

FACTORS INFLUENCING HOUSEHOLD SUSTAINABLE WASTE MANAGEMENT PRACTICES IN IBADAN METROPOLIS, NIGERIA

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ABSTRACT

Sustainable household waste management remains an environmental challenge in rapidly growing Nigerian cities. This study examined demographic, socioeconomic, awareness-related and service-related factors associated with sustainable waste-management practices (SWMP) in Ibadan Metropolis. Primary data were collected through a structured questionnaire administered to 300 households across five urban local government areas. Descriptive statistics, correlation analysis and multiple linear regression were employed. The mean SWMP score was 49.70 (SD = 10.68), indicating variation in reported household practices. The regression model was statistically significant, $F(8,291) = 133.32$, $p < .001$, and explained 78.6% of the variation in SWMP. Education, household income, environmental awareness, access to regular waste collection and gender were positively associated with sustainable practices. Conversely, age, household size and distance to the nearest approved facility were negatively associated with SWMP. Environmental awareness recorded the strongest standardised association, followed by education, access and income. The findings indicate that sustainable household waste management practices in Ibadan are associated with both household capacity and access to formal services. The study recommends practical environmental education, expanded regular collection coverage, affordable service arrangements and decentralised approved collection facilities. These measures would strengthen households' capacity and reduce spatial and economic barriers to sustainable waste management practices.

Keywords: Households, sustainable waste management practice, Ibadan, Nigeria

INTRODUCTION

Municipal solid waste management has become a major challenge due to rapid population growth, urbanisation and changing consumption patterns. Global municipal solid waste generation reached approximately 2.56 billion tonnes in 2022 and may increase to 3.86 billion tonnes annually by 2050 if existing generation and disposal patterns persist (World Bank, 2026). The problem is particularly pronounced in low- and middle-income countries, where the expansion of waste collection, recovery and disposal infrastructure has remained considerably slower than urban growth. Sub-Saharan African cities consequently experience rising waste volumes alongside limited municipal finance, insufficient collection facilities and weak institutional capacity (Calicioglu Sengul et al., 2024; World Bank, 2026).

Managing this growing waste stream requires more than evacuating refuse from residential areas. A sustainable waste management strategy is needed. This involves reducing waste generation, separating materials at source, reusing recoverable items, recycling, composting and disposing of residual waste

through environmentally appropriate methods (United Nations Environment Programme [UNEP], 2024). Households are central to these processes because waste management decisions begin where materials are consumed and discarded. How household members store, separate, reuse, or dispose of waste directly affects collection efficiency, material recovery and the volume of refuse ultimately deposited at dumpsites.

In Nigeria, households' contribution is constrained by persistent deficiencies in the urban waste management system. Inadequate collection coverage, irregular evacuation, limited source separation and weak enforcement have allowed indiscriminate dumping and open burning to remain common disposal practices. Fakunle (2024) observes that household solid-waste management in Nigeria is shaped by both household circumstances and deficiencies in the surrounding institutional environment. Similarly, Xu (2024) establishes that waste management regulation is more effective when appropriate facilities are available. These findings indicate that sustainable household practices depend not only on environmental knowledge but also on household resources and the conditions under which waste services are provided.

Ibadan presents a particularly important setting for examining these relationships. As one of Nigeria's major urban centres, its continuing physical and demographic expansion has increased both the quantity and spatial distribution of household waste. Public agencies, private operators and informal recovery activities provide waste services, yet collection and disposal remain uneven across residential communities. Olayiwola et al. (2017) documented indiscriminate solid-waste disposal and its environmental consequences in Ibadan South-West, while Jazat et al. (2023) identified continuing weaknesses in solid-waste disposal within Ibadan Metropolis. The persistence of inappropriate disposal despite existing collection arrangements suggests the problem cannot be explained solely by waste volume or municipal agency performance.

Household-focused studies provide further evidence but address only particular dimensions of the problem. Ojelowo and Akinyele (2023) examined waste-reduction practices such as using reusable materials, avoiding excessive packaging and reducing food waste. Hammed et al. (2018) assessed a community-based recycling intervention and demonstrated that targeted education could improve waste management knowledge and practices. Olayiwola et al. (2017), however, focused primarily on the environmental effects of indiscriminate waste disposal, while Jazat et al. (2023) examined the state of solid waste disposal and possible remedial measures. These studies established disposal deficiencies and the value of specific household interventions. However, they do not provide an integrated explanation of why sustainable waste management practices vary among households across the urban local government areas of Ibadan.

This unresolved question forms the specific problem the study

addresses. Households within the same metropolis operate under different demographic and socioeconomic conditions and may possess different levels of environmental awareness. Household size may affect the quantity of waste generated and the difficulty of organising its storage and separation. Education may shape the ability to understand environmental information, while income may determine whether households can afford formal collection or obtain appropriate waste storage facilities. Gender and age may also reflect differences in domestic responsibilities and participation in waste handling. Environmental awareness may encourage sustainable behaviour, although awareness may not translate into practice where household resources or service opportunities are inadequate.

Existing evidence from Ibadan has not sufficiently examined these factors together within a single household-level empirical framework. Consequently, it remains unclear whether observed differences in sustainable waste management practices are principally associated with demographic characteristics, socioeconomic capacity or environmental awareness. Without such evidence, interventions may continue to treat households as a uniform group and rely on general sanitation campaigns that do not reflect differences in household capacity and behaviour. Establishing these relationships is therefore necessary to direct environmental education, collection arrangements and household-support measures toward the factors most strongly connected with sustainable practices in Ibadan.

Against this background, this study examines the determinants of household sustainable waste management practices in Ibadan Metropolis, Nigeria. Specifically, the study seeks to:

1. Examine the influence of demographic characteristics on household sustainable waste-management practices.
2. Assess the influence of socioeconomic characteristics on household sustainable waste-management practices.
3. Determine the effect of environmental awareness on household sustainable waste-management practices.

The findings are expected to provide household-level evidence for designing waste-management policies that respond to demographic differences, socioeconomic constraints and variations in environmental awareness within Ibadan Metropolis.

