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IMPACTS OF CLIMATE CHANGE AND POPULATION GROWTH ON FOOD SECURITY IN NIGERIA

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Abstract: Food production in Nigeria has not matched with the rate of population growth leading to reduction of national food independence and self-reliance. As a result, Nigeria is facing serious food insecurity. Therefore, this research examined the impacts of climate change and population growth on food security in Nigeria. Annual time-series of food security (proxy of food production index), annual rainfall, annual temperature, population growth rate, urban population rate and agricultural land used from 1980 to 2019 were used. The research used Augmented Dickey-Fuller (ADF) unit root test, Vector Autoregressive (VAR) model, Johansen Cointegration test and Vector Error Correlation Models (VECM) were used to analyze the data. ADF unit root test result shows that all variables were completely stationary at the first different orders I(1) at both at intercept and intercept with trend at level of significance of 1%. Three (3) lags were conclusively selects as the optimum lag in the VAR model. The result of the estimation indicates that the Johansen cointegration shows an existence of long-run relationship among the variables used in the study. The result of the VECM estimation shows that rainfall, temperatures, population growth rate and agricultural land used were negatively significantly related to food security at various levels of significance (1%, 5% and 10%). At the long-run all the variables were adversely related to food security in Nigeria. The coefficient of multiple determinations (R^2) indicates about 91%, the adjusted R^2 of 0.86 was obtained and Durbin-Watson of 2.1 was obtained which implies that the tools were good fit to estimates the data. Decomposition of variance shows dwindling in food security. The research therefore recommends public enlightenment campaign on birth control; and appropriate climate change adaptation methods should be adopted to enhance food security in Nigeria among others.

Keywords: Agricultural land, Climate change, Food security, Nigeria, Population growth

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1. Introduction

Food insecurity and hunger are increasing globally, with above 30 percent of the worldwide population presently facing food insecurity (Sibanda and Mwamakamba, 2021). Food and Agriculture Organization of United Nation FAO (2021) reported that about 927.6 million people suffered food insecurity in diverse and several periods in 2020. Out of this, about 346.6 million signified 37.3% in Africa people suffered food insecurity (Xie et al., 2021). Coronavirus (COVID-19) pandemic has added to the prevailing causes of food insecurity, climate change, unstable economic factors, undernourishment, and population growth rate in most countries. Nations that are experiencing food insecurity are mostly susceptible to climate change and adaptation strategies capacities are limited (Ntiamoah et al., 2022). Climate change is contributing largely to the effect of food security in Sub-Saharan African. Nigeria's food insecurity has been increased by climate change such as prolonged drought, increase in temperatures, erratic rainfall patterns, carbon emissions (CO_2), and flood among others.

Nigeria has an enormous capacity to attain and reach food security with her absolute excessive natural endowment and human resources. In spite of this, Nigeria has a nation is not capable and proficient to feed its populaces owing to various difficulties and setbacks distressing agricultural sector productivity. Foremost amongst these difficulties are climate change and rapid population growth. The rapid population growth remains one of the key difficulties confronting foods security in Nigeria. However, agricultural productivity has increased, yet, it has not overtaken population growth. According to United Nations as cited in Pontianus and Oruonye (2021), Nigeria population will be about 440 million by 2050, with five live births per woman and a population growth rate of 3.2 percent per annual. This means that there will be more populaces to feed in Nigeria. Hence, if agricultural production is not outpaced the rapid population growth rate in the country, it is certain it might lead to critical food crisis in years to come, coupled with climate change impacts (severe drought and intense flooding) on agricultural production. The impacts of this climate change include reduction in land availability for food production, high cost farmland procurement, devastation of crops and livestock and subsequently, decrease in food production. It is in contrast to this scenery that this research is planned. Therefore, this research examined the impacts of climate change and population growth on food security in Nigeria empirically.

