

# Climate Change Vulnerability, Food Insecurity and Poverty Nigeria

<sup>1</sup>Isreal Obisike Onuoha,  
<sup>2</sup>Samuel Oseloka Okafor  
& <sup>3</sup>Chris Ulua Kalu

<sup>1,2&3</sup>Department of Economics,  
Nnamdi Azikiwe University,  
Awka

**Article DOI:**

10.48028/iiprds/ijdshms.v14.i1.16

**Keywords:**

Carbon emission,  
Climate change, Food  
inflation, Food  
insecurity, Nigeria,  
Vector autoregressive  
distributed lag

*Corresponding Author:*

Isreal Obisike Onuoha

## Abstract

One of the most challenging issues in the world today is how to provide sufficient food to more than seven billion people including Nigerians around the global. This paper examined the impact of climate change, food insecurity on poverty in Nigeria from 1986 to 2022. The paper was anchored on the neoclassical theory of poverty, while the variables of this paper included poverty headcount ratio, carbon emission, food inflation, unemployment, real gross domestic product, health index, education index, and corruption and energy consumption. These variables were sourced from the Central Bank of Nigeria and the National Bureau of Statistics respectively. The techniques utilized in this paper are the Granger causality approach and the vector error correction modeling involving the impulse response function and variance decomposition. From the Granger causality results, there was a unidirectional causality between poverty headcount ratio and climate change and no trace of causality between food inflation and poverty headcount ratio, however, from the variance decomposition result, unemployment had a major shock on poverty about 66 percent, while the impulse response function showed that a one-unit shock in unemployment caused poverty to rise speedily and is the quickest compared to climate change and food insecurity. This paper therefore recommended the promotion of employment opportunity in the public and private sectors for poverty reduction, as well as measures to reduce climate change and food insecurity in Nigeria.

### **Background to the Study**

Poverty is defined as lack, or possession of minimally adequate capabilities to function essentially (Umo, 2012). This definition extends the meaning of poverty beyond income and/or expenditure metrics. The importance of studying poverty in Nigeria now is a welcome development since Nigeria has been described as the poverty capital of Nigeria. Studying poverty would provide a deeper understanding of this development challenge in Nigeria. There has been an increasing agreement that sustainability is very relevant to food security, but its position is in the food security framework within the dimensions of food availability, accessibility, stability and affordability (Smith & Gregory, 2013). For others, sustainability should be considered as a separate fifth dimension of food security (Hanson, 2013). Food security means the availability of food in a country (or a geographical region) and the ability of individuals within the country to access, afford, and source adequate food stuff. The last version to the definition of food security came at the 2009 World Summit on Food Security which, within the Five Rome Principles for Sustainable Global Food Security, added a fourth dimension: that of stability as the short-term indicator of the ability of food systems to withstand shocks, whether natural or man-made (FAO, 2009).

Vulnerability (to climate change) has been defined as the extent to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate change variability and extremes (Ahmad & Fajher, 2009). Climate change makes it harder to find sustainable solution to other problem including that of poverty and food insecurity. It is widely accepted that climate change would directly affect the availability and distribution of water in the future. During the next 50 years, Western Himalayan glaciers are projected to melt significantly, and this will be accompanied by increased rainfall thus further increasing frequency of flooding of the rivers. However, subsequently, the river flows and rain would diminish adversely affecting production of food and other crops thus adding to food insecurity and poverty in Nigeria (Igbal, Ahmad & Mastafa, 2015).

Food insecurity in Nigeria is currently at alarming rate calling for urgent and immediate intervention. Nigeria's ranking in Global Food Security Index (GFSI) has continued to increase since 2013 (ranked 86 among 107 countries with 33/100 score) and reached a disturbing rank of 94 (with 48.4/100 score) 2019 GFSI overall ranking (the closer to 100 score the better) (EIU, 2019). Moreover, Nigeria overtook India which was previously regarded as the country with the highest number of people living in extreme poverty globally. Nigeria has overtaken India to become the world poverty capital with the highest number of populations living in extreme poverty reaching 86.9 million. It is quite alarming that the poverty situation in Nigeria is increasing. As of May 2020, 102.4 million Nigerians live in extreme poverty implying that an additional 15.5 million Nigerians have plugged into poverty in 24 months (World Data Lab, 2018; 2020). The precarious state of acute food insecurity in Nigeria is occasioned by chronic and hidden hunger, extreme poverty, corruption, conflict events (insurgency in the North East) and unfavourable climatic change.

Previous studies abound on the subject matter of climate change, food insecurity and poverty in the development literature. Some of these studies are: (Garcia, 2012; Nwosa, 2013; El-Ladan, 2014; Ayo *et al.*, 2014; Okoli & Ifeakor, 2014; Osuafor & Nnorom, 2014; Maitra & Rao, 2014; Wight *et al.*, 2014; Akinboade *et al.*, 2016; Etana & Tolossa, 2017; Etim *et al.*, 2018; Akinyetun, 2018; Ayinla *et al.*, 2020; Idumah *et al.*, 2016; Makinta *et al.*, 2016; Enakhe & Tamuno, 2021). However, majority of these papers focused either on poverty or unemployment or food insecurity, while Akinboade *et al.* (2016) focused on the determinant of food security. Wight *et al.* (2014) focused on poverty and household food insecurity. There are also different conclusions and results from these arrays of studies. Furthermore, there are different variables and different techniques from these papers. These conflicting results posed serious challenge to economic policy and clear understanding of climate change and poverty in Nigeria in the medium-to-the longer term. This paper is novel because it examined the combined impact of climate change and food insecurity on poverty.

The focus of this paper is on the following questions: i) What is the impact of climate change vulnerability and food insecurity on poverty in Nigeria? ii) What is the causality between climate change vulnerability, food insecurity and poverty in Nigeria?

Addressing these research questions is the focus of this paper. To achieve this objective, the variables of this paper are carbon emission, food inflation, and poverty headcount ratio, proxy for poverty. The other variables are unemployment, real GDP, health index, education expenditure and energy consumption. The inclusion of these variables in the model was justified by economic theory and applied research. The data for these variables were sourced by the Central Bank of Nigeria Statistical Bulletin (CBN), National Bureau of Statistics (NBS) and World Development Indicator (WDI, 2020). The variables were estimated using EView version 12 Econometric Software, employing the Granger causality and vector error correction approaches. The scope of this paper is from 1986 to 2022. The rest of the paper is structured as follows: Section 2 presents the stylized facts; section 3 addresses the methodological issues while section 4 presents the empirical results. Section 5 concludes with policy implications.

### **Conceptual Clarification**

Several authors have come up with dimensional approaches to defining the key concepts of the paper-poverty, food insecurity and climate change. Poverty: This involves a state of one who lacks a usual or socially acceptable amount of money or material possessions. Poverty is said to exist when people lack the means to satisfy their basic needs. Definitions of poverty really matter. They set the standards by which we determine whether the income and living conditions of the poorest in society are acceptable or not. Definitions of poverty are also important, as they influence the way interventions and policies addressing poverty are shaped. Despite, these issues of definition, there is no clarity as to how the term 'poverty' is used in practical terms, as the definitions are influenced by different disciplinary approaches and ideologies (Handley *et al.*, 2009). The absolute definitions of poverty are based on income (or consumption) in relation to a specific living standard or minimum income level deemed necessary to meet basic needs. In 1990, the

extreme poverty line for developing countries was set at US\$1 per person and a day. The US\$1-a-day threshold was adjusted in 2008 and increased to US\$1.25, and in October 2015 to US\$1.90 to reflect the actual national poverty lines in the 15 poorest countries (POVOCAL Net- the World Bank).

