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Impact of Household Consumption on Ecological Footprint in Nigeria

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Abstract

The authors investigate the impact of household consumption on ecological footprint in Nigeria. The researchers employ Ordinary Least Squares (OLS) estimation to assess the effect of household consumption on the ecological footprint in Nigeria using annual time series data from both World Bank Development Indicators and Global Footprint databases within 1990-2021 period. The researchers also investigated the causal link between household consumption and ecological footprint using the Granger Causality Test. Our findings clearly show that household consumption has both significant and positive effect statistically on ecological footprint in Nigeria. That is, a unit increase on household consumption will increase ecological footprint by 6.1% when other factors are well behaved. Furthermore, there is no causal link existing between household consumption and ecological footprint in Nigeria. The authors recommend that policies should be directed towards promoting sustainable consumption practices among households, and as well managing population explode through family planning.

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Introduction

Ecological Footprint (EF) is an accounting method, which focuses on land appropriation and provides a means for measuring and communicating human induced environmental impacts on the planet earth (Subha & Athira, 2013). It is the amount of biologically productive land and sea area required to replenish the resources human beings use as well as to absorb and render innocuous the corresponding waste (Raj et al., 2012). It is a total of the areas (ecologically productive space) required to support each person's lifestyle (Subha & Athira, 2013). The conference held in 1972 at Stockholm by the United Nations on the Human Environment birthed the modern discourse of political and public environmental (Baylis & Smith, 2005). Ecological footprint has been on the domain of ecological debate by environmentalists (Jóhannesson et al., 2018). To be more precise, worries have been expressed regarding socio-economic metabolism potentially consuming resources and producing waste at unsustainable rates worldwide (Ellis et al., 2010, Krausmann et al., 2013, & Rockström et al., 2009). Although Hoekstra (2009), Wackernagel et al. (2002) & Galli et al. (2012) maintained that the earth's ability to seclude waste was threatened due to population rise and global overshoot, the lifestyle choice and consumption patterns pose more threats as these economic realities require the use of natural stock and leads to generation of waste in the process (Abd'Razack, 2013). Lending credence to this, Davidson et al. (2015) maintained that the continued challenge in climate change, environmental degradation, and economic instability, are primarily related to unsustainable consumption of goods and services. With the depleting trajectory in environmental sustainability and growing household consumption (Shahbaz et al., 2022; & Meena, 2019) as standpoints, our study makes a departure on what impacts household consumption could have on ecological footprint.

Households consume a proportionate sum of food, energy, and water resources (Fox & Ward,

2008) and account for almost three-fourths of the global greenhouse emissions worldwide (Hertwich & Peters, 2009; Ivanova et al., 2020). This implies that the lifestyle of households is directly or indirectly associated with damages to the environment, specifically affecting the stocks of natural resources, environmental quality, and climate change (Abd'Razack, 2013; & [OECD], 2011). A significant waste index for household is carbon emission, with its global footprint contribution in 2007 stood at 22 Gt CO_2-eq (Ivanova et al., 2016). For instance, Tian (2014) maintained that the carbon emissions generated by household consumption contributes significantly to the increase in China's carbon emissions, which was 35% as at 2006. Whereas in Pakistan, Rashid et al. (2018) reported that the EF of Bahria town is 8.6g ha (global hectares) and Gulraiz Colony is 6.9g ha, which indicates a consumption pattern that stretches far more than the biocapacity of Pakistan. A quarter of global emissions, or 5.6Gt CO_2-eq, comes from households in the United States alone. Ivanova et al. (2016) further discovered that household consumption impacts the world's household consumption patterns unevenly, with households in the four major economies—China, Japan, Russia, and the United States—contributing to approximately half of the emissions.There is no shortage of research on sustainable consumption and lifestyle choices (Anantharaman, 2018; Allen et al., 2019; Baabou et al., 2017; Ding et al., 2019; Salo et al., 2016; Yates & Evans, 2016; Zhang et al., 2017). However, the bulk of these studies were conducted in developed nations, neglecting the sizeable portion of the global population that resides in middle- and low-income nations (Shahbaz et al., 2022). Another drawback of extant research in this area is the fact that there is undue concentration on the impact of industrialization, urbanization, population etc. on environmental sustainability (Uttara et al., 2012; Ohwo & Abotutu, 2015; Weber & Sciubba, 2019), neglecting the multidimensional threat (vis-à-vis ecological footprint) that household consumption poses to environmental sustainability (Shahbaz et al., 2022). Nigeria does not rank within the top 10 nations with the largest ecological footprint (World Population Review, 2023), despite its 1.02g ha, unsustainable and indiscriminate consumption by households pose threats to the sustainability of the Nigerian environment (Abd'Razack, 2013). For example, Razack & Ludin (2014) reported that should the trend of consumption continue in Minna, Niger state in terms of preference for non-animal food compared to animal food (70 percent ratio 30 percent respectively), ecological footprint will depreciate. Therefore, this study seeks to examine the impact and also the path of causality between household consumption and ecological footprint in Nigeria.

