Synthesis of Climate and Non-Climate Variable on Environment and Ecosystem in Nigeria

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ABSTRACT

Changes in climate and non-climate factors have been observed to impose significant environmental and economic costs, leading to widespread degradation of ecosystems and deterioration of environmental quality. Hence, the research survey examined synthesis of climate and non-climate variables on the environment and ecosystems in Nigeria. The study explored time-series data covering for 30 years (1993–2023), found from Global footprint Network, Food, Agriculture and Organization, Worldometer and Statista. Climate change variables considered include, temperature, rainfall, while the non-climate variables include population growth and energy consumption. Data obtained were analyzed using autoregressive distributed lag (ARDL) model. The result shows that temperature, rainfall, population growth and energy consumption all exerts a devastating negative influence on the environment and ecosystems. These negative exertions degrade the environment and cause ecosystem imbalances. The result reveals that about 85% of the disturbances in environment and ecosystems normalized following a rapid disruption in climate and non-climate variables. Results further showed absence of multicollinearity, homoscedasticity, heteroskedasticity and autocorrelation between the considered variables. The study recommends effective legislation and policy engagements regarding climate change mitigation, financing and trade-offs. Also, policy pitched towards population growth control and use of renewable energies in place of fossil fuels should be enforced and championed. These will restore the ecosystem saneness and environmental balances.

Keywords: Temperature, Rainfall, Population Growth, Energy Consumption, Ecosystems.

1.0 INTRODUCTION

The issue of weather and climatic eruptions has bedeviled the universe causing undue disturbances for both the environment and ecosystems. Driven largely by actions of humans—especially fossil fuels combustion, tree removals, and industrialized operations—climate change is altering natural balance of the Earth's systems (United Nations, 2023). From rising temperatures and sea levels to increasingly extreme weather events, the effects of a warming planet are being felt across continents and oceans. The most direct consequence of weather change is a steady raise in universal temperatures. Judging from Intergovernmental Panel on Climate Change (IPCC), the planet is already warmed more than 1.1°C above pre-industrial levels, with projections showing more severe warming if emissions are not drastically reduced (Shiv et al., 2024). As temperature rise and rainfall patterns change, many ecosystems become unsuitable for the species that inhabit them. The use of raw gas, coal and fossil fuel heating are responsible for these adverse changes, this substance emits vast quantities of greenhouse gases (GHGs), notably substance of carbon (CO_2) and methane (CH_4), into the ambiance. These gases intensify the natural greenhouse effect by trapping heat, thereby destabilizing the Earth's climate system. Additional contributors include deforestation, unsustainable agricultural practices, industrial emissions, and land-use changes, all of which either exacerbate GHG concentrations or diminish the planet's capacity to sequester carbon (Uzair et al., 2023). Heatwaves are increasing in both frequency and intensity, and climatic zones are shifting latitudinally and altitudinally. Although extreme cold events are becoming less frequent in some regions, the redistribution of temperature patterns is fundamentally altering precipitation regimes. In certain areas, heightened rainfall intensity precipitates severe flooding, whereas in others, prolonged deficits in precipitation result in persistent drought. These shifts, compounded by greater climatic unpredictability, undermine the ability of societies to anticipate and adapt to extreme events. Elevated temperatures also accelerate evaporation rates, amplifying water scarcity and intensifying drought impacts. Hydrological systems are undergoing significant disruption. The accelerated melting of ice mass combined with rise of seawater, is contributing to measurable growth in global sea levels, posing acute risks to coastal settlements, ecosystems, and infrastructure through flooding and erosion (Shivanna et al.,2022). Freshwater resources are becoming increasingly stressed, as recurrent droughts diminish river flows and deplete groundwater reserves. Warmer water temperatures encourage the proliferation of harmful algal blooms and pathogenic bacteria, thereby degrading water quality and threatening aquatic biota. Concurrently, the world's oceans are experiencing unprecedented transformation: elevated sea surface temperatures, ocean acidification due to CO_2 absorption, shifts in current patterns, and the incursion of invasive marine species are reshaping marine ecosystems. Such changes disrupt fish distribution, degrade coral reef systems, and jeopardize the livelihoods of communities reliant on fisheries (Abbass et al., 2022).