Food security, generally to availability and accessibility of food. Typically, a household is regard as food secured when its occupants do not live in hunger or the fear of starvation. It measures the resilience to future disruption or unavailability of critical mass of food supply due to various risk factors. Further, the World Health Organization (WHO) explained the three dimensions-food availability, food access and food use (WHO, 2014). These dimensions are explained thus: food availability is having enough food on a consistent basis; food access is having sufficient resources both economic and physical, to obtain appropriate use based on knowledge of basic nutrition and care as well as adequate water and sanitation. Table 1 copiously highlights these dimensions of food security.

**Table 1:** Effect of Climate Change on Food Security

<b>Food Security Dimension</b>	<b>Consequences of Climate Change</b>
Availability (enough food for consumption)	<p>Reduced agricultural production in some areas locally.</p> <p>Changes in the suitability of land for crop production; changes in precipitation patterns could affect the sustainability of rain-fed. Increases in temperature could lead to longer growing seasons in temperate regions.</p> <p>Co<sub>2</sub> fertilization could increase yields for those crops with the physiology to benefit from Co<sub>2</sub> enrichment.</p>
Access (obtaining food regularly)	<p>Lower yields in some areas could result in higher food prices.</p> <p>Loss of income due to the potential increase in damage to agricultural production</p>
Stability (Access to resources required to consume food)	<p>Instability of food supplies due to an increase in extreme events</p> <p>Instability of income from agriculture</p>
Utilization (quality and safety of food including nutrition aspects)	<p>Food security and health impacts include increased malnutrition.</p> <p>Ability to utilize food might decrease were changes in climate increase disease.</p> <p>Impact of food security due to changes in pests and water pollution</p>

**Source:** Ayo et al., (2014)

The United Nation Framework Convention on Climate Change (UNFCCC, 2005:197) defined climate change as “a change of climate, which is attributed directly or indirectly to human activity, that alters the composition of the global atmosphere, and in addition to natural climate variability, observed over comparable period of time”, while the Intergovernmental Panel on Climate change (IPCC, 2007:8) defined it as 'any change in climate over time whether due to natural variability or as a result of human activity'. Acceptably, climate change refers to the statistical properties of the climate system when considered over a long period of time, regardless of the cause. Meanwhile, change/fluctuations over periods shorter than a few decades do not represent climate change. The term is, sometime used to refer specifically to climate change caused by human activity, as opposed to changes in climate that may have resulted as part of the earth's natural processes. In this perspective, mostly within the context of environmental policymaking, the term climate change has become akin to anthropogenic global warming. However, global warming refers to surface temperature increases while climate change includes global warming and everything else that increasing free house gas levels will affect.

Generally, climate scientists agree that the major factors to the current global warming are human expansion of the “greenhouse effect”, warning that result when the atmosphere traps heat radiating from earth toward space. Greenhouse gasses, or gasses that contributes to the greenhouse effects, includes water vapour, carbon dioxide (Co<sub>2</sub>), Methane (CH<sub>4</sub>), Nitrous Oxide (N<sub>2</sub>O) and Chlorofluorocarbons (CFCS). Vulnerability to climate change refers to the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (EEA, 2012). Climate change is expected to impact on the agricultural sector in multiple ways, among others through increased variability with regard to temperature, rainfall, frequency and intensity of extreme weather events, changes in rain patterns and in water availability and through disturbances of the ecosystems. In the study, we measured climate change vulnerability by carbon dioxide (Co<sub>2</sub>)- carbon dioxide is the primary greenhouse gas contributing to recent climate change. Carbon dioxide enters the atmosphere through burning of fossil fuels, solid waste, tress and other biological materials.

### **Stylized Facts on Poverty, Food Insecurity and Climate Change in Nigeria**

Nigeria by all standards is the giant of Africa but ironically the poverty capital of Africa. Despite the great endowment and opportunities, the country has been characterized by abject poverty. Poverty has become serious issue in Nigeria as a greater proportion of the population is in abject poverty (Ozughalu, 2010). In the 1960s, the poverty level was estimated at 15 percent. Twenty years after precisely 1980s, the poverty level in the country increased rapidly to about 66 percent and fourteen years after in the early 2000s, the poverty level in the country increased to 69.0 percent and it was estimated to increase again to 71.5 percent in the years (National Bureau of Statistics 2012a, 2012b). In terms of



per capita income, the country has been declining over the years and has become very low in recent times. It is regrettable to observe that though the country has experienced high and impressive economic growth rates over the years in the past recent times, these have not translated into significant reduction in unemployment rate and significant reduction in poverty. In 2018, six of the 10 fastest-growing economies in Africa were in West Africa (Cote d'Ivoire, Senegal, Ghana, Burkina Faso, Benin and Guinea), and Cote d'Ivoire, Ghana and Senegal were among the 10 fastest-growing economies in the world (Coulibaly, 2019).

The region has seen impressive economic growth, and, in a few countries, this has been matched by a significant reduction in poverty levels. However, in most countries the benefits of the unprecedented economic growth have gone to a tiny few. Inequality has reached extreme levels in the region, and today the wealthiest 1% of West Africans own more than everyone else in the region combined. In Nigeria, Africa's largest economy, the richest man earns about 150,000 times more from his wealth than the poorest 10% of Nigerians spend on average on their basic consumption in a year. It would take 46 years for the richest Nigerian man to spend all of his wealth, even if he spent it at a rate of \$1 million a day (Oxfam, 2019). It would cost about \$24bn a year to lift all Nigerians above the extreme poverty line of \$1.90 a day by comparison, the wealth of the five richest Nigerian men combined stands at \$29.9bn-more than the country's entire in the past three years. Nigeria's stark level of inequality are comparable only to those in Brazil, where the richest 5 percent of the population have as much wealth as the remaining 95 percent (the six richest men in Brazil have as much wealth as the poorest 50 percent of the population over 100 million people). Poverty in Nigeria has over the years been a rural phenomenon than urban poverty. Also, poverty has often been more pronounced in Northern Nigeria than in Southern Nigeria. This has been traced primarily to lack of Western education. The rich are apparently getting richer while the poor are getting poorer. There is evident gross inequality in the distribution of income and wealth in Nigeria. The 2018 Harmonized Nigeria Living Standard Survey shows that the per capita expenditure and consumption of the poorest quintile (FGN, 2017) and as such, the Gini coefficient-the measure of inequality for Nigeria increased from 0.4296 to 0.447 between 2017 and 2019 (National Bureau of Statistics, 2018). Most studies of the World Bank classify Nigeria among the top five poorest nations in the world; in fact, the country is rated third home to poor people, shattering 7.0 percent of the entire global poor people.