Climate change is the variations that can be ascribed to the direct and indirect activity of human that alters the components of the atmosphere globally which is observed over some considerable periods (UNFCCC, 2011). These variations in climatic factors extremities may possibly impact the food chain; from the point of production on the farm activities to consumption. Extreme weather factors such as floods, droughts, storms and fires impact negatively on food security.

The United Nations' Food and Agricultural Organization describes food security as "when all the people at all times, have physical, social and economic access to sufficient, safe and nutritious food for an active and healthy life" individuals in households are the hub of concern against hunger and poverty. Four scopes of food security according to Bajagai (2013) are:

Food availability: This is related to adequate in both quantity and quality of food supply via national agricultural production and/ or import, distribution, and marketing.

Food accessibility: Refers to individuals or households have sufficient economic resources to afford apt and suitable quantity of quality food (devoid of stealing, scavenging, emergency food supply, or other surviving systems).

Food utilization: This comprises food preparation, household-level food distribution, clean water and hygiene, as well as good health care systems.

Food stability: This scope means ability to acquire or get food at all times. Hence, nations cannot be regarded food secured until there is availability, accessibility, adequate utilization stipulations, and stability of food for the majorities.

Population is the aggregate number of residents comprising a specific race, group or class in an identified area (AbdulRahaman, 2013). Population growth is the change in the proportions of population due to natural increases (AbdulRahaman, 2013) both by birth and immigrants, it is determined in absolute and relative terms. While, population growth rate is the mean yearly percentage change in the population, which is influenced by birth and death rate, and the balance between immigrants and emigrants in a particular nation within a definite period (Mundi Index, 2021). Hence, population growth rate is a key factor in determining food security, greenhouse gases (GHGs) emission, and other infrastructures stability of a nation. Increase in population growth and rural-urban migration are distressing domestic agricultural productivity which is the backbone of securing food in the country.

2. Efforts in Achieving Food Security in Nigeria

In view of the importance of the status of food security in sustainable development goals, and the role of food security in eradicating hunger and malnutrition which wear away human capacity and decreases labour supply for economy productivity; Nigeria government as a matter of urgency as diving into programmes, which hope to facilitate the alleviation of hunger and poverty in the country. Some of these programmes embarked in Nigeria according to Osu (2017) includes the following: Operation Feed the nation (OFN) which aim at sensitizing Nigerian on food production; River Basin Development Authority (RBDA) equipped with regard of increasing fish production, control of flood, and water pollution as well as erosion in the country specially in the Southern part of the country; Agricultural Development Project (ADP) equipped towards increasing the technical and economic productivity and profitability of the small-scaler farmers; Green Revolution geared to alleviate hunger; The National Special Food Security Programme geared towards spreading the adoption of relevance innovations to the farmers at minimum cost; The National Fadama Development project (that's FADAMA I, II and III) equipped towards reducing the distresses and misfortunes of the farmers to empower and facilitate them to achieved their maximum potential profit in agricultural production operations. All these programmes were inaugurated to achieve food security and economic growth in Nigeria. Regardless of the impressive and creditable objectives of all these programmes, it could not achieve it expectation because of the impact of climate change, population growth rate and other socio-factors.

3. Theoretical Framework

The theoretical behind this study is based on Malthusian population theory. Reverend Thomas Malthus (1798) published his theory on population titled, *"An Essay on the principle of population."* Malthus in his classical work postulated that population have a propensity to exceed the means of sustenance, that's incessant increase in population growth will result in economy standstill if necessary and immediate measures are not adopted to curb this (Aidi et al., 2016; Pontianus and Oruonye, 2021). He claimed that population increased in a geometrical succession (such as 2,4,8,16,32,64…) while food production increased in arithmetical succession (such as 2,4,6,8,12,14…), this disequilibrium will negatively affect food security and economic growth. Consequently, Malthus argued that at the proper and right time there would be food supply deficiency resulting in reduction in the living standard, poverty as well as misery (Oladimeji, 2017), since farmland reduces as poor or deficient quality farmlands are planted as a result of rapid increase in population density. This opinion was substantiated and upheld by scholars such as Coale and Hoover (1958) and Ehilich (1968) as cited in Pontianus and Oruonye (2021) who investigated and remarked that rapid increase in population growth has the propensity to impact economy adversely since it could devastate any stimulated reaction by technological advancement, food production and capital accumulation. Malthus theory was based on population pessimistic.