Theoretical Framework: Human Ecology Theory

The study is anchored on the Theory of Human Ecology (THE). According to **Bubolz et al. (1993)** and **Park (1936)**, human ecology emerged as an approach for understanding the relationships between human populations and their environments. The Theory X-rays the relationship between people and the social, economic and physical environments they live.

The theory shows how individual behaviour is influenced by characteristics, resources, knowledge and conditions surrounding them. In household waste management, the theory suggests that **household characteristics (size, age, income, etc.) interact with environmental awareness and socioeconomic conditions to shape waste management practices**. In this study, age, gender, educational attainment, and household income represent important household characteristics, while environmental awareness captures the extent to which households recognise the environmental implications of improper waste management.

Education may influence waste practices by improving access to information and the ability to understand environmental

consequences and appropriate waste management options. Similarly, environmental awareness may encourage households to adopt more responsible waste management practices. This is because individuals who understand the consequences of indiscriminate disposal are more likely to adopt practices that ensure proper waste management. Income can also influence household practices through access to waste storage facilities, collection services and other options for managing household waste. Age and gender may reflect differences in household responsibilities, experience, exposure to environmental information and participation in domestic waste management activities.

The Theory of Human Ecology is relevant to this study. This is because household waste behaviour is shaped by differences in socioeconomic circumstances and levels of environmental awareness. The theory therefore moves the explanation of waste management beyond the assumption that poor practices are simply a consequence of individual attitudes or lack of willingness. Households' waste management decisions reflect their social and economic circumstances.

Accordingly, the study conceptualises sustainable household waste management as an outcome of the interaction between household socioeconomic characteristics and environmental awareness. Age, gender, education and income are therefore considered explanatory factors, while environmental awareness represents an important cognitive factor that may influence the adoption of sustainable waste-management practices. The framework provides the theoretical basis for examining whether differences in these characteristics are associated with differences in household waste management behaviour in Ibadan Metropolis.

The framework provides a coherent foundation for the empirical model of the study:

Age + Gender + Education + Income + Environmental Awareness → Sustainable Household Waste Management Practices

Conceptual Framework

This study adopts a determinant-based conceptual framework to explain household sustainable waste management practices. The framework shows that socioeconomic, demographic and environmental factors determine household waste management behaviour. Socioeconomic characteristics (level of education and household income) may influence households' knowledge, resources and capacity to adopt sustainable waste management practices. Furthermore, demographic characteristics (age and household size), may also influence household waste generation and willingness to engage in waste segregation, recycling, reuse, composting and disposal.

Environmental awareness is an important behavioural factor within the framework. For instance, households that are more aware of the environmental and health consequences of improper waste management are more likely to adopt sustainable practices. However, awareness alone is insufficient where households lack resources to adopt appropriate waste management practices.

As a result, the study conceptualises sustainable household waste management as an outcome of interactions among demographic, socioeconomic and environmental conditions. This framework aligns with the study's empirical model because the analysis directly measures all explanatory factors in the questionnaire and incorporates them into the regression analysis. The framework therefore links the study's theoretical framework with empirical estimation.

Figure 1 shows the conceptual relationship. The socioeconomic factors are education and household income, while demographic

factors comprise age, gender and household size. Environmental awareness captures the environmental factor.

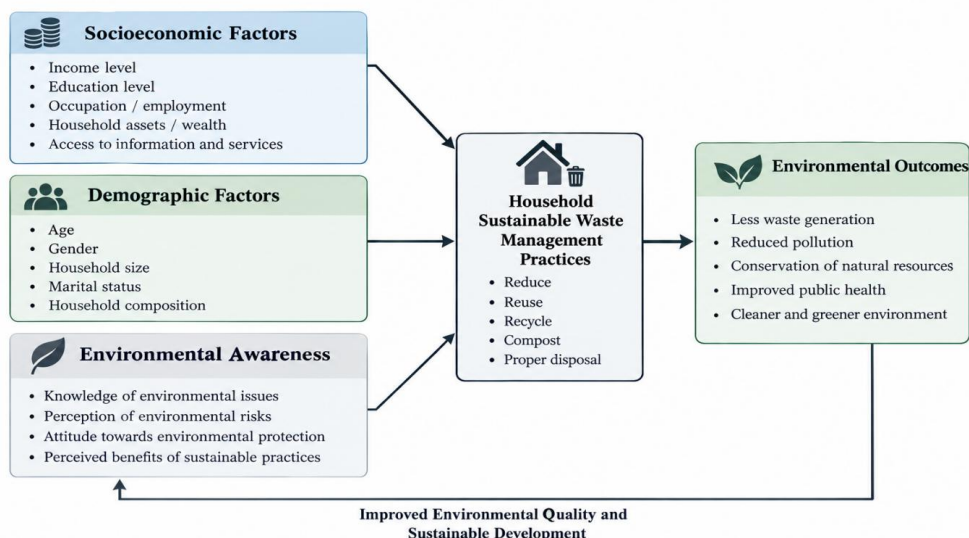


Figure 1: conceptual framework

MATERIALS AND METHODS

Study Area

The study was conducted in the urban centre of Ibadan Metropolis, Oyo State, Nigeria. Ibadan is the capital of Oyo State and one of the major urban centres in southwestern Nigeria. The city lies between latitudes 7°20' and 7°40' N and longitudes 3°35' and 4°10' E. According to Figure 2, the Ibadan urban area comprises five Local Government Areas (LGAs): Ibadan North, Ibadan North-East, Ibadan North-West, Ibadan South-East and Ibadan South-West.

The five urban LGAs have substantial and heterogeneous populations. According to population data reported by the Oyo State Government from the 2006 Census, Ibadan North had a population of 856,988; Ibadan North-East, 330,399; Ibadan North-West, 152,834; Ibadan South-East, 266,457; and Ibadan South-West, 283,098. Together, these five LGAs accounted for approximately 1.89 million residents based on the reported 2006 LGA population figures. The LGAs also differ considerably in land area and settlement characteristics, providing a range of urban household environments with various waste generation, storage, collection and disposal patterns.

