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The Nexus of Environmental Quality and Agricultural Growth in Nigeria (1981 - 2023)

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A R T I C L E I NFO

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ABSTRACT

The study assessed the nexus of environmental quality and agricultural growth in Nigeria from 1981 to 2023. The study adopted a historical survey design using time series data in the period of 43 years. Data on the variables for the study were collected from the archives of World Bank and Food and Agriculture Organization database. The data collected were analyzed using both descriptive statistics such as mean, maximum and minimum with trend graphs and inferential statistics such as the Johansen co-integration test after testing for unit root, Granger causality test, impulse response function and Vector Error Correction Model (VECM) model. The result of the analysis revealed that environmental quality with a mean of 267821.1 kilotonnes and agricultural growth with a mean of 5.31% during the period under review. The result of Augmented Dickey Fuller (ADF) test for unit root indicated that all the variables (environmental quality, agricultural growth, population growth and urbanization) were found to be integrated of order one and became stationary on first differencing. The result of Johansen co-integration revealed that the computed trace statistics for none (99.12988) and at most 1 (59.40875) were greater than the critical value at 0.05 level (69.81889 and 47.85613) for none and at most 1 respectively which implied that a long run relationship exists among environmental quality and agricultural growth in Nigeria. The Granger-causality test result revealed a significant causal relationship between population growth and environmental quality, urbanization and environmental quality at 10% level of significance. More so, result of the impulse response found that environmental quality responds positively to itself both in the short and long run, positively to population growth both in the short and long run and positively to urbanization in the short run but responds negatively in the long run over the periods. Finally result of the ARDL analysis revealed that in the long run, the coefficient of environmental quality (3.861) was positive and statistically significant at 1%. In the short run, change in the coefficient of environmental quality (3.737) was positive and statistically significant at 1% probability level; therefore, environmental quality have significant effect of on agricultural growth in Nigeria both in the short and long run. The study therefore recommended that government should strengthen environmental regulations to improve environmental quality. This could involve stricter enforcement of pollution controls, incentives for adopting environmentally friendly farming practices, and investments in renewable energy to reduce the environmental impact of agricultural activities.

1.0 Introduction

Environment has been defined broadly as all the elements that surround an organism; this includes the physical, chemical and biotic conditions (Nwokoro and Dekolo, 2012). Man's environment includes the biosphere, atmosphere, lithosphere, and the hydrosphere. He interacts with these four spheres for his day to day survival but dominates and often destroys these components of the environment, which he depends on and ultimately becomes vulnerable.

The environmental landscape of Nigeria, like many other nations, has undergone significant transformations over the years due to human activities and land use changes. These changes have profound effects on the environmental quality of the country, impacting ecosystems, biodiversity, agricultural growth and the overall well-being of its populace (United Nations Environment Programme, 2019).

In Nigeria, a rapidly growing population coupled with urbanization, agricultural expansion, industrialization, and infrastructure development has intensified the pressures on resources, leading to extensive deterioration of these resources affecting environmental sustainability (Frapolli, 2019). According to Ayotamuno (2022) most cities in Nigeria have witnessed a continuous and unprecedented population growth in the last 40 years. This has resulted in a lot of pressure on available resource. This improper use of resource without considering their sustainability plan may have invariably affected the environmental quality which consequently affect agricultural growth.

