



Environmental Degradation and Food Security in Nigeria

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ABSTRACT

This study investigates the effects of environmental degradation on food security in Nigeria using an annual data for the period 1970-2017. The theoretical framework was based on the Malthusian theory and the environmental Kuznets curve (EKC) hypothesis. The empirical model developed was estimated using the Johansen and vector error correction analysis. The empirical evidence suggest an inverse relationship between food production and environmental degradation implying that food security is threaten with rising degradation of the environment. In the same manner, food production responded inversely to gross domestic product per capita, hence justifying the EKC hypothesis. Since pollution is a rising function of income at the initial development stages, the rising pollution associated with income growth tends to hamper food security. On the other hand, the evidences reveal a positive influence of agriculture land and population growth on food production. However, the effect of the latter (population growth) is negligible suggesting that an increase in population results in lesser proportionate increase in food production, hence confirming the Malthusian theory.

Keywords: Food Security, Environmental Degradation, Malthusian Theory, Environmental Kuznets Curve

JEL Classifications: L66, Q15, Q56, Q53, H24

1. INTRODUCTION

Food is an essential ingredient for good life, wellbeing and growth. The available statistics show that 240 million people, or better still, one out of every four persons in the Sub-Saharan Africa lack access to adequate food. Food security is very essential for survival, growth and the productiveness of an economy (Matemilola and Elegbede, 2017). The World Economic Summit 1974 defined food security as “availability at all times of adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset fluctuations in production and prices.” There are 4 (four) dimensions of food security namely, food availability, food access, food utilisation and food stability (Food and Agriculture Organisation [FAO], 2018). According to National institute of Food and Agriculture (2017), food security produces wide ranges of positive impacts such as economic growth, job creation, poverty reduction, trade opportunities, increased global security and stability, and improved health and healthcare.

Food security is the second most important target of the United Nations sustainable development goals after poverty. This goal is to end hunger and all forms of malnutrition by 2030. It also commits to complete and easy access to safe, nutritious and sufficient food at all times of the year. Achieving this goal requires sustainable food production systems and durable agricultural practices, equal access to land, technology and markets and international co-operation on investments in infrastructure and technology to boost agricultural productivity. The policy of zero hunger adopted in 2015 is aimed at addressing provision for the worlds 7.3 billion people which is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100 (United Nations, 2016).

Despite the pressing effort by international institutions, the population of the undernourished people in the world still constitutes a major problem in most parts of the world. Based on 2015 assessment of the Food and Agriculture Organization

of the United Nations (FAO), around 795 million people in the world remained undernourished. This figure represents 167 million and 216 million reductions in the last decade and since 1990 respectively. The United Nations International Children Emergency Fund (UNICEF) explains that about 65% of our population are food insecure and so many people die of hunger every day. Nigeria depends solely on the importation of food; and spends about 1 trillion naira annually on the importation of food and by doing this it reduces the revenue of the economy and the money that should have been invested in other sectors of the economy to yield more revenue. The country is blessed with abundant agricultural land which is sufficient for production of agricultural output. It has about 79 million hectares of arable land of which 32 million hectares are cultivated but constraints include poor storage of food supply and also an unequal distribution.

Omorogiuwa et al. (2014) stated that Nigeria is blessed with abundant fertile agricultural land and favourable climate as well as enviable human resources. But identified constraints facing food security as including: insufficient production, gender inequality, inefficient policies and corruption, conflict and civil insecurity, low technology for processing and storage and environmental degradation (climate change, pollution, and natural disasters). Also, the episode of occurrence in the recent time points to environmental degradation¹ as a major constraint with a long run impact and negative effects on food security and growth in Nigeria.

One of the major consequences of environmental degradation in Nigeria is the loss of vast agricultural land. For instance, desertification and its twin brother deforestation have swallowed about 35% of land cultivated 50 years ago in eleven northern states and are said to be moving southward at the rate of 1 km/annum. Since agriculture employs about 80% of Nigeria's total population, loss of agricultural land will render many jobless, increase competition for the remaining lands resulting to conflict over land. Total food production may also decline leading to hunger, diseases and deaths among the citizens (Ogundipe et al., 2018).