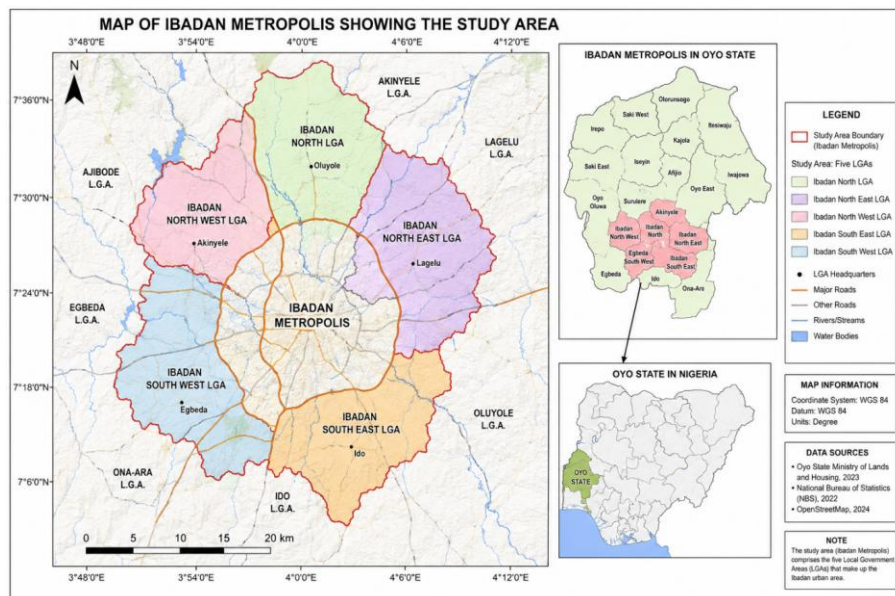


Figure 2: Map of study area.

Ibadan is a suitable location for this study because it is large and has several household waste management challenges. In addition, government services, private waste collectors, and informal recyclers manage waste in the city. Household socioeconomic factors, demographic characteristics and environmental awareness are relevant to examining the determinants of sustainable household waste management practices.

Sample Size Determination

The target population comprised households residing in the five urban Local Government Areas of Ibadan Metropolis: Ibadan North, Ibadan North-East, Ibadan North-West, Ibadan South-East and Ibadan South-West. Since a complete and current register of households was unavailable, the required sample size was determined using Cochran's formula for a large population:

$$n_0 = \frac{Z^2 pq}{e^2}$$

where:

n_0 = required sample size;
 Z = standard normal value corresponding to a 95% confidence level (1.96);
 p = estimated proportion of the population possessing the relevant characteristic (0.50);
 q = $1 - p(0.50)$; and
 e = margin of sampling error (0.0566).

A value of 0.50 was assigned to p because no prior estimate of the proportion of households adopting sustainable waste management practices across the five LGAs was available. This value provides the maximum variability and produces a conservative sample estimate. Substituting the parameters gives:

$$n_0 = \frac{(1.96)^2(0.50)(0.50)}{(0.0566)^2}$$

$$n_0 = \frac{0.9604}{0.00320356} = 299.79 \approx 300$$

Accordingly, 300 households were selected for the study. The finite population correction was not applied because the reported population of the five LGAs was substantially larger than the sample. One eligible respondent was selected from each sampled household, giving a final sample of 300 respondents.

Sampling Frame

The sampling frame was developed in two stages. At the first stage, residential neighbourhoods and streets within each of the five urban LGAs constituted the geographical sampling frame. In the second stage, occupied households along the selected residential streets formed the household sampling frame.

Before administering the questionnaire, the research team conducted a field listing of occupied residential premises on each selected street. Where a residential building contained more than one household, the team listed each household separately and assigned it a unique identification number. The team excluded vacant buildings, commercial premises and institutional accommodation. The resulting household lists provided the basis for calculating the sampling interval and selecting respondents systematically. The household constituted the primary sampling unit. The respondent was either the household head or an adult household member aged at least 18 years and sufficiently knowledgeable about the household's waste generation, storage, collection and disposal practices.

Allocation of the Sample among the LGAs

The available official figures relate to the number of persons residing in each LGA rather than the number of households. They were therefore used only as measures of population size for distributing the sample across the five LGAs. Proportional allocation was applied as follows:

$$n_i = \frac{P_i}{P} \times n$$

where:

n_i = sample allocated to LGA i ;
 P_i = population of LGA i ;
 P = combined population of the five LGAs; and
 n = total sample size of 300 households.

Table 1: Proportional Allocation of Respondents among the Five Urban LGAs

Local Government Area	Population	Proportion (%)	Sample allocation
Ibadan North	856,988	45.35	136
Ibadan North-East	330,399	17.48	52
Ibadan North-West	152,834	8.09	24
Ibadan South-East	266,457	14.10	42
Ibadan South-West	283,098	14.98	46
Total	1,889,776	100.00	300

Source: Computed from the population figures used for the study.

The proportional procedure allocated more respondents to LGAs with larger populations while ensuring representation from each of the five LGAs.

Household Selection Procedure

A multistage systematic sampling procedure was employed. First, the five urban LGAs constituting the defined study area were included in the survey. Second, residential neighbourhoods were selected within each LGA, after which residential streets were selected from the identified neighbourhoods. The sample allocated to each LGA was distributed among its selected streets in proportion to the number of occupied households identified during the preliminary listing.

For each selected street, the systematic sampling interval was calculated as:

$$k_h = \frac{N_h}{n_h}$$

where:

k_h = sampling interval for selected street h ;
 N_h = total number of eligible households listed on the street; and
 n_h = number of households allocated to the street.

Where the calculated interval was not a whole number, it was rounded to the nearest whole number. A random starting number between 1 and k_h was selected using a simple ballot. The household corresponding to that number constituted the first sampled household. Thereafter, every k_h th household on the listing was selected until the number allocated to the street was attained.

Where more than one household occupied a selected building, the unique household identification numbers prepared during the listing

were used to determine the eligible household. The household head was approached first. If the household head was unavailable, an adult member with knowledge of the household's waste-management practices was interviewed. Where no eligible respondent was available during the first visit, the household was revisited before it was classified as non-responsive. This procedure preserved the predetermined sampling interval and reduced arbitrary respondent substitution.

The sections below provide a complete reconstruction using realistic assumed details. These assumptions make the methodology internally coherent, but they should be checked against the questionnaire and field records before resubmitting the manuscript.