Conceptual framework

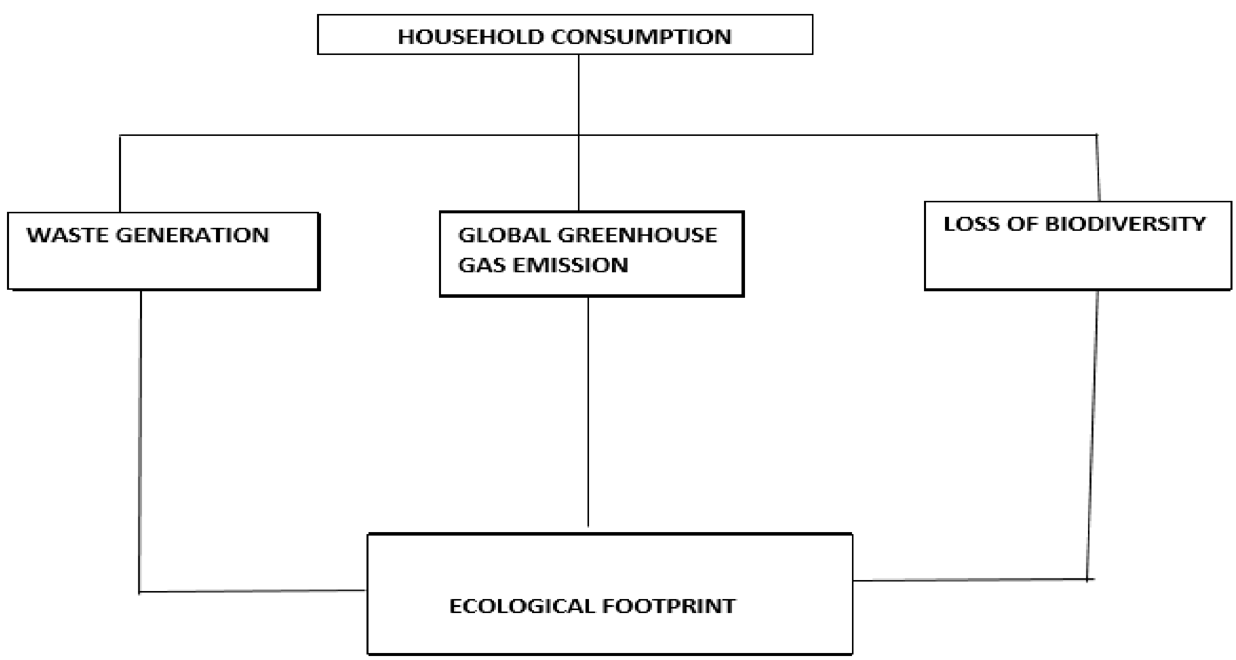

Fig 1: The study's conceptual framework flow chart

Given the available literatures that were reviewed by the authors, it is certain that related studies have been carried out around the thematic area of this research. For example, Wenlong (2022) analyzed the effects on the USA's ecological footprint from 1995 to 2018 related to transportation, coal rents, energy use, and economic globalization. From 2000 to 2019, Naeem et al. (2023) looked into how innovation, industry, and infrastructure improved environmental sustainability in Africa. Güney (2017) conducted a study to analyze the impact of population growth on sustainable development utilizing Savings, population, GDP growth, corruption, consumption and trade openness among 146 countries covering 1990-2012 period. Using data accessible from 1980 to 2019, Lawal (2023) investigated the relationship between economic development, energy consumption, agricultural production, and CO2 in Africa. The Granger causality estimation approaches in the frequency domain and time domain were employed by the researcher to compare the outcomes over various time horizons.

On the other hand, using data from 1981 to 2017, researchers in Nigeria, such as Kojo & Paschal (2018), investigated how urban population expansion affected environmental sustainability. The factors that are employed as explanatory variables include the following: exports of agricultural raw materials, arable land, food production index, urban population growth, use of fossil fuels, carbon emissions, and forest reserves. They employed autoregressive distributed lag (ARDL) model technique in their analysis. After adjusting for the effects of energy use, trade openness, and economic growth using data from 1971 to 2015, Nathaniel & Bekun (2020) evaluated the link between urbanization and deforestation. They used vector error Correction-Granger causality approach and Pesaran's autoregressive distributed lag cointegration technique in their investigation. Omoke et al. (2020) used the nonlinear autoregressive distributed lag (NARDL) framework to analyze the impact of financial development on ecological footprint in Nigeria over the years 1971–2014. In order to find out how urbanization, international commerce, and economic expansion affect CO_2 emissions in sub-Saharan Africa (SSA), Iheonu et al. (2021) conducted research on that account with the panel quantile regression technique used in their analysis while data from these years 1977-2016 were used. Solarin et al. (2021) examined how urbanization and economic expansion affected Nigeria's ecological footprint (EFP), taking into consideration trade and foreign direct investment. The autoregressive distributed lag (ARDL) was utilized in their investigation along with the ecological footprint (EFP) variable.

Dada et al. (2022) investigated the effects of trade openness, natural resource availability, urbanization, human capital, financial development, and economic growth on Nigeria's ecological footprint (EFP) from 1970 to 2017. The model utilized was the Autoregressive Distributive Lag (ARDL). Adebayo et al. (2023) studied the impact of national hazards and renewable energy use on the state of the environment in the MINT countries (Mexico, Indonesia, Nigeria, and Turkey) between 1990 and 2018. Urbanization, trade openness, and economic growth were the study's three key variables. Cross-Sectional Autoregressive Distributed Lag (CS-ARDL) was used as the primary model, while Common Correlated Effects Mean Group (CCEMG) and Augmented Mean Group (AMG) were used for robustness tests.