Agricultural sector contributed about 3.2% value addition to economic growth in Sub-Saharan Africa, and about 37% to the GDP of Nigeria by the close of the last decade (Africa Agriculture Status Report, 2021). However, the African continent as a whole is expected to contribute more to the GDP from the agricultural sector alone in the next decade compared to the contribution recorded in the previous decade, owing to the impact of the COVID19 pandemic (OECD, 2021), and the effect of climate change. Not surprising, Fisher *et al.* (2021) highlight 1.16%, 0.97%, and 1.6 % mortality and morbidity loss percentage in GDP owing to environmental pollution respectively in some African countries by the end of 2019. Organisation for Economic Co-Operation and Development (2009) advocated environmentally and socially sustainable economic recovery as key challenges to agricultural growth and development. It is imperative for governments to implement strategies that aim at restoring resilient economic pathways towards recovery. As the Nigeria economy is struggling, the importance of agricultural growth in the recovery process cannot be underscored enough as the sector employs a significant proportion of the working population. In light of these, it becomes imperative to assess the impacts of environmental quality on agricultural growth and devise sustainable land management strategies that promote ecosystem resilience, biodiversity conservation, and human well-being.

2.0 Methodology

2.1 Study Area

The study was carried out in Nigeria. Nigeria has a total geographical area of 923,768 square kilometers constituting a land area of 910768 square kilometers and water area of 13000 square kilometers respectively. It has coast lines of 853 square kilometers and is located on the Gulf of the Guinea in West Africa. It is one of the eight most populous countries in the world with a population of about 140 million (NPC, 2006). With a population growth rate of 2.6%, Nigeria has a projected population of about 218.87 million in 2023 (www.statista.com). Nigeria lies wholly within the tropics along the Gulf of Guinea on the western coast of Africa. The topography ranges from mangrove swampland along the coast to tropical rain forest and savannah to the north. Nigeria is located between latitude $4^{o}16$ and $13^{o}53$ north and longitude $2^{o}40$ and $14^{o}41$ east (Central Intelligence Agency, 2009).

The country is divided into seven agro – ecological zones. These are semi-arid, found in the northern region, savannah, found in the northern and middle region, a small high land area found in the middle and southern regions, a larger transition environment of savannah derived from the forest overlapping the southern and middle regions; mangroves in the Niger Delta; freshwater swamps in the Niger Delta and lowlands rainforest in the South. The annual rainfall in these zones varies from as low as 250mm in the extreme north-eastern part to 750mm in the southern part (Library of Congress, 2006). Climatically, Nigeria is equatorial in the south, tropical in the centre and arid in the north. Mean maximum temperature ranges from $30\text{-}32^{0}$c in the south and $33\text{-}35^{0}$c in the north (Library of Congress, 2006). The climate varies with equatorial in south, tropical in centre and in the north. There are two seasons – the wet season (April-October) and the dry season (November-March). In terms of employment, at least 60% of Nigeria's population is estimated to be engaged or employed in agriculture (mainly small holders). The major crops produced in the country include millet, sorghum, rice, maize, cassava, yam, groundnut, cocoa amongst others.

2.2 Data Collection and Data Analysis Techniques

Data on the variables for the study were collected from the archives of World Bank and Food and Agriculture Organization database. The data collected were analyzed using descriptive statistics such as mean, maximum and minimum with trend graphs, Johansen co-integration test after testing for unit root, Granger causality test, Impulse response function and Vector Error Correction Model (VECM) model.

2.3 Model Specification

Unit Root Test

The Augmented Dickey Fuller (ADF) test for the presence of unit root (evidence of non-stationarity) was employed. The advantage of the method lies on its robustness to handle both first order and higher order auto regressive processes (Nkang *et al.*, 2007):

$$\Delta Ag_t = \alpha + \sigma Agt - 1 + \psi T + \sum_{k=0}^{N} \beta_k \Delta Ag_{t-k} + u_t \quad \dots\dots\dots\dots\dots (1)$$

$$\Delta EQT_t = \alpha + \sigma EQTt - 1 + \psi T + \sum_{k=0}^{N} \beta_k \Delta EQT_{t-k} + u_t \quad \dots\dots\dots\dots (2)$$

$$\Delta POG_t = \alpha + \sigma POGt - 1 + \psi T + \sum_{k=0}^{N} \beta_k \Delta POG_{t-k} + u_t \quad \dots\dots\dots\dots (3)$$

$$\Delta UB_t = \alpha + \sigma UBt - 1 + \psi T + \sum_{k=0}^{N} \beta_k \Delta UB_{t-k} + u_t \quad \dots\dots\dots\dots\dots (4)$$