Ecosystems and biodiversity are acutely vulnerable to these climatic shifts. Direct impacts include habitat loss, alterations in species abundance and geographic range, and modifications to phenological cycles such as migration and reproduction. Many species are unable to adapt swiftly enough to the accelerated pace of environmental change, thereby facing heightened risks of extinction (Yakubu et al., 2024). Warmer conditions also facilitate the spread of pests, invasive species, and vector-borne diseases affecting both wildlife and humans. Indirect impacts—such as habitat fragmentation, resource over-exploitation, and the pollution of air, water, and soil—further erode ecosystem resilience. As these systems weaken, their capacity to deliver essential ecosystem services, including climate regulation, water purification, food production, and natural flood control, is diminished. Soil systems, integral to ecological and agricultural productivity, are equally affected. Abnormal weather changes, such as temperature rise, varied rainfall distributions, modified relative humidity exacerbate erosion, salinization, and the loss of organic matter. Soil biodiversity is declining, while processes such as desertification and landslides are becoming more prevalent (West & Marland, 2022). Disruptions to the carbon cycle, induced by higher atmospheric CO_2 concentrations and shifting climatic conditions, threaten soil carbon storage and contribute further to GHG emissions. The societal implications of climate change are extensive and multifaceted. Intensifying extreme weather events damage infrastructure, disrupt transport and trade networks, and impair agricultural output. Food and water security are increasingly at risk as crop yields and livestock productivity decline. Human health faces growing threats from heat stress, respiratory illnesses linked to deteriorating air quality, and the expanding range of infectious diseases. Coastal populations are particularly vulnerable to displacement from flooding and erosion, with attendant socio-economic and cultural consequences (Hansen et al., 2013). Moreover, climate change engenders powerful feedback mechanisms that compound its progression. The reduction of the Earth's albedo, resulting from ice-mass loss, heightens absorption of sun's energy which speeds up earth's heating. Simultaneously, the degradation of forests, wetlands, and soils releases sequestered carbon, further elevating atmospheric GHG concentrations. As ecosystems deteriorate, their ability to mitigate climate change through carbon sequestration and climate regulation is progressively undermined (Caineng et al., 2021).

However, apart from climate variables, there are other non-climatic variables that affect the environment and ecosystems. These non-climatic factors often pose great dangers to the environment causing environmental imbalance and ecosystem disruptions (Murshed et al., 2021). These factors include human induced activities (land use patterns, deforestation, mining, etc), geological events, urbanization, population growth, energy consumption, and biological activities, all of which can have significant impacts on the Earth's systems, and complicating the ecosystem and environment. Geological events, such as volcanic eruptions or earthquakes, can lead to significant environmental shifts that influence biodiversity and ecosystem. Biological factors like invasive organisms, species migrations and other harmful activities can further complicate habitat, ecosystem displacements and disintegration (Muhammad et al., 2023). Consequently, as populations expand, more land is needed for agriculture, urban development, and infrastructure. This often results in deforestation, particularly in urban regions where forests are cleared for buildings and infrastructures. Forests serve as crucial ecosystems that regulate rainfall, prevent erosion, and support wildlife. Their loss and frequent destructions disrupt the natural processes and environments, making affected areas more vulnerable to environmental shocks, like rising tides, earthquakes and landslides. On other hand, deforestation contributes directly to weather changes by scaling down the earths ability to take up carbon dioxide. It also destroys habitats, displacing countless species and leading to a sharp decline in biodiversity (Arogundade et al., 2024). Similarly, population growth is a defining feature of modern society. With the global population surpassing 8 billion, the strain on Earth's natural systems is becoming increasingly evident. As more people inhabit the planet, the demand for resources grows exponentially. This surge leads to various environmental challenges, including deforestation, pollution, loss of biodiversity, and climate change. Increased consumption, driven by population growth, intensifies the strain on natural resources like water, land, and energy. For example, water scarcity has become a major issue in densely populated regions. Agricultural expansion to feed growing populations leads to overuse of land and water, often resulting in soil degradation and desertification (Amare et al., 2023). Energy consumption which comprises of fossil fuels heating results in emissions of gaseous substances aggravating environmental concerns and pollution. Currently, Nigeria fossil fuels consumption account for roughly 77% which represents a significant energy consumption rate and poses serious consequences for the teeming populace and the environment at large.