An increase in the country's level of environmental degradation will increase the country's chances of being less food secure, this suggests that the more the environment deteriorates due to various human or artificial factors, it leads to reduced agricultural production, cause the farm lands aren't as productive as they should be useful and the little that are produced aren't sufficient to feed half of the population forcing people to fend for themselves and the government to increase importation.

Many issues of the environmental problems facing Nigeria as a country are typical of developing countries due to poverty, industrial activities, lack of economic development and awareness. Excess cultivation of crops has resulted in loss of soil fertility which makes it difficult for farmers to produce crops, making the economy less food secure. Increased cutting of timber for firewood or as a construction material has made inroads into forest resources, exceeding replanting's. By 1985, deforestation claimed

1544 square miles of the nation's forest land. Between 1983 and 1993, Nigeria lost 20% of its forest and woodland areas. Oil spills, the burning of toxic wastes and urban air pollution are problems in more developed areas. In the 1990s Nigeria was among the 50 nations with the world's highest levels of carbon emissions, which totalled 96.5 million metric tons, a per capita level 0.84 metric tons. Water pollution is also a problem due to improper handling of sewage.

Nigerian is confronted by major environmental problems, which are: deforestation, drought and desertification, soil and coastal erosion, water pollution, oil pollution, water hyacinth invasion, loss of biodiversity, flooding, urban decay and industrial pollution which all has a crucial effect on agricultural produce. According to 2018 statistics from the Federal Ministry of Agriculture and Rural Development (FMARD), Nigeria's population is among the fast growing populations in the world however, food production increases but marginally increases year on year although at a lower rate compared to the population growth rate. As the nation's population continues to grow rapidly the level pollution (air pollution, water pollution and soil contamination) and other environmental problems continue to rise which makes it difficult for a developing country such as Nigeria to be food secure and as the growing population surpasses the level of food production it becomes detrimental to the economy.

A lot of programs have been established by the government to improve the problem of food security but even with all these programs and policies, the problem of and food insecurity still persists in the economy and also not forgetting that without evident awareness of sustainable agricultural practices and environmental practices there won't be any improvement in achieving food security.

2. FOOD SECURITY AND ENVIRONMENT DEGRADATION IN NIGERIA

2.1. Food Security Issues in Nigeria

With over 160 million people, Nigeria is the most populated country in Africa and represents about 47% of the population of the whole of West Africa. It is extremely known that Nigeria is highly abundant with load of natural resources from its agricultural land, resources to its mineral resources and yet Nigeria is one of the largest importers of food.

Agriculture was formerly one of the major occupations in Nigeria, employing almost two-thirds of the active work force and contributing 40% of the national gross domestic product (GDP). In the 40's and 50's food insecurity wasn't a problem which Nigeria struggled with, the country as a whole was able to produce a large quantity of food for personal consumption and also for the purpose of exportation. Different regions in Nigeria specialised in different kinds of crop production which included cash crops or food crops and there was unity in diversity.

Every part of the country was into the production of different varieties of crops which made the country to be self-reliant and

¹ Mostly in rural communities such as deforestation, loss of biodiversity, loss of soil fertility, leaching of the soil, land degradation, land and water pollution, desertification, drought, flood and erosions.

food secure. However, the industrial revolution following the discovery of oil in the 90's changed the tides. Among this were the decline of the country's agricultural produce and the neglect of the sector – formerly the economy's primary source of revenue and foreign exchange earnings. The impact of the decline of agricultural produce was steady and gradual with rising cost of food items and scarcity of certain commodities. For example the cost of rice increased significantly by 100% over the years going back to 2006. Present statistics show that 2.5 million tons of rice is expected to sustain the country annually, implying over 2 million tons deficit of rice, thus there's a rising need to meet up with the annual demand.

Today despite the vast potential of the agricultural sector, the country is a net food importer of food commodities with the vast majority of people engaged in agriculture operating at the subsistence level and many others malnourished because they unable to afford basic food due to the extremely high prices of the imported food products. The rural areas of the country have become vulnerable to malnutrition, erratic supply of food items, high and unaffordable food products, low quality foods and most of time complete lack of food. This situation is more prevalent in many parts of the northern region of Nigeria which is caused by crisis and political insurgences.

