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Climate change and Food security: Implications for Sustainable Development in SANE African Countries

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Abstract

The sustainability of any society is undeniably linked to food security. Despite most Africans engaging in agricultural activities, the continent's unpredictable weather has left many of them food insecure. Therefore, this paper aims to examine the impact of climate change on food security in SANE (South Africa, Algeria, Nigeria and Egypt) countries over the period from 2012 to 2023. The data were sourced from the World Development Indicator (WDI), the Food and Agricultural Organization data bank (FAO). The study used the framework of panel fixed effect model to reveal that both carbon dioxide emission and average precipitation rate had negative impact on food production index but their impact is not significant. The study equally reveal that employment in agriculture and agricultural raw material import impacted positively on food production index but without a significant outcome, while food import had a negative and significant impact. Consequently, the study recommends that the countries in this bloc should implement policies meant to mitigate the threat posed by climate change, while food import should be encouraged as a short-term measure to boost the shortfall in local supply. In the long-run, the objective should be to improve local food production using several measures.

Keywords: Food security; Climate change; Agricultural productivity; CO_2; Africa

1. Introduction

Over the past decades, food, as a necessity for human survival, has remained a prominent global issue, given its direct relevance to human life (FAO, 2020; Azra, Okomoda, Hassan, &Ikhwanuddin, 2021). It is a fundamental concept of human existence that shouldn't be ignored; hence, governments everywhere have made it a priority to ensure that everyone has access to sufficient food needed for survival. As a result, they have embarked on various development initiatives, with food security serving as one of their key targets (James, 2021; Imoagwu, et al. 2024). The urge to achieve food security is a global concern since it entails "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The availability, accessibility, use and stability of food are outcomes of food security and nutrition. Ensuring access to safe, nutritious, and sufficient food for all people year-round, as well as eliminating all forms of malnutrition, are the main policy objectives of the Sustainable Development Goals (SDG 2), which include ending hunger and improving food security and nutrition. These goals are outlined in the 2003 Maputo Declaration, the 2014 Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods to End Hunger in Africa by 2025 (Wang, 2019).

In Africa, like other developing countries in Asia and Europe, food security and nutrition have historically fallen behind other regions of the world as they are facing a food crisis of unprecedented proportions (UNECA, 2023). Africa has seen

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the food security situation worsen over the past few years, and in 2019, there were 250.3 million hungry people in Africa. Consequently, the number of acutely food-insecure people in Africa increased by 47.9 million between 2014 and 2019, accounting for about 58.9 million increases globally. In 2021, hunger affected 278 million people in Africa ie about 20.2%. In 2022, the number grew to about **282 million**, or roughly the same **20% of Africa's population**, making up a little over **38% of the world's total**. By 2023, hunger remained very high, affecting around **298 million Africans**, while in 2024, the situation became even more severe, with about **307 million people** in Africa going hungry making their share increased to about **46%** of the global figure (FAO, 2025).

In addition, insecurity remains one of the main aggravating factors of this food insecurity situation, generating large flows of malnourished persons in Africa, irrespective of their fertile lands. These shocks frequently aggravate the situation such that the most recent estimates show that in 2022, the proportion of Africa's population facing severe food insecurity reached 61 percent. This prevalence is very high and is more than twice the prevalence of 29.6% at the global level (FAO, 2025). According to the most recent estimates, these shocks typically make matters worse, to the point that 61% of Africans faced extreme food insecurity in 2022. This steady decline was largely due to catastrophic climate occurrences, economic shocks, prolonged droughts, increased pest attacks, unknown pests, diseases, and invasive species, among others (FAO, 2023; Imoagwu, et al 2023; Khurshid, & Abid, 2024).

