UMARU MUSA YAR'ADUA UNIVERSITY, KATSINA (UMYUK)
Journal of Economics and Development (UJED)

IMPACT OF CLIMATE CHANGE AND CAPITAL FORMATION ON FOOD SECURITY IN NIGERIA

[1] Yusrah Ahmad *, [2] Muhammad M. Abdullahi, & [3] Ahmed H. Malumfashi
[1-3] Department of Economics, Umaru Musa Yar'adua University, Katsina – Nigeria
***Corresponding authors' email**: yusrahahmadlawal@gmail.com

Journal Info:
ISSN (e): 3026-8028
(p): 3027-0928
Vol: 01
Issue: 02
December 2024

Pages: 29 – 44

ABSTRACT

The study examined the impact of climate change and capital formation on food security in Nigeria using annual time series data from 1990-2022. Secondary data were extracted from the databases of Food and Agricultural Organization (FAO) and World Bank (WDI). The food production index (FPI) was used as the dependent variable, while the independent variables include, CO2 emissions and gross fixed capital formation (GFCF), made up the main explanatory variables. Annual population growth (POP), Gross Domestic Product (GDP), and consumer price index (CPI) were used as control variables. The Autoregressive Distributed Lag (ARDL) Model Approach was used for the analysis. The findings showed a negative and statistically significant effect between climate change and food security in Nigeria both in the long-run and short-run. Moreover, the study established a positive and statistically significant effect between capital formation and food security both in the long run and short run. The study also revealed negative and significant interaction effect of climate change and capital formation on food security in the long-run. This implies that negative CO2 emissions counteract the positivity of gross fixed capital formation. The study thus, recommends climate-smart resilience policies that are beneficial to crops production and promoting storage facilities. Emphasis should also be placed on investment in tools and machineries, provision of improved seed variety processing units and facilitation of climate change adaptation strategies.

Keywords:
Climate, Capital, Formation, Food security, Nigeria

1.0 Introduction

Food security has four major components, which includes, availability, accessibility, stability and utilization. Availability is having a balanced food supply, not only in quantity but also having a quality and variety of food (Peng & Berry, 2018). It also includes domestic production, imports, or food aid programs (Kumar et al, 2017). Accessibility covers being economically and financially strong to get the required meals either through production or purchase from the markets, whereas Utilization and stability consist of whether there is a stable capacity to pass shocks and the degree of diversity of nutrients in one's food system. However, achieving all four pillars of food security is challenged by high CO2 emissions, environmental problems, poor infrastructure, and low storage facilities among others (Adesete et al, 2022). Thus, a stable climate is among the critical factors that result in better agricultural productivity and thereby improve food security. Currently, Nigeria is far from achieving many climate resilient goals due to greenhouse gas emissions, deforestation, land degradation, and exploitation of natural resources (McGuire, 2015). Climate change is becoming worse. A report from IPCC (2021) indicates that the temperature will rise by more than 2 degrees in the coming two decades.

Carbon dioxide emission (CO2) is a significant greenhouse gas that retains heat in the Earth's atmosphere and also released gas through human activities. It also arises from the combustion of fossil fuels like coal, oil, and natural gas from deforestation and industrial processes (World Bank, 2023). CO2 emissions cause a lot of issues globally and have become more threatening to the sustainable development of agriculture especially in Nigeria. It affects the quantities and types of food produced as well as production-related income (Gobezie & Boka, 2023). It has also been observed that CO2 emissions phenomenon affect agriculture in a number of ways. For example, uncertainties at the onset of the farming season, due to changes in rainfall characteristics (early rains may not sustain, and crops planted at their instance may become smothered by heat waves) which can lead to an unusual sequence of crop planting and replanting which may result in food shortages due to harvest failure and food security challenge (FAO, 2021). Therefore, addressing CO2 emissions has become crucial for ensuring sustainable agriculture and food security in Nigeria. It is significant to observe that food is basic for all economies developmental needs and for a for a healthy and productive life (Gobezie & Boka, 2023).

Capital formation on the other hand, is the proportion of present or current income that is saved and invested in order to augment future output and income. It usually results from acquisition of new factory along with machinery, equipment and all productive capital goods. Capital formation determines the national capacity to produce including agricultural productivity (Ifeyinwa, 2017). Capital formation is therefore, measured through 'Gross fixed capital formation' leading to more technical progress, helps realize the economy at large-scale production and enhance specialization in terms of provision of machines, tools, resources and equipment for growing labor force (Kalu, 2015). Capital formation can also lead to increase in CO2 emissions, as many types of physical capital require energy to operate and maintain (Onwiodiokit, 2023).

Studies, like (Prakash & Sethi, 2023; Von Grebmer et al, 2022; Dauda, 2023) proved that extreme climatic condition that manifest high CO2 emissions have very adverse consequences on food security in Nigeria (Ani, 2022). Ahmad et al, (2019) reported that the interaction effect between climate change and capital formation is that investment tends to harm the environment, due to the fact that CO2 emissions increase in the stage of growth and industries expansion which tends to decrease income and stabilize food security in the economy. In fact, CO2 emissions are the result of a rise in energy consumption based on fossil fuels and agricultural wastes (Segbefia et al, 2023). According to climate trace report (2022), CO2 emissions trend of seven years shows fluctuation analysis of agricultural emissions at 9.81m, 9.57, & 9.82 tones released in 2015, 2016 and 2017 respectively. However, it increased to 10.58m tones in 2018, then fell drastically to 8.96m tones in 2019, and then rise again to 9.14 and 8.70m tones in 2020 and 2021. Therefore, it is observed that from 2019 to 2021 respectively. A CO2 emission from agricultural sector in Nigeria has reduced compared to previous years. However, this is only limited to emissions from cropland fires alone. Infrastructure is also threatened by high CO2 emissions, with evidence of encroachment of coastlines, stress to the energy grid, decreased hydroelectric power supply and shifting structures or landscapes, loss of shelter, bad roads and degraded farmlands due to erosion in some parts of Nigeria (Cossimon et al, 2022).