According to World Bank statistics over twelve million people are undernourished, hungry and living without adequate daily calories as they suffer from hunger and live without secure access to food. The people most affected by this problem are those living in poverty. The number of undernourished people in Nigeria as at 2008 has been on a continuous increase from 5.9% to 7% as at 2015. About 7% of Nigeria's population still remains undernourished. Thus, around one in fourteen people in Nigeria are likely to be suffering from chronic hunger, not having enough and sufficient food for an active and healthy life. Nigeria has been experiencing a rapid increase of undernourishment since 2008.

The worsening food insecurity trend is associated with environmental degradation, persistent increase in food prices, political instability, inadequate natural resources due to rapid population growth, loss of soil fertility. According to Kendall and Pimentel (1994), only a third of the earth's soil is suitable for agriculture. It is expected that 30% of arable soil would experience erosion by 2050 due to unsustainable agricultural practices. Although the area of arable land is expected to increase by 500 million hectares by 2050, the agricultural productivity of this land will be below current levels.

The impact of price swings and scarcity of food commodities will leave consumers switching between food items. When there's an increase in food commodities, consumers often shift from more expensive and more nutritious food to less expensive but often also less nutritious foods that settling for less. This allows consumers maintain dietary energy intake but at the same time increases the risks of other forms of malnutrition.

Ending hunger and achieving food security as well as improved nutrition and promoting sustainable agriculture is the second goal of the United Nations sustainable development goals which is to be

achieved on or before the year 2030 which is why ensuring food security in all countries is very crucial to sustainable development.

2.2. Environmental Degradation in Nigeria

Nigeria is one of the most vulnerable countries to the most severe impact of environmental degradation, as the burden is felt in our 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 OECD 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. One of the major reasons behind the viscous circle of poverty and environmental degradation is the fact that poverty limits options and also resources which leaves them no choice than to settle for the next available that is fast depleting (Reardon and Vosti 1995). 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. According to Ukpong (1994), some noted 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.

2.3. Link between Environmental Degradation and Food Security in Nigeria

Global environmental degradation affects all aspects of our lives and so it will for many more years to come and this impact is very much inevitable. The difficulty for everyone is not just identifying the problem but rather discovering ways to control the rising environmental depletion. Food insecurity is the greatest danger of environmental degradation and everyone most developing countries are vulnerable to it. Some of the impacts environmental degradation has on food security include: depletion of farm lands,

reduced yields, increased irrigation, planting and harvesting changes, decreased arability, more pests, and risk to fisheries (Egbetokun and Ogundipe 2016).

Environmental degradation not only causes natural disasters, wildfire, droughts, and environmental problems which makes it extremely hard for one to grow food crops. Among all the impacts of environmental degradation, the most crucial is the capability to increase the menace of food insecurity and malnutrition which has both direct and indirect effects on the economy and it makes it difficult for a country such as Nigeria to be productive. From recent studies it is indicated that countries with rising population growth are expected to have an increased burden of environmental degradation due to the fact that as the population rises, it is expected to witness an increase in industrial activities, rate of deforestation and so much more. The implication for a fast growing economy like Nigeria include: high rates of poverty, creation of slums, land degradation – which are results of increase in human activities (Ogundipe et al., 2018).

This menace would bring about a decrease in crop yields which entails increase in costs and for a developing country such as Nigeria with high inequality and poverty rate, it becomes difficult for people to afford food commodities resulting in malnutrition and increased rate of illness and deaths. Environmental degradation which has an impact on climate change brings and causes a rise in sea level which causes flood and excessive moisture in the soil, this in turn reduces the oxygen levels and interrupts the plants' breathing process leading to build-up of carbon dioxide, methane and nitrogen gases, basically it makes the roots weak and so they suffocate and die.

