MKAR JOURNAL OF ECONOMICS AND DEVELOPMENT VOL. 1 NO. 1 2022.

ISSN 3043-5110 journals.umm.edu.ng

THE IMPULSE RESPONSE OF AGRICULTURAL PERFORMANCE TO CLIMATE VARIABILITY AND ENERGY CONSUMPTION IN NIGERIA.

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ABSTRACT

The study employs Ordinary Least Squares (OLS) equations and Annual time series data from 1960 to 2017 were obtained from the Central Bank of Nigeria's Statistics Bulletin 2017. Having carried out the necessary pre- and post-diagnostic tests, the results reveal that, at period five (5) of shocks in annual rainfall (CLM) in Nigeria, 57,137,222 response of agricultural output to innovations in CLM is noted. That is to say, 57,137,222 response of agricultural output to innovations in CLM is noted in period five (5) aftershocks. At the same stated period of shocks in Carbon Dioxide (CO_2), Nitric Oxide (N_2O), Methane (CH_4) and Chlorofluorocarbons (CFCs) in Nigeria, respective responses of agricultural output to innovations in these energy-enhanced atmospheric gases stands at: 159,543.4%, 2,378,401%, -4,526,529%, 2,296,124%. This same trend of responses repeat itself in period ten (10), clearly separating CFCs and CLM as having the dominant influence on the Nigeria's agriculture. This reveals to the minds that, the Nigeria's agriculture is highly sensitive to energy use (especially fossil fuel resources that enhances the emission of chlorofluorocarbons) and climate (i.e., annual rainfall).

Keywords: Agricultural Output; Climate Variability; Energy Consumption; Greenhouse Gas Emissions; Impulse Response Analysis; Nigeria.

JEL Classification: Q15; Q43; Q54; Q56; C32.

INTRODUCTION

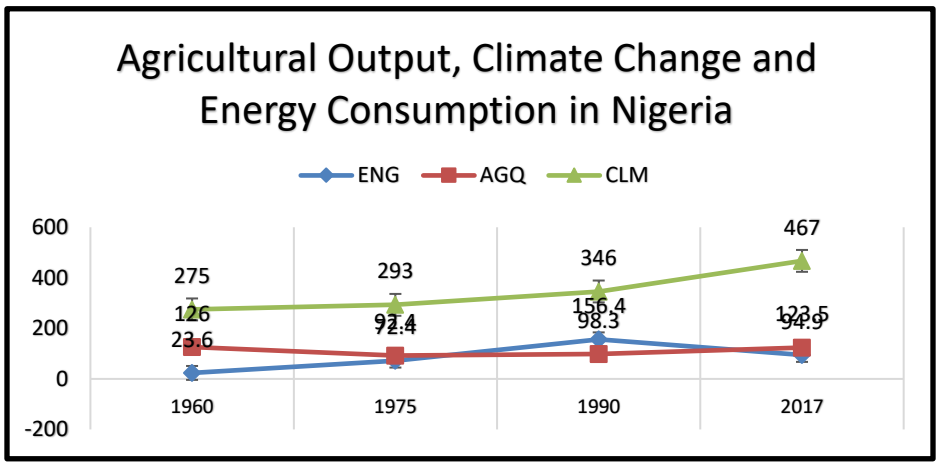
Adesina, Odekunle, Balarabe, Dami, Bulus, Ambio and Gworgor (2010) clearly shows that, increased energy consumption increases the chances of global warming that negatively increased variations in climatic issues which are the major determinants of food supply and the general

prosperity of agricultural sector. It is quite justifiable that, the major climate and environmental problems relates to energy production, distribution and consumption in the country, these are mainly deforestation and pollution of the air with fossil fuel consumption.

But then, the available statistics from the Central Bank of Nigeria (2006) shows that total energy consumption rose significantly in recent times. For instance, the index of energy consumption rose from 87.7 in 1999 to 169.2 in 2001, from 170.7 in 2002, to 171.2 in 2003, and from 175.7 in 2004, to 176.7 in 2005. Again, the chart below highlights the pattern of interaction between agricultural outputs (AGQ), climate change (CLM) and energy consumption (ENG) in Nigeria from 1970 to 1988.

Following this, the report in IPCC (2001) and Abiodun (2011) explains without doubt that, the combustion products (CO_2, N_2O, CFCs, CH_4 etc., from fossil fuel) are greenhouse gases (GHG) stimulated by increased energy consumption that further leads to global warming and climate change, with attendants negative consequences on agriculture, water supply, forest resources, sea level rise, health, etc. Oladipo (2008) and World Bank (2009) also confirm that, there is substantial water and soil pollution occurring due to oil spillage during oil production and transportation. It true that, over the years this has had significant adverse impact on fisheries and marine life in the oil producing areas in Nigeria.

Fig 1: Agricultural Output, Climate Change and Energy Consumption in Nigeria from 1960 – 2017



Source: Plotted by the Researcher from CBN Statistical Bulletin, 2017

The forecast of Speranza (2010) shows that, the nation's 15 million hectares of forest and woodland reserves could be depleted within the next 50 years if the present trend in energy consumption is not seriously checked. It is certain that, these would result in negative impact on the environment, such as soil erosion, desertification, loss of biodiversity, micro-climate change and terrible flooding.

A recent study funded by Food and Agricultural Organization (2007) showed projected economic impact of climate change in Nigeria with a sound warning that, if no adaptation is implemented, climate change could result in a loss of within 2% and 11% of Nigeria's GDP by 2020, increasing to between 6% and 30% by year 2050. This loss is similar to between N15 trillion (US $100 billion) and N69 trillion (US $460 billion). The Federal Government of Nigeria (2009), in addressing agricultural problems acknowledged that, climate change strongly affects crop yield. Boko (2007) also predicted that, crop yield will fall in places that are subject to increase drought and heat stresses. His forecast showed that, a warmer climate will reduce flexibility in crop distribution and increase irrigation demand by the economic units. He also explains that, expansion of the ranges of pests will also increase vulnerability and results in greater demand of pesticides.

THEORETICAL FRAMEWORK

The Modified Gaia Hypothesis

The Gaia hypothesis, also known as Gaia theory or Gaia principle, proposes that organisms interact with their inorganic surroundings on Earth to form a self-regulating, complex system that contributes to helping to maintaining the conditions for life on the planet. In Lovelock (2006), the Gaia hypothesis posits that the Earth is a self-regulating complex system involving the biosphere, the atmosphere, the hydrosphere and the pedosphere, tightly coupled as an evolving system. The hypothesis as proposed by Lovelock (1972) contends that this system as a whole, called Gaia, seeks a physical and chemical environment optimal for contemporary life. The theory further explains how the biosphere and the evolution of life forms affect the stability of global temperature, ocean salinity, oxygen in the atmosphere and other environmental variables (such as greenhouse gases) that affect the habitability of Earth.

The hypothesis was formulated by the chemist James Lovelock and co-developed by the microbiologist Lynn Margulis in the 1970s.Gaian hypotheses suggest that organisms co-evolve

with their environment: that is, they "influence their abiotic environment, and that environment in turn influences the biota by Darwinian process". Lovelock (1995) gave evidence of this in his second book, showing the evolution from the world of the early thermo-acido-philic and methanogenic bacteria towards the oxygen-enriched atmosphere today that supports more complex life.