Based on the hypothesizes and proposes of Malthus theory, he recommended positive and precautionary curbs (control). The positive curbs include rise in death rates due to wars, scarcity of food, hunger, pandemics among others. For precautionary curbs, Malthus promoted and endorsed decrease in the birth rates through pure and modest restrictions. By pure and modest restrictions, he advocated birth control methods like marrying late and restriction by married couples. Being a clergyman, he did not agree with unnatural birth control methods such as using contraceptives drugs, abortions among others. Malthus was viewed as a prophet of tragedy in the western economy due to his projections which falls short of prospect. However, in Sub-Saharan African countries, the certainties of Malthus's projections cannot be condemned and criticized. Albeit Nigeria population has not increased at geometric rate as proposed by Malthus, ultimately population growth rate has been enormous (Ewugi and Yakubu, 2012). The vice predicted by Malthus's theory is obvious and distinct in Nigerian economy and persist chasing Nigerians, thus the brutal, agitation and restlessness experience in the nation, which has resulted in scores of deaths. Domestic food production continually falls behind the food requirements of the population rate of the nation; this has led to huge importation of food which is destructive to national balance of payment. Despite the fact that there has not been dire and grave starvation in Nigeria over the past years, yet reports show that food security has been supported by food importation to feed rapid population growth in the country. The government report as at 1985, which assess the food condition in Nigeria reported that there was hardly a single food commodity in which the country can states categorically to be independent and self-reliant (Asua, 2016). This pathetic fact mirrors the condition of Nigeria even presently; that is to say, Nigeria's ever-increasing population growing rate cannot provide sufficient food to feed her populace.

Some of the research carried out on the relationship between food security, climate change and population growth include Kumar and Sharmar (2013) who carried out their studies on the impact of climate variation on food security in rural India discovered that climate variation impact negatively on food security. Josephson, Ricker-Gilbert and Florax (2014) examined the relationship between rural population growth and agricultural intensification and production in Ethiopia. Their result shows a significant relationship between population growth and farm sizes and reduction in agricultural productivity. Zewdie (2014) stated categorically that climate change has harmful impacts on food stability in Sub-Sahara Africa. Mahrous (2019) found out that temperature has negative influence on food security whereas rainfall and increase in cereal crops planting has a positive effect on food security in the East African Community (EAC) region under the five countries considered for the study.

Osuafor and Nnorom (2014), Ladan (2014), Mbah, Ezeano and Saror (2016), and Idumah et al. (2016) found out that climate change adversely affects food security in Nigeria negatively. Ahungwa et al. (2019); and Osu (2017) established that rapid population growth negatively affecting food production in Nigeria. While Oladimeji (2017) confirmed the Malthusian population theory in his research on the relationship between population growth and rice production in Nigeria, and found out that population was increasing exponentially whereas rice production was increasing arithmetically in Nigeria.

From the empirical studies in Nigeria, most of the studies focused on either the impact of population growth rate or climate change in relation to food security in Nigeria. Some research examined only one crop, and some used only one State or Region for their studies. Therefore, to fill the knowledge gaps, this research incorporated the impacts of both climate change and population growth on food security in Nigeria, by using national-wide data to examine the impact of climate change and population growth on food security in Nigeria.