Poverty dynamics is a real dynasty and over the past years to the recent period, the standard of living of Nigeria has deteriorated and continued to decline. Some policy agenda of the Nigerian government to reverse the trend of poverty in Nigeria is ongoing. To reduce the impact of poverty on the household and the entire economy, the following policy measures have been adopted by the government. First, investment in critical infrastructure to drive the development of the real sector of the economy such as in the areas of transport, energy, agriculture and water supply is imperative. Second, the government has also instituted governance and institutional reforms to strengthen policy making, implementation and tax administration. The government has also tried to reduce

shocks resulting from oil price instability by strengthening and consolidating the emerging growth in non-oil production and revenues. Strengthening fiscal discipline, financial management and accountability would promote efficient uses of the scarce resources for development which in the long run reduce poverty. Some other policy measures are sustenance of policies and reforms, and particularly fiscal and monetary policies to provide stable economic policy framework.

Other programmes designed to facilitate development and impart positively on the quality of life of the poor include River Basin Development Authorities (RBDAs), the National Agricultural Land Development Authority (NALDA) and the Directorate of Food, Roads and Rural Infrastructure (DFRRI). In addition, Special Relief Programmes targeted at poverty reduction include the National Directorate of Employment (NDE); Family Support Programme, later replaced by the Better Life Programme and again changed to Family Economic Advancement Programme; the People's Bank, Community Banks, rural health schemes and the Expanded Agency whose purpose is to mobilize and encourage the participation of rural people in development. Also, the Action Programme for Poverty Alleviation (CAPPA), the Universal Basic Education (UBE), the Poverty Alleviation Programme (PAP) and the National Poverty Eradication Programme (NAPEP) (Ogwunike, 2001). The efforts by the government to tackle poverty situation were addressed within the broader policy objectives of national development as the following targets were set in the nation's rolling plan:

- i. Reduction of overall incidence of poverty to 20 percent by the year 2010:
- ii. Ensuring adequate availability of infrastructure and access to land, credit and technology by the poor: and
- iii. Ensuring increase in primary school enrolment from the current level of 69 percent to 100 percent and adult literacy rate from 52 percent to 76 percent by the year 2010.

Meanwhile, twelve years afterward, precisely 2022, these targets (particularly the first target) are far from being met since over 50 percent of Nigerians are still living in absolute poverty. This implies that the nation's poverty reduction efforts have not been able to attain the desired results. Data from the World Bank poverty and shared prosperity report shows that Nigeria's poverty level has further increased in the wake of the COVID-19 pandemic. More specifically, 79 million people in Nigeria live in extreme poverty, accounting for 20 percent of the people living in poverty in SSA (CSEA, 2022). COVID-19 and its associated economic crisis are enabling factors of the high-power headcount. Data from COVID-19 phone surveys in Nigeria suggest that about 85 percent of households experienced higher food prices, with half reducing their food consumption as coping strategists. The upward trend in poverty is expected to continue based on broad economic growth, inability to create jobs, and high population growth rate. According to the 2022 Global Hunger Index (GHI) report, Nigeria ranked 103<sup>rd</sup> out of 121 countries, suggesting Nigeria's weak and fragile food system. The GHI is a tool for measuring and tracking hunger at global, regional and national levels. It is calculated based on the values of four component indicators- undernourishment, child wasting, child stunting and child

mortality- Nigeria's index score in the 2022 report is 27.3, which is more than five times the score of Belarus, which is the hunger with the lowest hunger level. Conflicts and climatic disaster have hampered food production in Nigeria, causing shortages that have progressively raised food prices and general inflation rates. The current flood disaster in Nigeria also affects food and agricultural production in several (food producing) states. This may likely affect food production in the coming years and could result in a shortage of food supplies, higher food and general inflation rates, and a more profound hunger crisis in the nations. There is need for the government to increase productivity and boost production levels. There is an urgent need to increase investment in climate mitigation and adaptation by both the private sector and the government. This call is necessary to reduce the occurrence of climate-induced disasters like floods and their effects on the nation's food security.

Food prices in Nigeria experienced a further increase in September 2022, according to the selected food prices Watch report for September 2022, published by the National Bureau of Statistics (NBS, 2022). The report highlighted the change in price of some selected food item. For example, the average price of 1kg of Tomato on a year-on-year (YOY) basis increased by 30.06 percent, from N342.25 recorded in September 2021 to N445.12 in September 2022 on a month-on-month (MoM) basis; 1kg of tomato increased by 3.29 percent to N445.12 in September 2022 from N430.93 recorded in August 2022. Also, the average price of 1kg of rice (local, sold loose) increased on a YoY basis by 13.14 percent from N492.13 recorded in September 2021 to N556.81 and so a MoM basis; 1kg of beans rose by 2.05 patterns from N545.61 in August 2022. Tomato, rice, and beans are major food items consumed daily in Nigeria (CSEA, 2022). Food is a necessity and a must-have for every household, implying that the increase in food prices leaves many households worse-off. The rising prices can be attributed to disruptions in food supply occasioned by insecurity and recent floods in most part of the country. Hence, there is a need to support farmers by addressing the problem of insecurity and flooding as well as providing them with improved seedlings to boost.

The National Agricultural Food Strategy Programme was launched in 1987 in response to the need for greater capacity to respond to food security challenges during disasters. The public food reserve system is a 3-tier programme that includes the strategic grain reserve operated by the federal government, the buffer stock programme operated at the state level, and on-farm storage operated at the local government level. The strategic reserve programme started with six grain silos in regions where the reserved crops are mostly produced and has gradually expanded to 33 silos already in operation. The states are expected to build and manage warehouse for reserving, but there are no hard facts about the limits of programme implementation. In addition to public reserves, private reserves are held by farmers, traders/middlemen, merchants, millers as well as private companies using grains as raid materials. It is estimated that grain merchants, traders and middlemen dominate private reserve holdings in the northern zones while private companies and marketers dominate in the southern zone. In general, the main objectives of the food reserve system are:



Across both developed and developing countries, the objective of food security is typically pursued by establishing and maintaining adequate food reserve levels and efficiently releasing stored food during periods of relative scarcity and rising prices. Throughout the years, public food reserves were considered salient to food security and construction and maintenance of reserves were active components of food security policies and reforms. However, maintaining public food reserve infrastructure (Silos) is costly, and met with difficulties. In many countries including Nigeria, public food reserve programmes became cost centres with limited effectiveness, to the point that they were considered inefficient ways of ensuring food security in the country.

The Food Reserve Silos Programme was first introduced in Nigeria in 1957 by the government of the Western region as a form of support to farmers to enable them to store excess grains during the immediate post-harvest periods of low prices and sell them back to the market during periods of rising prices. Although public support is provided, the food reserves are owned and managed by the farmers. Prevention of post-harvest crop losses, estimated between 20 percent and 35 percent of annual production, arising principally from poor on-farm storage mechanisms adopted by poor farmers (Alonge *et al.*, 2011). Always Making food available at affordable prices by stabilizing food prices, encouraging farmers to remain in production and make food available during the off-harvest seasons. Provision for first line of response in times of internal disaster, including but not limited to floods, droughts, fires, and ethnic and social conflict leading to displacement of people from their domain of economic activities and then, give assistance to friendly countries in times of disaster.