The scientifically accepted form of the hypothesis as in Charleson, Lovelock, Anndreae and Warren (1987) has been called "influential Gaia". It states that, biota influence certain aspects of the abiotic world, e.g. temperature and atmosphere. They state that, the evolution of life and its environment may affect each other. An example as stated in Lovelock (1995) is how the activity of photosynthetic bacteria during Precambrian times have completely modified the Earth atmosphere to turn it aerobic, and as such supporting evolution of life (in particular eukaryotic life).

Biologists and Earth scientists such as Charleson, Lovelock, Anndreae and Warren (1987) usually view the factors that stabilize the characteristics of a period as an undirected emergent property or entelechy of the system; as each individual species pursues its own self-interest, for example, their combined actions may have counterbalancing effects on environmental change. Opponents of this view such as Jagtap (1995) and Enger and Smith (2008) sometimes reference examples of events that resulted in dramatic change rather than stable equilibrium, such as the conversion of the Earth's atmosphere from a reducing environment to an oxygen-rich one.

Less accepted versions of the hypothesis claim that changes in the biosphere are brought about through the coordination of living organisms and maintain those conditions through homeostasis. Lovelock (1972) stated in some versions of Gaia philosophy that, all life forms are considered part of one single living planetary being called *Gaia*. That, the atmosphere, the seas and the terrestrial crust would be results of interventions carried out by Gaia through the coevolving diversity of living organisms. However, Enger and Smith (2008) argued that, the Earth as a unit does not match one of the generally accepted biological criteria for life: there is no evidence to suggest that "Gaia" has reproduced yet.

Gaia evolves through a cybernetic feedback system operated unconsciously by the biota, leading to broad stabilization of the conditions of habitability in a full homeostasis. Craig, Vaughan and Skinner (2011) noted that, many processes in the Earth's surface essential for the conditions of life depend on the interaction of living forms, especially microorganisms, with inorganic elements. These processes establish a global control system that regulates Earth's surface temperature, atmosphere composition and ocean salinity, powered by the global thermodynamic disequilibrium state of the Earth system.

According to Munasinghe (1999), ocean salinity has been constant at about 3.4% for a very long time. Salinity stability in oceanic environments is important as most cells require a rather constant salinity and do not generally tolerate values above 5%. The constant ocean salinity was a long-standing mystery, because no process counterbalancing the salt influx from rivers was known. Recently Tiwari (2000) suggested that salinity may also be strongly influenced by seawater circulation through hot basaltic rocks, and emerging as hot water vents on mid-ocean ridges. However, Thipse (2014) argued that, the composition of seawater is far from equilibrium, and it is difficult to explain this fact without the influence of organic processes. One suggested explanation lies in the formation of salt plains throughout Earth's history. It is hypothesized that these are created by bacterial colonies that fix ions and heavy metals during their life processes

The Gaia hypothesis as in Lovelock (1972) also states that the Earth's atmospheric composition is kept at a dynamically steady state by the presence of life. The atmospheric composition provides the conditions that contemporary life has adapted to. He argued that all the atmospheric gases other than noble gases present in the atmosphere are either made by organisms or processed by them.

According to the theorists, the stability of the atmosphere in Earth is not a consequence of chemical equilibrium. Oxygen is a reactive compound, and should eventually combine with gases and minerals of the Earth's atmosphere and crust. Enger and Smith (2008) believe that, oxygen only began to persist in the atmosphere in small quantities about 50 million years before the start of the Great Oxygenation Event. Since the start of the Cambrian period, atmospheric oxygen concentrations have fluctuated between 15% and 35% of atmospheric volume. Traces of methane (at an amount of 100,000 tons produced per year) should not exist, as methane is combustible in an oxygen atmosphere.

Dry air in the atmosphere of Earth contains roughly (by volume) 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases including methane. Lovelock (1995) originally speculated that concentrations of oxygen above about 25% would increase the frequency of wildfires and conflagration of forests. Recent work such as Charleson, Lovelock, Anndreae and Warren (1987) on the findings of fire-caused charcoal in Carboniferous and Cretaceous coal measures, in geologic periods when oxygen (O_2) did exceed 25%, has supported Lovelock's contention.

Since life started on Earth, the energy provided by the Sun has increased by 25% to 30% according to Charleson, Lovelock, Anndreae and Warren (1987); however, Enger and Smith (2008) argued that the surface temperature of the planet has remained within the levels of habitability, reaching quite regular low and high margins. Lovelock (1972) has also hypothesized that methanogens produced elevated levels of methane in the early atmosphere, giving a view similar to that found in petrochemical smog, similar in some respects to the atmosphere on Titan. This, he suggests tended to screen out ultraviolet until the formation of the ozone screen, maintaining a degree of homeostasis. However, the Snowball Earth research as stated in Lovelock (1995) has suggested that "oxygen shocks" and reduced methane levels led, during the Huronian Sturtian and Marinoan/Varanger Ice Ages, to a world that very nearly became a solid "snowball". These epochs are evidence against the ability of the prephanerozoic biosphere to fully self-regulate.

Gaia scientists (Lovelock, 1972; 1995; 2006) see the participation of living organisms in the carbon cycle as one of the complex processes that maintain conditions suitable for life. The only significant natural source of atmospheric carbon dioxide (CO_2) is volcanic activity, while the only significant removal is through the precipitation of carbonate rocks. Carbon precipitation, solution and fixation are influenced by the bacteria and plant roots in soils, where they improve gaseous circulation, or in coral reefs, where calcium carbonate is deposited as a solid on the sea floor. Rudolf and Hermann (2009) noted that calcium carbonate is used by living organisms to manufacture carbonaceous tests and shells. Once dead, the living organisms' shells fall to the bottom of the oceans where they generate deposits of chalk and limestone.

Enger and Smith (2008) states that, one of these organisms is Emilianiahuxleyi, an abundant cocolithophore algae which also has a role in the formation of clouds. CO_2 excess is compensated

by an increase of coccolithophoride life, increasing the amount of CO_2 locked in the ocean floor. Coccolithophorides increase the cloud cover, hence control the surface temperature, help cool the whole planet and favor precipitations necessary for terrestrial plants. Lately the atmospheric CO_2 concentration has increased and there is some evidence that concentrations of ocean algal blooms are also increasing.

METHODOLOGY

We adopt the modified Gaia Hypothesis and form a composite function for this study as below:

$$\mathbf{AGQ_t = f\,[CLM_t\,(ENG_t)]} \quad \text{(1)}$$

We form equation (2) by substituting energy consumption (ENG_t) with the major atmospheric pollutants resulting from energy use such as; log of carbon dioxide ($logCO_{2t}$), log of nitrous oxide ($logN_2O_t$), log of methane ($logCH_{4t}$), log of chlorofluorocarbons ($logCFCs_t$) as in (3) below.

$$\mathbf{CLM_t = f\,(CO_{2t}, N_2O_t, CH_{4t}, CFCs_t)} \quad \text{(2)}$$

We include (α) as intercept, $(1-L)^n$ as difference operator, $(1-L^s)$ as seasonal difference and other slope parameters (β, φ, θ, λ, γ,) and the error term (υ) to have equation (3) as

$$\mathbf{(1-L)^n(1-L^s)Log(CLM_t) = \alpha + \beta(1-L)^n(1-L^s)log(CO_{2t}) + \varphi(1-L)^n(1-L^s)log(N_2O_t) + \theta(1-L)^n(1-L^s)log(CH_{4t}) + \gamma(1-L)^n(1-L^s)log(CFCs_t) + \upsilon_t} \quad \text{(3)}$$