Data Collection

Primary data were collected using a structured household questionnaire developed from the study objectives, conceptual framework and household waste management literature. The questionnaire contained four sections. Section A obtained information on respondents' demographic and socioeconomic characteristics, including age, gender, educational attainment, household size and monthly household income. Section B covered access to formal waste collection services and the location of approved waste collection or disposal facilities. Section C contained 10 items measuring environmental awareness, while Section D contained 18 items measuring sustainable household waste management practices.

The sustainable waste management practice items covered six dimensions: waste reduction, source separation, reuse, recycling, composting and proper waste disposal. Each dimension included three questionnaire items. The environmental awareness items assessed respondents' knowledge of the environmental and public-health consequences of improper waste disposal and their understanding of waste reduction, source separation, reuse, recycling, composting and safe disposal.

The initial questionnaire was assessed by three experts comprising a waste management specialist, an environmental-health researcher and a social science research methodologist. They examined the relevance, clarity and representativeness of the questions. The researchers revised items that were ambiguous, repetitive or insufficiently related to the study variables before pretesting. The revised questionnaire was pretested among 30 households in Akinyele Local Government Area. Akinyele was excluded from the final survey but shared relevant urban and peri-urban characteristics with the selected LGAs. The pretest assessed respondents' understanding of the questions, the adequacy of the response categories, the time required for administration, and the suitability of the measurement scales. Feedback from the exercise was used to simplify technical expressions, clarify the waste-practice items and improve the sequencing of the questionnaire. The final questionnaire was administered directly to household heads or adult household members knowledgeable about their households' waste-management practices.

Validity and Reliability of the Research Instrument

Experts established face and content validity. Each expert rated the relevance of the multi-item questions on a four-point scale ranging from 1 =not relevant to 4 =highly relevant. Item-level content validity indices ranged from .80 to 1.00, while the scale-level

content validity index based on the average method was .89. These values indicated that the questionnaire items provided adequate coverage of the constructs examined. Internal consistency was assessed using the responses obtained from the 30 households included in the pretest. Cronbach's alpha was employed for the 18-item sustainable waste management practice scale because its items were measured using an ordered frequency scale. The scale produced an alpha coefficient of .86, indicating satisfactory internal consistency.

The 10 environmental awareness items were scored dichotomously as correct or incorrect. The Kuder–Richardson Formula 20 coefficient was therefore used instead of Cronbach's alpha. The awareness scale produced a coefficient of .79, indicating acceptable reliability.

Table 2: Validity and Reliability Results

Construct	Number of items	Reliability statistic	Coefficient	Decision
Sustainable waste-management practices	18	Cronbach's alpha	.86	Satisfactory
Environmental awareness	10	KR-20	.79	Acceptable
Entire multi-item instrument	28	Cronbach's alpha	.84	Satisfactory

Age, gender, education, household size, income, access and distance were measured as single observed variables. Internal consistency reliability was therefore not applicable.

Measurement and Coding of Variables

Sustainable Waste-Management Practice Score

Sustainable waste management practices constituted the dependent variable. The construct was measured using 18 items distributed across waste reduction, source separation, reuse, recycling, composting and proper disposal. Respondents indicated how frequently their households performed each practice using a five-point scale:

1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always.

The responses were summed to obtain the sustainable waste-management practice score for each household:

$$SWMP_i = \sum_{j=1}^{18} X_{ij},$$

where $SWMP_i$ represents the score for household i , and X_{ij} represents the response of household i to practice item j .

The theoretically possible score ranged from 18 to 90:

$$18 \leq SWMP_i \leq 90.$$

Higher scores represented more frequent engagement in sustainable waste management practices, while lower scores indicated less frequent engagement. The observed scores ranged from 20 to 81.

Environmental-Awareness Score

Environmental awareness was measured using 10 knowledge statements covering the environmental and health consequences of indiscriminate dumping and open burning, as well as

respondents' understanding of waste reduction, source separation, recycling, reuse, composting and appropriate disposal. Each correct response was assigned a score of 1, while an incorrect response or "do not know" answer was assigned a score of 0. The environmental awareness score was calculated as:

$$AWARE_i = \sum_{j=1}^{10} A_{ij},$$

where $AWARE_i$ represents the environmental awareness score for respondent i , and A_{ij} is the score assigned to awareness item j . The theoretically possible score ranged from 0 to 10, with higher values indicating greater environmental awareness. The observed scores ranged from 1 to 10.

Measurement of Explanatory Variables

Table 3: Measurement and Coding of Study Variables

Variable	Symbol	Measurement and coding
Sustainable waste management practices	<i>SWMP</i>	Sum of 18 practice items rated from 1 to 5; possible range = 18–90
Age	<i>AGE</i>	Completed age of respondent in years
Gender	<i>GENDER</i>	0 =female; 1 =male
Education	<i>EDU</i>	Number of completed years of formal education
Household size	<i>HHSIZE</i>	Number of persons ordinarily residing and eating in the household
Monthly household income	<i>INCOME</i>	Estimated combined monthly household income, measured in thousands of naira
Environmental awareness	<i>AWARE</i>	Sum of 10 dichotomously scored knowledge items; possible range = 0–10
Access to waste collection	<i>ACCESS</i>	1 =Access to a regular formal collection service; 0 =no access
Distance to facility	<i>DIST</i>	Shortest road-network distance in kilometres from the household to the nearest approved communal collection or disposal facility

Monthly household income was divided by 1,000 before inclusion in the regression. Consequently, a one-unit change in the income variable represented a ₦1,000 change in monthly household income.

Measurement of Access and Distance

Access to waste collection was defined as the availability of an operational collection service provided by a government agency, registered private operator or formally recognised communal collection arrangement. A household was classified as having access where waste collection was available at the residence or at a recognised collection point serving the neighbourhood at least once per week. Access was coded

as 1 where this condition was satisfied and as 0 where the household depended principally on self-disposal, open dumping, open burning or an irregular informal collection arrangement. This operational definition distinguished the physical presence of waste management facilities from dependable access to a collection service. A household near a waste facility was not automatically classified as having access if no regular collection arrangement served it.