4. Materials and Methods

The study used yearly time-series data from 1980 to 2019. The data were collected from FAO, World Bank, and Macro trends database (2022). The mathematical model function is specified thus (equation 1);

$$FPI = f(RF, Temp, PGR, UPR, ALU) \quad (1)$$

Where; FPI is food production index (a proxy for food security; covers food crops that are edible and contain nutrients); RF is rainfall (mm); Temp is temperatures (°C); PGR is population growth rate; UPR is urbanization population rate (used as control variable); and ALU is the agricultural land used (km^2).

Ordinary Least Square OLS is expressed thus (equation 2);

$$FPI = \beta_0 + \beta_1 RF + \beta_2 Temp + \beta_3 PGR + \beta_4 UPR + \beta_5 ALU + e \quad (2)$$

Where;
β_0= Regression constant
$\beta_1 - \beta_5$= Coefficients of independent variables
e = Error term

In logarithm form as (equation 3);

$$LnFPI = \beta_0 + \beta_1 LnRF + \beta_2 LnTemp + \beta_3 LnPGR +$$

$\beta_4 LnUPR + \beta_5 LnALU + e$ (3)

Where; Ln is natural logarithm

In accordance with the assumption that the data used is time-series and stationary. In order to prevail over the non-stationarity incident and other limiting factors related time-series analysis, Augmented Dickey-Fuller (ADF) unit root test was utilized to test the stationarity of the data. In accordance with the properties of time series, it is very essential to carry out the unit root test on the series in the Vector Autoregressive (VAR) model (Salako, Lawrence, Aremu and Egbekunle, 2015).

Johansen Cointegration test has been ascertained to be consistent and dependable (Salako et al., 2015) and it is adopted in this study. In accordance with the result of ADF unit root test, Johansen cointegration test was utilized to test the long-run relationship and the vector error correlation models (VECM) was utilized to estimates the short-run variability of the data to equilibrium trend. The data were analyzed using gretl software. The VECM model can be expressed as (equation 4);

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-1} + \mu + \epsilon_t \quad (4)$$

Where;

Δy_{t-1} = First difference operator of (n x 1) vector of the n variables

y_{t-1} = Lagged values of Y_t

Δ = Difference operator

Π = (n x n) coefficient matrix

Γ = (n x (k-1)) matrix of short-run coefficients

μ = error term

ϵ_t = (n x 1) vector of white noise disturbances

The fundamental theory of the Johansen cointegration test is that if the coefficient matrix (Π) has decreased rank (r < n), this could be disintegrated into a matrix (n x r) of the loading coefficients alpha (α) and a matrix (n x r) of cointegrating vectors beta (β) such that coefficient matrix becomes products of alpha and beta, that's Π = αβ (Idumah et al., 2016). The cointegrating rank (r) is the number of the cointegrating relationships. The coefficients of alpha (α) specify the cointegration relationships in the individual equations of the system in the model and the rate of the adjustment to disequilibrium, whereas the cointegrating vectors beta (β) indicates the long-run equilibrium relationship.

Idumah et al. (2016) described two likelihood ratio tests specifically they are Trace and maximum Eigen value statistic tests which are utilized to ascertain the number of cointegrating equations specified by the cointegration rank (r). The trace statistic test equation specified thus (equation 5);

$$Trace = -T \sum_p \ln(1 - \sigma i) \quad (5)$$

The Trace test examines the null hypothesis that there are most rank (r) cointegrating vectors in contrast to the alternative hypothesis that there are ranks (r) or additional cointegrating vectors (Idumah et al., 2016). The Maximum Eigen-value (Lmax) examines the null hypothesis that there are more r cointegrating vectors in contrast to the alternative of r + 1 cointegrating vector and expressed as (equation 6);

$$Lmax = -T.\ln(1\gamma r + 1) \quad (6)$$

A priori theoretical expectations

$LnFPI = \beta_0 + \beta_1 LnRF + \beta_2 LnTemp + \beta_3 LnPGR + \beta_4 LnUPR + \beta_5 LnALU + e$

($\beta_1 < 0$, + $\beta_2 < 0$, $\beta_3 < 0$, $\beta_4 < 0$, $\beta_5 < 0$)

5. Results and Discussion

Non-stationarity data may generate unauthentic and specious regression; consequently the result may perhaps be misleading the end users and policy-makers. As a result, it is rational and sagacious to ascertain the stationarity of the data. The stationarity test result of the Augmented Dickey-Fuller (ADF) unit root test for the time-series variables data employed in the estimation are presented in Table 1.