We form equation (4) by increasing other determinants of Agricultural output (in log form), i.e., ($logAGQ_t$) such as; log of public expenditure on agriculture ($logPEA_t$), log of Labor force ($logLBF_t$), log of Inflation rate ($logIFR_t$), log of Exchange rate ($logEXR_t$), log of Interest rate ($logITR_t$), log of Private sector investment in agriculture ($logPIA_t$) as in (4) below:

$$\mathbf{AGQ_t = f\,(CLM_t, PEA_t, LBF_t, IFR_t, EXR_t, ITR_t, PIA_t)} \quad \text{(4)}$$

We include Ω as intercept, $(1-L)^n$ as difference operator, $(1-L^s)$ as seasonal difference and other slope coefficients (ψ, Φ, Π, Ъ, χ, δ, ξ) and the error term (ω) to have equation (5) as below:

$$\mathbf{(1-L)^n(1-L^s)Log(AGQ_t) = \Omega + \psi\ (1-L)^n(1-L^s)log(CLM_t) + \Phi(1-L)^n(1-L^s)\ log(PEA_t) + \Pi\ (1-L)^n(1-L^s)\ log(LBF_t) + \text{Ъ}\ (1-L)^n(1-L^s)log(IFR_t) + \chi\ (1-L)^n(1-L^s)log(EXR_t) + \delta\ (1-L)^n(1-L^s)log(ITR_t) + \xi(1-L)^n(1-L^s)log(PIA_t) + \omega_t} \quad \text{(5)}$$

we consider relevant variables from equation (3) and (5), we further substitute (3) into (5) and linearize the composite function as below;

$$(1\text{-}L)^n(1\text{-}L^s)Log(AGQ_t) = \Omega_1 + \psi_1(1\text{-}L)^n(1\text{-}L^s)Log(CLM_t) + \beta_1(1\text{-}L)^n(1\text{-}L^s)Log(CO_{2t}) + \varphi_1(1\text{-}L)^n(1\text{-}L^s)Log(N_2O_t) + \theta_1(1\text{-}L)^n(1\text{-}L^s)Log(CH_{4t}) + \gamma_1(1\text{-}L)^n(1\text{-}L^s)Log(CFCs_t) + \upsilon_{1t} \qquad (6)$$

Since Vector Autoregressive (VAR) model is more dynamic than the simultaneous equation model, we specify VAR explicitly to help us capture objective two and solved endogeneity problem associated with a composite function. It is quite common in economics to have models where some variables are not only explanatory variables for a given dependent variable, but they are also explained by the variables that they are used to determine. In those cases, we have models of simultaneous equations, in which it is necessary to clearly identify which are the endogenous and which are the exogenous or predetermined variables. The decision regarding such a differentiation among variables was heavily criticized by Sims (1980) as stated in Dimitrios Asteriou and Stephen (2007).

According to Sims (1980) in Dimitrios Asteriou and Stephen (2007), if there is simultaneity among a number of variables, then all these variables should be treated in the same way. In other words, there should be no distinction between endogenous and exogenous variables. Therefore, once this distinction is abandoned, all variables are treated as endogenous. This means that in its general reduced form each equation has the same set of regressors which lead to the development of VAR models as below after accounted for the contemporaneous term:

$$AGQ_{1t} = \alpha + \sum_{j=1}^{k} \varphi AGQ_{t-j} + \sum_{j=1}^{k} \delta\, CLM_{t-j} + \sum_{j=1}^{k} \varphi CO2_{t-j} \sum_{j=1}^{k} \lambda\, N2O_{t-j} + \sum_{j=1}^{k} \beta CH4_{t-j} + \sum_{j=1}^{k} \pi CFCs_{\,t-j} + \varepsilon_{1t} \ldots \qquad (7)$$

$$CLM_{\,2t} = \alpha_2 + \sum_{j=1}^{k} \varphi_2 AGQ_{t-j} + \sum_{j=1}^{k} \delta_2\, CLM_{t-j} + \sum_{j=1}^{k} \varphi_2 CO2_{t-j} + \sum_{j=1}^{k} \lambda_2\, N2O_{t-j} + \sum_{j=1}^{k} \beta 2CH4_{t-j} + \sum_{j=1}^{k} \pi 2CFCs_{\,t-j} + \varepsilon_{2t} \ldots \qquad (8)$$

$$CO2_{3t} = \alpha_3 + \sum_{j=1}^{k} \varphi_3 AGQ_{\,t-j} + \sum_{j=1}^{k} \delta_3\, CLM_{t-j} + \sum_{j=1}^{k} \varphi_3 CO2_{t-j} + \sum_{j=1}^{k} \lambda_3\, N2O_{t-j} + \sum_{j=1}^{k} \beta 3CH4_{t-j} + \sum_{j=1}^{k} \pi 3CFCs_{\,t-j} + \varepsilon_{3t} \ldots \qquad (9)$$

$$\mathbf{N2O}_{4t} = \alpha_4 + \sum_{j=1}^{k}\varphi_4\mathbf{AGQ}_{t-j} + \sum_{j=1}^{k}\delta_4\,\mathbf{CLM}_{t-j} + \sum_{j=1}^{k}\phi_4\mathbf{CO2}_{t-j} + \sum_{j=1}^{k}\lambda_4\,\mathbf{N2O}_{t-j} + \sum_{j=1}^{k}\beta 4\mathbf{CH4}_{t-j} + \sum_{j=1}^{k}\pi 4\mathbf{CFCs}_{t-j} + \varepsilon_{4t} \ldots\ldots \text{(10)}$$

$$CH4_{5t} = \alpha_5 + \sum_{j=1}^{k}\varphi_5\mathbf{AGQ}_{t-j} + \sum_{j=1}^{k}\delta_5\,\mathbf{CLM}_{t-j} + \sum_{j=1}^{k}\phi_5\mathbf{CO2}_{t-j} + \sum_{j=1}^{k}\lambda_5\,\mathbf{N2O}_{t-j} + \sum_{j=1}^{k}\beta 5\mathbf{CH4}_{t-j} + \sum_{j=1}^{k}\pi 5\mathbf{CFCs}_{t-j} + \varepsilon_{5t} \ldots\ldots \text{(11)}$$

$$CFC_{S6t} = \alpha_6 + \sum_{j=1}^{k}\varphi_6\mathbf{AGQ}_{t-j} + \sum_{j=1}^{k}\delta_6\,\mathbf{CLM}_{t-j} + \sum_{j=1}^{k}\phi_6\mathbf{CO2}_{t-j} + \sum_{j=1}^{k}\lambda_6\,\mathbf{N2O}_{t-j} + \sum_{j=1}^{k}\beta 6\mathbf{CH4}_{t-j} + \sum_{j=1}^{k}\pi 6\mathbf{CFCs}_{t-j} + \varepsilon_{6t} \ldots\ldots \text{(12)}$$

Please note: where CO2, N2O and CH4 represents CO_2, N_2O and CH_4 respectively.