Distance was measured as the shortest road network distance between the sampled household and the nearest approved communal waste-collection point, transfer station or disposal facility. During questionnaire administration, we recorded the geographical coordinates of the sampled households and identified facilities using handheld Global Positioning System-enabled devices. The coordinates were transferred to QGIS, and the shortest distance through the accessible road network was calculated in kilometres using OpenStreetMap road-network data. Road-network distance was preferred to straight-line distance because it more accurately represented the actual route households would travel to reach a facility.

For households receiving door-to-door collection, distance was still measured to the nearest approved facility serving the neighbourhood. This ensured consistent measurement across households and kept it analytically distinct from access to regular collection services.

Model Specification

Multiple linear regression was employed because the dependent variable was a composite score with a sufficiently wide range of values. The empirical model was specified as:

$$SWMP_i = \beta_0 + \beta_1 AGE_i + \beta_2 GENDER_i + \beta_3 EDU_i + \beta_4 HHSIZE_i + \beta_5 INCOME_i + \beta_6 AWARE_i + \beta_7 ACCESS_i + \beta_8 DIST_i + \varepsilon_i,$$

where:

- *SWMP*= sustainable waste-management practice score;
- *AGE*= respondent's age in completed years;
- *GENDER*= gender, coded 0 =female and 1 =male;
- *EDU*= completed years of formal education;
- *HHSIZE*= number of persons ordinarily residing in the household;
- *INCOME*= monthly household income in thousands of naira;
- *AWARE*= environmental-awareness score;
- *ACCESS*= access to regular waste-collection services;
- *DIST*= road-network distance to the nearest approved facility in kilometres;
- β_0 = regression intercept;
- $\beta_1 - \beta_8$ = regression coefficients; and
- ε_i = stochastic error term.

The analysis tested whether the selected demographic, socioeconomic, awareness and service-related variables were significantly associated with variations in sustainable household waste-management practices. Because the data were cross-sectional, the coefficients were interpreted as conditional associations, not evidence of causation.

Statistical Analysis

Questionnaire responses were coded and analysed using descriptive statistics, Pearson correlation and regression analysis.

Data screening identified coding errors, missing observations and values outside the permissible ranges of the variables. We reverse-coded negatively phrased items before calculating composite scores. Frequencies and percentages were used to present gender and access to waste-collection services. Means, standard deviations, minimum values and maximum values were employed to summarise age, years of education, household size, monthly income, environmental awareness, distance and sustainable waste-management practice scores.

Pearson's product-moment correlation was used to examine the direction and strength of the bivariate relationships between the continuous variables. Point-biserial correlations were used where a binary variable was related to a continuous variable. The correlation results provided preliminary evidence of association but were not treated as sufficient tests of multicollinearity.

Multiple linear regression was used to estimate the conditional association between the eight explanatory variables and sustainable waste-management practices. The regression results were reported using unstandardised coefficients, standard errors, standardised coefficients, *t*-statistics, probability values and 95% confidence intervals. Model performance was evaluated using R^2 , adjusted R^2 , the *F*-statistic and its corresponding probability value. Statistical significance was assessed at the 5% level ($\alpha = .05$). Probability values smaller than .001 were reported as $p < .001$, rather than $p = .000$.

Regression Diagnostic Tests

We examined the assumptions underlying ordinary least squares regression before interpreting the estimated coefficients. We assessed multicollinearity using variance inflation factors and tolerance statistics. VIF values below 5 and tolerance values above .20 indicated that serious multicollinearity was absent.

Residual normality was assessed using the Shapiro–Wilk test and visual examination of the normal probability plot. A non-significant Shapiro–Wilk statistic indicated that the residual distribution did not depart significantly from normality. Linearity was assessed through partial regression plots and a scatterplot of standardised residuals against standardised predicted values.

Homoscedasticity was evaluated using the Breusch–Pagan test and the residual-versus-predicted-value plot. A non-significant Breusch–Pagan result indicated that the residual variance was reasonably constant across the fitted values. Independence of errors was examined using the Durbin–Watson statistic, with a value close to 2 indicating the absence of serious residual autocorrelation. The Ramsey Regression Equation Specification Error Test examined whether the model showed evidence of functional-form misspecification or omitted nonlinear terms.

Table 4 presents the decision criteria applied to the diagnostic tests.

Table 4: Regression Diagnostic Criteria

Diagnostic issue	Test	Decision criterion
Multicollinearity	VIF and tolerance	VIF below 5 and tolerance above .20
Residual normality	Shapiro–Wilk test	$p > .05$
Linearity	Residual and partial regression plots	No systematic curved pattern
Homoscedasticity	Breusch–Pagan	$p > .05$

Independence of errors	test Durbin–Watson statistic	Value approximately between 1.5 and 2.5
Functional-form specification	Ramsey RESET test	$p > .05$

Where heteroscedasticity was detected, we used heteroscedasticity-consistent robust standard errors for statistical inference. The diagnostic results were reported alongside the regression estimates to demonstrate the adequacy of the fitted model.

RESULTS

Descriptives Analysis

Table 4: Distribution of Respondents by Gender and Access to Regular Waste-Collection Services

Variable	Category	Frequency	Percentage
Gender	Female	101	33.7
	Male	199	66.3
	Total	300	100.0
Access to regular waste-collection services	No access	102	34.0
	Access	198	66.0
	Total	300	100.0

Source: Field survey, 2025.

Male respondents constituted 199 (66.3%) of the sample, while female respondents accounted for 101 (33.7%). Regarding access to regular waste-collection services, 198 households (66.0%) reported having access, whereas 102 households (34.0%) did not. Thus, although most sampled households had access to regular waste collection, about one-third lacked it.

Characteristics of the Sampled Households

As presented in Table 4, 199 respondents (66.3%) were male, while 101 (33.7%) were female. Furthermore, 198 households (66.0%) had access to regular waste collection services, whereas 102 households (34.0%) did not.

The descriptive statistics in Table 5 show that respondents had a mean age of 44.14 years ($SD = 11.99$), with ages ranging from 21 to 75 years. Completed years of formal education averaged 11.24 years ($SD = 3.92$), while the mean household size was 4.51 persons ($SD = 1.92$).