3. EMPIRICAL ISSUES IN LITERATURE

Nwokoro and Chima (2017) carried out a study to examine the impact of environmental degradation on agricultural production and poverty in rural Nigeria. They examine that minimizing the use of natural resources is essential to ensure sustainable environmental conservation. They explained that the continuous pressure placed on the environment exceeding the capacities to which the ecosystem can carry is the major cause of the problem. Their paper aimed at addressing the issues of rural poverty and unsustainable agricultural practices, which have a negative impact on the environment and also, highlighted policy implications on sustainable agricultural production in Nigeria. Also, Amponsah et al. (2015) studied the impact of carbon dioxide emission on cereal yield in Ghana using the auto regressive distributed lag (ARDL) and made use of data period from 1961 to 2010. The study examined the effect of carbon dioxide emissions on cereal yield. The estimated result showed that there is a significant negative relationship between the two variables and that there is a significant short and long run link between cereal yield and income.

Oke (2015) carried out a study on the determinants of national food security in Nigeria. He identified the problems encountered by the food sector in the economy to include; policy ineffectiveness, high cost of production, high exchange rate, increasing population etc. the study also suggests that food

production should be in line with population growth in order to save the country from the high rate of poverty. He made use of secondary data from 1970 to 2004 and the ordinary least square estimation technique. Gundu et al. (2014) in their joint study analysed that environmental degradation will continue to hinder Nigeria's economic growth until efforts are made to solve the problem. And as the economy continues to lose her agricultural land and resources, people who depend on them for their survival are being plunged into poverty as their sources of livelihood is lost. Some type of plants and animals are threatened by this problem while others have already gone into extinction.

Alege and Ogundipe (2013) in their study investigated the relationship between environmental quality and economic growth in Nigeria using a fractional co-integration analysis over the period 1970-2011. The paper concluded that at early stage of economic development would trigger the growth of environmental degradation. The study also explains that population growth would give rise to environmental measures and consciousness for a cleaner environment, found out that weak institutions and policies could lead to a rise in environmental degradation by enhancing environmental dumping in the quest of economic growth through the importation of emission intensive products as well as investment made by foreign companies to produce co2 emitting goods which causes a long term harm to the environmental quality. Their study promotes the restriction of importation of certain products and also the institutions need to be tightened for the policies implemented to work effectively.

Tersoo and Ogochukwu (2014) a joint study explained that agriculture is not only affected by climate change but rather it contributes to a rise in climate change due to emission of greenhouse gases. So by encouraging better environmental agricultural practices which would help to reduce or control climate change. Osabohien et al. (2017), in their joint study of food security, institutional framework and technology using the ARDL approach concluded from their result that there is a high level of food insecurity which results from low little or no attention to food production caused by the reliance on the oil sector. According to Wada (2012), Nigeria has a great potential to be food secure due to her enormous endowed natural resources and land. The economy could be food secure if only agricultural sector could be re-oriented and adjusted and adopt strategies such as rural development, access to basic farm inputs, peasant farmer education and so much more. These strategies not only encourage the farmers but also help in promoting their activities.

As stated by Adebisi et al. (2017), economic development and environmental problems are inseparable and that they are jointly dependent on each other. The study revealed the major contributions of degradation of the physical environment in Nigeria to include deforestation and desertification, crude oil exploitation and exploration, soil mineral extraction, construction activities. The study suggests a pressing need to reduce the industrial activities because of the dangers it has on the environment in the quest for the attainment of economic and technological development. Apata (2018) in his empirical

analysis of the effect of global warming on agriculture explains how hunger or malnutrition related deaths are expected to rise if grain production does not keep up with the growing population rate. It further explains how the lack of access to information on climate change is crucial and could help enhance the farmer's potential to adapt to the global change of the climate and design strategies to help the rural communities respond effectively. Similarly, Chaplin et al, (2017) in his article on the effects of climate change on food security in Nigeria states that climate change could potentially interrupt progress towards attaining a world without hunger which goes to say that climate change has a crucial impact in an economy.