Here we assume that both variables are stationary and the stochastic terms are uncorrelated white noise error terms. Equations (7) to (12) constitute a first order VAR models because the longest lag length is unity. These equations are not reduced-form equations the series has a contemporaneous impact on each other in the systems, rewriting the system with the use of matrix algebra, we get:

$$\begin{pmatrix} \mathbf{AGQ}_{1t} \\ \mathbf{CLM}_{2t} \\ \mathbf{CO2}_{3t} \\ \mathbf{N2O}_{4t} \\ CH4_{5t} \\ CFC_{S6t} \end{pmatrix} = \begin{pmatrix} \alpha \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \end{pmatrix} + \sum_{j=1}^{k} \begin{pmatrix} \varphi & \delta & \phi & \lambda & \beta & \pi \\ \varphi_2 & \delta_2 & \phi_2 & \lambda_2 & \beta 2 & \pi 2 \\ \varphi_3 & \delta_3 & \phi_3 & \lambda_3 & \beta 3 & \pi 3 \\ \varphi_4 & \delta_4 & \phi_4 & \lambda_4 & \beta 4 & \pi 4 \\ \varphi_5 & \delta_5 & \phi_5 & \lambda_5 & \beta 5 & \pi 5 \\ \varphi_6 & \delta_6 & \phi_6 & \lambda_6 & \beta 6 & \pi 6 \end{pmatrix} \begin{pmatrix} \mathbf{AGQ}_{t-j} \\ \mathbf{CLM}_{t-j} \\ CO2_{t-j} \\ \mathbf{N2O}_{t-j} \\ \mathbf{CH4}_{t-j} \\ \mathbf{CFCs}_{t-j} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{pmatrix} \ldots\text{(13)}$$

$$\text{Let} \begin{pmatrix} \mathbf{AGQ}_{1t} \\ \mathbf{CLM}_{2t} \\ \mathbf{CO2}_{3t} \\ \mathbf{N2O}_{4t} \\ CH4_{5t} \\ CFC_{S6t} \end{pmatrix} = \mathbf{\Omega}, \begin{pmatrix} \alpha \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \\ \alpha_6 \end{pmatrix} = \psi, \quad \begin{pmatrix} \varphi & \delta & \phi & \lambda & \beta & \pi \\ \varphi_2 & \delta_2 & \phi_2 & \lambda_2 & \beta 2 & \pi 2 \\ \varphi_3 & \delta_3 & \phi_3 & \lambda_3 & \beta 3 & \pi 3 \\ \varphi_4 & \delta_4 & \phi_4 & \lambda_4 & \beta 4 & \pi 4 \\ \varphi_5 & \delta_5 & \phi_5 & \lambda_5 & \beta 5 & \pi 5 \\ \varphi_6 & \delta_6 & \phi_6 & \lambda_6 & \beta 6 & \pi 6 \end{pmatrix} = \theta,$$

$$\begin{pmatrix} \mathbf{AGQ}_{t-j} \\ \mathbf{CLM}_{t-j} \\ \boldsymbol{CO2}_{t-j} \\ \mathbf{N2O}_{t-j} \\ \mathbf{CH4}_{t-j} \\ \mathbf{CFCs}_{\ t-j} \end{pmatrix} = \mho, \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{pmatrix} = \Phi, \text{So that;}$$

$$\boldsymbol{\Omega} = \boldsymbol{\psi} + \sum_{j=1}^{k} \boldsymbol{\theta} \mathbf{\Xi} \mho + \Phi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (\mathbf{14})$$

Note that the above standard form of VAR has accounted for the contemporaneous term.

DATA PRESENTATION AND ANALYSIS

Presentation of VAR (1, 3) output for equation (14) for post-estimation diagnostics to examine the response of agricultural output to changes in climate and energy consumption in Nigeria.

The OLS equation (14) was carried out in this section. The objective is to examine the impulse response of agricultural output to changes in other variables in this equation from the period of 1960 to 2017. The root of this objective is to interpret the economic implications of the impulse response and recommendation of possible ways to improve the agricultural output and the economy in general after accounting for proper post-estimation diagnostics.

To help account for post-estimation checks, the vector autoregressive (VAR) output is presented below and proper diagnostics are carried out to test the output validity and purify it from spuriousity after which proper interpretations will be made. Some of the post-estimation checks that shall be carried out here may include; VAR granger causality/block exogeneity Wald tests, VAR lag order selection criteria, autocorrelation tests: VAR residual portmanteau tests for autocorrelations; VAR residual serial correlation LM tests, VAR residual normality tests, Variance Decomposition, and impulse response.

Table 1: The VAR (1, 3) Estimates of OLS Equations (7) to (12) for Objective Two

	D(AGQ)	*D(CLM)*	*D(CO2)*	*D(N2O)*	*D(CH4)*	*D(CFCS)*
D(AGQ(-1))	*-55.41286*	*-5678.225*	*4.71E-05*	*-426.7506*	*-4.528510*	*-625.2754*