Drawing from the foregoing therefore, it is observed that poor storage facilities and fluctuating temperature are negatively affecting food security as CO_2 emissions contribute to unfriendly weather conditions, leading to low agricultural productivity, while low investment in agricultural sector, and inadequate farm mechanization are leading to poor storage facilities which in the same vein affects the agricultural sector negatively. In addition, the interactive effect between climate change and capital formation as aforesaid earlier explained that capital formation leads to the increase in high CO_2 emissions as numerous types of physical capital requires energy to operate and maintain which is adding more to food security challenges. The challenge between these factors makes it critical to the study, thereby ascertaining to the fact that climate change and capital formation are affecting food security in Nigeria.

Achieving food security is challenged by climate change problems (Irfan et al, 2023), and capital formation factors (Cassimon, Fadare & Mavrotas, 2022). Therefore, a consistent climate is among major factors that result in stable agricultural productivity and thereby improve food security (Kubik, Douglas & Mirzabaev, 2023). However, the world currently is far from achieving many development of infrastructural facility that will leads to achieving the component of food security and climate resilience goals due to green house gas emissions, deforestation, land degradation and exploitation of natural resources (Adekunle, Omosebi & Sulieman, 2014; Ajose & Oyedokun, 2018). The prospect of climate change is becoming worse. A report by the IPCC (2021) indicates that temperatures will rise by more than 2 degrees Celsius in the coming decades.

This study examined the impact between climate change and capital formation on food security in Nigeria, using CO_2 emissions as a proxy for climate change, gross fixed capital formation as a proxy for capital formation and food production index as a proxy to food security (Adesete et al., 2022; Kumar et al., 2015). The primary goal of the paper was to understand food security and the interactive effect between CO_2 emission and capital formation in Nigeria.

2.0 Literature Review

Ohiomu & Ozor (2021) conducted a study "Relationship between Climate Change and Food Security in Sub-Saharan Africa" with variables; Agricultural output, temperature, rainfall, government expenditure on agriculture, inflation, exchange rate, gross fixed capital formation and labor force. The study covers the years from 1980 to 2019, Preliminary diagnostic tests on Panel data across the 17 sub-Sahara African countries and result shows that the climate change exerts negative impact on food security through temperature variations which degenerated during the period. It also showed positive significant impact of government expenditure which increased during the period.

On the other hand, Ceesay & Ndiaye (2022) studied the impact of Climate change, food security and economic growth nexus in the Gambia: Evidence from an econometric analysis from 1971 to 2020. The model were VAR, ARDL and ECM and the variables are; Agricultural value added, average annual rainfall, GDP per capita, population growth annually, and GDP current. The findings revealed that food security growth has strong optimistic correlation with the agriculture sector but negative correlation with rainfall variation.

Similarly, Cassimon, Fadare & Mavrotas (2022) Combined the Effect of Institutional Quality and Capital Flows on Food and Nutrition Security and Undernourishment in Sub-Saharan Africa from 1996 to 2018. Panel data for 25 SSA countries over the year. The findings clearly demonstrate the importance of a heterogeneity approach and reflect on earlier work regarding the role of institutional quality in the overall nexus between external capital flows and various measures of food and nutrition security which leads, and as expected, to an interesting variation in the results obtained,

DOI:10.70861/ujed20240102003

depending on the type of capital flows and the interaction with the governance indicators.

Satrovic, Muslija & Abul (2020) took the same model approach of Toda-Yamamoto causality test with limited variables in the study to examined the Relationship between CO2 emissions and Gross capital formation in Turkey and Kuwait from 1971-2014. Variables used were CO2 emissions, gross capital formation (% of GDP) and energy use (ENE). Toda and Yamamoto approach was used in the model and the findings confirm a bi-directional links between all the variables of interest not only in the case of Turkey, but also in the case of Kuwait.

3.0 Methodology

The study utilized time series data from World Bank database and FAOSTAT 1990-2022. The data covers food production index (FS) which is the dependent variable and obtained from FAOSTAT, CO2 emissions was sourced from World Bank database, while gross fixed capital formation (GFCF) was also obtained from World Bank database. In addition, annual population (POP), gross domestic product (GDP), and consumer price index (CPI) are the control variable, which all are also obtained from World Bank database. The study adopted ARDL model to examine the interactive effect between CO2 emissions and capital formation on food security in Nigeria. This is because ARDL model has become more appropriate to use for the study, the test of the unit root was conducted using Augmented Dickey-fuller (ADF) and Phillip-Perron (PP) test, while the diagnostics tests (normality test, serial correlation test, heteroskedasticity test and Ramsey reset test) were conducted for reliability checks.

3.1 Model Specification

In order to examine the impact of climate change and capital formation on food security in Nigeria, a specific model in which food security is dependent on climate change, capital formation and other variables is specified as follows:

$$FPI_t = \beta_0 + \beta_1 CO_{2_t} + \beta_2 GFCF_t + \beta_3 POP_t + \beta_4 GDP_t + \beta_5 CPI_t + \mu_t \quad (1)$$

Where, FPI is the dependent variable, CO2 emissions and GFCF are the independent variables, while, POP, GDP, and CPI represents the control variables. Thus, the variables are written as; food production index, climate change, capital formation, annual population growth, and consumer price index respectively. β_0 Is the constant or intercept, while $\beta_1 \beta_2 \beta_3 \beta_4$ and β_5 are the parameters. Lastly, μ_t is the Error Term.

3.2 Estimation Techniques

The study used estimation techniques to achieve the objective of the interactive effect between carbon emissions and capital formation on food security in Nigeria in stages. Firstly, it involves conducting unit root tests to establish the stationarity test of the study by employing Augmented Dickey Fuller (ADF) and Phillip-Perron (PP). Secondly, the study establishes the cointegration (long-run and short-run) relationship among the variables using ARDL bound testing procedures which is developed by Pesaran & Shin (2001). Lastly, it involves the estimation of the coefficients of the model using ARDL. The ARDL model is specified as follows:

$$\begin{aligned}\Delta(\ln FPI)_t &= \beta_0 + \sum_{i=1}^{p} \beta_1 \ln FPI_{t-1} + \sum_{i=0}^{k} \beta_2 \ln CO2_{t-1} \\ &+ \sum_{i=0}^{l} \beta_3 \ln GFCF_{t-1} + \sum_{i=0}^{m} \beta_4 \ln POP_{t-1} + \sum_{i=0}^{n} \beta_5 \ln GDP_{t-1} \\ &+ \sum_{i=0}^{r} \beta_6 \ln CPI_{t-1} + \sum_{i=0}^{s} \beta_7 \ln\left(CO2_{t-1} * GFCF_{t-1}\right) + \delta_1 \ln\left(\ln FPI\right)_{t-1} \\ &+ \delta_2 \ln\left(\ln Co2\right)_{t-1} + \delta_3 \ln\left(GFCF\right)_{t-1} + \delta_4 \ln\left(POP\right)_{t-1} + \delta_5 \ln\left(GDP\right)_{t-1} \\ &+ \delta_6 \ln\left(CO2_{t-1} * GFCF_{t-1}\right) + \varepsilon_t\end{aligned} \tag{2}$$

In equation 2, "ln" represents the natural logarithms of variables; β_0 denotes the intercept, while $\beta_1 \beta_2 \beta_3 \beta_4$ *and* β_5 are the parameters that signify the magnitude and direction of each of the variable on food security (FPI) and μ_t is the error term which represents the unobserved factors affecting food security (FPI) that are not explained by the included independent and control variables.