Table 1 shows the stationarity test result of the ADF unit root test of the variables. The existence of unit root signifies that the variables are non-stationary. LnFPI, LnPGR and LnALU variables were non-stationary at their own levels I(0) both at intercept and intercept with trend, but are completely stationary at the first different orders at both at intercept and intercept with trend. While LnRF, LnTemp and LnUPR were both stationary at their own levels and at first different orders at both intercept and intercept with trend. All tested at level of significance of 1%. This implies that the variables are of the mixed order zero and one orders, i.e *I(0)* and *I(1)*. Thus, the null hypothesis of possessing a unit root is therefore rejected and accepted the alternative hypothesis.

Table 1. Stationarity: Augmented Dickey-Fuller (ADF) unit root test

Variables	Level				First Difference			
	t-value	*p*-value	OI	Remarks	*t*-value	*p*-value	OI	Remarks
Intercept:								
LnFPI	-1.7019	0.4225	I(0)	NS	-8.7571	0.0000	I(1)	S
LnRF	-5.9741	0.0000	I(0)	S	-9.7271	0.0000	I(1)	S
LnTemp	-3.3269	0.02032	I(0)	S	-8.4256	0.0000	I(1)	S
LnPGR	-0.7453	0.8231	I(0)	NS	-3.7404	0.0072	I(1)	S
LnUPR	-4.3534	0.0013	I(0)	S	-10.4095	0.0000	I(1)	S
LnALU	-2.2177	0.2036	I(0)	NS	-5.6583	0.0000	I(1)	S
Intercept and trend:								
LnFPI	-1.0705	0.9212	I(0)	NS	-9.7158	0.0000	I(1)	S
LnRF	-5.7905	0.0001	I(0)	S	-9.6971	0.0000	I(1)	S
LnTemp	-4.8780	0.0017	I(0)	S	-8.3212	0.0000	I(1)	S
LnPGR	-1.1402	0.9087	I(0)	NS	-3.6688	0.0371	I(1)	S
LnUPR	-3.8364	0.0250	I(0)	S	-11.1656	0.0000	I(1)	S
LnALU	-1.2986	0.8732	I(0)	NS	-7.0537	0.0000	I(1)	S

OI= order of integration; NS = non stationarity; S = stationarity; I(0) = zero level; I(1) = first different

Table 2 above shows the estimation of the VAR model for decisive of an optimal lag orders. The asterisks (*) above signify the best values of the respective information criteria level of significance at 5%. Akaike Information Criterion AIC (-39.8859) and Hannan-Quinn Criterion HQC (-38.1371) called for three (3) lags, exclusive of Bayesian Information Criterion BIC (-36.0360) that called for one lag. Therefore, this study conclusively selects three (3) lags as the optimum lag in the model.

The results of Johansen Cointegration test in Table 3, shows that Trace test and Lmax test indicates 3 cointegrating equations respectively at 5% level. This means that the null hypothesis of not having a cointegrating equation (that's r = 0) is rejected and the alternative hypothesis of possessing three (3) cointegrating equations (r = 2) is accepted. This indicates that the Johansen cointegration result shows the existence of a long-run relationship among the variables used in the research. This finding agrees with Idumah et al. (2016) who reported cointegrating equation in their research on climate change and food production in Nigeria between 1975 and 2010.

The presence of cointegrating relationship between the dependent and explanatory variables as shown by Johansen cointegration test demanded the assessment of the short-run dynamic contrast between the variables in the cointegrating relationship equation by assessing the error correlation model.

