Environmental Degradation and Food Productivity in Nigeria

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Abstract

This study analyzed the effect of environmental degradation on food productivity in Nigeria for the period 1990 - 2023. Data on air pollution, annual rainfall and population density were the independent variables while food production as a ratio of gross domestic product was the dependent variable. The data were subjected to econometric analysis specifically unit root, Johansen cointegration test and error correction model. The results showed that air pollution decreased food productivity in Nigeria but not significantly, annual rainfall and population density significantly increased food productivity in Nigeria. The study concluded that environmental degradation especially air pollution in Nigeria is slowly eroding food production and this trend needs to be checked to ensure food security. The recommendation was that air pollution can be minimized when land exploration for minerals is done in a safe manner and in line with global low emission standards that will guarantee safer environment and sustainable food production.

Keywords: Annual rainfall, Environmental degradation, Food production & Population density

Introduction

Nigeria is one of the most vulnerable countries to the impact of environmental degradation, as the burden is felt by the people in their daily lives either directly or indirectly (Etuonovbe, 2009). Human activities and the environment are jointly dependent on each other because any activity of man is done in the environment and the result is usually either negative or positive. The concept of environmental degradation is as old as human existence and could either be caused by natural or through human activities, but environmental concerns have been neglected for a long time. Environmental problems will cause environmental degradation and they are multidimensional in nature, some of the problems could be local or global in nature. At the local level they include land degradation, water pollution, air pollution, loss of soil fertility while at the global level they include climate change, loss of biodiversity, and depletion of the ozone layer. Environmental degradation as defined by Organisation for Economic Co-operation and Development (2020) is known to be the deterioration of the environmental quality from concentrations of pollutants and other human activities and processes such as improper land use, cutting down of trees and natural disasters. Environmental degradation mostly occurs when there's excess exploitation of natural resources or when the environment is manipulated beyond its capacity for the quest of achieving economic development.

Environmental degradation through human activities has depleted Nigeria's natural resources such as land, air, water, wildlife, soil, forest etc. pushing people into poverty. Nwokoro and Chima (2017) stated that poor people are the agents of environmental degradation and also, they are the main victims of a depleted environment meaning that they are forced to over exploit areas for farming and shelter for their livelihood. OECD (2020) asserted that over 40 million people in

Nigeria are affected by the problem of land degradation and it is known to be the worst environmental problem facing many countries in the world. Ukpong (2019) opined that causes of land depletion include improper resources management, deforestation, over grazing, flooding erosion, natural landslides and so much more. This menace has a crucial effect on an economy as the lands are needed to produce food commodities for immediate consumption and for trade.

Agriculture is known to be the base of developing economies, especially Nigeria where it constitutes more than 50% of the total employment and livelihood (Osabohien, Adeleye & De Alwis, 2020; Mgbomene, 2024). Farming method in Nigeria is mainly at a subsistence level. Thus, the effects of emissions and climatic shocks are predicted to result in low productivity, shortage of food and welfare of the farmers (Osabohien, Matthew, Aderounmu & Olawande, (2019). In addition, emission-related risks and other agricultural issues may negatively affect productivity, if not properly tamed. Recently, the continent has witnessed severe reduction in natural resources, constraining the productivity of the agricultural sector (Ouiminga, 2021). Increasing heat intensity and variations in the pattern of rainfall also have direct impact on agricultural productivity and an indirect impact due to the availability of water rewired for irrigation (Adeleye *et al*, 2024). Estimates from *Intergovernmental Panel on Climate Change* (IPCC) showed that crop yields have reduced from 10 to 25% and this reduction will worsen by 2050 from climate change effects (Ouiminga, 2021).

Studies linking environmental degradation and food production in Nigeria appear to be silent on issues surrounding growing population density which is a factor that leads to degradation of the environment. Due to human activities, land for agriculture is depleted and this sends strong signal to stakeholders concerning the dire consequences of human activities on the environment. Policies that will help to ensure safer environment for agriculture emanate from research studies such as this. Thus, this problem of environmental degradation cannot be effectively tackled without identifying the problem and solving it through research. This is the core problem that this present study intends to solve. Consequently, the following objectives are set to be achieved in this study;

i. Analyze the effect of air pollution rate on food productivity in Nigeria;
ii. Investigate the extent to which annual rainfall in Nigeria affects food productivity, and
iii. Investigate the effect of population density on food productivity in Nigeria.