The research explains that in the long run climate change would affect crop yields, land and basically agricultural production. It will also affect food prices as a result of scarcity of commodities, the prices are said to rise rapidly depending on the economy's development. Climate change is also said to increase the number of malnourished individuals especially in the least developed economies. In essence, the result shows that this change would spread, unequally affecting mostly those who are more liable to hunger and poverty. Ojo and Adebayo (2012) emphasized that any system where food demand is not sufficiently matched by supply will loom with food crisis. Dahlberg (1998) identified four global threats that have serious implications on food security. The First is Population explosion. When food supply cannot meet up with the population, there will be poverty and famine. At the global level, somewhere in the world, a child dies of hunger every second. So many people cannot afford to eat three-square meal a day and this will lead to malnutrition and sometimes death. In addition, another global threat is Global Warming. Some agricultural areas suffer from droughts and flood and also storm. The Third is the loss of biodiversity which is perhaps the greatest long term threat to global sustainability. And finally the last global threat is poverty and globalization of Injustice. Poverty is a great threat to food security. When prices of food globally increases, people are not able to afford it and there is food insecurity. Availability of food does not explain the attainment of food security in a country. Food can be available in a country due to effective agricultural policy, good harvest that year or due to the importation of food most especially by developing countries and having negative impact on foreign reserve. Food hygiene should be given important consideration in order to protect the health of others because when the food is not healthy, it can lead to sickness and therefore death. Preservatives such as chemicals used to preserved food can be unhealthy at times which may lead to the ill health of people. In addition chemicals used to treat crops can also be dangerous to the crop.

Nwajiuba (2011) in his study talked about how Nigeria can diversify the economy and stop focusing alone on the oil sector. About 70% of Nigeria's population lives on less than (US\$ 0.70) per day suffering hunger and poverty. The agriculture sector contributes over 40% of the GDP with about 60% of the population engaged in farming thereby reducing unemployment. It was said that as the population of Nigeria keeps growing, food security challenges will keep growing because it does not have the ability to feed its population or meet the demand of the rising

population. Nigeria's Urban Population has outstripped the rural population. Due to the fact that people want to earn a living, they leave the rural area and move to the urban area thereby making it so crowded; causing increases in unemployment poverty, hence food insecurity.

4. THEORETICAL FRAMEWORK AND METHODOLOGY

4.1. Theoretical Framework

The Malthusian theory was used as the theoretical background for this study on environmental degradation and the effects on food security in Nigeria. This theory was initially proposed by Thomas Robert Malthus (1766-1834) who warned 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, not forgetting that poverty is one of the main characteristics of a developing economy and increased population would mean that the series of environmental problems is on an increase. In this process, food production becomes hampered. So basically there is a link between population growth, environmental degradation and food security.

In his essay he developed a theoretical framework about the earth's carrying capacity and the growing population. He explained how the earth's growing population outweighs the earth's capacity to produce subsistence for man. Population would grow faster than food supply and this leads to famine and pestilence and even agricultural innovation will not be able to improve food production. When there is insufficient or no access to food it leads to sickness, malnutrition, death as well as decline in the productivity of an economy.

Intently the study addresses the availability of resources and the environment as a whole. The Malthus theory explains that there are limited resources and as a result of the population status which grows faster than the food production, there would be increased poverty, malnutrition, low productivity if the growth is not controlled or utilized. As result of the rapid growing population there will be deterioration in the quality of the environment implying higher level of pollutions, deforestation, over exploitations of resources for human consumption and congestion which bring about more slums.

4.2. Model Specification

The theoretical framework discussed in this study is premised on the Malthusian theory. A number of extant studies including Mulatu et al. (2016) expressed the theoretical as follows:

$$FPI=f(CO_2, PGR, PCI, AGL)$$

Where FPI is food production index, CO₂ is carbon emissions, PCI is GDP per capita, PGR is population growth rate, and AGL=agricultural labour.

Specifying the model in an explicit and econometrics form, it becomes:

$$\text{Ln FPI} = \alpha_0 + \alpha_1 \text{Ln CO}_2 + \alpha_2 \text{Ln PGR} + \alpha_3 \text{Ln PCI} + \alpha_4 \text{Ln AGL} + \varepsilon_t$$

Where α_0 is the intercept term and ε is the error term.