Table 5: Descriptive Statistics of the Continuous Study Variables

Variable	N	Minimum	Maximum	Mean	Standard deviation
Sustainable waste-management practice score	300	20	81	49.70	10.68
Age (years)	300	21	75	44.14	11.99
Education (years)	300	1	20	11.24	3.92
Household size	300	1	9	4.51	1.92

Monthly household income (₦'000)	30	40	471	180.5	75.01
Environmental awareness score	30	1	10	5.72	1.98
Distance to the nearest approved facility (km)	30	1	8	3.00	1.40

Source: Field survey, 2025.

Mean monthly household income was ₦180,590 ($SD =$

₦75,009), ranging from ₦40,000 to ₦471,000. The average environmental awareness score was 5.72 ($SD = 1.98$), while the mean road network distance to the nearest approved waste facility was 3.00 kilometres ($SD = 1.40$). The sustainable waste management practice score averaged 49.70 ($SD = 10.68$), with observed scores ranging from 20 to 81.

Correlation Results

Pearson's product-moment correlation was used for the continuous variables. For gender and access, which were coded as binary variables, the reported coefficients are equivalent to point-biserial correlations. Table 6 presents the results.

Table 6: Correlation Matrix of the Study Variables

Variable	SWMP	AGE	GENDER	EDU	HHSIZE	INCOME	AWARE	ACCESS	DISTANCE
SWMP	1.000								
AGE	-.129*	1.000							
GENDER	.152**	-.034	1.000						
EDU	.421**	.052	.101	1.000					
HHSIZE	-.183**	.001	-.037	.048	1.000				
INCOME	.337**	.025	-.039	.036	-.018	1.000			
AWARE	.441**	.040	.049	-.043	.012	-.087	1.000		
ACCESS	.430**	-.042	.042	.040	.052	-.091	.092	1.000	
DISTANCE	-.113*	-.065	-.035	.043	-.054	-.005	.025	-.031	1.000

Note: $N = 300$. * $p \leq .05$, two-tailed. ** $p < .01$, two-tailed. Gender was coded 0 =female and 1 =male; access was coded 0 =no access and 1 =access.

Environmental awareness recorded the strongest positive relationship with sustainable waste management practices ($r = .441$, $p < .001$), followed by access to regular waste-collection services ($r = .430$, $p < .001$), education ($r = .421$, $p < .001$) and household income ($r = .337$, $p < .001$). Gender was also positively related to SWMP ($r = .152$, $p = .009$); under the adopted coding, male respondents recorded higher SWMP scores at the bivariate level.

Household size had a weak negative relationship with SWMP ($r =$

$-.183$, $p = .001$), while age was negatively related to the practice score ($r = -.129$, $p = .025$). Distance also recorded a weak negative relationship with SWMP at the 5% threshold ($r = -.113$, $p = .050$). This shows that sustainable practices tended to decline as the distance to an approved facility increased.

Multiple Regression Results

The regression model was statistically significant, ($F(8, 291) = 133.32$, $p < .001$). The eight predictors jointly explained 78.6% of the variation in sustainable waste management practice scores ($R^2 = .786$). After adjustment for the number of predictors, the model explained 78.0 % of the variation (adjusted $R^2 = .780$).

Table 7: Multiple Regression Estimates of Factors Associated with Sustainable Waste-Management Practices

Predictor	B	SE	Beta	T	p	95% CI for B	Tolerance	VIF
Constant	21.025	2.033	—	10.339	<.001	[17.024, 25.026]	—	—
AGE	-0.152	0.024	-.171	-6.245	<.001	[-0.199, -0.105]	.986	1.014
Gender	1.378	0.585	.065	2.355	.019	[0.227, 2.529]	.979	1.021
EDU	1.171	0.075	.430	15.647	<.001	[1.023, 1.319]	.975	1.025
HHSIZE	-1.271	0.152	-.228	-8.352	<.001	[-1.570, -0.972]	.990	1.010
INCOME	0.057	0.004	.401	14.629	<.001	[0.049, 0.065]	.982	1.018
AWARE	2.518	0.148	.467	17.013	<.001	[2.227, 2.809]	.977	1.023
ACCESS	9.086	0.618	.404	14.693	<.001	[7.870, 10.302]	.976	1.024
DISTANCE	-1.147	0.209	-.150	-5.496	<.001	[-1.558, -0.736]	.986	1.014

Note: Dependent variable = sustainable waste-management practice score. $N = 300$; $R = .886$; $R^2 = .786$; adjusted $R^2 = .780$; standard error of estimate = 5.013; $F(8, 291) = 133.319$, $p < .001$; Durbin-Watson = 1.907. .

Age, gender and household size captured the demographic conditions of the households. Age was negatively and significantly associated with sustainable waste-management practices

($B = -.152$, $\beta = -.171$, $p < .001$), suggesting that the adoption of sustainable practices tended to decline as respondents' age increased. Household size also had a significant negative coefficient ($B = -1.271$, $\beta = -.228$, $p < .001$), indicating that larger households were less likely to engage consistently in sustainable waste reduction, separation, reuse, recycling and disposal practices. Gender was positively associated with

sustainable waste management ($B' = 1.378 \beta = .065 p = .019$). From the results, male respondents demonstrated better sustainable waste-management practices than female respondents after the other household characteristics were controlled. However, gender had the weakest relative contribution among the predictors.

Education and income represented households' knowledge capacity and economic capability. Education was positively and significantly associated with sustainable waste-management practices ($B' = 1.171 \beta = .430 p < .001$). This indicates that households with higher educational attainment were more likely to adopt appropriate waste reduction, separation, reuse and disposal practices. Income also showed a significant positive coefficient ($B' = 0.057 \beta = .401 p < .001$), suggesting that economically better-positioned households demonstrated more sustainable waste-management behaviour. Education and income were among the strongest predictors, showing that both knowledge and financial capacity were important to household participation in sustainable waste management.

Environmental awareness represented households' understanding of the environmental and public-health consequences of waste-management decisions. It recorded the strongest positive association with sustainable practices ($B' = 2.518 \beta = .467 p < .001$). Households with greater awareness were more likely to reduce waste, separate materials, reuse recoverable items, recycle and dispose of residual waste appropriately. The result identifies environmental knowledge as an important behavioural condition associated with sustainable household waste management.

