence of socio-demographic variables on Attitudes (Parameter Estimates)

Parameter Estimates

		Estimate	Std. Error	Wald	Df	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Threshold	[Q1.extent you believe that reducing your personal carbon footpri = 1]	-1.258	1.346	.873	1	.350	-3.897	1.381
	[Q1.extent you believe that reducing your personal carbon footpri = 2]	-.815	1.345	.367	1	.545	-3.450	1.821
	[Q1. Do you believe that reducing your personal carbon footpri = 3]	1.046	1.345	.604	1	.437	-1.591	3.682
	[Q1. Extent do you believe that reducing your personal carbon footpri = 4]	3.009	1.351	4.961	1	**.026**	.361	5.658
Location	[Q2.Gender=1]	.529	.201	6.887	1	.009	.134	.924
	[Q2.Gender=2]	0[a]	.	.	0	.	.	.
	[Q3. Educational Level=1]	-1.569	.393	15.899	1	**.000**	-2.340	-.798
	[Q3.EducationalLevel=2]	-1.117	.644	3.011	1	.083	-2.378	.145
	[Q3.EducationalLevel=3]	-.605	.299	4.087	1	**.043**	-1.191	-.018
	[Q3.EducationalLevel=4]	0[a]	.	.	0	.	.	.

	[Q4.Occupation=1]	.920	1.357	.459	1	.498	-1.740	3.580
	[Q4.Occupation=2]	1.151	1.355	.722	1	.396	-1.504	3.807
	[Q4.Occupation=3]	1.016	1.352	.564	1	.453	-1.635	3.666
	[Q4.Occupation=4]	1.136	1.412	.647	1	.421	-1.632	3.904
	[Q4.Occupation=5]	2.184	1.525	2.051	1	.152	-.805	5.174
	[Q4.Occupation=6]	0[a]	.	.	0	.	.	.

Source: (Author's Analysis, 2025).

Table 5 reveals that Gender is statistically significant, p = 0.009, indicating males are more likely to exhibit positive attitudes toward reducing their carbon footprint compared to females. This means that male respondents were more likely to express stronger agreement with the importance of reducing their carbon footprint. Also, education level had a significant effect. This indicate that respondents in category 1 (lowest education) were highly significant, but less likely to hold positive attitudes (B = -1.569, p < 0.001). While categories 2 and 3 were also less positive, though with weaker significance. Other variables, including occupation, are not statistically significant.

Influence of socio-demographic variables on behaviors

Sustainable behaviors related to carbon footprint reduction were captured through multiple-choice options, representing nominal categories. A multinomial logistic regression was used to examine the relationship between socio-demographic characteristics and the types of behaviors adopted by residents of Kaduna Metropolis. The results are presented in Tables 6 and 7.

Table 6 Influence of socio-demographic variables on behaviors (Model Fitting Information)

Model Fitting Information

Model	Model Fitting Criteria -2 Log Likelihood	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept Only	349.602			
Final	278.250	71.352	54	.057

Source: (Author's Analysis, 2025).

Table 6 reports a Chi-square of 71.352 with p = 0.057, which is borderline significant. This suggests that the model has moderate explanatory power, indicating that the predictors moderately account for variations in carbon footprint-related behaviours.

Table 7 Influence of socio-demographic variables on behaviors (Likelihood Ratio Tests)

Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests Chi-Square	Df	Sig.
Intercept	278.250[a]	.000	0	.
Q2. Gender	287.399[b]	9.149	6	.165
Q3. Educational Level	311.285[b]	33.035	18	.017
Q4. Occupation	309.146	30.896	30	.421

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

b. Unexpected singularities in the Hessian matrix are encountered. This indicates that either some predictor variables should be excluded or some categories should be merged.

Source: (Author's Analysis, 2025).

Table 7 indicates that level of education is the only variable found to be statistically significant (p = 0.017), suggesting that it has a notable influence on the type of sustainable behaviour adopted by respondents. While gender (p = 0.165) and occupation (p = 0.421) are not statistically significant.