Table 2. Vector Autoregressive (VAR) model lag order selection criteria

Lags	Loglik	P(LR)	AIC	BIC	HQC
1	705.29259	N/A	-37.9024	-36.0360*	-37.2581
2	741.54846	0.0003	-37.9171	-34.4509	-36.7205
3	812.00372	0.0000	-39.8859*	-34.8199	-38.1371*

Table 3. Johansen Cointegration results

Rank = r	Eigen value	Trace test	*P-value*	Lmax test	*P-value*
r = 0*	0.8301	173.49	0.0000	62.035	0.0000
r ≤ 1*	0.7729	111.45	0.0000	51.885	0.0000
r ≤ 2*	0.6207	59.568	0.0022	33.933	0.0047
r ≤ 3	0.3566	25.634	0.1441	15.434	0.2705
r ≤ 4	0.2128	10.200	0.2705	8.3746	0.3498
r ≤ 5	0.0508	1.8253	0.1767	1.8253	0.1767

* Indicates rejection of the hypothesis at the 5% level

Table 4 shows the Vector Error Correction Models (VECM) result contains the short-run estimate and diagnostics measurements. Rainfall lagged by one period (LnRF (-1)) coefficient is positive and significant at 5% relating with food security (proxy of FPI – food production index). At lagged two periods (LnRF (-2)) rainfall coefficient is also positive and significant at 10%, while the long-run the coefficient is negative (-2.7576). This indicates that rainfall will have negative impact on food security at long-run in Nigeria. However, coefficient of LnRF (rainfall) that is positive in the short-run and negative in the long-run and significant at 1% and 10% in the short-run. This implies and proofs that the vagaries of change in the climatic of rainfall will have negative impacts on food security; availability, accessibility, utilization and stability in Nigeria both presently and in the future. This result agrees with Idumah et al. (2016) who reported negative and positive coefficient of rainfall at long-run and short-run respectively affecting agricultural output in Nigeria.

Table 4. Vector Error Correction Models (VECM) of food security (PFI)

Variables	Coefficient	Std. Error	t-ratio	p-value
Const	-1.13795	0.241794	−4.706	0.0001***
ΔLnRF(-1)	0.872805	0.368989	2.365	0.0277**
ΔLnRF(-2)	0.372304	0.187892	1.981	0.0608*
ΔLnTemp(-1)	7.66926	1.48921	5.150	0.0000***
ΔLnTemp(-2)	3.56993	1.17803	3.030	0.0064***
ΔLnPGR(-1)	−29.3567	19.5126	−1.504	0.1473
ΔLnPGR(-2)	−72.4525	18.1278	−3.997	0.0007***
ΔLnUPR(-1)	1.88965	6.39658	0.2954	0.7706
ΔLnUPR(-2)	5.54598	6.54922	0.8468	0.4066
ΔLnALU(-1)	−3.15678	1.19590	−2.640	0.0153**
ΔLnALU(-2)	−1.39756	0.774330	−1.805	0.0855*
EC1	−2.75762	0.490033	−5.627	0.0000***
EC2	−8.08636	1.71979	−4.702	0.0001***
Mean dependent var	0.006962	S.D. dependent var		0.199354
Sum squared resid	0.118725	S.E. of regression		0.075190
R-squared	0.912135	Adjusted R-squared		0.857743
Rho	−0.055787	Durbin-Watson		2.111077

***, **, * Significant at 1%, 5% and 10% respectively.

Temperature lagged by one period (LnTemp (-1)) and two periods (LnTemp (-2)) has a positive coefficient and significant at 1% respectively in relationship with food security, with negative coefficient (-0.0637) in the long-run. This implies that temperature has a significant impact on food security in Nigeria. Therefore, the variables of climate factor of rainfall and temperature employed in the research proved that climate change has a significant harmful impact on food security in Nigeria.