Stemming from these objectives, the study formulated three hypotheses as follows:
H_{01}: There is no significant effect of air pollution on food productivity in Nigeria.
H_{02}: There is no significant effect of annual rainfall on food productivity in Nigeria.
H_{03}: Population density has no significant effect on food productivity in Nigeria.

Theoretical Framework

This study emanates from knowledge of the Malthusian theory which was initially proposed by Thomas Robert Malthus (1766-1834). The theory proposed that population would increase according to geometric progression and this would lead to chaos in the long run. At the same time rapid growth in the population level in a developing economy would lead to cutting down of trees for the purpose of building houses or for the use of fuel i.e. household chores which causes air pollution, creation of slums, Thus, increased population in developing economy would mean that the series of environmental problems will be on a rapid increase (Egbulonu, Duru & Dim, 2018;

Ibeaja, Amadi & Dim, 2022). In this process, food production becomes hampered. So basically, there is a link between population growth, environmental degradation and food production.

The theory is limited on the ground that Malthus focused primarily on food supply neglecting other important factors such as technology, economic development and lack of consideration for international trade and globalization. Also, Malthus assumed that economic growth would not be sufficient to keep pace with population growth leading to poverty and famine. However, the limitation of this theory is that it failed to foresee globalization or technological advancements which can alter the negative outcome of growing population density. When population grows, it may not directly lead to low food production because of the impact of technological advancements. Technological advancement can then give rise to more environmental degradation through the release of toxic air pollutants which affects environmental safety and retards food production in the long run.

Review of Empirical Studies

Empirical findings from Nwokoro and Chima (2017) linked poverty and environmental degradation from three premises using explorative discussion method. The first premise held that poor people are agents of environmental degradation citing the fact that the poor are compelled to over exploit marginal areas for farming and other agricultural purposes or derive resources from endangered areas. The second premise was that poor people are the victims of a depleted environment. Because of their limited access to land, poor people are compelled to settle in marginal lands and to cultivate degraded soils which further deplete the soil and increases more vulnerability to poverty for the people. They further held that in the third premise, people move from rural to urban settlements thus unsettling the climate and causing more pollution due to growing urban population. They concluded that rural environmental resources are being depleted, which emanate from excessive rate at which rural population utilize their immediate environmental resources for agricultural production, without considering appropriate resource management practices. The third premise is that poverty can cause people to put more pressure on the environment which can result in larger families, improper waste disposal and over exploitation of natural resource thereby leading to resources depletion.

Ogundipe, Obi and Ogundipe (2019) investigated the effects of environmental degradation on food security in Nigeria using an annual data for the period 1970-2017. The vector error correction analysis revealed an inverse relationship between food production and environmental degradation implying that food security is threatened with rising degradation of the environment. In the same manner, food production responded inversely to gross domestic product per capita, hence justifying the Environmental Kuznets Curve hypothesis. On the other hand, the result of the study revealed a positive influence of agriculture land and population growth on food production. Godson-ibeji and Chikaire (2021) examined the consequences of environmental pollution on agricultural productivity in developing countries using Nigeria as a case by distributing Questionnaires to elicit information on soil fertility, crop growth, and crop productivity, using descriptive statistics and found that environmental pollution reduces the level of soil nutrients and fertility, crop growth and crop yield are negatively affected by pollution, there by concluding that agricultural productivity is negatively affected in Nigeria.

Olurinola and Osabuohien (2021) studied socio-economic and environmental issues and their implications for food security in Nigeria. The study discussed agricultural programmes of government since the 1970s and narrowed t down to food crop productions for Nigeria for the same period. Their study concluded that Nigeria has made many policies toward improving the contribution of the agricultural sector in the economy; however, there is a need to fine-tune some of the policies, particularly regarding food security.