Where:

Ag_t represents current values agricultural growth, EQT_{t-i} is the immediate past values of agricultural growth;

EQT_t represents current values environmental quality, EQT_{t-i} is the immediate past values of environmental quality;

POG_t represents current values population growth, EQT_{t-i} is the immediate past values of population growth;

UB_t represents current values urbanization, EQT_{t-i} is the immediate past values of urbanization;

Δ is the change operator, t represent the variable time and u_t is the white noise error.

Vector Error Correction Model (VECM)

The vector error correction model was be used to model the effect of environmental quality on agricultural growth between non stationary I(1) variables with evidence of long run relationship. The vector error correction model is useful for the evaluation of a short term adjustment which adjusts towards the long run equilibrium in each time period. Since the variables are found to be co-integrated, a VECM is estimated because a co-integrating relationship deals only with long-run relationship without considering the short-run dynamics. The advantage of this procedure lies in the fact that both long run and short run influences of the endogenous variables in the model can be determined will the mechanism that keeps the variable in equilibrium evaluated. The relationship between these variables can be described by VAR such that:

$$\Delta \ln Ag_t = \varphi_1 + \sum_{i=1}^{p} \alpha_{1i} \Delta \ln Ag_{t-i} + \sum_{i=1}^{p} \beta_{1i} \Delta \ln EQT_{t-i} + \sum_{i=1}^{p} \Upsilon_{1i} \Delta \ln UB_{t-i} + \sum_{i=1}^{p} \mu_{1i} \Delta \ln POG_{t-i} + \sigma_1 ECT_{t-i} + \xi_{1t} \quad \dots\dots\dots\dots (5)$$

Where: Ag = Agricultural growth, EQT = Environmental quality, POG = Population growth, UB = Urbanization,

φ *and* σ are mx1 vector of parameters; α, β, and γ are mx1 and m x p vectors of parameters respectively; p is the optimal lag order that minimizes information criteria; n is the number of endogenous variables under investigation (Agricultural growth); ξ_{jt} is an mx1 vector of random variables assumed to be normally distributed white noise process.

3.0 Results and Discussion

3.1 Preliminary Analysis

Summary statistics of the variables

Table 1. Summary Statistics of Variables

	Land Use	Agricultural Growth	Environmental Quality	Population Growth	Urbanization
Mean	64087.20	5.314404	267821.1	2.606929	4.710495
Median	65705.68	3.792027	263368.0	2.586844	4.713375
Maximum	69902.80	55.57805	332247.0	3.002988	6.143857
Minimum	56649.00	-4.382437	206368.6	2.379888	3.793588
Std. Dev.	4284.746	8.618417	35025.08	0.129689	0.644764
Skewness	-0.579788	4.789681	0.322079	0.629694	0.509648
Kurtosis	1.876613	28.41582	2.219608	3.773034	2.133238
Jarque-Bera	4.670182	1321.763	1.834581	3.912351	3.207511
Probability	0.096802	0.000000	0.399600	0.141398	0.201140
Sum	2755750.	228.5194	11516308	112.0979	202.5513
Sum Sq. Dev.	7.71E+08	3119.639	5.15E+10	0.706412	17.46026
Observations	43	43	43	43	43

Source: Data analysis, 2024.

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3.2 Unit Root Test

As shown in Table 2, a necessary preliminary test, the Augmented Dickey Fuller (ADF) test for unit root was employed to test whether or not the variables are stationary and also determine the order of integration of the variables. The result indicated that all the variables (environmental quality, agricultural growth, population growth and urbanization) were found to be integrated of order one and became stationary on first differencing. This indicates that the variables exhibit random walk (Unit roots) or the future values of these variables do not converge from their past values.