The coefficient of population growth rate lagged at one period (LnPGR (-1)) has a negative but insignificant relationship with food security, while at lagged of two periods (LnPGR (-2)) is negatively significant at 1% relating to food security, with negative coefficient (-0.0637) in the long-run. The implication of this is that, if the rapid population growth rates continues unchecked or control it has a capacity to throw the country into food crisis as stated in Malthus theory in literature. On the other hand, urbanization population growth rate at both one (LnUPR (-1)) and two lagged periods (LnUPR (-2)) are positive and insignificant related to food security at short-run. This implies that urbanization population growth is an essential component in the development of any nation economy growth; it provides labour-force needed for production of goods and services to enhance and achieve economic growth and development, as well as a vital determinant capacity of a nation investment. This result agrees with Pontianus and Oruonye (2021) who stated that increase in population growth is a crucial dynamic in national economic development, and nation's benefit from its rapid population growth is a function of such nation's quality of her human capital prowess. At long-run the coefficient of urbanization population growth rate shows negative (-0.0103) relationship with food security. This maybe has a result that most urban dwellers do not engaged in agricultural activities that will results in food security, this may have happened as a result of migration from rural areas to urban areas in search of green pastures for livelihood of Nigerians.

The lagged period of agricultural land used at one (LnALU (-1)) and at (LnALU (-2)) were negatively significant at 5% and 10% respectively, with negative coefficient (-0.0081) at long-run related to food security. The implication of this short-run negative but insignificant related to food security could be that the farmland is not maximally utilized for production of food needed to feed many mouths as a result of rapid population growth and rural-urban migration in Nigeria. This could lead to food crisis, hunger and malnutrition; if the agricultural land is not maximally utilized and the migration to urban areas goes on unchecked.

The error correction (EC) coefficient EC1 and EC2 indicates a negative signed, this implies that the error correction is rightly signed. The coefficient of EC1 and EC2 were negative and significant at 1% respectively. This substantiating the existence of long-run relationship between dependent and explanatory variables (food security with climate change, population growth rate), *ceteris paribus*. This shows the rate of adjustment to the previous year short-run disequilibrium from long-run equilibrium value of the independent variables; this reveals that the food security in Nigeria is a consequence of rainfall, temperatures, population growth rate, urban population growth rate and agricultural land used in the same way as other tropical countries.

The coefficient of multiple determinations (R^2) is 0.912135. This indicates that about 91% of the overall variations in the dependent variable FPI (food security) was jointly explained by the action of all the independent variables. The adjusted R^2 is 0.857743 implying that decrease in the degree of freedom as a consequence of the including additional independent variable may not alter significantly the goodness of fit of the regression level and also shows the reliability of the variables included in the model. Durbin-Watson test is use to examines the null hypothesis that the linear regression residuals of any time-series data are uncorrelated. Durbin-Watson estimation coefficient (2.1) was obtained; this indicates a negative serial correlation, this falls within the acceptable value (1.50 - 2.50). The implication of this negative autocorrelation is that the variable under consideration has influence on itself over time. For instance, if there is food insecurity in the previous year, there is a greater likelihood that there will be stability in food security in the preceding year or *vice versa*. This can be proved in the variance decomposition as sown in Table 5 as well.

Table 5. Variance decomposition of food security (PFI)

Period	Std. Error	LnPFI	LnRF	LnTemp	LnPGR	LnUPR	LnALU
1	0.0363	100.000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0382	90.0877	0.3512	7.5339	0.3539	0.0107	1.6626
3	0.0550	87.9908	4.3789	5.1570	0.4897	0.5674	1.4161
4	0.0559	86.0033	6.1886	5.0477	0.5488	0.5735	1.6382
5	0.0640	85.5527	6.6141	5.5583	0.4452	0.5692	1.2605
6	0.0654	85.3706	6.4479	5.9433	0.4306	0.5990	1.2087
7	0.0701	86.0779	6.0761	5.7067	0.3929	0.6733	1.0730
8	0.0719	86.1311	5.7843	6.0166	0.3779	0.6675	1.0226
9	0.0755	86.3891	5.5212	6.0923	0.3496	0.7130	0.9348
10	0.0776	86.6132	5.2356	6.2102	0.3313	0.7231	0.8867