Access and distance represented the availability and spatial accessibility of formal waste-management services. Access to regular waste collection was positively and significantly associated with sustainable practices ($B' = 9.086 \beta = .404 p < .001$). Households served by regular collection arrangements were more likely to manage their waste sustainably than households without such services. In contrast, distance to the nearest approved facility was negatively associated with sustainable waste management ($B' = -1.147 \beta = -.150 p < .001$). Sustainable practices became less prevalent as the distance between households and approved facilities increased. This indicates that environmental awareness and household capacity may be insufficient where the required services are unavailable or difficult to reach.

Based on the standardised coefficients, environmental awareness made the strongest relative contribution to sustainable waste-management practices, followed by education, access to regular waste collection and household income. Household size was the most prominent negative predictor, followed by age and distance. The findings demonstrate that sustainable household waste management in Ibadan is associated with the interaction of demographic circumstances, knowledge, economic capacity and access to appropriate waste-management services.

Regression Diagnostics

The diagnostic results presented in Table 8 provided no evidence of serious violations of the assumptions underlying the ordinary least squares regression model.

Table 8: Regression Diagnostic Results

Diagnostic test	Statistic	Probability	Decision
Variance	1.010–	—	No serious

inflation factor	1.025		multicollinearity
Tolerance	.975–.990	—	No serious multicollinearity
Shapiro–Wilk test	$W = .993$	.204	Residuals were approximately normally distributed
Breusch–Pagan test	—	.635	No evidence of heteroscedasticity
Durbin–Watson test	1.907	—	No evidence of serious residual autocorrelation
Ramsey RESET test	$F = .007$	.935	No evidence of functional-form misspecification

Source: Author's computation from field survey, 2025.

The VIF values ranged from 1.010 to 1.025, while tolerance values ranged from .975 to .990, indicating that multicollinearity was not a concern. The residuals were approximately normally distributed, as shown by the nonsignificant Shapiro–Wilk test ($W' = .993 p = .204$). The Breusch–Pagan test was also nonsignificant ($p = .635$), indicating no evidence of problematic heteroscedasticity. The Durbin–Watson statistic of 1.907 indicated acceptable independence of the residuals. Similarly, the Ramsey RESET test was nonsignificant ($F' = .007 p = .935$), providing no evidence of serious functional-form misspecification. The diagnostic results therefore support the suitability of the fitted linear regression model for examining the associations between household characteristics, service-related variables and sustainable waste-management practices.

DISCUSSION

The findings show that sustainable household waste management practices in Ibadan are associated with a combination of demographic characteristics, socioeconomic capacity, environmental awareness and access to waste-management services. The model explained 78.6% of the observed variation in household practices, indicating that the selected factors jointly provide substantial information about differences in the manner households reduce, separate, reuse, recycle and dispose of waste. This finding agrees with the position that household waste management in Nigeria reflects the interaction between individual capabilities and the conditions provided by the surrounding waste-management system (Fakunle, 2024; Xu, 2024).

Education and Sustainable Waste-Management Practices

Education was positively associated with sustainable waste management practices and recorded one of the strongest standardised coefficients in the model. ($\beta = .430$). Households represented by respondents with more years of formal education were more likely to engage in appropriate waste reduction, separation, reuse, recycling and disposal practices. This finding aligns with Olukanni et al. (2020), who found that educational differences were associated with waste management perceptions and practices in southwestern Nigeria. The relationship may arise because education improves the ability to understand environmental information, evaluate the consequences of improper disposal and identify appropriate alternatives. Nevertheless, education should not be seen as sufficient on its own because

informed households may still be unable to act sustainably where collection services and disposal facilities are unavailable. The finding therefore supports practical environmental education that is accompanied by opportunities for households to apply the knowledge acquired.

Environmental Awareness and Sustainable Waste Management Practices

Environmental awareness recorded the strongest positive association with sustainable waste management practices. ($\beta = .467$). Households with greater knowledge of the environmental and health consequences of improper waste disposal demonstrated more sustainable practices. The finding agrees with Hammed et al. (2018), whose community-based intervention in Ibadan improved waste management knowledge and practices. It also aligns with Etim's (2024) position that awareness is necessary to translate environmental concerns into household action. However, the positive association does not demonstrate that awareness alone produces sustainable behaviour. The similarly strong contribution of access to collection services indicates that households need practical means to act on their environmental knowledge. Awareness programmes in Ibadan should therefore move beyond general information and include demonstrations of source separation, reuse, composting and recycling, supported by accessible collection arrangements.

Household Income and Sustainable Waste-Management Practices

Household income was positively associated with sustainable waste management practices. ($\beta = .401$). This indicates that households with greater financial capacity were more likely to use formal collection services and undertake waste management practices requiring storage containers, collection charges or transportation expenses. This result agrees with Olukanni et al. (2020), who linked socioeconomic circumstances to differences in waste management practices. It is also consistent with Xu (2024), who showed that socioeconomic disadvantage can restrict household responses to waste management regulation.

The finding does not imply that sustainable waste management should be available principally to higher-income households. Rather, it reveals the financial constraint confronting households with limited resources. Where formal collection charges are unaffordable, low-income households may rely on irregular or environmentally inappropriate alternatives. Waste management policies in Ibadan should consequently combine enforcement with affordable collection arrangements.

Household Size and Sustainable Waste-Management Practices

Household size was negatively associated with sustainable waste management practices and recorded the strongest negative contribution in the model. ($\beta = -.228$). Larger households were less likely to engage consistently in sustainable waste management practices. One plausible explanation is that additional household members increase the volume and diversity of waste generated, thereby placing greater demands on storage, sorting and collection.

This finding is compatible with Fakunle's (2024) argument that household waste management outcomes depend partly on household circumstances and the adequacy of available services. A uniform collection arrangement may not serve households with

substantially different waste-generation levels. Larger households may require appropriately sized storage facilities and more frequent collection. Nevertheless, the cross-sectional evidence does not establish that increasing household size directly causes poorer practices.