It is evident that no research has been conducted on the thematic area of this work that examines the effect of household consumption on the ecological footprint in Nigeria. This study utilizes some control variables like per capita GDP, industrial output, population growth, and trade openness of which some of the variables have been used by some authors in Nigeria. The most current data available were used to run the analysis thereby updating the existing literature in

Nigeria.

Materials and Methods

The authors used secondary data from the Global Footprint database and World Bank Development Indicators database which is an annual time series that spanned from 1990-2021. The explained variable in this study is ecological footprint, while the core independent variable is household consumption. Other control variables are population growth, industry output (proxied by industry value added), GDPPC, and trade openness. To analyze the data, Eviews 9 was used as it allowed the researchers to estimate the classical linear regression model. With the exception of population growth rate and trade openness, all relevant data were transformed using a logarithmic function in Microsoft Excel after being obtained from their original sources. The data upload and import to Eviews was also done using Excel. The Granger Causality Test was employed to test for causality while the OLS method of estimation was used in reporting.

The Environmental Kuznets Curve (EKC) model was adopted for this study. Since its development by Grossman and Krueger in 1991, the EKC has been the predominant method used by economists to simulate ambient pollution concentrations and aggregate emissions. The functional form of the model is stated as:

$$Eit = (\alpha + \beta iFi) + \delta Yit + \varphi(Yit)2 + kt + \varepsilon it \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where;

E = the environmental indicator (which is ecological footprint in this study), either in the form of concentrations or per capita form.

Y = per capita income (which is represented by GDP Per Capita in this study)

F = country-specific effects

k = a linear time trend, and

i and t = country and year, respectively.

The Environmental Kuznets Curve model was extended to include other control variables like household consumption, industry output, trade openness, and population growth rate.

The econometric form of the model specification:

$LEFP_t = \beta_0 + \beta_1 HHC_t + \beta_2 LPGDP_t + \beta_3 LINDQ_t + \beta_4 PGR_t + \beta_5 TO_t + \mu_t$ -----------------(2)

The error correction model specification:

$\Delta LEFP_t = \beta_0 + \beta_1 \Delta HHC_t + \beta_2 \Delta LPGDP_t + \beta_3 \Delta LINDQ_t + \beta_4 \Delta PGR_t + \beta_5 \Delta TO_t + \lambda ECM_{t-1} + \mu_t$ --(3)

Empirical Results and Discussion

Descriptive Analysis

	HHC	LEFP	LINDQ	LPGDP	PGR	TO
Mean	60.7498	7.0082	24.5101	21.4364	2.6042	36.1602
Median	60.6309	7.2705	24.7334	21.4887	2.5888	36.5402
Maximum	81.5353	8.0712	25.6756	22.9027	2.7641	53.2780
Minimum	34.5684	5.5985	22.9432	19.5179	2.4064	16.3522
Std. Dev.	11.9615	0.7806	0.8873	0.9950	0.1009	9.3940
Skewness	-0.2623	-0.2313	-0.1335	-0.2560	-0.0845	-0.1573
Kurtosis	2.5459	1.4811	1.4943	1.9961	1.8377	2.4653
Jarque-Bera	0.6418	3.3613	3.1178	1.6933	1.8394	0.5132
Probability	0.7255	0.1863	0.2104	0.4289	0.3986	0.7737
Sum	1943.9920	224.2610	784.3243	685.9649	83.3331	1157.1250
SumSq.Dev.	4435.3680	18.8872	24.4070	30.6889	0.3157	2735.6410
Observations	32	32	32	32	32	32

Source: Author`s Computation: All the variables are in their log form except HHC, PGR, and TO

Considering the overview of the model's variables' statistical properties, it shows the measures of central tendencies and dispersion of the data. The table basically summarizes the data utilized in the model as it exists at face value. The variable HHC has the highest mean, while PGR has the lowest mean. The mean and median for all the variables are generally close to one another. Likewise, the extreme and lowest values for all the variables are also close to each other. This pair of observations shows that there is no outlier in the results. The standard deviation is greater than zero (0) for all the variables, this implies that the variables are indeed, varying. The P-Values of the Jarque-Bera Statistics for all the variables are greater than the 5% level of significance; this shows that the variables are all normally distributed. Further evidence that the variables are normally distributed comes from the fact that their kurtosis values are all less than three (3). In terms of skewness of data, all the variables are negatively skewed because they all have values less than zero (0). There are 32 observations for each of the variables, this shows that there are no missing data for any of the variables

PRE-ESTIMATION TEST RESULTS

Results Unit Root Test

TABLE 2: Augmented Dickey-Fuller Unit Root Test Results

VARIABLES	ADF T-STAT AT LEVELS	ADF 5% CRITICAL VALUE	ADF T-STAT AT FIRST DIFFER-ENCE	ADF 5% CRITICAL VALUE AT FIRST DIFFER-ENCE	ORDER OF INTEGRA-TION	DECISION YES or NO
HHC	-3.2629	-3.5629	-7.1834	-3.5684	I (1)	YES
LEFP	-1.3626	-3.5629	-4.2501	-3.5684	I (1)	YES
LINDQ	-2.3683	-3.5629	-4.6321	-3.5684	I (1)	YES
LPGDP	-2.4293	-3.5806	-6.7283	-3.5684	I (1)	YES
PGR	0.1486	-3.5875	-4.0722	-3.5742	I (1)	YES
TO	-3.3427	-3.5629	-5.4366	-3.5742	I (1)	YES

Source: Author`s Computation

Test Hypotheses:

H_0: Series are non-stationary (unit root)

H_1: Series are stationary (no unit root)

Decision Rule:

Reject H_0 if |T-stat| > |T-tab| or critical value of ADF at 5% level of significance and conclude that there is no unit root problem, that is, series are stationary. Otherwise, fail to reject the null hypothesis.