However, several studies Arogundade et al., 2024, Amare et al., 2023, Okon et al., 2021, Ojo & Baiyegunhi, 2020a, Shiru et al., 2020, & Okoh, & Okpanachi, 2023) on climate change have been conducted in Nigeria, some of these studies have looked at the impacts of climate change on agriculture, environment, urbanization, ecosystem, biodiversity and aquatic waters, no doubt, these previous studies had contributed to new knowledge and information. Interestingly, these past studies have used similar and common climate variables such as temperature and rainfall using simple statistical models and thus creating a knowledge gap by the exclusion of other important non-climatic variables such as population growth and energy consumption, howbeit, the inclusion of these two non-climate variables set this present study apart from previous studies. Population growth and energy consumption remains crucial non-climatic factors affecting the environment and ecosystems which are barely explored by research, hence the rationale and justification for the study. Again, the present study hopes to fill in the existing gap in knowledge and contributes to new and novel insight by exploring the impacts of other non-climatic variables (population growth and energy consumption) using a more robust econometric model such as autoregressive distributed lag (ARDL) model and error correction model (ECM). Moreover, the present study will serve as a reference document and contribute to existing literature by reviewing these two important novel factors affecting the environment and ecosystem in Nigeria. Hence, the survey examined synthesis of climate and non-climate variables on the environment and ecosystem in Nigeria covering a period of 30 years (1993-2023).

2.0 MATERIALS AND METHODS

The survey took place in Nigeria. Nigeria being the most populous country is domiciled in West Africa and projected to be 228 million individuals. It has two coordinates, 9.0820^0N and 8.6753^0E with a total land area of $923,768km^2$. It occupies 4047km with Cameroon, 1690km with Niger, 1497km with Benin Republic and 773km with Chad. Nigeria has 36 States and bedeviled with many environmental issues such as pollution (air, water, land), crude spills, mining issues, water erosion, poor waste disposals, frequent tree felling, desertification, etc (Ojo et al., 2020b). The study obtained data from different sources (Global footprint Network, Food, Agriculture and Organization, Worldometer and Statista). Time series data covering a period of 30 years (1993-2023) were sourced for the study and the gap allows for reliable and sufficient data analysis using time series. Precisely, temperature, rainfall data were obtained from Food, Agriculture and Organization, and data on population growth and energy consumption were obtained from Worldometer and Statista respectively. Ecological footprint was used as proxy for environment and ecosystem and was obtained from Global footprint Network.

Table 1 showed the variables and data source used for the study. Autoregressive distributed lag (ARDL) model was deployed to explore the impacts of climate and non-climate variables on the environment and ecosystem in Nigeria. The econometric model was deployed considering its capacity to check long-run and short-run relationships among investigated variables and also checking of cointegration of investigated variables both at the first and second stages using the F-test. The model also checks for time period of investigated factors and the rectified error vector. In order to determine the stationarity and non-stationarity of investigated factors, the Augmented Dickey Fuller (ADF) tested the unit root. However, additional tests conducted in this study were VIF test, LM test, ARCH test, White test, Ramsey RESET test, F-test, DW-test, and Cusum test. In this study, dependent variable is environment and ecosystem proxied as ecological footprint and the explanatory variables include climate change variables (temperature, and rainfall) and non-climate change variables (population growth and energy consumption). The ARDL model is implicitly presented, thus,

$Y = f(X_1, X_2, X_3, X_4, e_t)$ ---- eqn. 1

Where

Y = Environment and Ecosystem proxied as ecological footprint (gha)

X_1= Temperature (°C)

X_2 = Rainfall (mm)

X_3 = Population growth (%)

X_4 = Energy consumption (%)

et = error term

Taking the natural logarithms, thus:

$LnY = LnX_1 + LnX_2 + LnX_3 + LnX_4 + et$ eqn. 2

$LnY = LnY = \beta 0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + et$ eqn. 3

Equation (3) defines unrestricted error correction model (UECM) using the ARDL model for co-integration test between the investigated variables.