	(0.31012)	*(30.5298)*	*(2.4E-05)*	*(2.24484)*	*(3.13042)*	*(3.35534)*
	[-178.681]	*[-185.990]*	*[1.96479]*	*[-190.103]*	*[-1.44661]*	*[-186.352]*
D(AGQ(-2))	***73.55302****	***7925.771****	*-0.000739*	***578.0037****	*-70.89072*	***873.3949****
	(7.61824)	*(749.973)*	*(0.00059)*	*(55.1452)*	*(76.8997)*	*(82.4250)*
	[9.65486]	*[10.5681]*	*[-1.25683]*	*[10.4815]*	*[-0.92186]*	*[10.5962]*
D(AGQ(-3))	*-17.33084*	*-2181.840*	*0.000727*	*-153.6528*	*53.80389*	*-241.0797*
	(7.78714)	*(766.601)*	*(0.00060)*	*(56.3678)*	*(78.6046)*	*(84.2524)*
	[-2.22557]	*[-2.84612]*	*[1.20853]*	*[-2.72590]*	*[0.68449]*	*[-2.86140]*
D(CLM(-1))	*-1.605433*	*-83.61376*	*0.000134*	*8.887033*	***44.43087****	*-8.959840*
	(1.60524)	*(158.027)*	*(0.00012)*	*(11.6197)*	*(16.2036)*	*(17.3678)*
	[-1.00012]	*[-0.52911]*	*[1.08335]*	*[0.76483]*	*[2.74204]*	*[-0.51589]*
D(CLM(-2))	*-4.117833*	*-209.2117*	*0.000281*	*6.102206*	***62.16566****	*-21.82684*
	(2.34285)	*(230.640)*	*(0.00018)*	*(16.9589)*	*(23.6490)*	*(25.3482)*
	[-1.75762]	*[-0.90709]*	*[1.55159]*	*[0.35982]*	*[2.62867]*	*[-0.86108]*
D(CLM(-3))	*-11.18910*	*-1038.394*	*0.000489*	*-88.31376*	*-31.45103*	*-114.2274*
	(4.59170)	*(452.027)*	*(0.00035)*	*(33.2374)*	*(46.3493)*	*(49.6796)*
	[-2.43681]	*[-2.29719]*	*[1.38002]*	*[-2.65706]*	*[-0.67856]*	*[-2.29928]*
D(CO2(-1))	*1991.684*	*134961.9*	*-0.210688*	*-2678.323*	*-42944.78*	*14542.25*
	(2581.79)	*(254163.)*	*(0.19939)*	*(18688.5)*	*(26061.0)*	*(27933.5)*
	[0.77144]	*[0.53101]*	*[-1.05668]*	*[-0.14331]*	*[-1.64786]*	*[0.52060]*
D(CO2(-2))	*4903.957*	*417837.0*	*0.048604*	*33727.24*	*3049.710*	*45839.12*
	(2803.61)	*(275999.)*	*(0.21652)*	*(20294.1)*	*(28300.0)*	*(30333.4)*
	[1.74916]	*[1.51391]*	*[0.22448]*	*[1.66192]*	*[0.10776]*	*[1.51118]*
D(CO2(-3))	*3504.318*	*386626.1*	*-0.013872*	*21482.22*	*-27920.75*	*42565.55*
	(2959.11)	*(291308.)*	*(0.22853)*	*(21419.7)*	*(29869.7)*	*(32015.8)*
	[1.18425]	*[1.32721]*	*[-0.06070]*	*[1.00292]*	*[-0.93475]*	*[1.32952]*
D(N2O(-1))	***1.093406****	***97.38362****	***-3.21E-06****	***10.33034****	***9.306374****	***10.76646****
	(0.32425)	*(31.9210)*	*(2.5E-05)*	*(2.34714)*	*(3.27307)*	*(3.50824)*
	[3.37207]	*[3.05077]*	*[-0.12817]*	*[4.40125]*	*[2.84332]*	*[3.06891]*
D(N2O(-2))	*-0.773234*	*-97.45387*	*1.59E-05*	*-2.078160*	***14.63564****	*-10.63070*
	(0.32220)	*(31.7189)*	*(2.5E-05)*	*(2.33228)*	*(3.25235)*	*(3.48603)*
	[-2.39985]	*[-3.07242]*	*[0.64043]*	*[-0.89104]*	*[4.50002]*	*[-3.04951]*
D(N2O(-3))	*-2.973466*	*-228.0276*	*8.14E-05*	*-10.16698*	***23.20956****	*-25.05254*
	(0.85503)	*(84.1730)*	*(6.6E-05)*	*(6.18921)*	*(8.63081)*	*(9.25094)*
	[-3.47761]	*[-2.70903]*	*[1.23292]*	*[-1.64269]*	*[2.68915]*	*[-2.70811]*
D(CH4(-1))	*-0.341026*	*-28.94214*	*4.52E-06*	*-2.739329*	*-1.996946*	*-3.197882*
	(0.06414)	*(6.31445)*	*(5.0E-06)*	*(0.46430)*	*(0.64746)*	*(0.69398)*
	[-5.31672]	*[-4.58348]*	*[0.91155]*	*[-5.89993]*	*[-3.08427]*	*[-4.60802]*
D(CH4(-2))	*0.166503*	***26.28278****	*1.99E-06*	*0.468086*	*-4.564159*	***2.865155****
	(0.09116)	*(8.97399)*	*(7.0E-06)*	*(0.65985)*	*(0.92016)*	*(0.98628)*
	[1.82654]	*[2.92877]*	*[0.28256]*	*[0.70938]*	*[-4.96017]*	*[2.90502]*
D(CH4(-3))	*-1.591801*	*-153.1977*	*4.57E-06*	*-11.29077*	*0.074654*	*-16.87342*
	(0.10333)	*(10.1722)*	*(8.0E-06)*	*(0.74796)*	*(1.04303)*	*(1.11797)*
	[-15.4051]	*[-15.0604]*	*[0.57216]*	*[-15.0954]*	*[0.07157]*	*[-15.0929]*
D(CFCS(-1))	*19.24623*	*1201.864*	*-0.001223*	*-48.70180*	*-409.5319*	*130.9273*
	(14.7744)	*(1454.45)*	*(0.00114)*	*(106.945)*	*(149.135)*	*(159.850)*
	[1.30268]	*[0.82633]*	*[-1.07178]*	*[-0.45539]*	*[-2.74606]*	*[0.81906]*
D(CFCS(-2))	***39.03064****	***2722.913****	*-0.001466*	*121.1265*	*-223.1152*	***298.8065****
	(9.74812)	*(959.648)*	*(0.00075)*	*(70.5625)*	*(98.3990)*	*(105.469)*
	[4.00392]	*[2.83741]*	*[-1.94740]*	*[1.71658]*	*[-2.26745]*	*[2.83312]*
D(CFCS(-3))	***293.4199****	***25256.90****	*-0.003645*	***1615.647****	*-885.7051*	***2779.587****
	(35.8648)	*(3530.69)*	*(0.00277)*	*(259.610)*	*(362.025)*	*(388.036)*
	[8.18128]	*[7.15353]*	*[-1.31596]*	*[6.22336]*	*[-2.44653]*	*[7.16322]*

C	*-153.9006*	*-18064.67*	*0.006006*	*-344.0378*	*4098.691*	*-1984.791*
	(361.638)	*(35601.3)*	*(0.02793)*	*(2617.75)*	*(3650.43)*	*(3912.72)*
	[-0.42556]	*[-0.50742]*	*[0.21506]*	*[-0.13143]*	*[1.12280]*	*[-0.50727]*

Note: Standard errors in ( ) & t-statistics in [ ], the highlighted with asterisk are statistically significant from zero at 5% using [s (β_i) < (β_i/2]): sβi = standard error; βi = coefficient.

Pre-Estimation Tests

The pre-estimation tests are basically for the purpose of examining and diagnosing the series from the likelihood of spurious analysis: in other to avoid exogeneity and the number of redundant series that may compound and constitute problems in the analysis. The basic pre-estimation tests that are conducted here include the VAR Granger causality/Block Exogeneity Wald Test, and VAR lag order selection criteria tests.

VAR Granger Causality/Block Exogeneity Wald Tests

From equation (14), the null hypothesis was rejected at 0.05 (i.e., p<0.05), and a given equation from the system have passed causality and block exogeneity tests, and should be able to perform excellently in the system.

Table 2: VAR Granger Causality/Block Exogeneity Wald Tests Results

Eq	*Null Hypothesis*	*Chi-Sq*	*df.*	*Prob.*
7	*CLM, CO2, N2O, CH4, and CFCs does not Granger Cause AGQ*	*196598.8*	*15*	*0.0000**
8	*AGQ, CO2, N2O, CH4, and CFCs does not Granger Cause CLM*	*253041.0*	*15*	*0.0000**
9	*AGQ, CLM, N2O,CH4, and CFCs does not Granger Cause CO2*	*25.60874*	*15*	*0.0423**
10	*AGQ, CLM, CO2, CH4, and CFCs does not Granger Cause N2O*	*264463.8*	*15*	*0.0000**
11	*AGQ, CLM, CO2, N2O, and CFCs does not Granger Cause CH4*	*394.8346*	*15*	*0.0000**
12	*AGQ, CLM, CO2, N2O, and CH4 does not Granger Cause CFCs*	*254191.2*	*15*	*0.0000**

Note: * p-value < 0.05

Although, individual variables in given equations did reject the null hypothesis but the overall results in each equation rejected the null hypothesis.

VAR Lag Order Selection Criteria

A test was conducted to help select the best lag length for the VAR model and all the tests suggested the model be estimated as VAR (1, 3). The below table of result has the details.

Table 3: VAR Lag Order Selection Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	*-3149.798*	*NA*	*7.99e+54*	*143.4453*	*143.6886*	*143.5356*
1	*-2334.369*	*1371.403*	*3.34e+39*	*108.0168*	*109.7198*	*108.6483*
2	*-2109.368*	*317.0468*	*6.80e+35*	*99.42580*	*102.5887*	*100.5988*
3	*-1862.398*	*280.6476**	*6.01e+31**	*89.83626**	*94.45894**	*91.55057**

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

From the above, it is obvious that the required ordered lag length is at lag three (3).