Interpretation:

From the ADF test for stationarity result in table 2, the t-stat at levels for all the variables in absolute terms are all less than the 5% critical value at levels in absolute terms. The null hypothesis cannot be rejected in this case, leading to the conclusion that there is unit root problem. Since the series are non-stationary at levels, the unit root test is considered at 1^{st} difference. From the table, the t-stat at 1^{st} difference for all the variables in absolute terms are all greater than the 5% critical value at 1^{st} difference in absolute terms. In this case, the null hypothesis (H_0) is rejected, leading to the conclusion that there is no unit root problem, that is, series are stationary at 1^{st} difference. In conclusion, the order of integration from the table shows that all the variables are stationary at order 1, that is, 1^{st} difference I (1).

Results Cointegration Test

TABLE 3: Johansen Cointegration Test Results

NO OF COINTEGRATING EQUATIONS	TRACE STATISTICS	0.05 CRITICAL VALUE	P-VALUE
None *	168.5339	117.7082	0.0000
At most 1 *	106.0407	88.8038	0.0017
At most 2 *	65.3019	63.8761	0.0377
At most 3	36.0467	42.9153	0.2046
At most 4	16.3716	25.8721	0.4631
At most 5	3.8429	12.5180	0.7647

Source: Author`s Computation

Because all the variables are non-stationary at levels, a cointegration test is carried out using the Johansen Cointegration Test, taking into account trend and intercept. Table 3, shows the cointegration test results which is used to check if there is a long run relationship among the variables in the model. If the P-value is less than or equal to the 5% threshold of significance, or if the Trace Statistics is more than the 5% threshold value, the cointegrating equation is considered significant. In the table the asterisks under the co-integrating equations column shows that cointegration exists. From the results shown in the table there are three (3) asterisks, this reveals the presence of at least three significant co-integrating equations which displays that there exist a long run cointegrating link among the series in the model.

REGRESSION RESULT

TABLE 4: OLS Regression Results (Explained Variable: LEFP)

VARIABLE	COEFFICIENT	STD. ERROR	T-STATISTIC	P-VALUE
HHC	0.0061	0.0019	3.2540	0.0032
LINDQ	0.7724	0.0343	22.4892	0.0000
LPGDP	0.0079	0.0351	0.2238	0.8247
PGR	1.1728	0.2932	3.9997	0.0005
TO	-0.0052	0.0024	-2.1750	0.0389
C	-15.3316	0.7097	-21.6035	0.0000

$R^{2} =$ 0.989195; Adj. R^{-2} = 0.987118; F-statistic = 476.0756; Prob. (F- statistic) = 0.000000
D-W Stat. = 0.972242
Source: Author's Computation

Presentation of OLS result of the impact of household consumption on ecological footprint in Nigeria

Constant or Intercept (C): From the regression result obtained as presented in the table 4, the coefficient of the constant term (that is, the intercept term) is -15.3316. This represents the level of EF that is independent of the regressors. Put simply, if the regressors are held constant or fixed, LEFP will decline by 1,533.16%. But this has no relevant economic implication, because in reality the regressors cannot take zero values.

Household Consumption (HHC): The coefficient of household consumption is 0.0061, suggesting that household consumption has a positive relationship with EF. This coefficient is also statistically significant. Therefore, a unit increase in household consumption leads to a 0.0061unit increase in ecological footprint EFP in the long run. Our finding is germane because household consumption is capable of increasing the EFP given the fact that majority of Nigerians lived in the rural areas where ecological activities take place.

Log of Industrial Output (LINDQ): The coefficient of industrialization proxied by industrial output is 0.7724, suggesting that industrialization has a positive relationship with ecological footprint. This coefficient is also statistically significant. Therefore, holding other variables constant, a per cent rise in industrial output leads to a 77.24% increase in EF in the long run. The finding is expected because industrial areas are mostly in rural where there could be vast land for industrial activities thereby increasing ecological footprint during the process of distribution of industrial output. The finding is contrary to the findings by (Naeem et al. 2023)

Log of GDP Per Capita (LPGDP): The coefficient of PGDP is 0.0079, suggesting that PGDP has a positive relationship with ecological footprint. This coefficient is not statistically substantial. Therefore, holding other variables constant, a per cent rise in PGDP leads to a 0.79% increase in EF in the long term. The outcome is surprising because this variable does not affect ecological footprint in Nigeria of which it is a total contradiction to what could increase ecological footprint. Our outcome is in alliance with the outcome of (Dada et al. 2022).

Population Growth Rate (PGR): The coefficient of population growth rate is 1.1728, suggesting that PGR has a positive link with EF. This coefficient is also statistically significant. Therefore, holding other variables constant, a unit increase in population growth rate leads to 1.1728 units rise in EF in the long run. The finding here is expected because population growth should increase ecological footprint in Nigeria. The outcome is line with the research done by (Weber & Sciubba,

2019) in Western Europe but contrary with the finding by (Güney, 2017).