Upon establishing the long-run relationship among the variables, in order to get the short-run coefficients, an error correction model (ECM) is cointegrated. The ARDL specification of the ECM is represented as:

$$\begin{aligned}\Delta(\ln FPI)_t &= \beta_0 + \sum_{i=1}^{p} \beta_1 \ln FPI_{t-1} + \sum_{i=0}^{k} \beta_2 \ln CO2_{t-1} + \sum_{i=0}^{l} \beta_3 \ln GFCF_{t-1} \\ &+ \sum_{i=0}^{m} \beta_4 \ln POP_{t-1} + \sum_{i=0}^{n} \beta_5 \ln GDP_{t-1} + \sum_{i=0}^{r} \beta_6 \ln CPI_{t-1} + \sum_{i=0}^{s} \beta_7 \ln\left(CO2_{t-1} * GFCF_{t-1}\right) \\ &+ \theta_1 ECT_{t-1}\end{aligned} \tag{3}$$

ECM is used in order to check the robustness of the result. According to Engle & Granger (1987), if cointegration is established among variables, causality relationship can be determined within a dynamic error correction term, and the statistical significance of the ECT_{t-1} is used to determine the long-term causality.

4.0 Results Presentation

4.1 Result of Unit Root Tests

Table 1 presents the result of the Augmented Dickey-Fuller (1981) and Phillips-Perron (1989) unit root tests. The result revealed that most of the variables have unit root at level which means they are not stationary. For instance, FPI, CO_2 emissions, GDP and POP have unit root at level [I(0)] both in ADF and PP tests. But after the first difference of the variables using ADF and PP, the unit root in the variables (FPI, CO_2 emissions, GDP and POP) became stationary and integrated of order one, I(1). The exceptions of the study are in the case GFCF and CPI which are found to have no unit root at level both in the ADF and PP tests, respectively.

Table 1: Results of Unit Root Tests

	Level				First Difference				
Vrbls.	**ADF**		**PP**		**ADF**		**PP**		
	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.	t-Statistic	Prob.	Status

LNFPI	-2.347	0.398	-3.116	0.120	-2.842***	0.065	-9.885***	0.000	I(1)
$LNCO_2$	-2.660	0.258	-2.751	0.225	-5.954***	0.000	-6.869***	0.000	I(1)
LNGFCF	-5.929***	0.000	-5.759***	0.000	-	-	-	-	I(0)
LNGDP	-1.6932	0.730	-0.627	0.851	-2.968**	0.049	-2.943**	0.051	I(1)
LNPOP	-2.018	0.278	-0.377	0.984	-4.139***	0.014	-3.423*	0.067	I(1)
LNCPI	-3.874***	0.006	-2.975***	0.048	-	-	-	-	I(0)

Note: ***'** and * are statistically significant at 1%, 5% and 10% respectively; both intercept and trend are used in the estimations, Akaike Information Criterion (AIC) was employed to select optimum lag length in the ADF test

Based on the results of the unit root tests, it is concluded that the variables are integrated at mixed order of [I(1) and I(0)]. Consequently, the study employs ARDL bound testing cointegration of Pesaran & Shin (2001) to explore the existence of the relationship among the variables.

4.2 Results of the ARDL Bound Tests

The results in Table 2 indicated that the computed F-statistics (8.524) is greater than the upper bound test even at 1% level. This result implies a strong cointegration among the variables or in other word, long-run relationship exists among climate change, capital formation, GDP, population, food price index and food production index.

Table 2: ARDL Bounds Testing Cointegration Results

F- Statistics	K	Significance	Lower(bound)	Upper(bound)
		10%	1.99	2.94
8.5240***	6	5%	2.27	3.28
		1%	2.88	3.99

Note: the *** denotes significant at 1% level and K indicates the number of variables used in the model. Only intercept was used in the model and the optimum lag was selected using Akaike information criterion (AIC). Selected Model: ARDL (1, 1, 2, 0, 0, 2, 2)

4.3 Discussions of Results

Having established that a long-run relationship exists among the variables, the next step presents the estimated relationship among food security, climate change and capital formation. The Akaike Information Criterion (AIC) indicated the optimal lag length (1, 1, 2, 0, 0, 2, 2). The results of the long-run and short-run for the selected models; as shown in the Tables, the variables are significant and the signs are consistent with a priori expectations particularly in the long-run.

Table 3: Long-run Estimated Coefficients

Variables	Coefficient	Std. Error	t-Statistic	Prob.
$LNCO_2$	-3.861	1.099	-3.511	0.003
LNGCF	5.697	1.627	3.508	0.003

LN(CO_2*GCF)	-3.384	1.121	-3.017	0.008
LNGDP	0.619	0.180	3.429	0.003
LNPOP	-0.244	0.531	-0.460	0.651
LNCPI	0.138	0.023	5.871	0.000

Note: *** and * denote significant at 1%, and 10% respectively. The Akaike Information Criterion (AIC) indicated the optimal lag length of (1, 1, 2, 0, 0, 2, 2).

Table 3 reports the long-run coefficients of the variables. It indicates that CO_2 emission has a negative and significant effect on food security in long-run at 5% level. A 1% increase in CO_2 emissions will lead to a 3.86% decrease in food security in Nigeria. This implies that higher levels of CO_2 emissions are detrimental to food security in the long run. The outcome is also consistent with Kuznet theory which postulate that the emissions of some undesirable substances such as sulfur dioxide and carbon dioxide emitted into the air, waste of various kinds of emissions into water bodies or dumped on ground first increase with economic growth and then fall, then affect the economy and food security negatively. Also, empirical studies of (Bouznit *et al*, 2022; Madaleno & Carlos, 2023) are consistent with the result.