In Nigeria, the four main climate change-related hazards (BNRCC, 2011) are: (i) increased temperature; (ii) change in amount, intensity, and pattern of rainfall, (iii) extreme weather events (including sea surge and drought), and (iv) sea level rise. These climate change-related hazards are already impacting the various sectors and activities in the Nigerian economy, including agriculture, (crops and livestock); forests, biodiversity; health and sanitation; human settlement and housing; energy, transport, and communications; industry and commerce; disaster, migration and security; livelihoods; and vulnerable groups (BNRCC, 2011; NASPA, 2011). The key impacts of climate change in Nigeria have resulted in sahelisation; loss of coastal zone infrastructure, loss of settlements, loss of agricultural land and harvests; reduced hydrocarbon extraction activities (Niger-delta case) and increased risk of oil spills; high food insecurity; negative effects on human health and lives; damaged transport routes; negative effects on electricity supply and distribution (Filho *et al.*, 2018; Ngigi, 2009). Sahelisation has led to increased and unpredictable dry season rains, rapid contraction of Lake Chad due to drought, which has shrunk significantly in size within the last 40 years. Decreased agricultural productivity in the country threatens and predisposes the nation to food insecurity. Also, reduced water availability for irrigation as well as desertification of the Guinea Savannah region are impeding agricultural and livelihood activities; how much more the increased social tensions in many parts of the country due to recurrent conflicts between farmers and pastoralists (climate refugees) coming from the north to seek water and pasture for their

herds in the Southern part of the country. The negative impact of climate change on human health result from higher temperatures, higher humidity, increased flooding, reduced freshwater availability, increased number of pests, and breeding sites, increased exposure to vector-borne (e.g. malaria) and water-borne (e.g. cholera) disease, increased heat stress mortality and increased risk of malnutrition (due to food insecurity, shortages or famine) are all climate-laden. The increase in malaria alone is expected to impact on annual GDP growth rate negatively. On infrastructure, climate change results in torrential flooding and storms, which results in damaged transport routes?

The approach adopted by the Nigerian government to tackle climate change impacts on sustainable growth has increasingly generated concerns among stakeholders over the trillions of Naira that is being lost annually to environmental problems such as erosion and desertification. The N19 billion Nigerian Erosion and Watershed Management Project (NEWMAP) is a project funded by the federal government in collaboration with the World Bank under the auspices of International Development Association (IDA), the Global Environment Facility (GEF) and the Special Climate Change Fund (SCCF). This funding facility was earmarked for seven states namely: Abia, Anambra, Cross River, Ebonyi, Edo, Enugu and Imo State. The intervention is a part of the ecological funds by the government with 2 percent allotted for general ecological problems in any part of the country and 3 percent specifically for the Niger Delta region to be derived from mineral revenue as well as the federation account. The laws guiding the eco-fund which was established in 1981 through the Federal Account Act with the prone objective of pooling finances for the execution of environmental projects was modified as Decree 36 in 1984, 106 in 1992 and 202 as a sub-unit of the Federation Account Modification Order. Although the said an upward re-evaluation of the allocation from the Federation Account from one percent in 1987 to three percent at the turn the new millennium, the allotted capital stipulated environmental schemes has been deemed insufficient. In Nigeria, the agriculture and food security sectors are particularly vulnerable to climate change. Most vulnerable regions are coastal regions and erosion and desertification prone areas in the southeastern and northern parts of the country respectively. While everyone is vulnerable, the most vulnerable groups are farmers, and poor people living in urban areas.

Responding to climate change falls into two broad classes of action, mitigation and adaptation. Mitigation refers to measures that may either reduce the increase in greenhouse emissions (abatement) or increase terrestrial storage of carbon (sequestration). Adaptation refers to all the responses that may be used to reduce vulnerability. Nigeria has taken the challenge of climate change seriously. The First National Communication was produced in November 2003). A stakeholders' initiation workshop on the Second National Communication (SNC) took place in December 2009, and is being finalized and a National Adaptation Strategy and Action Plan (NASPA) has been concluded. Nigeria now has a Climate Change Department (CCD) in the Federal Ministry of Environment in Abuja, Nigeria. The CCD is created to implement the Climate Convention and protocol activities. It also coordinates the activities of the Inter-

ministerial committee on climate change. Nigeria already has several policies and strategic initiatives which if properly implemented in these policies (example, Oases rehabilitation in National Action to Combat Desertification and National Policy on Drought and Desertification) can be taken as anticipatory adaptation measures and plans, which can be fine-tuned into policy options for climate change response in the county. This comprehensive policy and response will enable these policies to translate into meaningful inter-sectoral activities for sustainable environmental management.

The complexity of the challenges and opportunities of climate change can be represented in the anthropogenic space (human-induced factors). This human induced relationship can enhance or limit the progress towards the achievement of the Sustainable Development Goals (SDGs). Increased climate change resulting from changing weather patterns and extreme weather events would lead to a shortage of natural resources like water. Water shortages in hydroelectric power capacity or for irrigation impede development in the sense that it results in low industrial capacity, food insecurity, hunger, high food prices and poverty. On the other hand, reduced climate change in terms of reforestation and production of solar-powered infrastructure and renewable energy use would lead to reliable power and economic empowerment that contribute to sustainable development, to the extent that it would reduce resource competition and communal conflicts. Similarly, climate change is not all about negativities or challenges. Climate change has the potential opportunities for improving positive transformation from a grey economy (industrialization based on fossil fuels) to a green economy is built on low carbon and/or carbon neutral development pathways.

As required in the SDGs, development of societies requires simultaneous growth in all the sectors of the economy such that the social services, environmental, economic and health management, as well as government policies are established and sustained (Nwuzor, 2015). The SDGs are thus, further classified into four dimensions, including social, economic environmental and governance sustainability. While governance is recognized as a cross-cutting issue in sustainability, the other three dimensions can be disaggregated and administered based on the country's established institutions; Ministries, Departments and Agencies (MDA). The MDA have established a policy framework of administration, monitoring and evaluation. The classification could also engender policy for domestication and operationalization of the SDGs. In the case of social policy framework, we have SDG 1-7, for economic policy, we have SDG 8-12, while an environmental policy framework will comprise related issues on SDGs 13-15. Table 2.4 show climate change and Sustainable Development Goals (SDGs).

**Table 2.:** Climate Change and Sustainable Development Goal

	Sustainable Development Goals (SDGs)	Climate change challenge	Opportunities for the Transformation
	1. End poverty in all its forms everywhere	Shortages of resources, vulnerability to flooding, spread of disease	Income sources, women's empowerment, reliable power, reliable energy
	2. End hunger, achieve food security and adequate nutrition for all and promote sustainable agriculture	Conflict, food insecurity, high food prices, land used to grow crops for biofuel instead of food, vulnerability to flooding, changing weather patterns and extreme weather events	Reduced competition and conflict, tree nurseries, income sources, solar drying of fruits, green along riverside for flood resilience.
	3. Attain a healthy life for all at all ages	Shortage of resources, unnecessary car use, food insecurity, spread of disease	Alleviation of related health problems.
	4. Provide equitable and inclusive quality education and life-long learning opportunities for all.	Conflicts, unplanned migration	Reduced competition and conflicts, women's empowerment.
	5. Attain gender equality, empower women and girls everywhere	Conflicts	Women empowerment
	6. Secure water and sanitation for all for a sustainable world	Shortage of resources, changing weather patterns, deforestation	Green along riverside for flood resilience, reforestation, forestation
	7. Ensure access to affordable and reliable modern energy services for all		
	8. Promote strong, inclusive and sustainable economic growth and decent work for all	Higher food prices, energy consumption, unplanned migration, shortage of resources	
	9. Promote sustainable industrialization	Energy consumption, conflict, shortages of resources	Renewable energy, reliable power.