4.3. Technique of Estimation

In order to achieve the objective of the study, it used the Johansen co-integration approach to ascertain the long run relationship and the vector error correction model (VECM) to assess the sustainability of the long- run relationship. The Johansen Time series can only be applied to series that are integrated of same order. Prior to applying the Johansen approach, it is necessary to ascertain the time series property of the series, in order to ensure there is no presence of unit root. In determining the stationarity and order of integration, two types of unit root test were used: namely, the Augmented Dickey-Fuller (ADF) test and the Philips-Perron (PP) test. The VECM analysis incorporates the error correction mechanism responsible for correcting the short run disequilibria as the model converges to the long run path. To ensure long run convergence of the model, the ecm must satisfy three main criteria which include: its absolute value must lie between zero and 1, the coefficient must be negative and its must be statistically significant.

4.4. Data Sources and Measurement

Data sources and variables are presented in Table 1.

5. ECONOMETRICS ANALYSIS AND DESCRIPTION OF DATA

5.1. Unit Root Test Result

The analysis begins by examining the time series properties of the variables. Prior to the use of variables in regression analysis, there is a need to check that such variables possess a mean and variance whose distributions are independent of time. This study employed the use of the ADF and the PP test to establish this. Unit root test is conducted to check for stationarity of the underlying time series variables. In line with recent developments in time series modelling, unit root tests of the time series properties of the data are examined to determine the order of integration of the variables used in the model. A series is said to be integrated of order d, denoted I (0), if the series become stationary or I (1) after being differenced d times. The Augmented Dickey Fuller is

performed. The results from the tests are consistent and it shows that all the variables are non-stationary at level (Table 2).

5.2. Johansen Co-integration Test

After ascertaining the stationarity of the variables at first difference, the Johansen co-integrating test is then applied to determine the long run relationship between the variables.

From the result, the trace indicates 1 co-integrating variables at the 0.05 level and also the Max-Eigen test indicates 3 co-integrating variables at the 0.05 level, and so it denotes rejection of the hypothesis at the 0.05 level (Table 3).

The key variables used in decision making include the Trace statistics, Mac-Eigen value and the MacKinnon-Haug-Michelins (1990) P-values. When the Trace statistics and Max-Eigen are >0.05 critical values, the null hypothesis that there is no co-integration is rejected.

The values in the parenthesis represent the t-statistics of the variables (Table 4).

The long run normalised co-integrating coefficients can be expressed explicitly as follows:

$$\text{Ln FPI} = -0.2263 \text{Ln CO}_2 + 4.3078 \text{Ln AGL} - 0.4357 \text{Ln PCI} + 0.0571 \text{Ln PGR}$$

The results showed that all the variables were statistically significant in explaining food production. Environmental degradation and Per capita income were found to negatively affect food production, while agricultural land and population growth rate exert a significant positive influence on food production in Nigeria.

The available result shows an inverse relationship between food production index and carbon emissions suggesting that food production dwindles with rising incidence of degradation. Specifically, in this context, a 100% increase in environmental degradation results in about 22.6% decline in food production in Nigeria. Food production in many states of the country has been gradually hampered due to natural disasters resulting in continuing exposure of the environment to degrading human activities. The consequences of environmental degradation has resulted in the depletion of soil and water resources, hence, hampering fertility and reducing yield for farmers, especially

Table 1: Definitions, sources and measurement of variables

| Variable | Definition | Source | Measurement |
|----------|---|--|---|
| FPI | It covers food crops that are considered edible and that contributes nutrients | World Development Indicators (WDI) of World Bank Publications 2017 | Constant dollar per person |
| CO2 | It is measured by emission per capita. This is the total carbon dioxide emission divide by the population | -do- | Metric tons per capita |
| PCI | Per capita income is simply the income per person in an economic aggregate | -do- | Constant \$US 2000 |
| PGR | This is the rate at which the population changes over time | -do- | Total population annual % |
| AGL | This is the land dedicated to agriculture | -do- | The land for agriculture % of land area or sq. km |