However, the long-run estimated coefficient for gross fixed capital formation is 5.697, indicating a positive and highly significant effect on food security at 1% level of significant. In practical terms, a 1% increase in gross capital formation (GFCF) is associated with about 5.697% increase in food security on the average, ceteris-peribus. This finding implies that high GFCF positively affects food security in Nigeria as in the Accelerator theory of investment which postulates that capital investment outlays is a function of output, this means the higher the capital formation in an economy the higher the food security ceteris-peribus (Ajose & Oyedokun, 2018).

Moreover, the long-run estimated coefficient for the interaction between carbon dioxide emissions and gross fixed capital formation (CO_2*GCF) is -3.384, suggesting a negative and statistically significant effect on the food security in Nigeria. A 1% increase in this interaction is associated with an approximately 3.384% decrease in food security, on the average, ceteris-peribus in the long-run. It has also been observed that capital formation tend to increase CO_2 emissions, as many types of physical capital require energy to operate and maintained, which lead to the decrease of the result and affecting food security negatively (Onwiodiokit, 2023).

Table 6: Short-run Estimated Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LCPI)	-0.076	0.034	-2.227	0.041
D(LCO_2)	-3.190	0.364	-8.758	0.000
D(LCO_2(-1))	-0.489	0.075	-6.518	0.000
D(LPOP)	2.719	0.601	4.527	0.000
D(LPOP(-1))	-1.134	0.494	-2.294	0.036
D(GFCF)	5.075	5.709	8.889	0.000
ECT_{t-1}	-0.908	0.105	-8.662	0.000
R-squared	0.904			
Adjusted R-squared	0.845			

Note: The maximum Selected Model: ARDL lags are (1, 1, 2, 0, 0, 2, 2).

The presented results in Table 6 outline the short-run estimated coefficients of the variables in the model. These coefficients represent the short-run impact of changes in the natural log of CO_2 emissions and its lagged values. The short-run estimated coefficient of CO_2 emissions is about -3.190, indicating a negative and statistically significant effect at 1% level on food security. This implies that 1% increase in CO_2 emissions is associated with an approximately 3.190% decrease in food security in the short run. The short-run estimated coefficient of gross fixed capital formation is about 5.075. The first lag of gross fixed capital formation has a positive and statistically significant effect on food security. A 1% increase in the first-differenced natural log of gross fixed capital formation from the previous period is associated with an approximately 1.20% increase in food security on the average, ceteris-peribus in the short run. The coefficient of error correction term lagged by one period ECT_{t-1} is -0.908. Its captures adjustments towards the long-run equilibrium indicate that any deviation from the long-run will be corrected by approximately, 91% in a year. The value for R-squared is (90%) and adjusted R-squared is (84%) respectively.

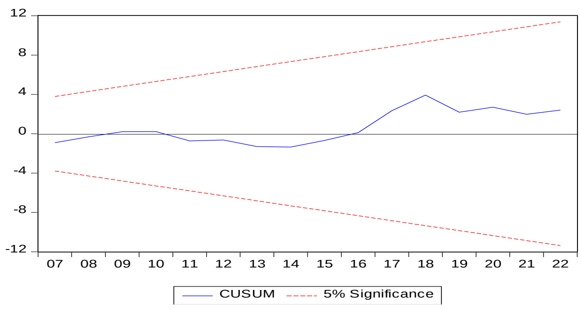
4.4 Results of Diagnostic Tests

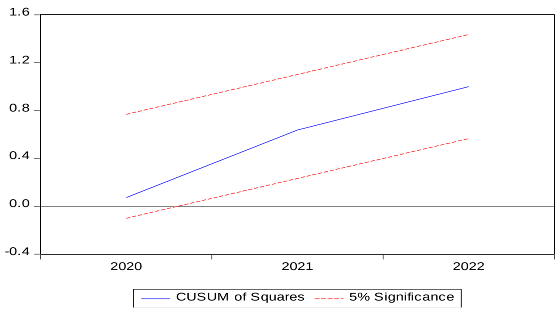
The results of diagnostic tests reported in Table 7 shows that the ARDL model passed the serial correlation, functional form, heteroskedasticity and normality tests.

Table 7: ARDL model diagnostic tests

Test Statistics	F-Statistic [Prob]
Normality: Jarque-Bera	0.228 [0.892]
Serial Correlation: Breusch-Godfrey LM Test; F (2, 14)	1.989[0.174]
Heteroskedasticity: Breusch-Pagan-Godfrey; F (14, 16)	0.969[0.519]
Functional Form: Ramsey Reset; F (1, 15)	0.035 [0.855]

According to the result obtained from Jarque-Bera test (JB) the result indicates that the p-value is (0.892) implying that data is normally distributed. Furthermore, Breusch-Pagan-Godfrey test was used to ascertain whether the residuals are homoscedastic. As reported in Table 7, the p-value (0.519). Therefore, the distance term is homoscedastic. In addition, the cumulative sum of square of recursive residuals (CUSUM) and the cumulative sum of square of recursive residuals (CUSUMQ) tests were conducted to check the stability property of the estimated parameters.





5.0 Conclusion

Generally, the study has achieved its objectives on the impact of climate change on food security, capital formation on food security, as well as the interaction effect among climate change and capital formation on food security in Nigeria. The study has shown a clear link between both the variable of interest on food security in Nigeria. However, while capital formation (GFCF) is positive and significant both in the long-run and short-run, climate change (CO2 emissions) is negative and significant both in the short-run and long-run. The positive impact of capital formation on food security is largely mediated through investment channel on agriculture and proper storage facilities, while the negative impact of climate change on food security is consistent with previous studies as being debated in literatures and largely due poor climate resilience adaptation policies sensitization on farmers. In addition, the interaction effect of climate change and capital formation on food security suggests the existence of negative and significant effect of the variable of interest both in the long-run and short-run. These findings explained that although capital formation (GFCF) is positive and significant, but the magnitude of climate change (CO2 emissions) counteract capital formation in Nigeria.