The decomposition of variance signifies the extent of information of each variable impact to the other variables in the autoregression. It shows to what extent the forecast error variance of each variable can be clarified by the exogenous shocks to the other variables. Table 5 shows the variance decomposition of the shocks received by the PFI (food security) to its component bases.

In the short-run for instance, in the period 3, shock to RF (rainfall) and Temp (temperatures) estimated to be about 4.38% and 5.16% respectively of the variation in PFI (food security). Whereas, the result shows that in the short-run the shock to PFI itself estimated to be about 87.99% deviations in its variability and flux. In the long-run, at period 10 the shock to RF and Temp estimated to be about 5.24% and 6.21% respectively variation in PFI, while the long-run shock to PFI itself was about 86.61%.

4. Conclusion

This research examined the impacts of climate change and population growth on food security in Nigeria. Augmented Dickey-Fuller (ADF) unit root test was utilized to test the stationarity of the data, Vector Autoregressive (VAR) model, Johansen cointegration test was utilized to test the long-run relationship and the vector error correlation models (VECM) was utilized to estimates the short-run trend. ADF unit root test result shows that all variables were completely stationary at the first different orders at both at intercept and intercept with trend. VAR model shows that Akaike Information Criterion AIC and Hannan-Quinn Criterion HQC were three (3) lags, hence, three (3) lags were conclusively selects as the optimum lag in the model.

The result of Johansen cointegration shows the existence of a long-run relationship among the variables used in this research. VECM result shows that climatic factors used in this research (rainfall and temperatures) has a negative and significant effects at lagged period of one and two respectively related to food security in Nigeria both at present and in the future in the short-run. Population growth rate is also negative and significant at lagged two periods, while urban population growth has positive effect on food security in the short-run. Since most of the urban dwellers did not engage in farming activities. The lagged one and two periods of agricultural land used were negatively significant related to food security. Hence, agricultural land used also has adverse effect on food security as most agricultural land are cleared for urban development and other social activities. The decomposition of variance signifies the extent of information of each variable impacts to the other variables in the autoregression. The research therefore, recommends that:

i. Since rapid population growth rate in itself is not a problem to the nation, migration from rural areas to urban areas should be controlled by providing social amenities needed for their comfort in the rural areas; at such it will lead to more land for cultivation which will eventually lead to more harvesting then food security. Similarly, to curb the adverse of urban population on food security, there should be public enlightenment campaign to educate Nigerians on birth control through family planning methods.

ii. To minimize the negative effect of climate change on food security, modern irrigation systems can be adopted to solve the problem of erratic rainfall pattern uncertainty in cropping systems. This will enhance crop productivity in such areas with such difficulties. While, drought resistant crop seed and seedling varieties should be grown while livestock with resistant to diseases should be rear for maximum productivity.

iii. For agricultural land use good soil management should be adopted, efficient manure application and agricultural waste management should be adopted, good agricultural land management techniques (like agroforestry, tillage maintenance, restoration and reintegration of degraded crop and pasture land) and indiscriminate bush burning and deforestation should be stopped and backed up with legal laws. Although, it will be challenging for most Nigerian farmers to adapt to the climate change because of their poverty levels without government aids. Hence, government can expedite the rate of adaptation through some measures like agricultural insurance, distribution of improved seed crop varieties, provision of timely information on climatic factors and practical production advice to farmers.

Author Contributions

The percentage of the author contributions is presented below. The author reviewed and approved the final version of the manuscript.

	A.R.A.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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