Source: Author's compilation

for subsistence farmers who can hardly afford climate smart farming. The situation has generally grown worse for rural and urban household who rely on raw food supply from subsistence farmers. The depletion of the environment overtime seems to be altering the climate, culminating into excess rainfall which has consistently wash away farmland in major food processing

Table 2: Unit root test

| Variables | Augmented Dickey-Fuller | | Philip-Perron | |
|-----------------|-------------------------|------------------|---------------|------------------|
| | Level | First difference | Level | First difference |
| FPI | -0.6327 | -4.7643 | 0.4505 | -7.2704 |
| CO ₂ | -2.2141 | -6.7186 | -2.4261 | -6.7373 |
| AGL | -0.6589 | -6.8731 | -0.7879 | -6.8944 |
| PCI | -0.7921 | -5.1027 | -1.7473 | -3.2595 |
| PGR | -1.8357 | -4.2505 | -2.7812 | -2.5079 |
| Critical value | | | | |
| | Level | First difference | | |
| 1% | -3.5885 | -3.5812 | | |
| 5% | -2.9297 | -2.9266 | | |
| 10% | -2.6031 | -2.6014 | | |

Source: Author's computation

Table 3: Johansen co-integration test (Trace)

| Cointegration rank | Trace test | | | |
|---|---------------------|------------|----------------|---------|
| | Eigenvalue | Statistics | Critical value | P-value |
| None | 0.908648 | 150.0426 | 69.81889 | 0.0000 |
| At most 1 | 0.431815 | 47.14189 | 47.85613 | 0.0583 |
| At most 2 | 0.286748 | 22.83363 | 29.79707 | 0.2543 |
| At most 3 | 0.137670 | 8.303044 | 15.49471 | 0.4336 |
| At most 4 | 0.043980 | 1.934001 | 3.841466 | 0.1643 |
| Johansen co-integration (Max-Eigen value) | | | | |
| Cointegration rank | Maximum Eigen value | | | |
| | Eigenvalue | Statistics | Critical value | P-value |
| None | 0.908648 | 102.9007 | 33.87687 | 0.0000 |
| At most 1 | 0.431815 | 24.30827 | 27.58434 | 0.1243 |
| At most 2 | 0.286748 | 14.53058 | 21.13162 | 0.3231 |
| At most 3 | 0.137670 | 6.369043 | 14.26460 | 0.5663 |
| At most 4 | 0.043980 | 1.934001 | 3.841466 | 0.1643 |

Source: Compiled by authors'

Table 4: Normalized co-integrating estimates (standard error in parenthesis)

| Ln FPI | Ln CO ₂ | Ln AGL | Ln PCI | Ln PGR |
|----------------|--------------------|------------|-----------|-----------|
| 1.000 | 0.226277 | -4.307798 | 0.435705 | -8.657171 |
| t-stat | (0.07673) | (0.19491) | (0.12778) | (0.42620) |
| Standard error | [2.9490] | [22.11015] | [3.4098] | [20.3125] |

Source: Compiled by authors'

Table 5: Vector error correction result

| Variable | Error correction coefficients | | | | |
|----------------|-------------------------------|--------------------------|-------------------------|-------------------------|-------------------------|
| | $\Delta(\text{Ln FPI})$ | $\Delta(\text{Ln CO}_2)$ | $\Delta(\text{Ln AGL})$ | $\Delta(\text{Ln PCI})$ | $\Delta(\text{Ln PGR})$ |
| ECM_1 | 0.24418 | 0.020433 | 0.40908 | 0.010004 | 0.028203 |
| Standard error | (0.02655) | (0.08345) | (0.01613) | (0.02513) | (0.00185) |
| t-statistics | [-0.54303] | [0.24486] | [2.53641] | [0.39803] | [15.2695] |

Source: Compiled by authors'. ECM: Error correction model

states. The occurrence has plunge regions into hunger; seriously affecting rural and urban dwellers. The former rely on proceeds from their farm produce for livelihood while the latter depend on farm produce to meet their food demand. The inability to meet these needs as further deepen by environmental degradation has culminated into expended cycles of hunger and poverty. The unfortunate situation is that most of states vulnerable to this depletion are central to agriculture production. For instance, in the third quarter of 2018, 10 states², 103 local government areas and 1.9 million people were affected by severe flooding. The incidence was particularly persistent in States like Jigawa, Kebbi, Anambra, and Kogi where farmers lost all that were planted. According to FAO assessment, achieving the zero hunger targets by 2030 might be thwarted due to the effect of environmental degradation in Nigeria. It further posits that agriculture sector absorbs about 22% of the total damage and losses caused by natural hazards. This disaster jeopardizes agricultural production and development and often posed adverse consequences on the economy.