Trade Openness (TO): The coefficient of trade openness is -0.0052, signifying that trade openness has a negative relationship with ecological footprint. This coefficient is statistically significant. Therefore, holding other variables constant, a unit rises in TO leads to a 0.0052 unit decline in EF in the long run. The outcome is surprising because an increase in trade openness means an increase in economic activities which tend to generate pollution, thus contributing to an increase in the economy's EF. The result is contrary to the outcomes by (Dada et al. 2022 & Adebayo et al. 2023).

In terms of magnitude and based on the variables' coefficients, population growth rate has the greatest impact on ecological footprint; industrialization has the second highest impact; GDP per capita has the third highest impact; household consumption has the second lowest impact; trade openness has the least impact on ecological footprint among the regressors in the model.

TABLE 5: Expected and Obtained A priori Signs

Variables	Expected Sign	Obtained Sign	Comments
HHC	Positive (+)	Positive (+)	Conforms
LINDQ	Positive (+)	Positive (+)	Conforms
LPGDP	Positive (+)	Positive (+)	Conforms
PGR	Positive (+)	Positive (+)	Conforms
TO	Positive (+)	Negative (-)	Does not conform

Source: Author's Assessment/Computation

The student t-Test:

The t-Test checks for the individual statistical significance of the variables in the model. This can be checked using either the informal 2-t rule of thumb, the t-statistic or the P-value. The 2-t rule of thumb states that any variable whose t-statistic is up to two (2) and above, is statistically significant. The student t-Test is a two-sided test of the individual statistical significance of the variables in the model, with a decision rule to reject the null hypothesis if the | t-statistic| > t-tab at the 5% level of significance, or if the P-value is less than or equal to the level of significance. Otherwise, the null hypothesis is not rejected.

Test Hypotheses:

H_0: βi = 0 (the variables are individually statistically insignificant)

H_1: βi ≠ 0 (the variables are individually statistically significant)

Decision Rule:

Reject H_0 if the P-value ≤ 0.05 critical value. Otherwise, fail to reject the null hypothesis.

This study will adopt the P-Value in evaluation of the individual statistical significance of the variables in the model. The results of the evaluation are summarized in table 6.

TABLE 6: t-Test Using the P-values of the Variables

Variables	P-Value	Critical Value	Decision	Conclusion
C	0.0000	0.05	Reject H_0	Statistically Significant
HHC	0.0032	0.05	Reject H_0	Statistically Significant
LINDQ	0.0000	0.05	Reject H_0	Statistically Significant
LPGDP	0.8247	0.05	Fail to reject H_0	Statistically insignificant
PGR	0.0005	0.05	Reject H_0	Statistically Significant
TO	0.0389	0.05	Reject H_0	Statistically Significant

Source: Author's Computation

The F-Test:

The F-test determines the overall significance of the model. It can be determined using the probability value of the F-statistic which should be ≤ 0.05 to establish that the model is statistically significant. From the regression result in table 4, the probability value of the F-statistic is 0.000000 which is less than the 5% level of significance. This means that the regressors are jointly statistically substantial.

The Coefficient of Determination (R^2):

The coefficient of determination is a measure of the goodness of fit of a model. It explains the total amount of variations in the dependent variable that are accounted for by changes in the independent variables. From the regression result in table 4, the R^2 for the model is 0.989195. This means that the regressors (HHC, LINDQ, LPGDP, PGR, TO), have been able to explain up to 98.9% of the variations in the dependent variable ecological footprint. Generally, the closer the value of the R^2 to one (1), the better the fitness of the model. In essence, the model is a good fit.

The Adjusted Coefficient of Determination (Adjusted R^{-2}):

The Adjusted R^{-2} performs the same function as the R^2, in addition to checking whether the R^2 over-estimated the success of the model. However, it penalizes the researcher's choice of data, that is, for any extra addition of regressors to a model, the Adjusted R^{-2} decreases. From the regression result in table 4, the Adjusted R^{-2} is 0.987118 or 98.7% which is very close to the value of the R^2. Therefore, the OLS regression model is parsimonious.

Evaluation Based on Econometric Criteria (Second Order Test)

This evaluation is carried out to determine if the regression model has been able to satisfy the assumptions of the Classical Linear Regression Model (CLRM). It is also used to determine the reliability and stability of the model in making a forecast.

Normality Test

One of the assumptions of the CLRM is that the error term is normally distributed. The normality test is a test conducted on the error term to check if it is normally distributed or not. The Jarque-Bera (JB) Statistic will be used to carry out this test.

Test Hypotheses:

H_0: JB $\neq 0$ (Error term is normally distributed)

H_1: JB $= 0$ (Error term is not normally distributed)

Decision Rule:

Reject H_0 if the P-value of JB-Stat. ≤ 0.05 level of significance. Otherwise, the null hypothesis is not rejected.

TABLE 7: Normality Test Result

Jarque-Bera Statistics	1.5252
Probability Value	0.4665
Conclusion/Comment	Normally Distributed

Source: Author's Computation

From table 7, the probability value of the Jarque-Bera statistics is 0.4665. Following the decision rule, since the P-value of the JB Statistics > 0.05, the null hypothesis cannot be rejected leading to the conclusion that the residuals are normally distributed, that is, the error term is normally distributed.

Autocorrelation Test

This test is conducted to ascertain whether there is serial correlation between any two pairs of the disturbance term. This means that it verifies whether the errors of different observations are correlated. If Autocorrelation exists, then the BLUE property (Best Linear Unbiased Estimator) of the OLS is violated. The Breusch-Godfrey (BG) Serial Correlation LM Test is the approach used in conducting this test. This test follows the normal chi-square distribution.