The role of climate change in influence food security has been identified in literature. Climate change is an environmental issue confronting all countries, regions, and nationals across the globe in varying degrees of intensity. It directly and indirectly interferes with all humanity's right to food, shelter, water, health, development, and a sufficient standard of living (Intergovernmental Panel on Climate Change, 2022). It poses significant challenges to global food security. Its impacts on agriculture are multifaceted and include shifts in temperature and precipitation patterns, changes in the frequency and intensity of extreme weather events, and alterations in pest and disease dynamics (USDA, ERS, 2022). These changes affect crop yields, livestock productivity, and fisheries, ultimately threatening the availability, accessibility, and stability of food supplies (Walsh, 2020). Rising temperatures can lead to heat stress in crops, reducing yields and affecting crop quality. Changes in precipitation patterns can result in droughts or floods, both of which can devastate crops (Gowda, 2018; Adokwe, Oguanobi, & Ugwunna, 2023).

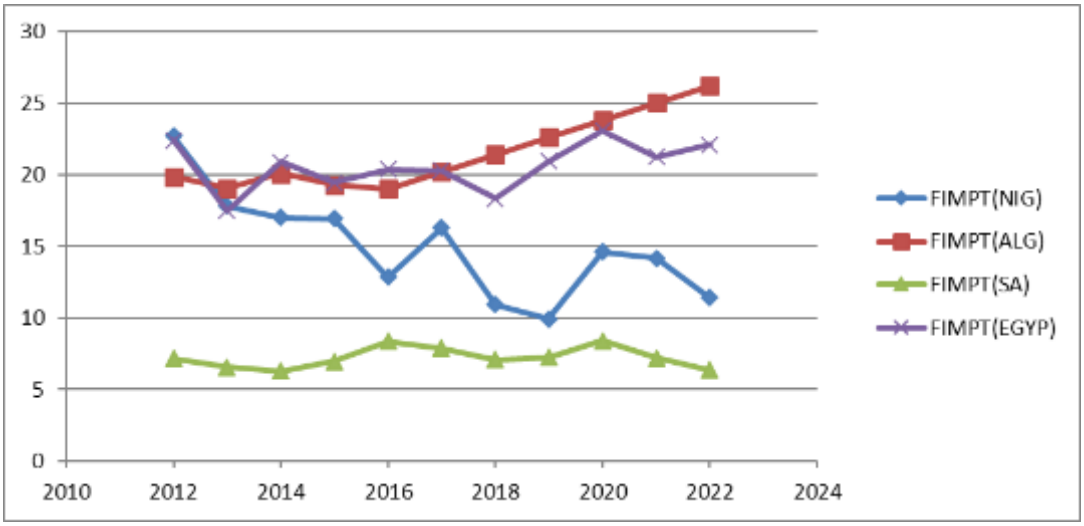
Moreover, increased CO_2 levels in the atmosphere can alter the nutritional content of crops, potentially reducing their quality and nutritional value. Smallholder farmers, particularly those in developing countries, are disproportionately affected by climate change due to their reliance on rain-fed agriculture, limited access to resources such as irrigation and technology, and vulnerability to extreme weather events (Ziska,2016; Ezeanyeji &Adokwe, 2025). These farmers often lack the financial resources and infrastructure to adapt to changing climate conditions, exacerbating food insecurity in vulnerable communities (Sabola, 2024; Caspah, & Sonal, 2025).

The goal of achieving food security through improvement in climate conditions has been reiterated recently, as reported at the COP28 global summit in Dubai. The indicators for measuring the progress of achieving this goal are explained in the corresponding COP 28 summit biennial review of the CAADP implementation progress and the UN World Food Programme (FAO, AUC, ECA &WFP, 2023). According to Hernandez & Gabbard, (2019) sustainability in food security development depends on improved climate conditions achievement. Without suitable climate policy/ strategy, countries will bear a large portion of the cost (to sustain food security by increasing domestic production and minimizing reliance on food imports which causes food security problems leading to high levels of chronic malnutrition, hunger, limitation in human capital development, high poverty rate, low labour productivity, low Life expectancy and unsustainable economic growth in Africa (Ajay, & Pritee, 2018); Dimnwobi et al 2022; Hamadjoda et al. 2024).