Olayide (2021) analyzed and synthesized literatures on climate change, land use, energy, livelihoods and sustainable development in Nigeria. Based on the assessment of literature in this study, the key trends and problems include inadequate attention to the agricultural sector over the years which caused a major setback in food security and productivity, inadequate energy supply, distribution and low per capita consumption in Nigeria and deforestation. The study concluded that lack of strong institutions has resulted in the weak performance witnessed in programme and policy implementation on climate change mitigation, land use, energy and sustainable development in Nigeria.

Ibimilua and Ayiti (2024) analyzed the socio-economic factors exacerbating environmental problems, such as poverty, inequality, and limited access to clean water and sanitation, and explored potential opportunities and solutions for promoting environmental sustainability and resilience in Nigeria. Survey of 200 residents in the Niger Delta region of Nigeria revealed that there is increasing deforestation rates, rising pollution levels, temperature changes, and declining biodiversity index.

The study of Adeleye, Daramola, Onabote and Osabohien (2024) investigated agro-productivity amidst environmental degradation and energy usage in Nigeria. Using annual time series data from 1980 to 2018, the study engaged the Johansen cointegration and impulse response functions (IRFs) techniques within the vector autoregressive (VAR) framework. Evidence revealed that carbon emissions significantly reduced agro-productivity by 0.23% while non-renewable energy boosts agro-productivity by 5.38%, on average, ceteris paribus. The study by Osabohien *et al.,* (2019) using the fixed and random effects approaches, examined how gas emissions affect crop production in the Economic Community of West African States (ECOWAS) sub-region. The study found that, carbon emissions, especially, greenhouse gases and other climate change components reduce agricultural productivity by about 0.13%.

In another study Gornall *et al* (2022), using in-depth review of the literature and stylized facts, asserted that farming, or in general, the agricultural system is highly controlled by climatic conditions. In this wise, unfavourable weather and climate induced by human efforts such as carbon emissions will reduce agricultural yields, which pose a threat to food security and human health. Rehman, Ozturk and Zhang (2021) examined the linkage between some emission indicators (C0 and energy usage) and agricultural productivity (measured by cropped yield) and other covariates such as enhanced seed distribution, overall food grains and adequacy of water (for the period 1987–2017). The study applied the ARDL econometric approach and found that, in the long-run, cropped area, consumption of energy, per capita GDP and the adequacy of significantly and positively related to emission indicators.

Across the global, especially, in the last two decades, outside the energy problems, carbon and the greenhouse gas emissions, are some of the most prominent causes of global warming, which have

gained prominence consideration in the literature (Osabohien *et al.*, 2019). The study of Pishgar-Komleh et al. (2020) examined how energy usage of energy and emissions of greenhouse gases affect agricultural productivity, using the cucumber farm in some greenhouses in Yazd district of Iran. The study found that energy use efficiency and productivity were 0.10 and 0.12 kg, respectively. In addition, diesel fuel and electricity power had the biggest contributions in the total energy input. Estimates form the econometric analysis showed that diesel fuel had a significant impact on agriculturally productivity in Iran.

The empirical review reveals a rather insufficient literature linking environmental degradation and food security in Nigeria especially as it concerns the use of variables such as rainfall statistics, air pollution and population density. Most of previous studies reviewed focused on greenhouse gas emissions and other components of air pollution but, this study takes on the aggregate of air pollution rate for Nigeria while filling the existing gap in literature by examining population density as a factor of environmental degradation and its effect on food security.

Methodology

The Quasi-experimental research design was used in this study. This establishes a linear relationship between the dependent variable and set of independent variables. The data were analyzed using the error correction model techniques. The annual time series data spanning the period 1990 - 2023 were sourced from the World Development Indicator (WDI) which is the database of the World Bank as updated in 2023.