$\Delta LnYiyt = \phi o + \sum_{i=0}^{t} \phi_1 \Delta LnYiyt - 1 + \sum_{i=0}^{t} \phi_2 \Delta LnX_{1t} - 1 + \sum_{i=0}^{t} \phi_3 \Delta LnX_{2t} -1 + \sum_{i=0}^{t} \phi_4 \Delta LnX_{3t} -1 + \beta_1 LnX_{1t-1} + \beta_2 LnX_{2t-1} + \beta_3 LnX_{3t-1} + \beta_4 LnX_4 + et$ eqn. 4

The long-run relationship is achieved using ARDL model, after exploring co-integration of the investigated variables.

$LnYiyt = \phi o + \beta_1 Yiyt\text{-}1 + \beta_1 LnX_{1t-1} + \beta_2 LnX_{2t-1} + \beta_3 LnX_{3t-1} + \beta_4 LnX_{4t-1} + et$ eqn. 5

Error Correction Model (ECM), explores short-run change in investigated variables.

$\Delta LnYiyt = \phi o + \sum_{i=0}^{t} \phi_1 \Delta LnYiyt - 1 + \sum_{i=0}^{t} \phi_2 \Delta LnX_{1t} - 1 + \sum_{i=0}^{t} \phi_3 \Delta LnX_{2t} -1 + \sum_{i=0}^{t} \phi_4 \Delta LnX_{3t} -1 + \beta_1 LnX_{1t-1} + \beta_2 LnX_{2t-1} + \beta_3 LnX_{3t-1} + \beta_4 LnX_{4t-1} + \delta ECM_{t-1} + et$ eqn. 6

Where, Ln = Natural logarithm; φo = Constant term; Δ = First difference operator; Yit—$\varphi 4$ = short run elasticities (coefficients of the first-differenced explanatory variables); β_1—β_4 = Long run elasticities (coefficients of the explanatory variables); δ = Adjustment speed; t= Lag length; ECMt -1 = Error correction term lag for one period.

3.0 RESULTS AND DISCUSSION

3.1 Source of Variables

Research variables, unit of measurement and their various data sources are presented in Table 1. From the table, global footprint network provided data for ecological footprint proxied for environment and ecosystem. Nimet provided data for temperature and rainfall, Worldometer provided data for population growth and energy consumption was gotten from Statista. The considered data formed both the dependent and independent variables used for study. The data were chosen based on its availability and indicators for environment and ecosystem in Nigeria.

Table 1: Variables and their sources

Variables	Unit	Source
Ecological footprint proxy for Environment & Ecosystem	Gha	Global footprint Network
Temperature	^{0}C	FAO
Rainfall	Mm	FAO
Population Growth	%	Worldometer
Energy Consumption	%	Statista

3.2 Summary Statistics of the Study Variables

Table 2 presented the description of study variables. The study covered a duration period of 30 years (1993-2023) which is long enough to show the impacts of the investigated variables. The mean temperature was 26.04 with minimum and maximum values of 23.04^{0}C and 27.02^{0}C. Temperature has a relatively high standard deviation of 6.01, and a negatively kurtosis which indicates abnormal distribution during the study coverage. Rainfall was associated with a mean value of 2510.03 with minimum and maximum values of 1200.08mm and 2702.05mm. Rainfall equally has a negative skewness and kurtosis of -3.71 and -1.05, which indicates uneven dispersion experienced during the covered period. Population growth has mean percentage value of 2.3 which was less when compared with the maximum value of 2.4. Also, the population growth has a high standard deviation and negative skewness, which indicates an upward progression growth in population in Nigeria during the study coverage. Energy Consumption had a high maximum value of 97%, with a high standard deviation of 4.09 and a negative kurtosis of -3.22, this indicates a higher energy consumption rate in Nigeria during the coverage period (Nwokolo et al., 2023).