From the foregoing, this study aimed to examine the impact of climate change on food security in Africa's big economies referred to as the SANE countries. The word "SANE" is the acronym for four countries within Africa with high gross domestic product (GDP) and they include: South Africa, Algeria, Nigeria and Egypt. According to Nzeh, et al 2023, the SANE is modeled after Brazil, Russia, India, and China (BRICS) countries. Duru & Siyan 2016; PWC 2024, observed that the SANE countries represent Africa's G4 that hold the key for Africa's growth poles in terms of unraveling its capacities for economic prosperity. On grounds of the huge economic activities in these countries, it has become relevant to study the bloc as a way to use the outcome for generalization within Africa. The above reason accounts for the choice of choosing these countries in this study. By focusing on the impact of climate change on food security in these countries, the study contributes to existing literature.

1.1. Stylized Facts

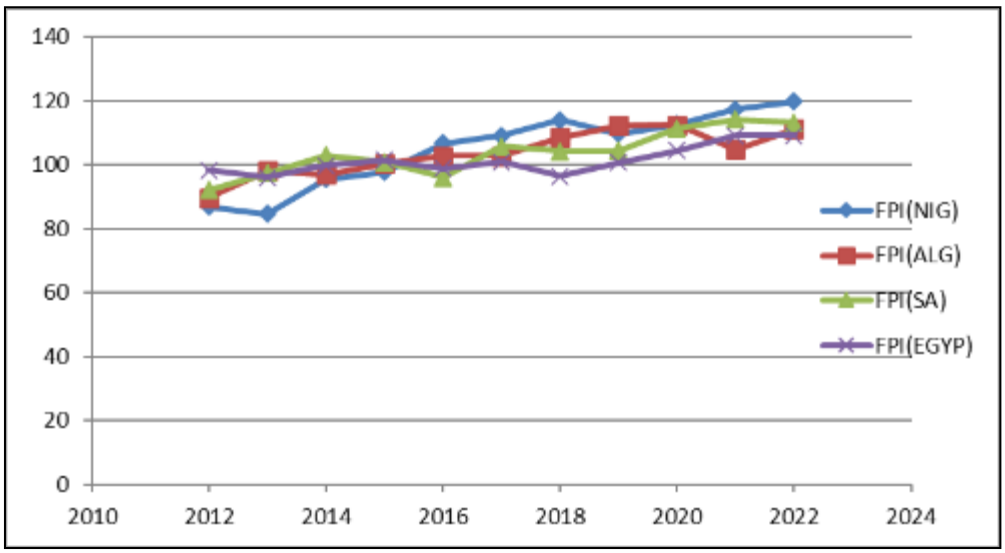
Under this sub-section, the study examined the trend in some relevant variables included in the paper. A critical look in figures 1 and figure 2 provides the state of affairs with respect to food import and food production in the SANE African Countries according to their GDP ranking, starting with the trend in food import in Figure 1.



Source: World Development Indicator (2025).

Figure 1 Trend in Food Import in SANE Countries

Figure 1 depicts that among the SANE countries, South Africa had the least food import within the sample period. This is followed by Nigeria whose food import was highest prior to 2014. Except between 2014 and 2017 when food import for Egypt was higher than that of Algeria, the trend for Algeria was highest after 2017. By implication, food import was high in the two North African countries, indicating that they are more food import dependent compared to South Africa and Nigeria.



Source: World Development Indicator (2025).

Figure 2 Trend in Food Production Index in SANE Countries

In Figure2, the trend in food production index among the countries was evaluated. It is observed that between 2012 to 2013, the trend in food production index was highest in Egypt, while the trend for Nigeria was the lowest within the period. Between 2014 and 2015, the trend for South Africa was highest but between 2016 to 2018 t Nigeria had the highest trend. It is equally observed that between 2010 to 2019 the trend for Algeria was highest. From 2020 all through the period covered, the trend for Nigeria was highest; however, Egypt had the lowest trend from 2017 to 2021. In summary, the two countries that have relatively high food production index are Nigeria and Algeria.