Model Specification

The study of Adeleye *et al* (2024) studied the factors that affect agro-productivity (carbon emissions per capita, non-renewable energy per capita, arable land, rural population growth, domestic credit) as independent variables with food productivity being the dependent variable. Their model is stated thus below:

FDPRD = *f*(CO2PC, ENUPC, CR, RUGR, ARL) [i]

Source: *Adeleye et al (2024)*

Where: FDPRD is food productivity, CO2PC is carbon emissions per capita, ENUPC is non-renewable energy per capita, ARL is Arable land, RUGP is rural population growth and CR is domestic credit

A cursory examination of the model specified in Adeleye *et al* (2024) indicates that they did not consider other facilitators of environmental degradation such as pollution rate, population density, etc. By way of modification, we aggregate all air-borne pollution as one variable called air pollution rate as explained in World Development Indicator (2023) and also use annual rainfall statistics in millimeters (obtained from the Central bank of Nigeria Statistical Bulletin 2023 edition) as a critical land degradation agent and re-specify the model as:

FDPRD = *f*(AIRP, RAIN, POPD) [ii]

Where:

FDPRD = Food productivity (measured as ratio of food production to GDP)

AIRP = Air pollution rate (mean annual exposure, micrograms per cubic meter)
RAIN = Annual Rainfall statistics (in millimeters as a proxy for land pollution)
POPD = Population density (people per sq. km of land area)

The equation [ii] is expanded to include the unknown parameters and the error term as follows:

$$FDPRD_t = \alpha_0 + \beta_1 AIRP_t + \beta_2 RAIN_t + \beta_3 POPD_t + U_t \quad [iii]$$

Where: α_0 is the intercept of the model, β_1, β_2 and β_3 are the unknown coefficients of the model to be estimated, 't' is the time variant, and U_t is the stochastic error term.

On the a-priori expectations, 'AIRP' and 'RAIN' capture environmental degradation which retards food production and output. They both have coefficients β_1 and β_2. It is predictable that as the environmental degradation worsens, its impact on food production will be adverse and so air pollution is expected to have negative coefficients or negative effects on agro-productivity i.e. $\beta_1 < 0$. But increase in rainfall is expected to have positive effect on food production i.e. $\beta_2 > 0$. Similarly, 'POPD' enhances environmental degradation as it is a facilitator resulting in human activities that erode the environment, and so it is expected that increased population density will decrease food productivity i.e. $\beta_3 < 0$.

Sources of Data

Data on Food productivity (measured as ratio of food production to GDP), annual rainfall statistics (in millimeters) are obtained from the Central bank of Nigeria (CBN) Statistical Bulletin 2023 edition while air pollution rate (mean annual exposure, micrograms per cubic meter) and population density (people per sq. km of land area) are obtained from the World Development Indicator (2023) edition. The data span the period 1990 – 2023.

Estimation Techniques

The research adopts Econometric approach specifically; the following tests are carried out (1) Augmented Dickey Fuller unit root test (2) Johansen cointegration technique (3) Error Correction Model estimation. Unit root determines the stationarity and suitability of the time series data for forecast, Johansen cointegration test ascertains the long run relationship amongst the variables of interest, error correction model estimates the model parameters including the t-statistics used in testing the hypotheses formulated. In testing the hypothesis, the null hypothesis is rejected if the probability value (*p-value*) of the t-statistic is less than 0.05 critical value, otherwise we accept the null hypothesis.

Results of the Findings

The results of the findings of this study are presented in Fig 1

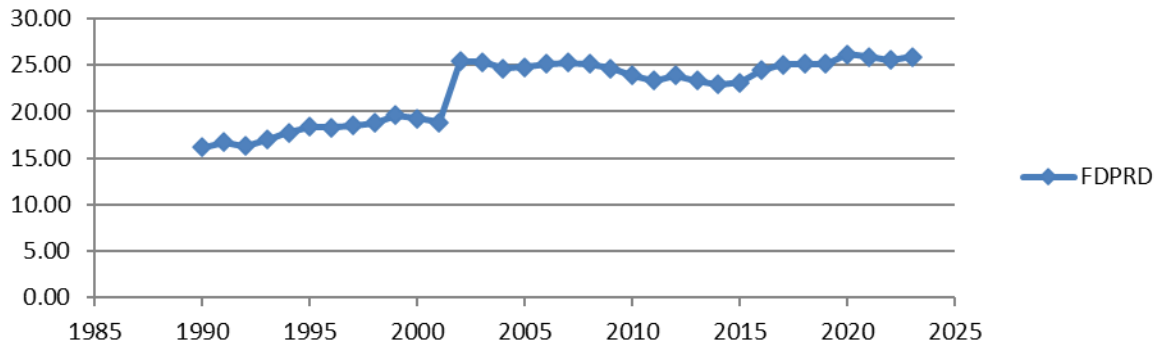

Figure 1: *Food production in Nigeria (1990 – 2023)*

The trend of food production as percentage of GDP in Nigeria is shown in figure 1 above. Food production as a percentage of total GDP reached 25.9 per cent up from 16 per cent recorded in the 1990s. This represents a steady progress in Nigeria's aim towards achieving food security.