Table 2. Results of Augmented Dickey-Fuller (ADF) Test

Variables	Level				First Difference				
	ADF	1%	5%	10%	ADF	1%	5%	10%	Inference
EQTY	-0.8896	-3.5967	-2.9332	-2.6049	-6.6467***	-3.6009	-2.9350	-2.6058	I(1)
AGTH	-1.9211	-3.6105	-2.9389	-2.6079	-6.2021***	-3.5966	-2.9332	-2.6049	I(1)
PGTH	-1.7129	-3.6329	-2.9484	-2.6129	-4.9068***	-3.6105	-2.9389	-2.6079	I(1)
Urbanization	-1.9328	-3.5966	-2.9331	-2.6049	-5.5455***	-3.6537	-2.9571	-2.6174	I(1)

EQTY = Environmental Quality; AGTH = Agricultural Growth; PGTH = Population Growth
*** Significant at 1%
Source: Data Analysis, 2024.

3.3 Co-integration Test

According to Engle and Granger (1987) regressing a non-stationary series on another non-stationary series yields spurious regression, but if the linear combination of the series is stationary, we could say the variables are co-integrated and the regression is no longer spurious. Variables are said to be co-integrated if they have long run association. Since the variables are non-stationary, it becomes imperative to test whether or not the variables are co-integrated. Using both trace and maximum Eigen statistics, the result revealed that combination of these variables has 3 co-integrating equations and this means that linear combination of these variables has a three long run linear combination of relationships or three co-integrating equations.

The result of co-integration analysis for long run relationship between environmental quality and agricultural growth as presented in Table 3 shows that the computed trace statistics for none (99.12988) and at most 1 (59.40875) were greater than the critical value at 0.05 level (69.81889 and 47.85613) for none and at most 1 respectively. Similarly, the maximum Eigen values for none, at most 1 and at most 2 (39.72113, 30.61249 and 21.48936) were also greater than their corresponding critical value (33.87687, 27.58434 and 21.1316) at 0.05 level respectively. Therefore, co-integration exists among the variables. This implies that a long run relationship exists among land use, environmental quality and agricultural growth in Nigeria.

Table 3: Johansen Co-integration Test for Unrestricted Co-integration Rank

Hypothesised No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.620465	99.12988	69.81889	0.0000
At most 1 *	0.526047	59.40875	47.85613	0.0029
At most 2	0.407930	28.79626	29.79707	0.0649
At most 3	0.150106	7.306897	15.49471	0.5422
At most 4	0.015452	0.638492	3.841466	0.4243
Maximum Eigenvalue Test				
Hypothesised No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.620465	39.72113	33.87687	0.0090
At most 1 *	0.526047	30.61249	27.58434	0.0198
At most 2 *	0.407930	21.48936	21.13162	0.0445
At most 3	0.150106	6.668406	14.26460	0.5291
At most 4	0.015452	0.638492	3.841466	0.4243

Max-eigenvalue test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: Data Analysis, 2024.

3.4 Lag Length Selection Criteria

The result of the lag length selection criteria is presented in Table 4. VAR model was fitted to the time series data in order to find an appropriate lag structure for the analysis. The lag length was selected from six different selection criteria. Akaike Information Criteria (AIC) was chosen because of its lowest value (36.17209) at lag 3. Therefore, lag 3 is the appropriate lag to be used for the model.

Table 4: Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-900.7338	NA	3.20e+13	45.28669	45.49780	45.36302
1	-722.8236	302.4473	1.55e+10	37.64118	38.90784*	38.09917
2	-678.1557	64.76854	6.16e+09	36.65778	38.97999	37.49742
3	-643.4418	41.65672*	4.46e+09*	36.17209*	39.54985	37.39338*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: Data Analysis, 2024.