DISCUSSION

This study examines the influence of demographic factors (age, education, income) on individuals' awareness, attitudes, and behaviours related to carbon footprints. This study revealed that a significant number of the respondents were between the ages of 25–34 (40%) and 35–44 (32.6%), indicating a youthful adult population in Kaduna Metropolis. According to Long et al. (2023), young people are likely to have a higher carbon footprint compared to older adults. The results also revealed the educational qualification of the respondents, with 77.5% possessing tertiary education. This demonstrates that the majority of respondents are literate. It has been suggested that a higher level of education is associated with greater awareness of climate-related implications. This high level of education is expected to correlate positively with awareness of complex environmental issues, including carbon footprint (Bello et al., 2025). The result also revealed that the gender was relatively balanced, with a slight male majority (55.6%) agreeing to adopting mitigation measures and sustainable practices to reduce carbon footprints. In terms of occupation, a large segment of respondents is self-employed (37.5%), followed by those who are employed (30.7%) and students (24.4%). These groups are likely to differ in their terms of access to environmental information daily in their exposure to activities that contribute to carbon emissions (e.g., transport, business operations, etc.). Studies have shown that students' knowledge of carbon footprint varies by their academic discipline. (Dash et al., 2023). Also, the result revealed that the majority of the households consist of 3-4 persons (39.5%), followed by 1-2 persons (22.5%). 5-6 persons (20.0%), and 7 or more persons (18.1%). This distribution indicates a trend towards smaller household sizes in the urban context of Kaduna Metropolis. This finding aligns with the observations of Ajaero and Madu (2014), who noted that metropolitan areas in Northern Nigeria, including Kaduna State, are experiencing a shift from large extended households to smaller, nuclear family units.

They further explained that, despite a national average household size of approximately 4.7, this trend is largely driven by urbanization, socio-economic transformations, and changing family dynamics.

The findings of the study indicate that education serves as a significant predictor of awareness, with respondents possessing higher levels of education being more likely to demonstrate familiarity with carbon footprint concepts. This finding is consistent with Oladokun et al. (2020), who found that higher education strongly influences climate change understanding in Nigeria. Madaki et al. (2023) also emphasized the role of education in shaping environmental literacy. These findings underscore the need to expand carbon literacy initiatives, particularly targeting individuals with lower educational backgrounds.

The study reveals that both education and gender are significant factors influencing attitudes toward carbon footprints, as demonstrated in Tables 4 and 5. Education likely shapes perception through exposure to scientific information and environmental reasoning. The gender difference could stem from cultural roles or varying access to decision-making power. These results are supported by Azu and Alakwe (2023) and Madaki et al. (2023), who found that both access to education and social roles shape climate attitudes in Nigeria, and educational and gender-inclusive climate programs are necessary. Gender-sensitive outreach and integrating climate literacy into curricula at all levels can enhance positive environmental attitudes.
The result shows that there is a moderate level of awareness of the concept of carbon footprint among the residents of Kaduna Metropolis, with significant variations based on education level, income, and age. While many respondents express positive attitudes toward environmental sustainability, actual adoption of low-carbon practices such as waste segregation and management practices, energy conservation, and use of public transport remains limited due to infrastructural and institutional barriers. Findings of this study reveal that level of education ($p = 0.017$) was a significant predictor ($p < 0.001$) of both awareness, attitudes, and behaviors, while gender ($p = 0.165$) and education significantly ($p < 0.001$) influenced attitudes toward carbon footprint reduction. Despite attitudes and awareness being linked to education, actual behavior shows weaker associations. The fact that only the education level was significantly predictive of behavioral differences. This finding aligns with Okafor et al. (2024), who concluded that structural and economic barriers often outweigh personal attributes in shaping climate behaviors. (White et al., 2025) emphasize that policies promoting sustainable behavior must prioritize enabling access to infrastructure and reducing economic barriers; educational campaigns alone are insufficient without systemic support for action.

Conclusion

This study provides empirical evidence on how socio-demographic factors shape carbon footprint awareness, attitudes, and behaviors among residents of Kaduna Metropolis. The results reveal that the population is predominantly youthful. Educational attainment is notably high; participants possess tertiary qualifications, underscoring a literate and potentially environmentally conscious community. Gender distribution among respondents was relatively balanced, with a slight male majority. In terms of occupation, a large segment of respondents is self-employed, followed by those who are employed and students, highlighting a diverse workforce with varying exposure to carbon-emitting activities. Household sizes are trending smaller, reflecting urbanization and changing family structures in Kaduna.
Statistical analysis confirms that education level is a significant predictor of awareness, while both gender and education significantly influence attitudes toward carbon footprint reduction. Males with higher levels of education were more likely to hold positive attitudes and demonstrate greater awareness. These findings strongly emphasize the urgent need for targeted carbon literacy initiatives to bridge knowledge gaps, especially among less-educated and female populations.
Lastly, the study recommends that the Kaduna State Government implement comprehensive carbon literacy programmes, particularly targeting individuals with lower educational backgrounds and women. Additionally, there is a need to address the environmental impacts of urbanisation and evolving household structures. The government should introduce incentives for adopting sustainable practices, such as improved public transportation, support for green businesses, and the development of urban green spaces. These initiatives will not only reduce carbon emissions but also improve the quality of life for residents in Kaduna Metropolis.

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