**Source:** Adapted from Olayide (2018).

**Table 3:** Climate Change and Sustainable Development Goal Continued

1. Reduce inequality within any among countries	Conflict, changing weather patterns and extreme weather events	Women’s empowerment, income source, reduced competition and conflict
2. Build inclusive, safe and sustainable cities and human settlements	Shortages of resources, vulnerability to flooding, unnecessary car use.	Fuel efficient cars, renewable energy reduced competition and conflicts, production of solar equipment and training of solar entrepreneurs
3. Promote sustainable consumption	Shortage of resources, deforestation, food insecurity, energy consumption, unnecessary car use.	Reforestation, solar drying of fruits, energy consumption, reliable power
4. Promote actions at all levels to address climate challenge	Changing weather patterns and extreme weather events, deforestation, vulnerability to flooding, unnecessary car use	Afforestation, reforestation, fuel-efficient cars, renewable energy, production of solar equipment and training, green along riverside for flood resilience.
5. Attain conservation and sustainable use of marine resources, oceans and seas	Changing weather patterns and extreme weather events, vulnerability to flood, water shortages, decrease in hydroelectric power capacity	Green along riverside for flood resilience
6. Protect and restore terrestrial ecosystems and halt all biodiversity loss.	Deforestation, unplanned migration, conflict	Tree nursery, reforestation
7. Achieve peaceful and inclusive societies, rule of law, effective and capable institutions	Conflict, unplanned migration, changing weather patterns, extreme weather events vulnerability to flooding	Reduced competition and conflict reforestation
8. Strengthen and enhance the means of implementation and global partnership for sustainable development	Conflicts, unplanned migration, spread of disease	Women’s empowerment, income source, reduced completion and conflict, energy conservation, buying fruits and vegetables from a developing world.

**Source:** Adapted from Olayide (2018).

## Theoretical Framework and Methodology

### Theoretical Framework

Climate conditions such as floods, droughts and extreme temperature are some of the consequences of climate change. These conditions have led to crop loses and has threatened the livelihood of farmers as well as poses food security with attendant consequences born by the poor. The Neoclassical theory of poverty is the theoretical framework of this paper. This theory emphasizes on the economics of uncertainty as a cause of poverty. Economic uncertainty refers to a situation in which the further economic environment is difficult to predict, and there is a high degree of risks or unknowns involved. This can be caused by a variety of factors, including political instability, changes in government policies, natural disaster like climate change and market fluctuation.



Climate change and food insecurity are shocks that affects the economy which has negative impact on the poor households.

Conventionally, there are some models that have been widely used to assess the economic impacts of climate change on food production (Hassan, 2008). This is the Ricardian cross-sectional model. The model simple examines how climate in different places affect the net revenue of household. It accounts for the direct impacts of climate on yields on different crops as well as the indirect substitution of different inputs, introduction of different activities, and other potential adaptation by farmers to different climates. Thus, the greatest strength of the model is its ability to incorporate the changes that farmers would make to tailor their operations to climate change. However, despite this major advantage that the model has been criticized on the grounds that (i) crops are not subject to controlled experiments across farmers as the cause with other models of climate change evaluation. It also fails to account for the effect of factors that do not vary across space such as carbon dioxide (Co<sub>2</sub>) concentration that can be beneficial to crops (Fonta *et al*, 2010).

The Ricardian model is captured in the following equation:

$$V = \sum P_i Q_i (X, F, H, Z, G) - \sum P_x X \quad 1$$

where  $P_i$  is the market price of crop  $i$ ,  $Q_i$  is the output of crop  $i$ ,  $X$  is a vector of purchased input (other than land),  $F$  is a vector climate variable, it is a water flow,  $Z$  is a set of soil variables,  $G$  is a set of economic variables such as market access and  $P_x$  is a vector of input prices. The farmer is assumed to choose  $X$  to maximize net revenues given the characteristics of the farm and market prices. The Ricardian model is a reduced form model that examines how several exogenous variables,  $F$ ,  $H$ ,  $Z$  and  $G$ , affect farm value. The standard Ricardian model relies on a quadratic formulation of climate:

$$V = \beta_0 + \beta_1 F + \beta_2 F^2 + \beta_3 H + \beta_4 Z + \beta_5 G + \mu \quad 2$$

Where  $\mu$  is an error term, both a linear and a quadratic term for temperature and precipitation are introduced. The quadratic term reflects the non-linear shape of the net revenue of the climate response and food insecurity functions. The empirical model of this study is presented in the next section.

### Model Specification

The model of this study to be estimated followed the Ricardian model with structural modifications of the Nigerian economy, and since the objective of this study is to examine the impact of climate change and food insecurity on poverty. The model is specified in its mathematical and theoretical forms as follows:

POV = F (climate change, food inflation, unemployment, RGDP, health index, education expenditure, corruption index, energy consumption)

This implies that poverty is a function of climate change and food inflation as the major independent variables, while unemployment, real gross domestic product (RGDP), health, education, corruption and energy are the control variable. Equation (3) transformed into estimable form becomes.

$$POV = \beta_0 + \beta_1 Co2 + \beta_2 FOODINF + \beta_3 UNM + \beta_4 INF + \beta_5 RGDP + \beta_6 HEL + \beta_7 EDU + \beta_8 CPT + \beta_9 ENECON \quad 3$$

Taking into cognizance the formulation of climate change and food insecurity following the Ricardian model, and the linearity of the functional formation, equation (3) becomes:

$$POV = \beta_0 + \beta_1 LnCo_2 + \beta_2 FOODINF + \beta_3 UNM + \beta_4 RGDP + \beta_5 LnHEL + \beta_6 LnED + \beta_7 LnCPT + \beta_8 LnENECON + \mu \quad 4$$

Where POV is the dependent representing poverty (Poverty headcount ratio); C02 = carbon emission, proxy for climate change, FOODINF = Food inflation, proxy food security; UNM represents unemployment, RGDP is real GDP; HEL represent health (Life expectancy); ED represent education (School attainment), CPT represent corruption and ENECON represents energy consumption. Where the variables included has already been explained,  $L_n$  represents the logarithmic value for proportional representation and for linearity purposes,  $\beta_0 - \beta_{10}$  are the parameter coefficients and  $\mu$  represents the stochastic term. On the theoretical assumptions, carbon emission, food inflation, unemployment, corruption (weak institution) is expected to impact negatively on poverty while real GDP, health index and education index are expected to impact positively on poverty.

### Estimation Technique and Procedure

The estimation techniques adopted for this study are the Granger (Johansen) causality test. Traditional Granger Causality tests developed by Engle and Granger (1987) and Johansen and Juselius (1990) have been relied upon for identification of direction of such relationships due to their ease of application and wide applicability. The inclusion of the error correction term in the model helps to capture the long-term causal relationships thereby making causality test meaningful. It's used to verify the usefulness of one variable to forecast another. A variable is said to: Granger-cause another variable if it is helpful for forecasting the other variable. Fail to Granger cause if it is not helpful for forecasting the other variable. The decision rule is if  $p < 0.05$  then reject the null and conclude there is causality, else conclude there is no short-run causality. The Granger Causality Test is among the common methods of causality tests (Madueme, 2023).