3.5 Long and Short Run Effects of Environmental Quality on Agricultural Growth

Consequent upon the existence of one co-integrating equation among the variables, implying the existence of long run relationship among environmental quality and agricultural growth, the Vector Error Correction Model (VECM) was estimated. The VECM shows the short run and long run effects among these variables.

The result of the VECM as shown in Table 5 indicated that in the long run, the coefficient of environmental quality (3.861) was positive and statistically significant at 1%. This implies that a unit increase in environmental quality will increase agricultural growth by 3.861 units in the long run. The result indicated the existence of long run effect of environmental quality on agricultural growth in Nigeria.

The result of the short run indicated that Error Correction Term [ECT (-1)] is statistically significant and negative (-1.437) indicating a high speed of adjustment (the speed at which the deviation from long run equilibrium is adjusted quickly where 1.437 of the disequilibrium is removed immediately in each period). The result implies that 143.7% deviation from the equilibrium position is corrected within the year.

The result further shows that in the short run, change in the coefficient of environmental quality (3.737) was positive and statistically significant at 1% probability level. This implies that an increase in environmental quality will lead to a 0.147 increase in agricultural growth in the second lagged period in the short run *ceteris paribus*. This finding connotes with earlier studies of Ahsan *et al.* (2020) who reported that environmental quality exerts a positive impact on crop production in the long run but a negative effect in the short run. Similarly, Chandio *et al.* (2020) reported positive effect of environmental quality on agricultural growth.

Table 5: The Vector Error Correction Model of Long and Short Run Effects of Land Use Change and Environmental Quality on Agricultural Growth in Nigeria

Regressors	CointEq1	
AGT (-1)	1.000000	
EQTY (-1)	3.861(7.5915***)	
Constant	-34.54720	
	AGT	**EQTY**
CointEq1	-1.437(-3.240***)	-0.0149(-0.9719)
D(AGT(-1))	-0.628(-2.2986**)	0.0226(1.2097)
D(AGT(-2))	-0.2878(-1.2619)	0.0041(0.2621)
D(EQTY(-1))	-0.7190(-0.1743)	-0.0450(-0.1596)
D(EQTY(-2))	3.737(2.988***)	-0.2210(-0.8551)
Constant	-0.013(-0.096)	0.017(1.82444*)
R-squared	0.6602	0.5139
Adj. R-squared	0.3928	0.1026
Sum sq. resids	4.8168	0.0225
S.E. equation	0.6087	0.0416
F-statistic	3.1565***	1.2495
Mean dependent	-0.0253	0.0155
S.D. dependent	0.7686	0.0439
Log likelihood		198.3355
Akaike information criterion		-10.6668
Schwarz criterion		-7.4978

Figures in parentheses are t-values, *significant at 10%, **significant at 5%, ***significant at 1% AGT = Agricultural Growth; EQTY = Environmental Quality
Source: Data Analysis, 2024.

3.6 Causal Relationship among Environmental Quality, Agricultural Growth, Population Growth and Urbanization in Nigeria

Using an optimal lag length of three, the pairwise granger causality test was carried out to examine the causal relationship among environmental quality, agricultural growth, population growth and urbanization in Nigeria. The result as presented in Table 6 showed a significant relationship between population growth and environmental quality, urbanization and environmental quality. Specifically, the result revealed that there is unidirectional causality between aforementioned variables at 10% level of significance. The implication of the results is that the past value of population growth can predict the future value of environmental quality and the past value of urbanization can be used to predict the future value of environmental quality The observed influence of population growth on environmental quality can be attributed to the fact that increase in size of the population can lead to different activities such as clearing of forest land for farming, construction, industrialization and urbanization which all affect environmental quality. This is consistent with the findings of Oyinloye (2017) who reported that deforestation for agricultural expansion and urbanization has led to soil erosion, loss of biodiversity, and reduced water quality in the country.