Integrate Climate-Smart Practices: Promote the integration of climate-smart agricultural practices that enhance resilience to changing climate patterns. This includes the adoption of sustainable farming methods, conservation agriculture, and the use of climate-resilient crop varieties.

Enhance Research and Data Collection: Invest in comprehensive research and data collection to better understand the localized impacts of climate change on agriculture. This knowledge can inform targeted interventions and adaptive strategies tailored to specific regions and crops.

References

A.Abubakar & S. Kassim (2016). Sectoral im pact of bank credit in Malaysia: ARDL modelling approach. Pertanika Journal s of social science and humanities, 24(S): 205211.

A. Bunyamin (2021). The effect of urban gro wth on historical land use/ land cover changes in the sunyani municipality, G hana. JENRM, vol. 7, 16-27.

A. H. Wudil, A. Ali, S. Aderinoye-Abdulwa hab, H. A. Raza, H. Z. Mehmood & A. B. Sannah (2023). Determinants of Foo d Security in Nigeria: Empirical Evide nce form Beneficiaries and Non-benefi ciaries Rice Farmers of the Kano River Irrigation Project. Frontiers in Sustaina ble Food Systems Journal, vol. 7, 33-89.

Abdussalam, B., & Adebayo, A. A. (2022). Fa rming adaptation strategies to climate change in rural communities along riv er Benue in Adamawa state Nigeria. Jo urnal of Agricultural Economics, Envir onment and Social Science, vol. 8(2), 34 -50.

Adejuwon, S. A. (2004). Effects of Climate V ariability on Cocoa Production in Ond o State, Nigeria. American Journal of C limate Change, vol. 8, 2-8.

Adetiloye, K. Adekunle, Adeyemo, K. Adere mi. (2012). Domestic investment, capit al formation and population growth in Nigeria. Journal of Emerging Trends i n Economics and Management Science s, vol. 4, 203-210.

Ahemefule, B. A., Oke, U. R., Nnamani, N. G ., & Ezeugo, K. O. (2023). Financial sav ings and capital formation among rura l farmers in Abia state, Nigeria. Nigeri an Agricultural Journal, vol. 54(1), 402-408

A. O. Manlosa, J. Hanspach, J. Schultner, I. D orresteijin& J. Fischer (2019). Livelihoo d strategies, capital assets, and food se curity in rural southwest Ethiopia, Spr inger, 168-181.

Akinfenwa, G. (2023). Determinant of Food Security. South African Journal of Botany, vol. 157, 1-678.

A.Nnaji, N. N. Ratna & A. Renwick (2022). Risk perception, farmer-herder conflicts and production decisions: evidence from Nigeria. Agricultural and Resource Economics Review, vol. 50(1), 683-716.

Andah (2016). Current greenhouse gas emission levels; Nigeria emissions reduction challenges. Climate Scorecard, www.climatescorecard.org.

A. E. Esekong, B. F. Ebuta, A. E. Deborah, N. A. Ndem, O. Asuquo. E, A. A. Akintoye (2022). Vulnarebility and Re-prioritization Measures for Fostering the Balance to Food Sufficiency in Africa. Journal of Food Security, vol.10, 1-9.

A. C. Ifeyinwa, O. S. Idenyi& N. G. Onyinye (2017). The effect of capital formation on economic growth in Nigeria, Asian Journal of Economics, Business and Accounting, vol. 5, 1-16.

A. Leogrande (2023). The rule of law in the ESG framework in the world economy. SSRN Journal, 35. https://ideas.respec.org.

A. Idris, O. A. Otekunrin& S. O. Akinbode (2020). Food security in Nigeria: Impetus for growth and development. Journal of Agricultural Economics and Rural Development, vol. 6(2), 808-820.

B. Ezeugo, Ekeanya, S. O. Adeniyi & O. O. Longe (2023). Examining the effectiveness of Guava leaf exract in mitigating corrosion of aluminium in potassium hydroxide solution. International Journal of Educational Research, vol. 12, 35-46.

Cadre Harmonise (2022). Fifth legislature of the ECOWAS, news report.

C. Cobb & P. Douglas (1947). Cobb-Douglas production function. CC BY-SA 4.0.

C. Amaefule, A. Shoaga, L. O. Ebelebe& A. S. Adeola (2023). Carbon emissions, climate change, and Nigeria's agricultural productivity. European Journal of Sustainable Development Research, vol. 7, 1-36.

Clover, J. (2003). Food security in Sub-Saharan Africa. African Security Review, vol. 12, 515.

D. Cassimon, O. Fadare& G. Mavrotas (2022). The combined effect of institutional quality and capital flows on food and nutrition security and undernourishment in subSaharan Africa. Journal PLOS ONE, vol. 17(10), 345-375.

D. Kumar, C. J. Smith & P. Kalita (2017). Reducing Postharvest losses during storage of grain crops to strengthen food security in developing countries. MDPI Journals, vol. 6(1), 8.

Dickey D. A. & Fuller W.A. (1981). Likelihood ratio statistics for autoregressive time series with unit root. Econometrica, 49, 1057-1072. https://dx.doi.org/10.2307/1912517.

E. K Ceesay & M. B. O. Ndiaye. (2022). Climate change, food security and economic growth nexus in Gambia. Research in Globalization Journal, vol. 5, 1-11.

E. Segbefia, Baozhendai, P. Adotey& A. K. Sampene (2023). A step towards food security: the effect of carbon emission and the moderating influence of human capital, Evidence from Anglophone countries. Heliyon Journal Homepage: www.cell.com/heliyon, 1-16.

EKpu (2020). Institutional process for infrastructural development in Nigeria. Sage Journals, vol. 20, 208-222.

E. Satrovic, A. Muslija& S. J. Abdul (2020). The relationship between CO2 emission s and gross capital formation in Turkey and Kuwait, south east, European Journal of Economics and Business, vol. 15(2), 28-42.

Enilolobo, O. S., Babalola, B. A., Nnoli, I. T., Ajibola, A. A. & Okere, W. (2022). Food security in Africa: The role of agricultural import and export. African Journal of Housing and Sustainable Development, vol. 3, 68-82.

E. Nkonya, D. Phillip, J. Pender & T. Mogues (2012). Impacts of community-driven development programs on income and assetacquisition in Africa: The case of Nigeria. World Development from Elsevier, vol. 40, 1824-1838.