2. Literature Review

Food insecurity has become an issue that has given countries, especially developing countries challenges in addressing it. Several factors have accounted for food insecurity as has been observed in literature. The impact of climate change on food security is an area that is interesting because of the threat posed by climate change. Some studies have thus investigated the impact of climate change on food security across different countries, using different proxies for food security.

In South Asia countries, Bandara & Cai (2014) revealed that climate change impacted negatively on food production within the study period. In another study in South Asian economies, Alvi & Jamil (2018) revealed that climate change reduces cereal production but the adoption of technology improves it. In Pakistan, Joyo, Ram & Magsi (2018) found a negative relationship between temperature, precipitation and rice output. However, a study in China by Wang (2019) indicated that climate change impacts food security significantly only in the current year, but there was no significant impact of food prices on food security. In a cross-country study that involves some countries in West Africa, Mashura (2021) showed revealed that climate variables such as temperature impacted negatively on food security but the impact of rainfall on food security is positive and significant. In South Asia, Ditta, Bashir, Hussain and Hashmi (2023) revealed that climatic variations impacted positively on food security in the long-run.

3. Methodology

This paper used annual dataset that spanned the period from 2012 to 2023. Global Food security index was used as a proxy for food security. Two climate change variables were used, namely: CO_2 emission and average precipitation rate. While CO_2 emission is measured in metric tons per capita, average precipitation rate is measured in millimeter per year. In addition to this, other explanatory variables that were used includes: employment in agriculture, food import and agricultural raw material import. Agricultural employment is measured as a percentage of total employment; food import is measured as a percentage of merchandise import, while agricultural raw material import is measured as percentage of merchandise import. All the data for the study were sourced from the World Bank Development Indicator and Food and Agricultural Organisation (2023). To examine the order of integration of the series, the study conducted a test for stationarity (unit root). To achieve this, two panel unit root tests were used, namely: the Levin, Lin and Chu (LLC) and the augmented Dickey-Fuller-Fisher (ADF-Fisher) panel unit root tests. The study equally conducted a test to determine the order of integration of the series using the Kao panel co-integration test. The impact of climate change and other relevant variables on food security was tested using the panel random effect model which was suggested by the result of the Hauseman test.

3.1. Model Specification

In our econometric analysis of climate change and food security in SANE countries, we specify our model thus:

FS = f (CC) 3.1

Based on equation (3.1), we rewrite our model and other variables of the study thus:

GFSI = f (CO2, APR, EMPAG, FIMPT, ARMI) 3.2

The model is further expressed in its Mathematical form as:

$$\text{GFSI} = \eta_0 + \eta_1 CO2_{it} + \eta_3 APR_{it} + \eta_4 EMPAG_{it} + \eta_5 FIMPT_{it} + \eta_6 ARMI \quad 3.3$$

Modifying equation 3.3 into econometric as thus:

$$GFSI_{it} = \eta_0 + \eta_1 CO2_{it} + \eta_3 APR_{it} + \eta_4 EMPAG_{it} + \eta_5 FIMPT_{it} + \eta_6 ARMI_{it} + \mu_{it} \quad 3.4$$

However, to have the variables interpreted in terms of elasticity, the model is again specified in a log linear form as shown below:

$$\text{LnGFSI} = \eta_0 + \eta_1 CO2_{it} + \eta_3 APR_{it} + \eta_4 EMPAG_{it} + \eta_5 FIMPT_{it} + \eta_6 ARMI + \mu_{it} \quad 3.5$$

Where:

$GFSI_{it}$ = global food security index at time t

$CO2_{it}$ = carbon dioxide emission at time t

APR_{it} = average precipitation rate at time t

$EMPAG_{it}$ = employment in agriculture at time t

$FIMPT_{it}$ = food import at time t

$ARMI_{it}$ = agricultural raw materials import at time t

μ_{it} = error term at time t

4. Results and Discussions

In Table 1, the results of the panel unit root indicate that only employment in agriculture is stationary at level, while others did not achieve stationary at level. Under the ADF-Fisher, finding indicates that none of the variables achieved stationarity at level. However, under the two panel unit root tests, all the variables became stationary at first difference. That is to say that they all became *I(1).*

Table 1 Panel unit Root Results

	LLC		**ADF-FISHER**	
Variable	Level	First Diff.	Level	First Diff.
GFSI	0.22(0.58)	-4.33(0.00)	1.49(0.99)	48.53(0.00)
CO2	-0.39(0.34)	-1.44(0.07)	4.40(0.81)	15.88(0.04)
EMPAG	-1.62(0.05)	-2.62(0.00)	5.83(0.66)	26.12(0.00)
ARMI	-0.80(0.21)	-1.62(0.05)	10.06(0.26)	63.62(0.00)

Source: Researcher's computation using Eviews 10.

The result of the Kao panel cointegration test in Table 2 indicated that at the 10% level of significance, the study cannot accept the null hypothesis of the absence of cointegration since the p-value of the residual is lower than the 10% level of significance. It is therefore concluded that the variables are co-integrated.

Table 2 Result of Kao Residual Cointegration Test

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
RESID(-1)	-0.20	0.11	-1.82	0.07

Source: Researcher's computation using Eviews 10

After conducting the test for co-integration, the study estimated panel fixed effect model to investigate the effect of climate change on food security. The choice of fixed effect model was inflamed by the result of Hauseman test. The Hausman test is guided by the assumption that there is no correlation between the random effect and the explanatory variables. The result of the Hauseman test shown in Table 3 indicates that the p-value is lower than the 5% level of significant, suggesting that the fixed effect model is appropriate for the study.

Table 3 Result of Correlated Random Effects - Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	395.033871	5	0.0000

Source: Researcher's computation using Eviews 10

The panel fixed effect results in Table 4 show that carbon dioxide emission impacted negatively on food production index even though the result is not significant. Average precipitation rate was also found to impact negatively on food security but the result is not significant. These results are in line with apriori expectation as some studies such as Alvi and Jamil (2018) and Mashura (2021) have revealed that climate change has an adverse effect on food security within the study period. Their none significance could be that the impact is not huge as to affect food production. It is also found that while employment in agriculture and agricultural raw material import impacted food security positively, even though the result is not significant, the impact of food import is negative and significant. Even though agriculture employs a lot of people in the countries included in the study, the fact that employment in agricultures did not have significant impact on food security is an indication that food production in these countries is done at a subsistence level, resulting in lower output. Agricultural raw material import did not also impact significantly on food security, indicating that these countries did not commit much resource in importing the relevant agricultural inputs. Rather, they spend more in the importation of food items which is shown in the result of food import. The fact that food import contributed negatively to food security indicates its displacement effect on food productivity in the countries sampled. It goes to show the food dependent nature of these countries as a way to augment local food supply.

Table 4 Results of Panel Random Effects

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	92.79	16.82	5.51	0.00
CO2	-0.47	1.33	-0.35	0.72
EMPAG	0.37	0.31	1.20	0.23
ARMI	1.94	2.55	0.76	0.45
APR	-0.00	0.01	-0.58	0.55
FIMPT	-0.93	0.46	-2.00	0.04
R-squared	0.88			
Adjusted R-squared	0.83			
Durbin-Watson stat	0.39			

Source: Researcher's computation using Eviews 10

5. Discussion

In this study, the focus is to identify the impact of climate change on food security in SANE countries over the period from 2012 to 2023. Findings indicate that the two climate change variables included in the study had negative impact on food security but they are not significant. In another vein, while employment in agriculture and agricultural raw material import impacted positively on food security but without a significant outcome, the impact of food import is negative and significant.