Post-Estimation Tests

To provide a valid interpretation of the result in table 1 above, certain criteria must be in place. According to Gujarati, Porter and Gunaseker (2013), and Koutsoyannis (1977), pre-estimation tests are necessary but not sufficient condition to a valid regression estimate. That post-estimation test is sufficient to validate regression estimates, and only when outputs are validated that any meaningful interpretation and inference can be made. Therefore, to validate the output in table 1 above, the following major post-estimation diagnostics are considered inevitable: Economic criteria, Statistical criteria and Econometric criteria.

Economic A-Priori Criteria

This test is a check on the signs and sizes of the parameters in line with the postulations from economic theory.

In line with the postulations of the above theoretical framework in (14), parameters of all the explanatory variables in equation (14) are expected to be positively related to independent variable(s) (AGQ,CLM, CO2, N2O, CH4, and CFCs). This is shown below; $\beta > 0$, $\varphi > 0$, $\theta > 0$, $\lambda > 0$, $\gamma > 0$ and $\psi > 0$, $\Phi > 0$, $\Pi > 0$, $Ъ > 0$, $\chi < 0$, $\delta < 0$, $\xi > 0$.

Table 4: The Test of Coefficients Conformity with the Theoretical Postulations.

S/N	Variables	Lags	Exptd signs/sizes	Eq. (7) **AGQ**	Exptd signs/sizes	Eq. (8) **CLM**	Exptd signs/sizes	Eq. (9) **CO_2**	Exptd signs/sizes	Eq. (10) **N_2O**	Exptd signs/sizes	Eq. (11)**CH_4**	Exptd signs/sizes	Eq. (12)**CFCs**

1.	AGQ	1.	*(+)*	*(-)*	*(-)*	*(-)***	*(+)*	*(+)***	*(+)*	*(-)*	*(-)*	*(-)***	*(-)*	*(-)***
		2.	*(+)*	*(+)***	*(-)*	*(+)*	*(+)*	*(-)*	*(+)*	*(+)***	*(-)*	*(-)***	*(-)*	*(+)***
		3.	*(+)*	*(-)*	*(-)*	*(-)***	*(+)*	*(+)***	*(+)*	*(-)*	*(-)*	*(+)*	*(-)*	*(-)***
2.	CLM	1.	*(+)*	*(-)*	*(+)*	*(-)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*	*(-)***
		2.	*(+)*	*(-)*	*(+)*	*(-)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*	*(-)***
		3.	*(+)*	*(-)*	*(+)*	*(-)*	*(-)*	*(+)*	*(-)*	*(-)***	*(-)*	*(-)***	*(-)*	*(-)***
3.	CO_2	1.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(+)***
		2.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(+)***	*(+)*	*(+)***	*(+)*	*(+)***	*(+)*	*(+)***
		3.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***
4.	N_2O	1.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(+)***	*(+)*	*(+)***
		2.	*(-)*	*(-)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*
		3.	*(-)*	*(-)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*
5.	CH_4	1.	*(-)*	*(-)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*
		2.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(+)***	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***
		3.	*(-)*	*(-)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*
6.	CFC_S	1.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(-)*	*(+)*	*(+)***
		2.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***
		3.	*(-)*	*(+)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***	*(+)*	*(-)*	*(+)*	*(+)***

*Note: ** indicates conformity with the Theoretical postulations.*

Statistical Criteria

This is also called the first-order test for the evaluation of the parameter estimates. In this study, the following first-order tests shall be used: tests of significance, and the coefficient of multiple determinations.

Tests of Significance: (Standard Error Test, F-Statistics)

In order to justify the significance (relevance) of a given series, the researcher employs exact (true) level of significance (Standard Error Test) approach in testing hypotheses of the study. Thus, any coefficient divided by two (β/2) with greater value relative to the value of the standard error[s (β)] is considered statistically significantly different from zero. In table 1 above, coefficients considered statistically different from zero are highlighted with asterisk. This implies that its effect on the dependent variable is recognized in this study.

In conducting the F-Statistic test, we use the F-Table taking; N=44 and K=19. But $\nu 1$=K-1=19-1=18; and $\nu 2$ = N-K=44-19=25. Therefore, by checking $\nu 1 = 18$ against $\nu 2 = 25$ in F-Table, we find F-tabulated to be approximately 2.05 as can be seen in the table above. This test is aimed at testing the overall significance of the regression and it implies testing null hypothesis (HO) that

the overall regression is not significant. Given that the decision rule is to reject HO if F* > F, (where F* = F-Statistics Cal. and F = F-Statistics Tab.) then, the test result from the above table 5 shows that equations (7), (8), (10), (11) and (12) rejected the HO while (9) accepted the HO. However, we conclude that the whole VAR system is significant.

Table 5: Test Result for F-Statistics for Equations (7) to (12).

S/N	*Models*	*F-Statistics Cal.*	*F-Statistics Tab.*	*Remark/Decision*
1.	*Equation 7*	*494150.1*	*2.05*	*Reject HO*
2.	*Equation 8*	*36876.66*	*2.05*	*Reject HO*
3.	*Equation 9*	*2.030857*	*2.05*	*Accept HO*
4.	*Equation 10*	*16093.13*	*2.05*	*Reject HO*
5.	*Equation 11*	*34.30745*	*2.05*	*Reject HO*
6.	*Equation 12*	*1162239.*	*2.05*	*Reject HO*

Coefficient of Multiple Determinations (R^2 and Adjusted R^2)

The test for coefficient of multiple determinations is a statistical test that tests the explanatory power of the independent variables in determining changes in the dependent variable.

Table 6: Test Result for Coefficient of Multiple Determinations

S/N	*Models*	*R^2*	*Adjusted R^2*
1.	*Equation 7*	*0.999997*	*0.999995*
2.	*Equation 8*	*0.999962*	*0.999935*
3.	*Equation 9*	*0.593862*	*0.301442*
4.	*Equation 10*	*0.999914*	*0.999852*
5.	*Equation 11*	*0.961092*	*0.933077*
6.	*Equation 12*	*0.999999*	*0.999998*

The result in equation (7) shows that, 99.97% of changes in the dependent variable is explained by the independent variables, other changes in the dependent variable that are not captured by the explanatory variables amounted to 0.013% including the adjusted, while in equation (8), 99.962% of variation in the dependent variable is determined by the changes in explanatory variables. Other changes in the dependent variable that are not captured by the explanatory variables amounted to 0.038% including the adjusted. Equations (10), (11), and (12) respectively captured variations in the dependent variables at 99.9%, 96.1%, and 99.9% with their respective adjusted R^2s, left only

insignificantly minute values un-captured by the explanatory variables. However, equation (9) captured changes in the dependent variable (CO_2) by 59.38% and the adjusted R^2 is only 30.14%. This means, 40.62% of variations in the response variable (CO_2) is explained by other variables not included in the model. Such variables may include; deforestation, aforestation rate, population growth rate, death rate, tropospheric ozone (O_3) etc.

Econometric Criteria

VAR Residual Portmanteau Tests for Autocorrelations.

The VAR residual portmanteaus test for autocorrelations is a test for the residual autocorrelations in VAR models. It actually considers the probability of the error term being free from autocorrelation if lags larger than the VAR lag order were taken. Here, the test considers the Null Hypothesis (HO): no residual autocorrelations up to lag h, but looking at

Table 7: Test Result for VAR Residual Portmanteau Tests for Autocorrelations.