Table 2: Summary statistics of the study variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation	Skewness	Kurtosis
Temperature	30	23.04	27.02	26.04	6.01	0.06	- 1.01
Rainfall	30	1200.08	2702.05	2510.03	4.03	-3.71	- 1.05
Population Growth	30	2.1	2.4	2.3	5.05	-0.07	0.91
Energy Consumption	30	91	97	95	4.09	0.27	-3.22

3.3 Results of Unit Root Test with Augmented Dickey-Fuller

Augmented dickey fuller (ADF) test for unit root is shown in Table 3. In examining the stationarity of the investigated variables (endogenous and non-endogenous), the ADF test was fully deployed. The result shows a combination of both stationarity and non-stationarity of the variables (Eze et al., 2024). Variables such as environment and ecosystem, temperature and energy consumption were not stationary, while rainfall and population growth were stationary at level 1(0). At first difference, the opposite was the case as all the investigated variables became stationary. This outcome presents the status for cointegration; on the ground that the investigated variables were of different orders and/ or levels and validated the test for ARDL-Bounds cointegration (Dioha et al., 2020). This further depicts that the investigated variables can affect environment and ecosystems in Nigeria.

Table 3: Results of unit root test with augmented dickey-fuller

Variable	At level 1(0) t-statistic	Remark	At first difference 1(1) t-statistic	Remark	Decision: $H_{O:}$	Order of Integration
Y_1	-1.003	Not stationary	-2.611**	Stationary	Reject	1(1) at 1%
X_1	-0.501	Not stationary	-2.020**	Stationary	Reject	1(1) at 5%
X_2	-3.018***	Stationary	-4.003***	Stationary	Reject	1(1) at 1%
X_3	-2.431**	Stationary	-3.212***	Stationary	Reject	1(1) at 5%
X_4	-0.009	Not stationary	-5.032***	Stationary	Reject	1(1) at 1%

3.4 Results of ARDL-Bounds Cointegration Test

ARDL-bounds cointegration test is presented in Table 4. It became necessary to know the relationship between the evaluated non-stationary and stationary variables, hence the application of ARDL-bounds test. In this survey, it was observed the investigated variables were of different order, hence validating the test for time series data involving short- and long-term relationships. The result indicated that the investigated variables (explanatory and dependent) were significant at both F-statistic of 5% and F-statistic at 1% respectively (Vicedo-Cabrera et al., 2021). This was shown using lower and upper bound statistical levels. This depicts the total rejection-of-no-cointegration and onward acceptance of existence of cointegration among the investigated variables. This equally shows that a relationship exists between the investigated variables (explanatory and dependent). Furthermore, short-term and long-term correlation exists between investigated variables considered. Although the result of the short-run may vary but could be predictable in the long-run. Consequently, the computation of (ARDL) and (ECM) were further validated by intertwined relationship among the considered variables.

Table 4: Results of ARDL-Bounds cointegration test

Statistic	Lower bound	Upper bound
F-statistic at 5%	2.001**	2.092**
F-statistic at 1%	3.101***	5.004***

Significance at **5% and *** 1% levels

3.5 Long and Short Run Impacts of Climate and Non-Climate Variables on Environment and Ecosystem

The result showing long and short run impacts of climate and non-climate variables on environment and ecosystem was presented in Table 5.