Procedurally, the estimation starts with the descriptive statistics, which is employed to examine the characteristics of the variables of estimate. The descriptive statistics involves the measures of central tendency and the measures of dispersion. Central tendency is defined as the statistical measure that identifies as a single value as representatives of an entire distribution. It aims to provide an accurate description of the entire data. The 3 most common measures are the mean, median and mode. The mode is the most frequent value.

The median is the middle number in an ordered data set. The mean is the sum of all values divided by the total number of values.

In statistics, the measure of dispersion helps to interpret the variability of data, i.e to know how much homogenous or heterogenous the data is. There are five most commonly used measures of dispersion. These are the range, variance, standard deviation, mean deviation and quartile deviation. This test is a test to check the linear/collinearity among the exogenous variables. That is, to check whether two or more explanatory variables are exerting the same influence on the dependent variable. If there exist a relationship among the regressors, it becomes difficult to determine their coefficients. According to Gujarati and Porter (2009), if the correlation coefficient between any pair of regressors exceeds 0.8 then there is multi-co linearity between the two variables.

**Table 4:** Summary of Data Set

Notation	Description	Measurement	Source(s)
POHC	Poverty Headcount Ratio	Measure for poverty	National Bureau of Statistics (NBS)
CO2	Carbon emission	Proxy for climate change. Measured as metric tons	World Development Indicator (WDI)
FOODINF	Food inflation	Proxy for food insecurity. Measured as percentage of GDP	CBN
UNM	Unemployment	Measured in percentages	CBN, Bulletin
RGDP	Real GDP	Dividing normal GDP by the deflator	CBN Bulletin
HE	Health	Life expectancy	FMOH
ED	Education	School attainment	NBS
CPT	Corruption	The Corruption Perception Index	CPI
ENECOM	Energy consumption		Demographic survey/WDI

**Source:** Researchers' Compilation (2023)

## Empirical Results

**Table 5:** Descriptive Statistic Test Result

	POHC	CO <sub>2</sub>	FOODINF	UNEM	HEL	EDU	RGDP	CPI	ENECOM
Mean	1.275	0.6759	72.5215	13.76778	48.80272	0.6311	40361.1	-1.060	112.698
Std.Dev	1.1149	0.11807	23.7993	5.857864	2.74462	0.0766	19660.12	0.114	26.418
Skewness	1.710103	0.413018	-0.1427	0.854633	0.1397	0.4047	0.4135	-1.059	0.0735
Kurtosis	6.3312.5	1.973968	1.97142	4.797174	1.397	2.355	1.5826	5.323	1.4948
Jarque-Bera	34.192	2.602617	1.70903	9.227139	3.9693	1.6463	4.028	14.835	3.4305
Prob	0.0000	0.272175	0.4254	0.0099	0.13742	0.4390	0.133	0.000	0.1799
Observ.	36	36	36	36	36	36	36	36	36

**Note:** POHC = Poverty headcount ratio; CO<sub>2</sub> = Carbon emission (climate change); Food INF = Food insecurity; UNEM = Unemployment, HEL = Health indicator; EDU = Education indicator; RGDP = Real GDP; CPI = Corruption and ENECOM = Energy consumption.

**Source:** Researchers' computation using EView 12.

The mean value for poverty headcount ratio is \$1.275, which is less than \$2.15, using the international poverty line. This implies that the Nigerian poverty line is below the international standard of \$2.15 per day. In Nigerian Naira-equivalent, an average Nigeria spends N1,485.375 less the international standard of N2,504,75, while the mean (average) value for climate change (CO<sub>2</sub>) is 0.6759; food security (food INF) stood at 72.52% year-on-year (YoY).

The standard deviation for poverty headcount is 1.1149; CO<sub>2</sub> with 0.11807 while food security has 23.7993. Unemployment has 5.857 and health has 2.744. There was a decline in Nigeria's real GDP at \$19660 compared to \$488,964 in 2022, while the Nigerian GDP growth stood at 2.51% in the third (Q<sub>3</sub>) of 2023 as against the Nigerian GDP Growth rate of 3.2% in 2022. This growth rate is lower than 3.54% recorded in the second quarter of 2022 and may be attributed to the challenging economic conditions being experienced in Nigeria including the spiking inflationary pressure and the soaring depreciation of the domestic currency in the midst of high energy cost.

In relation to the skewness, all the included variables except food inflation (proxy for food security) and corruption were negatively skewed to the right. For the Kurtosis, poverty head count ratio and unemployment exhibited a platykurtic distribution ( $K > 3$ ), while carbon emission, food inflation, health indicator, education and RGDP. The probability values showed that poverty headcount ratio, unemployment and corruption are significant positively, while the rest of the variables are insignificant. There are 36 observations for this study-from 1986 to 2022. Generally, the table describes the several futures of the variables in terms of the measures of central tendency-the averages and the measures of dispersion-the standard deviation which measures the extent of the variability of these variables. Table 2 presents the correlation matrix, a measure of the multicollinearity of the included variables.

**Table 6:** Multicollinearity Test

Covariance Analysis: Ordinary  
Sample: 1986 2021  
Included Observation: 36

Correlation	PoHC	CO <sub>2</sub>	FOODINF	UNEM	RGDP	HEL	EDU	CPI	ENECOM
POHC	1.000000								
CO <sub>2</sub>	0.282352	1.000000							
FOODINF	-0.771776	-0.551293	1.000000						
UNEM	-0.562654	-0.503620	0.890537	1.000000					
RGDP	-0.673246	-0.699436	0.913230	0.811212	1.000000				
HEL	-0.670632	-0.762766	0.926852	0.861411	0.969025	1.000000			
CPI	0.389268	-0.667965	0.953889	0.940360	0.913875	0.961463	1.000000		
ENECOM	-0.563298	0.461663	-0.669153	-1.713458	-0.600383	-0.693796	-0.760537	1.000000	
EDU	-0.633407	-0.733136	0.801977	0.811968	0.892570	0.913741	0.858635	-0.551459	1.000000

**Source:** Researcher's computation using EView 12.

Tables 6 showed the multicollinearity test. This test is to check for the linearity among the exogenous variables. That is, to check whether two or more explanatory variables are

exerting the same influence on the dependent variables. If there exist such a relationship among the regressors, it becomes difficult to determine their coefficients. According to Gujarati and Porter (2009), if the correlation coefficient between any pair of regressors exceeds 0.8 then there is a multicollinearity between the two variables. From Table 2 the result showed that there is no multicollinearity between poverty headcount ratio (PoHC) and the explanatory variables (CO<sub>2</sub>, FOODINF, UNEM, RGDP, HEL, EDU, CPI and ENECOM).

Table 3 presents the stationarity test using the Augmented Dickey Fuller approach. If the Augmented Dickey Fuller calculated exceeds the tabulated, then the variables in question are stationary at the chosen level of significance and vice versa. This test was carried out alongside the Philip-Perron test (PP) as shown in Tables 7a and 7b.