Lags	*Q-Stat*	*Prob.*	*Adj Q-Stat*	*Prob.*	*Df*
1	*73.78359*	*NA**	*75.49949*	*NA**	*NA**
2	*115.9746*	*NA**	*119.6996*	*NA**	*NA**
3	*138.0268*	*NA**	*143.3654*	*NA**	*NA**
4	*152.7646*	*0.0000*	*159.5770*	*0.0000*	*36*

*Note: P<0.05 is taken here; *the test is valid only for lags larger than the VAR lag order. df is degrees of freedom for (approximate) chi-square distribution*

the table above, at lag 4, the test actually rejects the HO, which means that, there are residual autocorrelations up to lag 4, if taken. However, the test accepts HO at lag three (3) which means there is no autocorrelation in the residuals.

Multicollinearity Test: (High R^2 but poor Standard Error Test)

The rule of thumb for dictating multicollinearity is that, the R^2 be high with poor significance test. The R^2 for equations (7) to (12) are 0.999997, 0.999962, 0.593862, 0.999914, 0.961092 and 0.593862 respectively. In result table 5.17 for the equation (7) to (12) rejected the null hypothesis of insignificance in almost all the models. This means, the overall significance tests agrees that, the models are statistically significant from zero except model (9), but actually speaking the R^2 for

model (9) is not high, but just 59.38%, and cannot be said to fulfill the condition for multicollinearity. This means, there is not collinearity among variables in the six models.

VAR Residual Serial Correlation LM Tests

The VAR residual serial correlation test is the test for the presence of serial correlation in the VAR systems given the lag ordering. The test is design to test the Null Hypothesis (HO) of "no serial correlation at lag order h". The HO is tested and

Table 8: Test Result for VAR Residual Serial Correlation LM Tests

Lags	*LM-Stat.*	*Prob.*
1.	*240.6312*	*0.0000*
2.	*115.0162*	*0.0000*
3.	*55.33342*	*0.0207*
4.	*22.80088*	*0.9572*

Note: Probs. from chi-square with 36 df. P-value <0.05, the result in the above table 5.20 accepted the HO at lag ordered h (4), however, at lags below 4, HO is rejected. This means, although at lag ordered h, there exist no serial correlation. The test actually excludes the ordered lags (1-3). This means the residuals are serially uncorrelated.

VAR Residual Normality Tests

The decision rule here about the null hypothesis is that: the residuals are multivariate normal, this null hypothesis will be rejected if the value of the probability of the Chi-Square calculated be less than 0.05. Therefore, from the below table, the joint p-value rejected the null hypothesis of multivariate normality, meaning that the OLS assumption of normality is violated.

Table 9: Test Result for VAR Residual Normality Tests.

Components	*Statistics*	*Chi-Sq*	*df.*	*Prob.*
Joint	*Skewness*	*80.41105*	*6*	*0.0000*
Joint	*Kurtosis*	*368.1868*	*6*	*0.0000*
Joint	*Jarque-Bera (448.5979)*		*12*	*0.0000*

Note: P-value <0.05,

However, the violation of this assumption does not affect the unbiasness of the parameter estimates (Koutsoyiannis, 1977). Again, the central limit theorem clearly stated that, 'even if the population is not normal, the sampling distribution of the mean tends to the normal distribution as the sample size *n* tends to infinity'.

Variance Decomposition

Variance decompositions give the proportion of the movements in the dependent variables that are due to their 'own' shocks, versus shocks to the other variables. Variance decompositions determine how much of the s-step-ahead forecast error variance of a given variable is explained by innovations to each explanatory variable for s = 1, 2, ...In practice, it is usually observed that own series shocks explain most of the (forecast) error variance of the series in a VAR. Consider the result in table 10 below:

Table 10: Test Results for Variance Decomposition.

Variance Decomposition of D(AGQ):							
Period	*S.E.*	*D(AGQ)*	*D(CLM)*	*D(CO_2)*	*D(N_2O)*	*D(CH_4)*	*D(CFC_S)*
1	*1792.856*	*100.0000*	*0.000000*	*0.000000*	*0.000000*	*0.000000*	*0.000000*
		(0.00000)	*(0.00000)*	*(0.00000)*	*(0.00000)*	*(0.00000)*	*(0.00000)*
2	*16610.39*	*7.483597*	*91.57440*	*0.001882*	*0.159207*	*0.564283*	*0.216632*
		(8.20661)	*(7.98654)*	*(0.08108)*	*(0.21626)*	*(0.41836)*	*(0.43223)*
3	*41554.70*	*2.110759*	*74.79509*	*0.628809*	*2.822400*	*7.955199*	*11.68775*
		(5.00613)	*(20.1307)*	*(2.88742)*	*(3.72840)*	*(6.19192)*	*(11.1915)*
4	*8428060.*	*98.72579*	*1.252624*	*3.40E-05*	*0.004046*	*0.009757*	*0.007745*
		(11.2583)	*(7.93338)*	*(0.04702)*	*(0.36197)*	*(1.29672)*	*(1.68710)*
5	*1.19E+08*	*76.54477*	*23.23143*	*0.000181*	*0.040263*	*0.145813*	*0.037546*
		(22.5343)	*(22.0649)*	*(0.03356)*	*(0.14018)*	*(0.26041)*	*(0.24826)*
6	*1.00E+09*	*5.233612*	*91.59195*	*0.023394*	*0.449907*	*1.620352*	*1.080785*
		(9.15194)	*(8.49620)*	*(0.33786)*	*(0.92913)*	*(2.36120)*	*(1.41655)*
7	*2.96E+10*	*99.45494*	*0.434128*	*0.005028*	*0.009651*	*0.034895*	*0.061354*
		(21.5684)	*(14.7368)*	*(0.53506)*	*(0.66959)*	*(4.09337)*	*(7.29531)*
8	*9.47E+11*	*97.76465*	*2.152011*	*6.12E-05*	*0.015452*	*0.050106*	*0.017715*
		(9.69181)	*(9.47351)*	*(0.01424)*	*(0.08086)*	*(0.15494)*	*(0.12230)*
9	*9.87E+12*	*44.72539*	*54.21888*	*0.004377*	*0.166034*	*0.598661*	*0.286657*
		(26.6951)	*(25.5207)*	*(0.11256)*	*(0.35716)*	*(0.83707)*	*(0.64352)*
10	*1.37E+14*	*70.33542*	*28.35841*	*0.017077*	*0.170329*	*0.613701*	*0.505059*
		(29.7266)	*(28.9690)*	*(0.11896)*	*(0.25979)*	*(0.50438)*	*(0.69746)*

Note: Cholesky Ordering D(AGQ) D(CLM) D(CO_2) D(N_2O) D(CH_4) D(CFC_S) Standard Errors: Monte Carlo (100 repetitions)

The above result shows that, after period 10 only 70.33542% of movements in the agricultural yield are explained by agricultural shocks. The agricultural yield seems particularly influenced by annual rainfall (CLM) (28.35841% after period 10) shocks.

Evaluation of the Research Hypothesis: $H0_2$: There is no significant response of agricultural output to changes in energy consumption, and climate in Nigeria.

This hypothesis was tested by carrying out the F-statistic on the regression output of equation (14). The decision rule to reject the null hypothesis that '*There is no significant response of agricultural output to changes in climate and energy consumption in Nigeria* will be reached only if the calculated F-statistic (F*) is greater than the tabulated F-statistics (F), but the null hypothesis will not be rejected if otherwise. Since the tabulated-statistics (F), are remarkably less than the calculated F-statistic (F*) at 0.05 for equations (14) (except 9), the study on average rejects the null hypothesis and concludes that there is a significant *response of agricultural output to changes in climate and energy consumption, in Nigeria*. In other words, energy consumption and climate change has a significant impact on agricultural output in Nigeria. Implication of this conclusion is that the rate at which the economy grows was significantly influenced or determined by developments in the energy sector and climate change in Nigeria. The finding points to the fact that climate change and the energy sector constitutes a part of key economic growth drivers in Nigeria despite the specific contributions from other economic sectors.