The estimate for temperature was favorable at 1% level and has a negative correlation with environment and ecosystem in long-run and short-run relationship, showing consistency of estimated results. This implies that higher temperatures affect environment and ecosystems with 70.5% and 50.2% corresponding negative impacts. Temperature changes, both increases and decreases, significantly impact the environment by altering weather patterns, affecting water resources, impacting ecosystems, and influencing sea levels (Hen et al., 2023). These changes can lead to more extreme weather events, disruptions to natural cycles, and various other environmental consequences. Higher temperatures increase evaporation, leading to more moisture in the atmosphere and intensifying rainfall, potentially causing floods and more severe storms. Changes in temperature also affect the frequency and intensity of heat waves, wildfires, and other extreme weather events (Okon et al., 2021). Changes in temperature affect the water cycle, influencing precipitation patterns, evaporation rates, and snowpack. This can lead to water shortages, reduced freshwater availability, and disruptions to ecosystems that rely on consistent water supplies. Temperature directly influences plant and animal life, affecting their habitats, growth patterns, and survival (Dioha & Kumar, 2020). Warmer temperatures can cause species to shift their ranges, disrupt food chains, and lead to biodiversity loss. Melting glaciers and rising sea levels also impact coastal ecosystems. Higher temperature causes melting glaciers and thermal expansion of water due to warming and contribute to rising sea levels. This threatens coastal communities, increases erosion, and impacts saltwater intrusion into freshwater sources.

Rainfall estimate showed a corresponding consistency regarding the long-run and short-run relationship. Rainfall was favorably at 1% but was negatively related with environment and ecosystem along long and short-run levels. This mean that a rise in rainfall patterns will result in a corresponding damaging impact on the environment and ecosystem by 75.5% and 99.9%. Rainfall, particularly heavy rainfall and floods, can negatively impact the environment and ecosystems in various ways, including soil erosion, nutrient loss, water contamination, and disruptions to aquatic ecosystems (Tebaldi et al., 2021). Flooding can also damage infrastructure, leading to further environmental problems. Intense rainfall can overwhelm drainage systems, leading to urban and river flooding, potentially causing damage to infrastructure and displacement of populations. Runoff from rainfall can carry pollutants into waterways, affecting water quality and harming aquatic life. Excessive rainfall can negatively impact vegetation, especially during the growing season, potentially reducing biomass and altering ecosystem structures (Okafor et al., 2025). Heavy rainfall washes away topsoil, leading to land degradation, denudation, and other environmental issues.

Population growth estimate was beneficial at 5% level and exhibited similar negative consistency in result estimates with long-run and short-run relationship. This depicts that, 1% growth rise in population will result in a corresponding damaging effect on the environment and ecosystem by 99.1% and 85.4%. Population growth significantly impacts the environment through increased resource consumption, pollution, and habitat destruction, ultimately contributing to climate change and biodiversity loss (Nura et al., 2020). This strain on resources can lead to shortages of food, water, and energy, while also increasing waste production and pollution. Increased consumption of energy, goods, and food, coupled with industrial activities, results in discharge of greenhouse gases escalating weather and climatic changes. Increased population necessitates more energy production, and this result in more fuel combustion leading to gaseous emissions and changes in climate. Climate change, fueled by population growth and associated activities, can lead to habitat loss, species extinction, and shifts in ecosystems. A larger population requires more food, water, energy, and raw materials, leading to overexploitation of natural resources causing harm to the environment and ecosystem (Nnadi et al., 2024).

Energy consumption estimate showed a similar negative consistency regarding the long-run and short-run relationship with significant differences at both 1% and 5% levels. This connotes that a 1% rise in energy consumption during the covered period resulted in a corresponding damage to the environment and ecosystem by 67.2% and 59% respectively. Energy consumption, particularly from fossil fuels, significantly impacts the environment by contributing to air and water pollution, climate change, and habitat degradation (Edomah, 2019). Combustion of fossil fuels emits gaseous substances like carbon dioxide, trapping heat, causing global warming. For instances, frequent crude burning, and gaseous emissions produces waste matter like sulfur dioxide, nitrogen oxides, particulate matter, and carbon monoxide, contributing to smog, acid rain, and other environmental pollutions. This occurrence leads to rising temperatures, extreme weather events, and environmental disturbances. Increased energy use in urban areas and industrial sectors can exacerbate environmental problems and contribute to a larger ecological footprint. These impacts disrupt natural processes, threaten biodiversity, and can lead to ecosystem instability (Olujobi et al., 2023).