**Table 7a:** Results of Stationarity Test (ADF)

Variables	ADF test stat.	5% Critical Value	Order of Integration	Decision
POHC	-5.125123	1% = -3.639	I(1)	Stationarity after First
CO <sub>2</sub>	-4.988501	5% = -2.95	I(1)	
FOODINF	-3.854519	10% = -2.614	I(1)	
UNEM	-4.093165		I(1)	
RGDP	-4.350769		I(1)	
HEL	-4.88454		I(1)	
CPI	-7.295094		I(1)	
ENECOM	-7.125729		I(1)	
EDU	-14.87038		I(1)	

**Note:** Critical value for ADF and PP (-1.94)

**Source:** Researchers' Computation using EView 12

The null hypothesis is generally defined as the presence of a unit root and the alternative hypothesis is either stationarity, trend stationarity or explosive stationarity. From the result of the stationarity test as presented in Table 3, the included variables are stationary after the first difference. This implies that the mean value and variance of the stochastic process are constant over time. Table 7b presents the stationarity test using the PP.



**Table 7b:** Result of Stationarity Test (Philip Perron)

Variables	ADF test stat.	5% Critical Value	Order of Integration	Decision
PoHC	-8.271755	1% = -3.632900	I(1)	Stationarity after First difference
CO <sub>2</sub>	-4.901678	5% = -2.948404	I(1)	First difference
FOODINF	-11.25173	10% = -2.612874	I(1)	First difference
UNEM	-4.124238		I(1)	First difference
RGDP	-4.605707		I(1)	First difference
HEL	-3.12502		I(1)	First difference
CPI	-7.521832		I(1)	First difference
ENECOM	-7.122074		I(1)	First difference
EDU	-13.54349		I(1)	First difference

**Source:** Researchers' Computation using EView 12

From the stationarity test in Table 7b using the PP approach, it was also shown that the variables are integrated at order one I(1) in compliance with the Augmented Dickey Fuller test. Since the variables are integrated of order 1, the appropriate method should be the Johansen co-integration test preceding the VECM specification approach. Following Granger's (1981) seminal paper on co-integration, this subject has received considerable attention in both theoretical and empirical research like the current study.

The general concept of co-integration is that there exists equilibrium or a long-run relationship between a set of time-series variables, provided that the series are integrated to the same order. The Johansen Juselius (JJ) approach was used. Hence when unit root tests are done to residuals and it's found to be stationary, the implication is that the variables in the model are co-integrated.

**Table 8a:** Johansen Cointegration Test

Sample (adjusted): 1988 - 2021				
Included Observations: 34 after adjustments				
Trend assumption: Linear deterministic				
Series: PoHC CO <sub>2</sub> FOODINF UNEM RGDP HEL EDU CPI ENECOM				
Lags interval (in first differences: 1 to 1)				
Unrestricted Hypothesized No of CE(S)	Cointegration (Trace) Eigenvalue	Rank Test Trace Statistic	0.05 Critical Vale	Prob **
None *				
At Most 1*	0.945455	357.2222	197.3709	0.00000
At Most 2*	0.858662	258.3252	159.5297	0.00000
At Most 3*	0.823198	191.8008	125.6154	0.0000
At Most 4*	0.766598	132.8882	95.75366	0.0000
At Most 5*	0.607212	83.41843	69.81889	0.0028
At Most 6	0.481950	51.64592	47.85613	0.0211
At Most 7	0.342566	29.28469	27.79707	0.0572
At Most 8*	0.259047	15.02470	15.49471	0.0588
	0.132453	4.830908	3.841466	0.0279

Trace indicates 6 co-integrating(s) at the 0.05 level

\* denotes rejection of the hypothesis at the 0.05 level

\*\* MacKinnon Haugh-Michelis (1999) P-values

Source: Researchers' computation using EView 12.

**Table 8b:** Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No of CE(S)	Eigenvalue	Max-Eigen Statistics	0.05 Critical Vale	Prob **
None *				
At Most 1*	0.945455	98.89699	58.43354	0.0000
At Most 2*	0.858662	66.52445	52.36261	0.0010
At Most 3*	0.823198	58.91257	46.23142	0.0014
At Most 4*	0.766598	49.46977	40.07757	0.0033
At Most 5*	0.607212	31.77250	33.87687	0.0873
At Most 6	0.481950	22.36124	27.58434	0.2024
At Most 7	0.342566	14.25999	21.13162	0.3441
At Most 8*	0.259047	10.19379	14.26460	0.1992
	0.132453	4.830908	3.841466	0.0279

Max-eigenvalue test indicates 4 cointegrating equ(s) at the 0.05 level, \* donates rejection of the hypothesis at the 0.05 level, \*\* MacKinnon-Haugh-Michelis (1999) p-value.

Sources: Researchers' Computation using EView 12.

The results from both the trace and Max-eigen value showed traces of co-integration relationship. For the Trace statistics, we have 6 co-integrating vectors while for the Max-eigen statistics, we have 4 co-integrating vectors. This implies a long-run relationship between climate change, food insecurity and poverty reduction in Nigeria under the

reviewing period. Table 5 presents the Granger causality test. Causality test is undertaken to investigate whether the degree of causation of one variable (climate change and food insecurity) on the other (poverty).

**Table 9:** Granger Causality Test Result

Pairwise Granger Causality Tests				
Sample: 1986 2022				
Lag: 2				
Null Hypothesis	Observation	F-Statistic	Probs.	Remarks
CO <sub>2</sub> does not Granger cause POHC	35	1.36354	0.2712	No Causality
POHC does not Granger cause CO <sub>2</sub>		3.88789	0.0315	Unidirection
FOODINF does not Granger cause POHC	35	0.00176	0.9982	No Causality
POHC does not Granger cause FOODINF		0.08384	0.9198	
UNEM does not Granger cause POHC	35	1.17813	0.3217	No Causality
POHC does not Granger cause UNEM		0.45580	0.6383	
RGDP does not Granger cause POHC	35	3.47947	0.0438*	Unidirection
POHC does not Granger cause RGDP		1.30734	0.2855	
HEL does not Granger cause POHC	35	10.7078	0.003*	Unidirection
POHC does not Granger cause HEL		0.79854	0.4593	
EDU does not Granger cause POHC	35	1.12898	0.3367	No causality
POHC does not Granger cause EDU		0.80721	0.4556	
CPI does not Granger cause POHC	35	0.53414	0.5916	No causality
POHC does not Granger cause CPI		0.25960	0.7731	
ENECOM does not Granger cause POHC	35	0.25598	0.7759	No causality
POHC does not Granger cause ENECOM		1-26078	0.2985	

**Source:** Researchers' Computation using EView 12 (2023)

Table 9 presented the Granger causality test results. The significance of the probability value (0.05) lead to the acceptance of the alternative hypothesis, while the insignificance of the probability lead to the rejection of the null hypothesis. From the Table (9), there's unidirectional causality between (POHC and CO<sub>2</sub>); no causality between (DOOINF and POHC); no causality between (UNEM and POHC); unidirectional causality between (RGDP and POHC), unidirectional causality between (Health and POHC); no causality between (EDU and POHC); no causality between (corruption and POHC) and no causality between (energy consumption and POHC). This implies the null hypothesis for CO<sub>2</sub> and POHC was rejected, and the alternative hypothesis accepted that CO<sub>2</sub> drive POHC during the examination period, whereas the null hypothesis for unemployment and poverty headcount ratio was accepted.