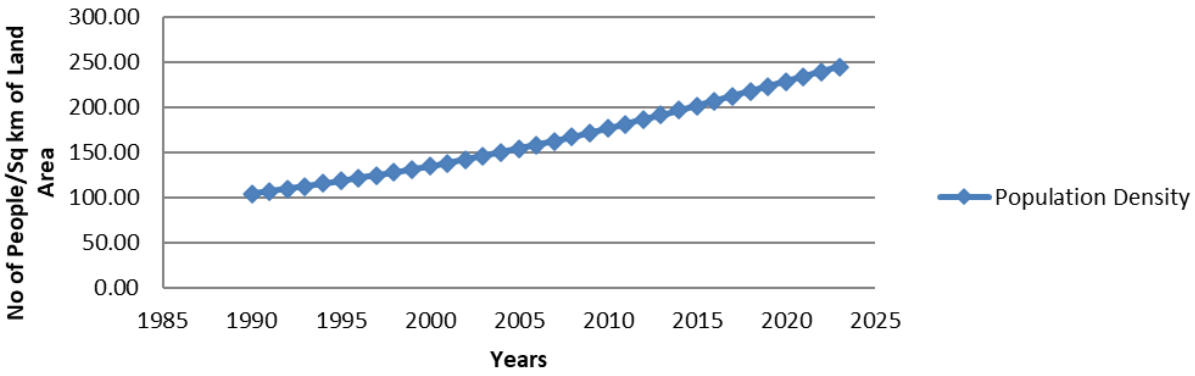

Figure 2: *Nigeria's population density (*people per sq. km of land area *from 1990 – 2023)*

Figure 2 above shows the trend of population density in Nigeria for the period under review. There is a steady rise in population density (people per sq. km of land area) reaching 244.97 in 2023. As at 1990, Nigeria's population density was 104.5 people per square kilometer and this represents more than 100% increase in population density for Nigeria for the period.

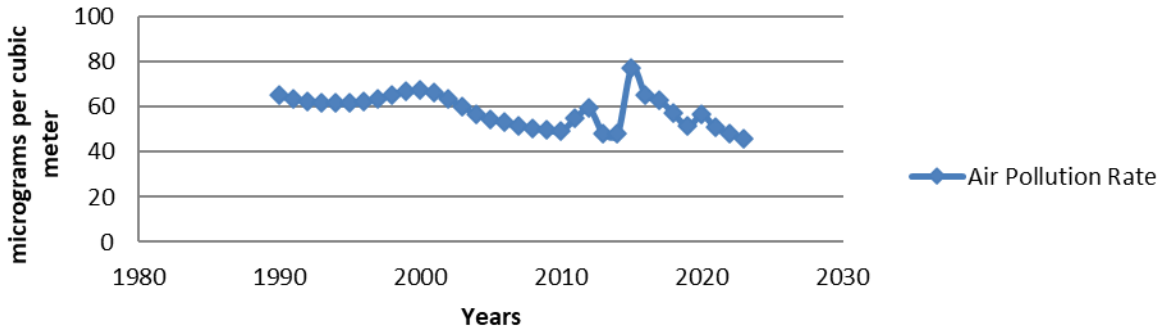

Figure 3: Air pollution rate for Nigeria (micrograms per cubic meter from 1990 – 2023)

Nigeria's air pollution reached its highest in 2015 attaining 77 micrograms per cubic meter. On the average, it was 60 micrograms per cubic meter for the entire period under study. The air pollution data represent average level of exposure of Nigeria's population to concentrations of suspended particles measuring less than 2.5 microns in aerodynamic diameter, which are capable of penetrating deep into the respiratory tract and causing severe health damage (World Development Indicator 2023). Exposure is calculated by the World Development Indicator by weighting mean annual concentrations of PM2.5 by population in both urban and rural areas.