Furthermore, the result shows a direct relationship between food production index and agricultural land, as a 100% change in agricultural land results in about 430% change in food production index. This implies that the larger the available land for agriculture out of the possible land area, the greater the potential for food production growth. Hence, government at all levels must deliberately intensify efforts to expand the proportion of land available for agricultural practises by implementing policies restricting grabbing of arable land for residential and industrial purposes and support intended farmers with land clearing and fertilizers for enhancing soil fertility. In addition, the result shows that food production responded inversely to GDP per capita. This evidence could have resulted due to the environmental Kuznets curve hypothesis or the wide disparity in income distribution in Nigeria. Considering the former, the hypothesis suggests that at the early stages of development, pollution rises with income. The rising pollution causes more degradation and hence hampering food production via its numerous consequences on the environment. On the other hand, the highly skewed income distribution enables the rich to develop taste for expensive imported food items hence jeopardizing local production. Finally, population growth rate exerts a positive influence on food production. This evidence suggests that increase in population results in corresponding increase in food production, though less proportionate. The evidence conforms to Malthusian theory that population grows at a rate faster than its subsistence.

2 Kebbi, Niger, Kwara, Edo, Kogi, Anambra, Rivers, Bayelsa, Delta, Taraba, Benue, and Adamawa.

5.3. VECM

The restricted VAR (VECM) is adopted in this study for estimation purposes due to the presence of co-integrating relationship between the variables. The model incorporates the error correction model (ECM) which shows the extent of convergence among variables in the long run while also correcting the short run errors that occur in the model. For the purpose of satisfying the stability condition, the coefficient of the ECM should be negatively signed, the absolute value must lie between 1 and 0 and the t-statistics must be statistically significant. The first characteristics explain the convergence in the long run, the second measures the rate of error correction while the last characteristic is of statistical significance which captures the speed of error correction.

From the results in Table 5, the coefficient of the ECM for the model of interest satisfies the three conditions for convergence. This suggests that about 24.4% of the short run disequilibria are moderately corrected on the long run equilibrium path.

6. CONCLUSION AND RECOMMENDATION

Food insecurity is an endemic phenomenon; it is a source of major worldwide concern in the face of growing global population. But this problem is more severe in developing countries such as Nigeria not only because of the relatively high prevalence of poverty, but also due to the myriad of environmental problems that characteristically plague mainly developing countries; such as deforestation, desertification, carbon emissions, water and air pollution. These environmental issues pose a considerable hindrance to food security through their negative effects on agricultural resources; exacerbating the already present issue of food import dependence. This has necessitated this study to examine the relationship between food security and environmental degradation using an annual data for the period 1970-2017. The Johansen Co-integration was used for analysis and results obtained showed an inverse relationship between food production and environmental degradation.

This shows that for food production to be promoted and thereby food security boosted, environmental degradation arising from carbon and fossil emissions must be minimized to the barest minimum, sustainable consumption should be prioritized and improved farming methods should be used to maximize output from agricultural land.

In conclusion, the following policy measures are recommended to promote food security in the Nigerian economy: based on the test results, carbon emissions had a negative and significant relationship with food production over the study period, as expected. Thus, government must implement policies to restrict emissions, such as taxes on goods that produce such emissions, greater use of renewable sources of energy, increased emphasis on recycling – with special focus on plastics as against burning them. Also, given the obtained inverse, policies should be geared towards sustainable consumption and production measures. In the same manner, government should gear efforts at cultivation of more arable land, incentivising private sector participation in

agriculture on a larger scale and promotion of capital intensive methods of farming to increase output.

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