Test Hypotheses:

H_0: No autocorrelation

H_1: Autocorrelation

Decision Rule:

Reject H_0 if the P-value ≤ 0.05 level of significance. Otherwise, fail to reject the null hypothesis.

TABLE 8: Autocorrelation Test (Breusch-Godfrey Serial Correlation LM Test) Result

Obs*R-squared	11.7402
Prob. Chi-square	0.0028
Conclusion/Comment	Autocorrelation

Source: Author's Computation

From table 8, the chi-square probability value is < 0.05, therefore, the null hypothesis is rejected. This implies that there is autocorrelation problem. The existence of autocorrelation means that the residual terms in the model are serially correlated. This constitutes a serious violation of the assumptions of the CLRM. However, this problem will be corrected using the Newey-West HAC Estimator.

Heteroscedasticity Test

This test is used to ascertain whether the error term is homoscedastic, that is, whether the error term of the different observations have equal variance (spread) or constant variance. The Breusch-Pagan-Godfrey (BPG) Test is the approach used in conducting this test. This test also follows the normal chi-square distribution.

Test Hypotheses:

H_0: Homoscedasticity

H_1: Heteroscedasticity

Decision Rule:

Reject H_0 if the P-value ≤ 0.05 level of significance. Otherwise, fail to reject the null hypothesis.

TABLE 9: Breusch-Pagan-Godfrey Heteroscedasticity Test Result

Obs*R-squared	10.2425
Prob. Chi-square	0.0686
Conclusion/Comment	Homoscedastic

Source: Author's Computation

From table 9, the chi-square probability value is > 0.05, therefore, the null hypothesis cannot be rejected. This implies that the error term of the different observations has equal or constant variance, that is, they are homoscedastic.

Newey-West HAC Estimation

The Newey-West Heteroscedasticity Autocorrelation Consistent (HAC) Estimator is used to correct the problems of autocorrelation as well as heteroscedasticity. This test is carried out in this report because autocorrelation was detected. The presence of autocorrelation means that the standard errors, t-statistics, and P-Values of the original regression model in table 4, are false. The Newey-West HAC Estimator simply restores the true or real values of the standard errors, t-statistics, and P-Values of the model. The result and interpretation are shown below:

TABLE 10: Newey-West HAC Test Result

Variable	Coefficient	Std. Error	t-Statistic	P-Value
HHC	0.0061	0.0026	2.3569	0.0262
LPGDP	0.0079	0.0354	0.2220	0.8260
LINDQ	0.7724	0.0431	17.9078	0.0000
PGR	1.1728	0.3249	3.6101	0.0013
TO	-0.0052	0.0026	-2.0049	0.0555
C	-15.3316	0.8086	-18.9607	0.0000

R^2 = 0.989195 Adj. R^{-2} = 0.987118 F-Statistic = 476.0756 Prob (F-Stat.) = 0.000000

D-W Stat. = 0.972242 Observations = 32

Source: Author`s Computation

To interpret the result of this test, the standard errors, t-statistics, and P-Values generated by the Newey-West HAC Estimator are compared to the initial regression result of the model. From table 10, it can be observed that the true values of the test statistics have been restored.

Note: The coefficients of the regressors did not change, this means that in the presence of autocorrelation OLS is still BLUE.

Multicollinearity Test

The Multicollinearity Test is used to ascertain whether there is correlation between two regressors. The correlation between two regressors is undesirable because its existence will make the estimation of the individual impacts of the regressors on the dependent variable very difficult thereby giving room for only the estimation of their joint impacts on the dependent variable. Multicollinearity exist if the correlation coefficient between two regressors is ≥ 0.8.

TABLE 11: Pair Wise Correlation Matrix of the Variables

VARIABLES	LEFP	LINDQ	LPGDP	PGR	TO	HHC
LEFP	1.0000					
LINDQ	0.9845	1.0000				
LPGDP	0.7755	0.7193	1.0000			
PGR	0.2286	0.1216	0.5627	1.0000		
TO	-0.2358	-0.2542	-0.0863	0.5205	1.0000	
HHC	0.7208	0.6929	0.4602	-0.0328	-0.3035	1.0000

Source: Author's Computation

From table 11, none of the correlation coefficients between any two regressors are equal to or greater than 0.8. This result is desirable and it implies the absence of multicollinearity in the model estimation.

Specification Test

This test determines whether there is specification error or specification bias in the estimation of the model. Under-fitting or over-fitting a model leads to the problem of specification bias. To test the specification of the model, the Ramsey RESET Test which follows the F-distribution, will be utilized.

Test Hypotheses:

H_0: Model is correctly specified

H_1: Model is incorrectly specified

Decision Rule:

Reject H_0 if the P-value of the F-statistic ≤ 0.05 level of significance. Otherwise, fail to reject the null hypothesis.**TABLE 12: Ramsey RESET Test Result of the Model**

F-Statistic	1.4942
Probability	0.2330
Conclusion/Comment	Correctly Specified

Source: Author's Computation

From table 12, since the probability value (P-value) of the F-statistic is greater than the 0.05 level of significance, the null hypothesis cannot be rejected, leading to the conclusion that the model is well specified and without specification bias.