Table 6: Granger Causality Test of the Relationship among Economic Growth, Environmental Quality, Population Growth, and Urbanization in Nigeria

Null Hypothesis	F-Statistic	Prob.	Decision
LNGDP_GROWTH does not Granger Cause LNENVT_QTY	1.36242	0.2922	Accepted
LNENVT_QTY does not Granger Cause LNGDP_GROWTH	0.15347	0.9258	Accepted
LNPOP_GROWTH does not Granger Cause LNENVT_QTY	2.40873	0.0830	Rejected
LNENVT_QTY does not Granger Cause LNPOP_GROWTH	0.40861	0.7478	Accepted
LNURBANIZATION does not Granger Cause LNENVT_QTY	2.43335	0.0824	Rejected
LNENVT_QTY does not Granger Cause LNURBANIZATION	1.43566	0.2500	Accepted
LNURBANIZATION does not Granger Cause LNPOP_GROWTH	0.76966	0.5193	Accepted
LNPOP_GROWTH does not Granger Cause LNURBANIZATION	0.44621	0.7216	Accepted

Source: Data Analysis, 2024.

Response of Environmental Quality to Shocks from Population Growth and Urbanization

The result of the impulse response analysis on the response of environmental quality to shocks from population growth, and urbanization is presented in Figure 1 and Table 7. The result revealed that environmental quality responds positively to itself both in the short and long run. The effect of this shock was higher in the short run specifically in the first period (0.047%) and decreased henceforth till the 10^{th} period where it ended at 0.006%. This implies that for every one-standard-deviation innovation in environmental quality, environmental quality will responds positively and decrease to about 0.006% in the 10^{th} period *ceteris paribus.* Also, the result revealed that environmental quality responds positively to population growth both in the short and long run over the period. The effect was minimal in the short run specifically during the first period (0.000%) and continues to increase till the 10^{th} period where it peaked at 0.017%. The implication of this result is that for every one-standard-deviation innovation shock in population growth will decrease environmental quality to about 0.0017% in the 10^{th} period *ceteris paribus*. This could be attributed to population growth mostly is associated with economic growth which leads to better way of maintaining the environment. This finding is in line with Ali *et al.* (2021) also found that population growth promotes environmental quality.

Finally, the result showed that environmental quality responds negatively to urbanization both in the short run and long run over the periods. The effect of this shock was zero during the first period (0.000%). However, the effect becomes negative and decreases till it ended at -0.0029% during the 10^{th} period. This implies that effects of shocks arising from one-standard-deviation innovation in urbanization has the tendency of decreasing environmental quality to about -0.0029% in the 10^{th} period *ceteris paribus.* The decrease in environmental quality due to urbanization could be attributed to deposition of urban centres to different means of pollution which are not environmental friendly. This gives credence to Oladipo (2020) who reported that the conversion of natural habitats for agriculture, urbanization, and industrial development that has led to soil erosion, water pollution, air pollution, loss of biodiversity, and other environmental problems.