Erhlich, P. R. (2009). Millennium Assessment of human behavior. The Bulletin of the Ecological Society of America, vol. 90, 325-326.

E. Boserup (1965). The conditions of Agricultural growth. The economics of agrarian change under population pressure. www.biw.kuleuven.be.

Fang & Zibo (2019). Agricultural productivity, food prices and inflation in Nigeria. Applied Finance and Accounting, vol. 5, 35-41 .

Food and Agriculture Organization of the United Nations (2006). SAVE FOOD: Global initiative on Food Loss and WasteReduction

Food and Agriculture of the United Nations (2015). Climate Change and Food Security: Risks and Responses.

Food and Agriculture Organization of the United Nations (2019). SAVE FOOD and Waste Reduction. Global Initiative on Food Loss and Waste Reduction.

Food and Agriculture Organization of the United Nations (2008). The state of food and agriculture FAO of the United Nations.

Food and Agricultural Organization of the United Nations (2022a). Nigeria Agriculture at a Glance report and GIEWS Country Brief Nigeria retrieved.

Food and Agriculture Organization of the United Nations (2022b). Crops prospects and food situation: Countries in need of food external support. FAO of the United Nations.

First Bank (2023). Climate Change in Nigeria report.

Global Hunger Index (2023). Annual country report 2023 Nigeria. WFP/Damilola Onafuwa; Emmanuella Boamah Empowering Communitie-Meeting urgent life. Retrieved from https://www.wfp.org

Granger C.W.J. (1986). Developments in the study of cointegrated economic variables. Oxford Bulletin of Economics and Statistics, 48, 213-227.

G. Semieniuk, P. B Holden, J. F. Mercure, P. Salas, H. Pollitt, K. Jobson, P. Vercoulen, U. Chewpreecha, N. R. Edwards & J. E. Vinuales (2022). Stranded fossil-fuel assets translate to major losses for investors in advanced economies. Nature Climate Change, vol. 12, 532-538.

Hamonise, C. (2022). Food Security: Nigeria/UN Cadre Harmonize Report.ait.live.

H. Hagemann (1956). Solow's 1956 contribution in the context of the Harrod-Domar model. History of political economy, vol. 41, 67-87.

H. Sseguya, R. E. Mazur & C. B. Flora (2017). Social capital dimensions in household food security interventions. Agric Hum Values, vol. 10, 1-13.

I. C. EKE (2016). The impact of capital accumulation on livestock production output in Nigeria. International Journal of Agriculture and Earth Science, vol. 2, 62-81.

Ike, M. N. (2017). Households food and nutr ition security in Enugu State, Nigeria. African Journal of Agriculture and Foo d security, vol. 26, 203-208.

I. A. Baig, M. Irfan, MD. A. Salam & C. Isik (2023). Addressing the effect of meteoro logical factors and agricultural subsidy on agricultural productivity in India: a roadmap toward environmental sustai nability. Journal of Bioeconomics, vol. 30, 15881-15898.

I. A. Baig, A. A. Chandio, I. Ozturk, P. K. Z. A. Khan & MD A. Salam (2022). Ass essing the long-run and short-run asy mmetrical effects of climate change on rice production; empirical evidence fro m India. Journal of Bioeconomics, vol. 23, 1-22.

J. C. H. Fei & G. Ranis (1964). Developm ent of labor surplus economy: Theory a nd policy. RecherchesEconomiques de Louvain/Louvain Economic Review, v ol. 30 750.

J. Dale (1967). Surplus Agricultural Labor an d the Development of Dual Economy. Oxford Economic Journal, vol. 3, 288-3 12. Growth 1, ch. 5, pp. 77-104.

J. Dake (1963). Capital theory and invest ment behavior. American Economic Re view Jouranl, vol. 53, 247-259.

Jung, I. (2023). International Monetary Fund , https://www.imf.org vol. 2, 4-27.

K. Ajose and G. E. Oyedokun (2018). Capi tal Formation and Economic Growth in Nigeria. Accounting and Taxation Rev iew, vol. 2, 131-142.

Kalu (2015). Domestic private investment an d economic growth in Nigeria: Issues a nd further consideration. International Journal of Academic Research in Busin ess and Social Science, vol. 5, 302-313.

K. Takahashi, Y. Mano, K. Otsuka (2019). Le arning from Experts and Peer Farmers about Rice Production: Experimental E vidence from Cote d'Ivoire. World Dev elopment, Elsevier, vol. 122(c), 157-169 .

K. J. Ani, V. O. Anyika, E. Mutambara (2022) . The impact of climate change on food and human security in Nigeria. Interna tional Journal of Climate Change Strat egies and Management, vol. 14, 148-16 7.

K. D. Strang, F. Che & N. R. Vajjhala (2019). Urgently strategic insights to resolve t he Nigerian food security crisis. Outlo ok on Agriculture Journal, vol. 49(1), 7 7-85.

Keynes, J. M. (2020). The Mean-Variance Por tfolio Choice with uncertain VarianceC ovariance Matrix, Journal of Finanacial Risk Management, vol. 2.

K. Yovo& K. T. Gnedeka (2023). Assess the l evel and the determinants of househol d food security in Togo: The food expe nditures approach. Scientific African Jo urnal, vol. 20, 1-9.

K. V. Grebmer, J. Bernstein, M. Wiemers, L. Reiner, M. Bachmeier, A. Hanano, O. T owey, R. N. Cheilleachair, C. Foley, S. Gitter, G. Larocque, & H. Fritschel (202 2). Global hunger index food systems t ransformation and local governance, G lobal Hunger Index.

M. Madaleno & M. C. Noguerira (2023). Ho w Renewable Energy and CO2 Emissio ns Contribute to Economic Growth, an d Sustainability: An Extensive Analysi s. MDPI, vol. 15(5), 1-15.

M. Madaleno, E. Vieira, D. Magueta& M. C. Nogueira (2023). Sustainability reporti ng and climate change energy requirm ents: The role of companies and their g overnance-A review. Doi: 10.20944/pr eprints202308.0352.v1, 1-29.

M. Nwalie I. (2017). The paradox of food insecurity in nigeria. African Journal of Agriculture and Food Security, vol. 5, 203-208.