Since the data are time series, it is pertinent to conduct test of stationarity to ascertain their order of integration as well as the long run test. These tests are summarized in the Table 1 below:

Table 1: Summary of Unit Root Test Result

	ADF Test statistics			
Variable	**At Level**	**1st Difference**	**Decision**	**Order of Integration**
FDPRD	-1.9877 [0.5863]	-5.9194 [0.0002]	Stationary at 1st difference	I(1)
AIRP	-3.1354 [0.1151]	-6.7067 [0.0000]	Stationary at 1st difference	I(1)
RAIN	-1.9159 [0.6023]	-3.7618 [0.0323]	Stationary at 1st difference	I(1)
POPD	-2.0197 [0.6731]	5.5823 [0.0021]	Stationary at 1st difference	I(1)

Source: Researchers' Computation using E-Views 9.0

The unit root test above reveals that the probability values of the variables are all less than 0.05 critical value at first difference. Therefore, the variables are said to be integrated at order one, I(1). This means that the data's statistical qualities do not change over time. Based on this conclusion, we test for the presence of a long-run relationship or cointegration amongst the variables.

The long run test or cointegration test has the following hypothesis:
H_0: No long run relationship exists amongst the variables (no cointegration)
H_1: There is long run relationship amongst the variables

Table 2: Summary of the Johansen Cointegration Test

Trace Statistic					**Max-Eigen Statistic**		
Hypothesized No of CE (S)	**Eigen-Value**	**Trace statistics**	**5% Critical Value**	**Prob**	**Max-Eigen statistics**	**5% Critical value**	**Prob**
None *	0.644330	54.23275	47.85613	0.0112	33.08007	27.58434	0.0089
At most 1	0.275009	21.15268	29.79707	0.3482	10.29106	21.13162	0.7169
At most 2	0.251582	10.86162	15.49471	0.2201	9.273390	14.26460	0.2641
At most 3	0.048421	1.588231	3.841466	0.2076	1.588231	3.841466	0.2076

Note: **Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

**Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

Table 2 presents the Trace and Max-eigen data for the Johansen cointegration test. Both statistics indicate a single cointegrating equation at the 5% level. The decision criteria are that there must be at least one cointegrating equation in order to reject the null hypothesis of no cointegration. Because the Trace and Max-eigen statistics indicate one cointegrating equation, we reject the null hypothesis and conclude that there is a long-run relationship between environmental degradation variables and food productivity in Nigeria.

Table 3: Error Correction Model Result

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	17.83029	4.512967	3.950902	0.0005
AIP	-0.065179	0.055446	-1.175551	0.2504
RAIN	1.048605	0.320522	3.271554	0.0006
POPD	0.051164	0.009628	5.314011	0.0000
ECM(-1)	-0.221764	0.051323	-4.320948	0.0359
R-squared	0.682210	Durbin-Watson stat		1.880301
Adjusted R-squared	0.633319			
F-statistic	13.95373			
Prob(F-statistic)	0.000303			

Source: Researchers' Computation using E-view 9

The short run estimates above show that as air pollution increases, food productivity decreases by 0.0652 units annually. This shows that air pollution has adverse and inverse effect on food productivity in Nigeria for the period under study. However, the negative effect was not significant as the *p-value* is 0.2504.

Conversely, rainfall and population density increase food productivity significantly by 1.0486 and 0.0512 units respectively. This represents positive and direct relationship between rainfall, population density and food productivity in Nigeria.

Table 3 above demonstrates that the coefficient of the model residual is both negative and significant. This suggests that the short-term model has high forecasting capabilities. The adjustment mechanism is thus calculated at 22.2% yearly.

Furthermore, the Durbin Watson statistic implies that there is no autocorrelation in the model, since the DW value of 1.880 is closer to 2 than 0. The adjusted R-squared value of 0.633 shows that environmental degradation accounts for up to 63.3 percent of the variations in food production in Nigeria.