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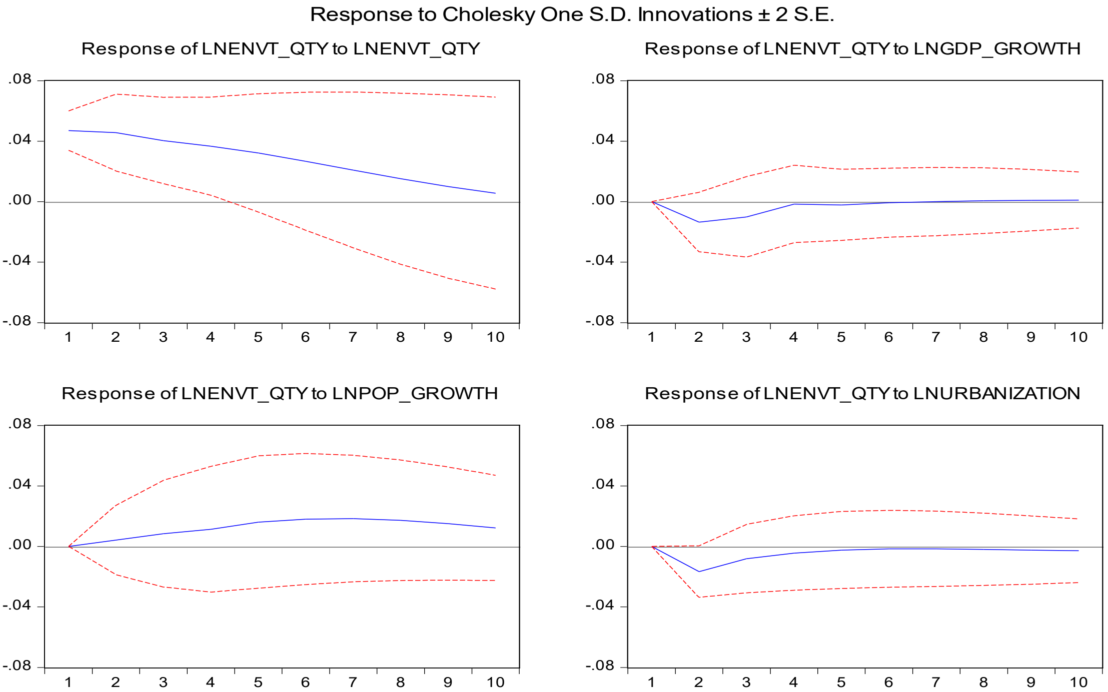

Figure 1: Impulse Response of Environmental Quality to Shocks from Population Growth and Urbanization and Economic Growth in Nigeria

Table 7: Cholesky Ordering: Response of Environmental Quality to Shocks from Population Growth and Urbanization in Nigeria

Period	Environmental Quality	Population Growth	Urbanization
1	0.046947	0.000000	0.000000
	(0.00651)	(0.00000)	(0.00000)
2	0.045672	0.004174	-0.016610
	(0.01272)	(0.01145)	(0.00851)
3	0.040382	0.008398	-0.008103
	(0.01427)	(0.01765)	(0.01131)
4	0.036644	0.011356	-0.004429
	(0.01623)	(0.02079)	(0.01230)
5	0.032183	0.016093	-0.002407
	(0.01956)	(0.02186)	(0.01271)
6	0.026694	0.018025	-0.001607
	(0.02282)	(0.02168)	(0.01272)
7	0.020862	0.018394	-0.001578
	(0.02575)	(0.02092)	(0.01246)
8	0.015155	0.017275	-0.001926
	(0.02828)	(0.01991)	(0.01196)
9	0.009975	0.015069	-0.002417
	(0.03031)	(0.01870)	(0.01129)
10	0.005598	0.012182	-0.002869
	(0.03173)	(0.01738)	(0.01052)

Note: Figures in parenthesis are standard errors
Sources: Data Analysis, 2024.

4.0 Conclusion and Recommendations

The study analyzed the nexus between environmental quality and agricultural growth in Nigeria from 1981 to 2023 and adopted a historical survey design using time series data in the period of 43 years. The study concludes that there is a long run relationship that exists among environmental quality and agricultural growth in Nigeria. The study further concludes that environmental quality responds positively to itself both in the short and long run, positively to population growth both in the short and long run and positively to urbanization in the short run but responds negatively in the long run over the periods. Finally, the study concludes that there is existence of short and long run effect of environmental quality on agricultural growth in Nigeria. The study therefore recommended that:

i. Government should strengthen environmental regulations to improve environmental quality. This could involve stricter enforcement of pollution controls, incentives for adopting environmentally friendly farming practices, and investments in renewable energy to reduce the environmental impact of agricultural activities.
ii. There should be increase public awareness and education on the importance of environmental sustainability in agricultural practices.
iii. Farmers and landowners should be encouraged to adopt practices that protect environmental quality and

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promote long-term agricultural productivity.

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