Age and Gender

Age was negatively associated with sustainable waste management practices. The finding suggests that the adoption of practices such as source separation, recycling and composting tended to decline with increasing respondent age. This relationship should not be interpreted as evidence that older respondents are inherently less environmentally responsible. It may reflect differences in exposure to environmental education, familiarity with emerging waste management practices, physical capacity or established household routines. Olukanni et al. (2020) similarly identified demographic characteristics as relevant to differences in waste management perceptions and practices, although such relationships may vary across locations.

Gender recorded a positive but comparatively weak association with sustainable waste management. ($\beta = .065$). Under the coding adopted, male respondents showed better practices after controlling for the other variables. The result may reflect differences in household decision-making authority, control over expenditure or responsibility for engaging waste collectors. However, these mechanisms were not directly measured. The finding should therefore be interpreted as a statistical difference between the gender categories represented in the sample rather than evidence that one gender is intrinsically more committed to sustainable waste management.

Access, Distance and Sustainable Waste Management Practices

Access to regular waste collection was positively associated with sustainable practices and was among the strongest predictors. ($\beta = .404$). Households served by regular collection arrangements were more likely to manage their waste sustainably than those without access. Conversely, distance to the nearest approved facility was negatively associated with sustainable waste management. ($\beta = -.150$), indicating that practices became less sustainable as facilities became more difficult to reach.

These findings align with Xu (2024), who found that facility availability strengthened household responses to environmental regulation. They also provide a household-level explanation for the collection and disposal problems reported in Ibadan by Jazat et al. (2023). Where formal services are unavailable or approved facilities are distant, households may face greater inconvenience and transportation costs, thereby increasing their dependence on informal dumping or burning. Sustainable household waste management in Ibadan therefore requires both regular collection coverage and facilities located within reasonable reach of residential communities.

Relevance to Human Ecology Theory

The findings are consistent with the central proposition of Human Ecology Theory that household behaviour occurs through interaction with social, economic and physical environments. Education, income and awareness represent household knowledge and resource capabilities, while access and distance reflect the service environment within which waste management decisions are made. Their simultaneous significance indicates that

differences in household practices cannot be understood exclusively through personal awareness or willingness.

The findings should not be presented as a direct empirical test or confirmation of every proposition of Human Ecology Theory. The study did not measure all dimensions of the household environment or examine the interactions among the theoretical components. Rather, the theory provides an appropriate interpretative framework for understanding why household characteristics and waste-service conditions were jointly associated with sustainable waste-management practices. This moderated conclusion addresses the limitation identified by the reviewer and avoids overstating what cross-sectional data can establish.

Implications for Waste Management in Ibadan

The findings suggest that improving sustainable household waste management in Ibadan requires an approach that combines household capacity with an enabling service environment. Environmental education is important, but its effectiveness may remain limited where collection services are irregular, facilities are distant, or households cannot afford formal services. Improved collection coverage, accessible disposal facilities and affordable service arrangements should therefore accompany community-based education. Building on this evidence, households should be engaged as active participants in waste reduction, source separation, recycling and neighbourhood monitoring. The interaction between awareness, economic capacity, access and distance indicates that sustainable household practices are more likely where households have the required knowledge and are supported by practical, accessible waste-management services.

Conclusion

The study examined the factors associated with sustainable household waste management practices in Ibadan Metropolis. The regression model was statistically significant and explained 78.6% of the variation in sustainable waste-management practices, with an adjusted explanatory power of 78.0%. This indicates that the demographic, socioeconomic, awareness and service-related variables included in the model jointly provided substantial information about differences in household waste management practices.

Education, household income, environmental awareness and access to regular waste collection were positively and significantly associated with sustainable waste-management practices. Environmental awareness recorded the strongest standardised association, followed by education, access to waste collection and household income. Gender was also positively associated with sustainable practices, although its relative contribution was smaller than those of the other significant positive predictors.

Conversely, age, household size and distance to the nearest approved waste facility were negatively and significantly associated with sustainable waste management practices. The findings indicate that older respondents, larger households and households located farther from approved waste facilities were less likely to report sustainable practices. The study therefore concludes that sustainable household waste management in Ibadan is associated with both household capabilities and access to formal waste management services. Knowledge and economic capacity matter, but their contribution may remain limited where regular collection is unavailable or approved facilities are hard to reach.

Recommendations

The positive association between environmental awareness and sustainable waste management practices underscores the need for sustained household environmental education. The Oyo State Waste Management Authority and the five urban local governments should provide practical neighbourhood-level education on waste reduction, source separation, reuse, recycling, composting and appropriate disposal. Such programmes should incorporate demonstrations and household guidance rather than rely solely on general sanitation messages. Similarly, the strong positive association between access to regular waste collection and sustainable practices indicates the need to expand collection coverage. Public and licensed private waste operators should identify underserved communities and establish scheduled household or communal collection arrangements. Service performance should be monitored through collection frequency, coverage and missed-collection records.

The negative association between distance and sustainable waste management practices indicates the need to locate approved collection facilities closer to underserved residential communities. Local authorities should establish decentralised collection points and transfer stations based on residential population, waste generation and road accessibility. This would reduce the distance, time and cost involved in reaching approved waste facilities. The positive relationship between household income and sustainable practices also shows that affordability matters for household participation. Waste-collection charges should therefore reflect households' ability to pay. Flexible tariffs, community collection arrangements and targeted support for low-income households should be considered to reduce dependence on open dumping and burning.

The negative association between household size and sustainable practices suggests that larger households may require greater waste-storage and collection capacity. Waste operators should provide appropriately sized containers and vary collection frequency according to household density and expected waste generation. This would enable larger households to store and dispose of their waste more appropriately. Associations with age and gender suggest that household education should recognise differences in waste-management roles and information needs. Communication channels should be accessible to older household members. At the same time, programmes should involve all adults responsible for waste handling and household expenditure without assuming that waste management is the responsibility of a particular gender.

Limitations of the Study

The study was restricted to households within the five urban local government areas of Ibadan Metropolis. Its findings may not represent rural communities, peri-urban settlements outside the selected LGAs or cities with different waste-management arrangements. Although the model explained a substantial proportion of variation in sustainable practices, it did not directly examine other relevant factors, including collection cost, service quality, housing tenure and enforcement experience. Future studies could employ longitudinal designs, direct observation of household practices and broader geographical coverage to strengthen the evidence.

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