Mbow, C., C. Rosenzweig, L.G. Barioni, T.g. Benton, M, Herrero, M. Krishnapillai, E . Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello and Y. Xu (2019). Challenges and opportunities fr enhancing food security and greenhouse gas mitigation in smallholder farming in sub-saharan Africa. Food Security, NASA 2022-11-23 02:21.

M. H. Pesaran, Y. Shin & R. J. Smith (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16: 289-326.

Malthus T. R. (1978). An essay on the principle of population. J. Johnson, london. Social Networking, vol. 5 (4).

M. Bouznit, M. Elaguab, M. M. Selt, M. Himrane& R. Aissaoui (2022). Climate Change and Agricultural Production in Algeria. Climate change in the Mediterranean and Middle Eastern Region journal, vol. 1, 249-268.

M. M. Abdullahi, N. AzninBt A. Bakar & S. B . Hassan (2016). Debt overhang versus crowding out effects: Understanding the impacts of external debts on capital formation theory. International Journal of economics and financial issues, vol. 6, 271-278.

M. M. Abdullahi & U. Bala (2019). The Impact of Oil price and Exchange Rate on Food Prices in Nigeria. Journal of Economics and Sustainable Development, vol. 10(8), 51-56.

N. O. Nnaemeka (2022). Empirical Factors Influencing Food Security in Nigeria, Do Local Farmer Investors In Farming Activities Mitigate Food Shortages? Evidence in the Short and Long Run. American Journal of Agriculture, vol. 4(1), 24-46.

N. Prakash & M. Sethi (2023). Relationship between fixed capital formation and carbon emissions: impact of trade liberalization in India, Cogent Economic & France, 11:2, 2245274.

N. A. Muhammad & S. F. Bin A. Sidique (2019). Determinants of Food Security among Households in Nigeria. Pakistan Journal of Nutrition, vol. 18, 1042-1052.

Nwankpa N. (2017). Sustainable Agricultural Development in Nigeria: A way out of hunger European Journal of Sustainable Development|, vol. 6, 175.

O. Gershon (2020). Investingating the Nexus Climate Change and Agricultural Production in Nigeria. International Journal of Energy Economics and Policy, vol. 10, 1-8.

O. Ekeh, A. Fangmeier & J. Muller (2014). Quantifying greenhouse gases from production, transportation and utilization of charcoal in developing countries: A case study of Kampala, Uganda. The International Journal of Life Cycle Assessment , vol. 19(9), 1643-1652.

Office, M. (2023). Causes of climate change . United kingdom's national weather service.

Ojakorotu, V. (2008). The Internationalization of Oil Violence in the Niger Delta of Nigeria. Turkish Journal of international relations, vol. 7, 92-118.

O. Kehinde O. Adebayo, O. Bolarin& A. Oyewale (2018). Impact of Irrigation Technology use on Crop Yield, Crop Inco,e and Household Food Security in Nigeria: A Treatment Effect Approach. AIMS Agriculture and food journal, vol. 3(2), 154-171.

O. J. Nnaemeka, E. C. Victoria, D. Edokpa, B . E. Diagi & S. I. Ajiere (2022). Perceive d Seasonal impact of Air Pollution on Health and Properties in Port Harcourt . Archives of Current Research International, vol. 22, 34-45.

Onwiodiokit, E. A. &Otolorin, G. F. (2021). Capital Formation and Economic Growth in Nigeria: an Empirical Re-examination. CBN Bulletin, vol. 45 (2), 58-72.

O. S. Eniololobo, T. I. Nnoli, T. A. Aderemi, A. O. Adewole, V. O. Olapade, J. F. Esedeke (2022). Determinants of Food Security in Nigeria. Danubius Journals, vol. 18, No. 3(2022).

O. G. Olusegun, Taiwo A & Mobolaji, AO (2021). Impact of Agricultural Input Supply on Agricultural Growth in Nigeria. Journal of Applied Science Environment and Management, vol. 25(7), 1317-1322.

Oyewole, S. O, A. F. Aderounmu, A. O. Adepoju & A. L. Oyewole (2022). Climate Change and Agricultural Production Trends in Nigeria: Implication for Sustainable Food Production. Journal of Meteorology and Climate Science, vol. 21(1), 1-14.

O. R. Ogunpaimo, Z. Oyetunde-Usman & J. Surajudeen (2021). Impact of Clmate Change Adaptation on Households Food Security in Nigeria. MDPI journal, vol. 13, 1444.

Pachauri, R. K. Harvey Zheng & Mayer, L. (2018). Analysis of Global Warming Using Machine Learning. Computational water, Energy, and environmental engineering, vol. 7.

P. Varangis (2022). Agriculture Finance and Agriculture Insurance. World bank report .

P. H. Douglas (1927). The changing basis of family support and expenditure. Sage Journal, vol. 8, https://doi.org/10.1177/104438942700800809.

P. Goswami (2017). Textile and clothing design technology. CRC Press, 48-53.

Phillips P.C.B. & Perron P. (1988). Testing for a unit root in times series regression. Biometrika, 75, 335-346. https://dx.doi.org/10.1093/biomet/75.2.335.

Prasanna, M.(2010). Direct and Indirect Impact of Foreign Direct Investment (FDI) on Domestic Investment (DI) in India. International Journal of Social Science, vol. 1(2), 77-83 .

Prasanna, N. (2012). Employee Engagement and Job Satisfaction. Journal of social science, vol. 8, 1-5.

R. Chand & P. Kumar (2019). Determinants of Capital Formation and Agriculture Growth: Some New Explorations. Economic and Political Weekly, vol. 39(52), 5611-5616.

Reutlinger. (1988). Urban Malnutrition and Food Interventions. Sage Journals, vol.10, 1215.

R. Dauda (2023). Climate change and food security in Nigeria. EPR-Journal 306, 17-23.

R. B. Pickson& E. Boateng (2022). Climate Change: A Friend or Foe to Food Security in Africa? Environmental, Development and Sustainability Journal, vol.24, 43874412.

R. Ugochukwu Onyeneke, C. O. Igberi, C. O Uwadoka& J. O. Aligbe (2018). Status of climate-smart agriculture in southeast Nigeria. GeoJournal, vol. 83, 333-346.

R. Ugochukwu Onyeneke, C. A. Nwajiuba, C . C. Emenekwe, A. Nwajiuba, C. Judith Onyeneke, P. Ohalete& U. I. Uwazie (2019). Climate Change Adaptation in Nigerian Agricultural Sector: A Systematic Review and Resilience Check of Adaptation Measures. AIMS Agriculture and Food, vol. 4, 967-1006.