Model Stability Test

This test is used to check the stability of the coefficients over the sample period. The cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) are plotted from a recursive estimation of the model and stability is indicated when the CUSUM and CUSUMQ statistic fall inside the critical bounds of the 5% confidence interval.

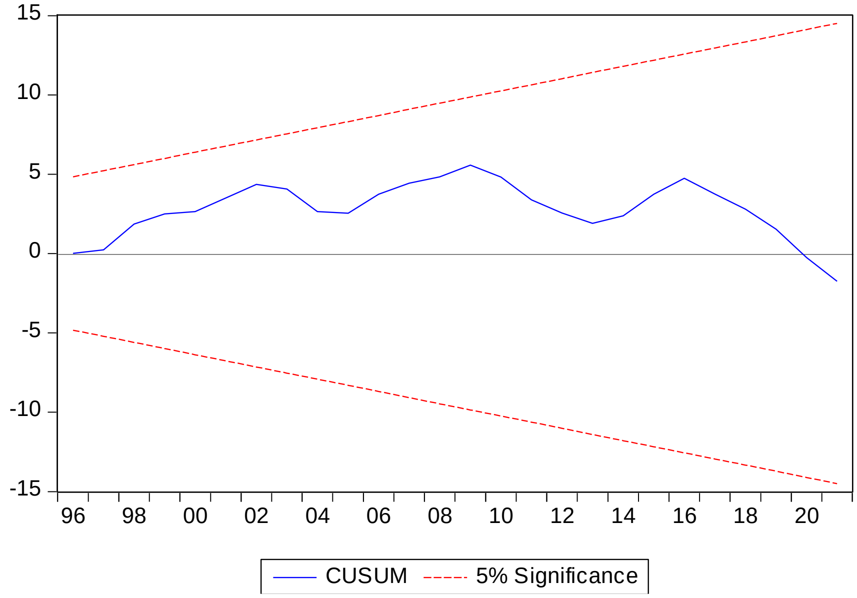

FIGURE 2: CUSUM Plot of the Model
Source: Author's Construct

Note: *The straight lines are the critical bounds at the 5% level of significance.*

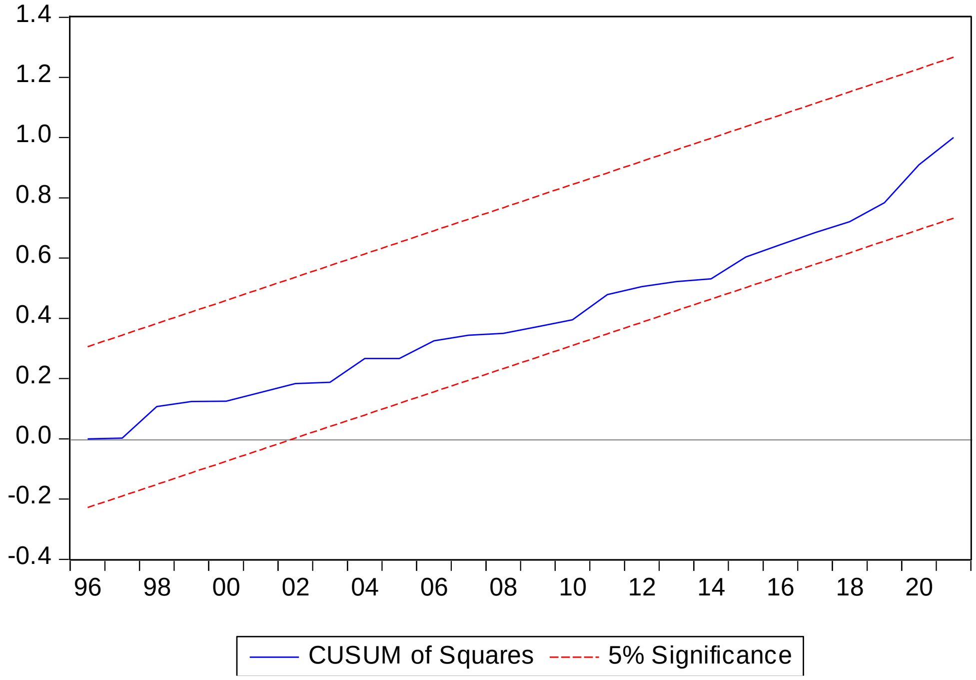

FIGURE 3: CUSUMQ Plot of the Model

Source: Author's Construct

Note: *The straight lines are the critical bounds at the 5% level of significance.*

The plots shown in figures 1 and 2 indicate stability in the coefficients over the sample period (32 years). This is because the plot of the CUSUM statistic fall inside the critical bound of the 5% confidence interval of parameter stability. The CUSUMQ has no deviation from the critical boundary of the 5% significance level which shows the stability of the model within the sample period. Therefore, the model appears to be generally stable.

Error Correction Model (ECM) Regression

The error correction model (ECM) is used to correct for the short run disequilibrium among the variables so as to link the short run behavior of LEFP to its long run value. The error correction coefficient, λ, which accounts for model disequilibrium and assesses adjustment speed, is essentially the only variable of interest. Therefore, it is assumed that the coefficient of the lag error term [ECM (-1)] will be negative and large in order to correct for any short-term disequilibrium that the model may experience.