The estimated error correction coefficient was -0.851, with anticipated negative outcome and was favorable at 1% level, and connotes normalization of the equilibrium following a shock. It shows that 85% of disturbances arising from previous impact normalized in the current long-term, meaning that the short-run distortions on the environment and ecosystem were considerably adjusted to a balance in longer period. Furthermore, this shows stability and a complete readjustment of the investigated variables in longer term.

Table 5: Long and short run impacts of climate and non-climate variables on environment and ecosystem

Variable	Coefficient	T-value	Std. Error
Long-run estimate			
LnX_1	-0.7052	-3.093***	0.227
LnX_2	-0.7552	-4.099***	0.184
LnX_3	-0.991	-2.677**	0.370
LnX_4	-0.672	-3.211***	0.209
Short-run estimate			
ECM (-1)	-0.851	-4.092***	0.207
ΔLnX_1	-0.502	-4.067***	0.123
ΔLnX_2	-0.999	-3.052***	0.327

Δ LnX_3	-0.854	-2.788**	0.306
Δ LnX_4	-0.590	-2.043**	0.288

Significance at **5% and *** 1% levels

3.6 Diagnostic Statistical Test of Investigated Variable

Table 6 presented the results of diagnostic statistical test. The result produced a value of 0.01, lesser when compared to higher value of 5 and was attributed to variance inflation factor (VIF), this suggests no occurrence of multicollinearity between considered exogenous variables. The LM tests gave a non-significant value of 1.11, which depicts the absence of serial correlation between investigated variables. The ARCH test and white test results (1.02 and 0.06) showed no significance and confirmed absence of heteroskedasticity and homoscedasticity of the considered variables (Odoh et al., 2024). The Ramsey RESET test value of 1.00 was not significant at 5% level, and indicates that no variable was missing. The R^2 value of 0.81 depicts that the investigated climate variables had 81% interference in the environment and ecosystem. The F-statistic value of 4.01 was beneficial at 1%, and showed the model's overall fitness and acceptance. Furthermore, the result reveals no existence of autocorrelation and erroneous relationships considering the value for DW-Statistic, 1.09, being greater than R^2 value, 0.81. The Cusum test showed stability, meaning that there was no structural break in the model employed.

Table 6: Diagnostic statistical test

Diagnostic statistical test	Statistical value
VIF Test	0.01
LM Test	1.11
ARCH Test	1.02
White Test	0.06
Ramsey RESET test	1.00
R^2	0.81
F-test	4.01
DW-test	1.09
Cusum Test	Stable

4.0 CONCLUSION AND RECOMMENDATION

The study used time series data obtained from Global footprint Network, Food, Agriculture and Organization, Worldometer and Statista and covered a period of 23 years. Result of ADF tests, depicts that the considered variables produced different integration orders. The ARDL-bounds test showed the existence of co-integration among the considered endogenous and exogenous factors.

The investigated covariates such as temperature, rainfall, population growth and energy consumption had a negative impact on the environment and ecosystems along the long and short run relationship. This reveals that any increase in these variables will result in a devastating and declining impacts on the ecosystem and environment and further result in biodiversity imbalances and ecosystem disruptions. The ECM indicated rapid recovery of environment and ecosystems disturbances after an overwhelming shift in climate change. The results of the diagnostic test showed no presence of multicollinearity, homoscedasticity and heteroskedasticity among the investigated variables. In addition, the result reveals no existence of autocorrelation and serial correlation between the considered variables, hence validating the stability of the model employed. In conclusion, the study recommends effective legislation and policy engagements regarding the climate change mitigation, financing and trade-off. Also, policy targeted towards population growth control and use of renewable energies in place of fossil fuels should be enforced and championed. These will restore the ecosystem saneness and environmental balances.

Conflict of interest

The authors declare that there is no conflict of interest.

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