Test of Hypothesis One

H_{01}: There is no significant effect of air pollution on food productivity in Nigeria.
t-statistic = -1.176

p-value = 0.2504

Decision Rule: Since the probability value of the t-statistic is greater than 0.05 critical value i.e. 0.2504 > 0.05, we accept the null hypothesis and conclude that there is no significant effect of air pollution on food productivity in Nigeria.

Test of Hypothesis Two

H_{02}: There is no significant effect of annual rainfall on food productivity in Nigeria.
t-statistic = 3.272

p-value = 0.0006

Decision Rule: The probability value of the t-statistic is less than 0.05 critical value i.e. 0.0006 < 0.05, we reject the null hypothesis and conclude that there is significant positive effect of annual rainfall on food productivity in Nigeria.

Test of Hypothesis Three

H_{03}: Population density has no significant effect on food productivity in Nigeria.
t-statistic = 5.314

p-value = 0.0000

Decision Rule: The t-statistic has a probability value that is less than 0.05 critical value (0.0000 < 0.05), therefore, we reject the null hypothesis and conclude that population density has significant positive effect on food productivity in Nigeria.

Discussion of Findings

This study investigated the effect of environmental degradation and food productivity in Nigeria from 1990 to 2023. Specifically, the study examined the effects of air pollution rate, annual rainfall and population density on food productivity in Nigeria. The statistical properties of the time series data were examined through stationarity test using the Augmented Dickey-Fuller (ADF) unit root test. The results showed that all the variables were integrated after first differencing. This necessitated the test for long run relationship amongst the variables using the Johansen Cointegration test. The result established the existence of a long-run relationship between environmental degradation and food productivity in Nigeria.

Consequently, the short run model estimates showed that annual rainfall and population density have positive and direct relationships with food productivity in Nigeria. Also, the positive effects of both annual rainfall and population density were found to have significant effect on food productivity in Nigeria for the period under study. This finding negates previous findings of Nwokoro and Chima (2017), Gornall et al. (2022) who found that environmental degradation depletes food production due to climate induced by human efforts and the fact that the poor are compelled to over exploit marginal areas for farming. However, this present study found population density to be highly beneficial to food productivity. The difference in findings may be due to the incorporation of recent data up to 2023 in this present research and the use of some salient variables which affected the eventual outcome.

Furthermore, the study found negative effect of air pollution on food productivity which shows that Nigeria's air pollution rate is adversely affecting the rate of production of food for the period reviewed. However, the short run negative effect of air pollution on food productivity was not found to be significant. This negative effect is in agreement with the works of Ogundipe *et al* (2019), Olayide (2021) and Osabohien *et al* (2019). These studies found that greenhouse gases and other climate change components reduce agricultural productivity.

The negative sign of the error correction coefficient indicated that there is adjustment towards long-run equilibrium. As a result, the study confirms that holding environmental degradation variables at a steady decreasing rate of 22.2 per cent annually, food productivity in Nigeria will experience long run equilibrium growth. The indices for environmental degradation used in the model jointly accounted for up to 63.3% of the changes in food productivity in Nigeria for the period reviewed.

Conclusion

The study made important findings which were in line with the specific objectives of the study. The findings led to the conclusion that environmental degradation especially air pollution in Nigeria is slowly eroding food production and this trend needs to be checked to ensure food security. Despite the positive effects of rainfall and population density on food productivity, Nigeria's food production is still growing at a slow pace with both variables increasing it by 1.048 and 0.051 units annually.

Recommendations

Based on the findings of the study the following recommendations are made:

i. Nigeria should ensure that air pollution rate is reduced by adhering to the United Nations protocol of low greenhouse emission, low carbon emission and ensure a safer climate that will guarantee increased food productivity. In addition, air pollution can be minimized when land exploration for minerals is done in a safe manner that will guarantee safe environment.

ii. Since population density enhances food productivity, Nigeria should further leverage on the growing population to grow food production beyond optimal level so as to guarantee long term food sustainability.

iii. Annual rainfall in Nigeria is favorable to food production, to this effect, efforts should be made to grow more food and ensure that food production grows to export demands.

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