TABLE 13: ECM Regression Result

Dependent Variable: LEFP

Variable	Coefficient	Std. Error	t-Statistic	P-Value
D(HHC)	0.0044	0.0019	2.3492	0.0274
D(LINDQ)	0.6660	0.0662	10.0542	0.0000
D(LPGDP)	0.0095	0.0230	0.4152	0.6817
D(PGR)	0.4772	0.3778	1.2631	0.2187
D(TO)	-0.0031	0.0015	-2.0356	0.0530
ECM(-1)	-0.5351	0.1749	-3.0596	0.0054
C	-0.0008	0.0139	-0.0561	0.9557

Note: The Standard Errors are HAC

Source: Author's Computation

From table 13, the coefficient of the error correction term lagged ECM (-1) is negative as expected (-0.5351) and also statistically significant at the 5% level of significance. This result suggests that the short run disequilibrium is actually corrected. Specifically, about 53.5 % of the discrepancy between long-term and short-term LEFP is corrected within a year. This also means that the speed of adjustment is moderate.

Granger Causality Test

The Granger causality test is an estimation to determine the direction of causality between household consumption (HHC) and ecological footprint (LEFP). This test is carried out in line with objective three (3) of this study.

Hypothesis:

H_0: No causality (absence of causal relationship)

H_1: Causality (presence of causal relationship)

Decision Rule:

Reject H_0 if P-Value $\leq$ 0.05 level of significance. Otherwise, fail to reject the null hypothesis.

Table 14: Granger Causality Test Result

Null Hypothesis	F-Statistic	P-Value
LEFP does not Granger Cause HHC	**2.3449**	**0.1166**
HHC does not Granger Cause LEFP	**0.6139**	**0.5492**

Source: Author's Computation

Note: The lag length of this test is two (2)

From table 14, the probability value of the first null hypothesis is greater than the 5% level of significance, therefore, the null hypothesis is not rejected, leading to the conclusion that there is no causality running from LEFP to HHC. Similarly, the P-Value of the second null hypothesis is greater than the 5% level of significance, therefore, the null hypothesis cannot be rejected, leading to the conclusion that there is no causality running from HHC to LEFP. Summarily, there is no causal link between household consumption (HHC) and ecological footprint (LEFP).

Conclusion and Policy Recommendation

The authors conducted a research to examine the impact of household consumption on ecological footprint in Nigeria using annual time series data from 1990 to 2021. The findings revealed several significant relationships and provided insights into the factors influencing the ecological footprint in the country. Firstly, the study establishes that household consumption has an affirmative and statistically significant effect on the ecological footprint in Nigeria. This suggests that as household consumption increases, so does the ecological footprint, indicating a greater demand for resources and resulting environmental impact. This emphasizes the need to address consumption patterns and promote sustainable practices among households to mitigate their environmental footprint. The study also highlighted the influence of other factors on the ecological footprint. Industrialization was found to have a positive and significant impact, indicating that as industrial activities expand, there is an associated increase in the ecological footprint. This underscores the importance of adopting cleaner and more sustainable production processes within industries to minimize their environmental impact. Furthermore, population growth rate was identified as a significant driver of the ecological footprint in Nigeria. As the population increases, so does the demand for resources, leading to a larger ecological footprint. This highlights the need for effective population management strategies, such as comprehensive family planning programs, to promote sustainable population growth and reduce the strain on natural resources. Ecological footprint was shown to be positively, although statistically not significantly, impacted by GDP per capita. This suggests that economic growth alone may not necessarily lead to a significant increase in the ecological footprint. However, it is important to note that sustainable development strategies should still be pursued to ensure that economic growth is decoupled from environmental degradation. Furthermore, there was a statistically significant and adverse effect of trade openness on the ecological footprint. This suggests that engaging in international trade can potentially reduce environmental pressures by promoting resource efficiency and specialization. Encouraging sustainable trade practices and ensuring adherence to environmental regulations in trade agreements can further enhance this effect. Post-estimation tests revealed the presence of autocorrelation in the model, which was addressed by employing the Newey-West HAC Estimator. The Error Correction Model (ECM) indicated a negative coefficient with statistical significance, suggesting that changes from the long run symmetry between household consumption and the ecological footprint are corrected over time, albeit at a moderate rate.

The study therefore recommends from its empirical outcomes that:

1. Government should Implement policies and initiatives that encourage sustainable consumption practices among households by creating adequate awareness on environmentally friendly products and services through education system, and advertisement. Additionally, provide incentives such as tax benefits or subsidies for energy-efficient appliances, eco-labeled products, and sustainable transportation options. Encourage recycling and waste reduction through the establishment of recycling infrastructure, waste management programs, and public awareness campaigns. Support the use of renewable energy sources by providing incentives for households to adopt solar panels or other clean energy technologies.
2. Government should play a key role in the population management since there is a high significant impact of population growth on the ecological footprint. Thus, implementing an effective population management strategy, such as comprehensive family planning programs that offer access to contraceptives and reproductive health services. Promote sex education and awareness about family planning options, highlighting the benefits of smaller family sizes for individuals and the environment. Support initiatives that empower women, such as access to education and economic opportunities, as studies show that educated and empowered women tend to have fewer children.
3. Industrial Practices should be enhanced by the government to encourage industries to adopt cleaner and more sustainable production processes thereby implement regulations and incentives that promote eco-friendly practices, such as setting emissions standards and providing financial incentives for adopting cleaner technologies. Promote the use of

renewable energy sources in manufacturing processes and provide incentives for energy-saving measures. Support research and development in sustainable manufacturing methods, circular economy models, and resource-efficient production techniques.

COMPETING INTERESTS

The authors have no competing interests to declare.

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