Evaluation of the Research Objective: To examine the response of agricultural output, to changes in climate and energy consumption, in Nigeria.

To properly evaluate our research objective two which requires the examination of the response of agricultural output, to changes in climate and energy consumption in Nigeria using a VAR technique, it is of necessity that the VAR technique of impulse response be employed: that is to say, F-test results alone will not reveal whether changes in the value of a given variable have a positive or negative effect on other variables in the system, or how long it would take for the effect of that variable to work through the system. Such information will, however, be given by an examination of the VAR's impulse responses and variance decompositions.

Table 11: Test Results for Impulse Response

Response of D(AGQ):						
Period	*D(AGQ)*	*D(CLM)*	*D(CO_2)*	*D(N_2O)*	*D(CH_4)*	*D(CFC_S)*
1	*1792.856*	*0.000000*	*0.000000*	*0.000000*	*0.000000*	*0.000000*
	(200.011)	*(0.00000)*	*(0.00000)*	*(0.00000)*	*(0.00000)*	*(0.00000)*
2	*4175.320*	*15895.23*	*72.06403*	*662.7672*	*-1247.752*	*773.1103*
	(2832.32)	*(2284.98)*	*(420.853)*	*(457.467)*	*(410.205)*	*(763.810)*
3	*3975.024*	*32231.94*	*-3294.393*	*-6949.657*	*11653.88*	*-14185.40*
	(7789.79)	*(13243.6)*	*(4395.89)*	*(5083.17)*	*(4192.52)*	*(6687.68)*
4	*8374190.*	*942589.5*	*-3650.133*	*-53154.33*	*82420.94*	*-72798.48*
	(4813790)	*(602684.)*	*(20093.5)*	*(20727.4)*	*(17071.4)*	*(21040.8)*
5	*-1.03E+08*	***57137222****	***159543.4****	***2378401****	***-4526529****	***2296124****
	(3.6E+07)	*(4.5E+07)*	*(1983802)*	*(2655413)*	*(3765991)*	*(5541073)*
6	*-2.05E+08*	*-9.60E+08*	*-15361903*	*-67329152*	*1.28E+08*	*-1.04E+08*
	(2.0E+08)	*(3.2E+08)*	*(3.9E+07)*	*(5.0E+07)*	*(5.6E+07)*	*(9.2E+07)*
7	*2.95E+10*	*1.70E+09*	*2.09E+08*	*2.83E+08*	*-5.38E+08*	*7.26E+08*
	(4.5E+10)	*(5.2E+09)*	*(2.9E+08)*	*(4.5E+08)*	*(5.1E+08)*	*(7.3E+08)*
8	*-9.36E+11*	*1.39E+11*	*7.11E+08*	*1.18E+10*	*-2.12E+10*	*1.26E+10*
	(6.8E+11)	*(3.4E+11)*	*(1.1E+10)*	*(1.8E+10)*	*(3.0E+10)*	*(5.0E+10)*
9	*6.53E+12*	*-7.27E+12*	*-6.53E+10*	*-4.02E+11*	*7.63E+11*	*-5.28E+11*
	(4.7E+12)	*(6.1E+12)*	*(3.1E+11)*	*(4.9E+11)*	*(7.5E+11)*	*(9.9E+11)*
10	*1.15E+14*	***7.27E+13****	***1.79E+12****	***5.65E+12****	***-1.07E+13****	***9.74E+12****
	(4.1E+14)	*(6.6E+13)*	*(4.1E+12)*	*(5.8E+12)*	*(7.2E+12)*	*(1.1E+13)*

Note: Cholesky Ordering D(AGQ) D(CLM) D(CO_2) D(N_2O) D(CH_4) D(CFC_S) Standard Errors: Monte Carlo (100 repetitions).

Impulse responses trace out the responsiveness of the dependent variables in the VAR to shocks to each of the variables. So, for each variable from each equation separately, a unit shock is applied to the error, and the effects upon the VAR system over time are noted. Thus, if there are *g* variables in a system, a total of *g*2 impulse responses could be generated.

From table 11 above, it is noted that after period five (5) of shocks in annual rainfall (CLM) in Nigeria, 57137222% response of agricultural output to innovations in CLM is noted. That is to say, 57137222% response of agricultural output to innovations in CLM is noted in five (5) periods after shocks. At the same period of shocks in Carbon Dioxide (CO_2), Nitric Oxide (N_2O), Methane (CH_4) and Chlorofluorocarbons (CFCs) in Nigeria, respective responses of agricultural output to innovations in these energy-enhanced atmospheric gases stands at: 159543.4%, 2378401%, -4526529%, 2296124%. This same trend of responses repeat itself in period ten (10) clearly separating CFCs and CLM as having the dominant influence on the Nigeria's agriculture. This reveals to the minds that, the Nigeria's agriculture is highly sensitive to energy use (especially

fossil fuel resources that enhances the emission of chlorofluorocarbons) and climate (i.e., annual rainfall).

Policy Implications of the Findings

The Vector-autoregressive (VAR) test unveiled that at period five (5) of shocks in annual rainfall (CLM) in Nigeria, 57137222% response of agricultural output to innovations in CLM is noted. That is to say, 57137222% response of agricultural output to innovations in CLM is noted in just five (5) periods after shocks. At the same stated period of shocks in Carbon Dioxide (CO_2), Nitric Oxide (N_2O), Methane (CH_4) and Chlorofluorocarbons (CFCs) in Nigeria, respective responses of agricultural output to innovations in these energy-enhanced atmospheric gases stands at:159543.4%, 2378401%, -4526529%, and 2296124%. This same trend of responses repeated itself in period ten (10), clearly separating CFCs and CLM as having the dominant influence on the Nigeria's agriculture. This reveals to the minds that, the Nigeria's agriculture is highly sensitive to energy use (especially fossil fuel resources that enhances the emission of chlorofluorocarbons) and climate (i.e., annual rainfall).

Policy recommendations

Agriculture should be highly encouraged, both at local production level using local implement and also mechanized farming to cope with changes that are likely to occur within a limited space of time. Government budget for 2019 should concentrate more on agriculture and welfare improvement among the citizens to cushion the effect of crop failure on human lives that is due to atmospheric changes evident in Nigeria and drive home an improved living standard. As such, the federal government should sit up in its commitment to tackle internal security issues, increase transparency in the fight against corruption and improve infrastructural development across the country. These measures will help to improve investment in agriculture and at the same time improve general economic welfare in Nigeria.

Conclusion

The significant *response of agricultural output to changes in climate and energy consumption in Nigeria* is a source of concern. This study therefore concludes that agricultural output is strictly

determined by both internal (inputs) and external (atmospheric reactions due to anthropogenic activities) factors that popularly administer variations in macroeconomic variables. It is also affirmed by the study that Nigeria should do more to implement adaptation and mitigation strategies to arrest the severe effect of fossil fuel consumption leading to climate change among nations especially in third world nations that are already poverty-driven. The study concludes that it could become detrimental to general economic welfare if the recent upward trend is allowed to escalate.

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