R. F. Engle & C.W.J. Granger (1987). Co-integration and error correction: representation, estimation, and testing. Econometrica, vol. 55, 251-276.

Ronald P. Willett & P. Ronald Stephenson (1969). Determinants of buyer response to physical distribution service. Journal of Marketing Research, vol. 6, https://doi.org/10.1177/002224376900600302.

S. Senthilnathan (2019). Usefulness of correlation analysis, SSRN Electronic Journal, 1-10.

S. Iftikhar & H. Z. Mahmood (2017). Human Capital Development and Food Security Nexux: An Empirical Appraisal from Districts of Punjab province. Punjab Province Journal Food Drug Res, vol. 1(1), 18-24.

S. Sanfo, S. Salack, I. A. Saley, E. K. Daku, N. O. Worou, A. Savadogo, H. Barro, S. Guug, H. Kone, B. Ibrahim, A. Rojas, C. Raimond & K. O. Ogunjobi (2022). Effects of Customized Climate Services on Land and Labor Productivity in Burkina Faso and Ghana. Climate Services, vol. 25, 1-13.

Scanlan & J. Craig. (2001). Food Security in Less Developed Countries, 1970 to 1990. American Sociological Association review, 718-744.

Shandong, Z. (2019). Food security in Nigeria. Journal of Coastal Research, vol. 94, 671676.

Shin, M. H. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. Journal of Applied Econometrics, vol. 16, 289-326.

Sr, William Andrew Clark. (1900). banking, mining and railroads entrepreneur, vol. 1, 1.

Stephen Baraka (2023). How to calculate standard deviation (plus definition & use), indeed career Guide, https://www.indeed.com.

StudySmart. (2020). Climate Change Geography. Geography GLobal Resource Management, report 2020.

Sylvester Ohiomu& Patience Ozor. (2021). Relationship between Climate Change and Food Security in Sub-Saharan Africa. Management Economic Resource Journal, vol. 7, 1-9.

T. T. Tajudeen, A. Omotayo, F. O. Ogundele & L. C. Rathbun (2022). The Effect of Climate Change on Food Crop Production in Lagos State. MDPI Journals, vol. 11(24), 1-15.

T. P. S. Wagle (2016). Spatial analysis of Cobb-Douglas production function in agriculture sector of Nepal: An empirical analysis. Journal of Advanced Academic Research, vol. 3(2): 101.

Thedore W. Schultz (1964). Changing relevance of agricultural economic. American Journal of Agricultural Economics, vol. 46, 1004-1014.

T. Jayne, F. K. Yeboah & C. Henry. (2017). The Future of Work in African Agriculture Trends and Drivers of Change. International labor organization journal,vol. 1, 142.

T. R. Malthus (1798). Malthusian Theory of Population Growth, Summary and Criticisms. Study.com.

Thomas Laubach (2009). New evidence on the interest rate effects of budget deficits and debt. Journal of European Economic Association, vol. 7, 858-885.

T. Ningi, A. Taruvinga, L. Zhou, S. Ngarava (2022). Factors that Influence Household Food Security in Hamburg and Melani, Eastern Cape, South Africa. African

Journal of Science, Technology, Innovation and Development, vol. 14(4), 10501058

U. V. Echebiri, J. O. Abode, A. E. Andrew , I. A. Onaghise& O. B. Amolo (2022). The Impact of Persistent Rise in Food Prices on the Nigerian economy. International Journal of Business and Management review, vol. 10(8), 21-29.

U. Bala and M. M. Abdullahi (2019). The Impacts of oil price and exchange Rate on Food Prices in Nigeria. Journal of Economics and Sustainable Development, vol. 10, 5156.

UNICEF (2022). Annual Report 2022, For every child, every opportunity. Division of Global Communication and Advocacy, https://www.unicef.org

U. Sambo & B. Sule (2024). Impact of climate change on food security in northern Nigeria. Green and Low-Carbon Economy, https://doi.org/10.47852/bonviewGLCE320256

V. Bjornlund, H. Bjornlund, A. V. Rooyen (2022). Why Food Insecurity Persists in SubSaharan Africa: A Review of Existing Evidence. Food Security Journal, vol. 14(4), 1-20.

Victor Ukaogo (2008). Resource Right Agitations and 'New forms of conflict' in the Niger-Delta.

W. Arthur Lewis (1954). Economic development with unlimited supplies of labor. The

Manchester School, vol. 22, 139-191. https://doi.org/10.1111/j.14679957.1954.tb00021.x.

W. C. S. M. Abeysekara, M. Siriwardana & S. Meng (2023). Economic Consequences of Climate Change Impacts on the Agricultural Sector of South Asia: A Case Study of Sri Lanka. Elsevier, vol. 77(c), 435-450.

World Bank (2020). Nigerian country development report: reconciling economic success, Journal of Leadership,organization and history.

World Bank (2022). Vietnam country climate and development report: reconciling economic successes with climate risks, Journal of Leadership, organization, and history.

World Food Program (2022). Partnerships and Advocacy Division. https://www.wfp.org.

W. O. Fawole, E. IIbasmis& B. Ozkan. (2015). Food Insecurity in Africa in Terms of causes, effects and solutions: A Case Study of Nigeria. Department of Agricultural Economics, Faculty of Agriculture, Akdeniz University Journal, vol. 2, 1-8.

Y. M. Gobezie & J. B. Boka (2023). The nexus between greenhouse gas emissions and food security in sub-Saharan Africa: A system GMM analysis. Cogent economic & finance, 1-18.

Y. S. Nadabo& S. M. Salisu (2023). The effect of carbon emissions on financial development, capital formation and economic growth in Nigeria. Periodicals of Social Sciences, vol. 3 22-41.

Z. Kubik, A. Mirzabaev, & J. May (2023). Climate Change, Food and Nutrition Security, and Human Capital. Handbook of Labor, Human Resources and Population Economics, vol. 10, 1-38.

Z. Ahmad, R. Hussain, M. Riaz & M. A. Khan (2019). Mitigation of toxic effects caused by tartrazine in wistar rats through oral administration of melon seed oil. Pakistan Journal of Agricultural Research, vol. 56, 435-44.