## Conclusion and Policy Implications

### Conclusion

This paper examined the impact of climate change and food insecurity on poverty in Nigeria from 1986 to 2022. The objectives of this study are emphasized as follows: To examine the impact of climate change and food insecurity on poverty. From the results

presented, climate change (CO<sub>2</sub>) has a positive relationship with poverty, as such; a percentage change in climate change will lead to 37.7% increase in poverty. Moreover, the result showed that food inflation at lag 2 has a positive relationship with poverty; such that a percentage change in food inflation will lead to 0.01 percentage increase in poverty. From the Granger causality result, it showed that there's a unidirectional casualty between poverty and climate change. The unidirectional causality implies any policy initiated by the government to reduce climate will automatically reduce poverty. From the result, there is no causality between food inflation and poverty, and a unidirectional causality between real GDP and poverty.

### **Policy Implication**

In line with the objectives and findings of this study, the following policy recommendations are suggested.

- i) Implementing adaption and mitigation measures that promote low-carbon development.
- ii) Government should promote agricultural food that enhances food sufficiency so as to reduce poverty. This can be through the provision of agricultural facilities and incentives.
- iii) It is advised that policy makers should increase social investment for employment generation to help urban and rural residents, particularly women and children escape poverty.
- iv) Policymakers should increase expenditure on health and education so as to reduce poverty. This becomes necessary in line with the Abuja Declaration of 15% of GDP on health.
- v) Real GDP has a directional causality with poverty. This implies that progressive and inclusive economic growth can reduce unemployment and reduce economic growth. For this to be achieved the economy has to be diversified and the non-oil sectors (agriculture) promoted.

### **References**

- Agri, E. M., Mallo, E. R., Dalut, N. A. & Garba, A. (2020). Impact of climate change on agriculture and food security in Nigeria, *Social Science Journal*, 6, 41-59, <https://www.purkh.com/index.php/tosocial>
- Alesina, A., & Rodrik, D. (1994). Distributive politics and economic growth, *Quarterly Journal of Economics* 109, 465-490.
- Ani, K. J., Anyika, V. O. & Mutambara, E. (2022). The impact of climate change on food and human security in Nigeria, *International Journal of Climate Change Strategic and Management* 14(2), 148-167.
- Ayinla, L.O, Sawyerr, H. O., & Shegen, V. O. (2020). Effects of climate change on food security among farmers in some selected communities in Edu Local Government Area, Kwara State, Nigeria.

- Ayo, J. A., Omosebi, M. O. & Sulieman, A. (2014). Effect of climate change on food security in Nigeria *Journal of Environmental Science, Computer Science and Engineering & Technology*, 3(4), 1763-1778.
- Bownan, P. (2010). *Total quality management: An introductory text*, London: Prentice Hall.
- Broca, S. (2002). Food insecurity, poverty and agriculture. A concept paper, *Agricultural and Development Economics Division, FAO*, 02-15 September.
- Cevik, S. & Jalles, J. T. (2023). Eye of the storm: The impact of climate shocks on inflation and growth, *International Monetary Fund Working Paper*, WP/23/87.
- Devison, E. F. (2008). *Sources of economic growth in the United States and alternative before US*, New York: The Penguin Press.
- Dollar, D. & Kraaay, A. (2001). *Growth is good for the poor*, World Bank Policy Research Working Paper N2587, Washington D.C. World Bank, August.
- El-ladan, I. Y. (2014). *Climate change and food security in Nigeria*, Umaru Musa Yar'adua University Katsina.
- Enakhe, B. O. & Tamuno, C. (2021). Poverty, unemployment and food insecurity: *Empirical evidence from Nigeria*. *AJEBA*, 21(6), 107-123.
- Faccia, D., Parker, M., & Stracca, L. (2021). *Feeling the heat. Extreme temperature and price stability*, ECB Working Paper No. 2626 (Frankfurt: European Central Bank).
- FAO (2004). *The state of food insecurity in the world towards the summit commitments: Education for rural people and food security. 6<sup>th</sup> edition*, Rome, Italy: Food and Agricultural Organization of the United Nations.
- Garcia, M. (2012). *The impact of climate change on food security*, <http://datos.bancomundial.org/tema/agriculture-y-desarrollarural>.
- Heinen, A., Khadan, J. & Strobl, E. (2019). *The price of tropical storms on households: Evidence from panel data on consumption*, *Oxford Bulletin of Economics and Statistics*, 22, 179-232.
- Hope, K. R. (2012). Climate change and poverty in Africa, *International Journal of Sustainable Development and World Ecology*, 16(6), 451-461.
- Idumah, F. O., Mangodo, C., Ighodaro, U. B. & Owombo, P. T. (2016). Climate change and food production in Nigeria: Implication for food security in Nigeria. *Journal of Agricultural Science*, 8(2), 74-83.



- Kabundi, A. Mlachila, M. & Yao, L. (2022). *How persistent are climate related price shocks? Implications for monetary policy*, IMF working paper No 22/207 (Washington, DC: International Monetary Fund).
- Kempe, R. H. (2009). Climate change and poverty in Africa. *International Journal of Sustainable Development of World Ecology*, 16(6), 451-461. <https://doi.org/10.1080/13504500903354424>
- Mashizha, T. M. (2019a). Building adaptive capacity: Reducing climate vulnerability of small holder farmers in Zimbabwe. *Business Strategy and Development*, 1-7. <https://doi.or/10.1002/bsd2.50>
- Masipa, T. S. (2017). The impact of climate change on food security in South Africa. Current realities and challenges ahead, *Jamba: Journal of Disaster Risk Studies*, 9(1), 1411. <https://doi.org/10/4102/jamba.v9il.411>
- Nyahunda, L. & Tirivangasi, H. M (2019). Challenges faced by rural people in mitigating the effects of climate change in the Mazungunye Communal lands, Zimbabwe. *Jamba Journal of Disaster Risk Studies*, 11(1), a 596. <https://doi.org/10.4102/janiba.v11il.596>.
- Okoli, J. N. & Ifeakor, A. C. (2014). An overview of climate change and food security: Adaptation strategies and mitigation measures in Nigeria, *Journal of Education and Practice* 5(32), 13-19.
- Omoniyi, M. B. I. (2013). The role of education in poverty alleviation and economic development: a theoretical perspective and counseling implication, *British Journal of Arts and Social Sciences*, 15(11), 176-186.
- Osuafor, A. M. & Nnorom, N. R. (2014). Impact of climate change on food security in Nigeria. *An International Journal of Science and Technology*, 3(1), 208-219.
- Ozturk, S.K. (2011). Investment in human capital, *American Economic Review* 51 (1), 334-342.
- Parker, M. (2018). *The impact of disaster on inflation. Economics of Disasters and climate change*, 2:21-48.
- Ravallion, M. (1997). Can high inequality developing countries escape absolute poverty, *Economics Letters*, 56, 51-57.
- Ravallion, M., & Chen, S. (1997). What can new survey data tell us about recent changes in distribution and poverty? *World Bank Economic Review* 11(2), 357-382.

Thompson, H. E., Lea, B. F. & Ford, J. D. (2010). Climate change and food security in Sub-Saharan Africa: A Systematic Literature Review, *Sustainability* 2, 2719-2733; doi: 10.3390/su2082919.

World Food Programme (2016). *What is food security?* World Food Programme, <https://www.wfp.org/node/359289>. Accessed 3 March 201