The implication of the result is that even though the results of the climate change variables included in the study are not significant, their impact on food security remains a threat and should not be ignored. In another angle, even though food import is relevant as it helps in augmenting the shortage of food in these countries, the adverse impact it has on food security index is an indication that policies meant to liberalize it should be properly evaluated. In an attempt to boost domestic production of some food items, these countries have place a ban on the importation of these food items. Much as the policies are good, they however resulted into high food inflation as the ban placed on them lead to food shortage.

6. Conclusion

The study shows that climate change slightly weakens food security in the SANE African countries, while heavy dependence on food imports significantly reduces food security. Improving local agricultural production and adopting climate-resilient farming practices will benefit society by ensuring stable food supply and livelihoods, with the way forward focused on sustainable agricultural and climate policies.

Recommendation

- The study recommends that the SANE countries should adopt the climate change mitigation and adaptation strategies, by working together to enhance sustainable agricultural practices such as drought-resistant crops, applying modern farming techniques, and improved irrigation systems.
- They countries should regulate food export to maintain sustainable food sufficiency, stable food price control measures etc.
- The SANE countries should also encourage innovation, and inclusive growth to reduce hunger, malnutrition, and improve rural livelihoods across the region.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest among the authors

Statement of ethical approval

The study relied on secondary data from publicly available sources and therefore, no ethical approval was required and no confidential information was used.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Adokwe, E. I., Oguanobi, C. R., & Ugwunna, O. T. (2023). Linkage effects of agriculture expenditure on food security in Nigeria. ANSU Journal of Arts and Social Sciences (ANSUJASS) 10(2) 64-83.

[2] Ajay, K. S., & Pritee, S. (2018). Implications of climatic and non-climatic variables onfood security in developing economies: A conceptual review. MOJ Food Process Technology, 6(1): 00138. https://doi.org/10.15406/mojfpt.2017.06.00138.

[3] Alvi, S., & Jamil, F. (2018). Impact of climate change and technology adoption on cereal yields in South Asian Countries. European Journal of Sustainable Development, 7(3), 237-237. https://doi.org/10.14207/ejsd.2018.v7n3p237.

[4] Azra, M.N., Okomoda, V.T., Tabatabaei, M., Hassan, M., & Ikhwanuddin, M. (2021). The contributions of shellfish aquaculture to global food security: Assessing its characteristics from a future food perspective. Front. Marine Science Journal 8(8), 654897. https://:doi.org/10.3389/fmars.2021.654897.

[5] Bandara, J. S., & Cai, Y. (2014).The impact of climate change on food crop productivity, food prices and food security in South Asia. Economic Analysisand Policy, 44(4), 451–465.

[6] Caspah, L.,& Sonal, K. (2025). Navigating the Effects of Climate Change and Fiscal Policy on Food Security in Sub Saharan Africa. Journal of Finance and Economics. 2025, Vol. 13 No. 3, 124-138. https://doi.org/10.12691/jfe-13-3-5.

[7] Dimnwobi, S. K., Okere, K. I., Onuoha, F. C. & Ekesiobi, C. (2022). Energy poverty, environmental degradation and agricultural productivity in Sub-Saharan Africa, AGDI Working Paper, No. WP/22/096. African Governance and Development Institute (AGDI), Yaoundé.

[8] Ditta, A., Bashir, F., Hussain, A., & Hashmi, M. S. (2023). Climate change and food security in selected developing countries: Panel data analysis. Journal of Social Sciences Review, 3(2), 963–974. https://doi.org/10.54183/jssr.v3i2.332.

[9] Duru, I. U., & Siyan, P. (2016). Empirical investigation of exports and economic growth: Evidence from sane countries. Asian Development Policy Review, 7(4), 318-354.

[10] Ezeanyeji. C. I., Adokwe, E. I., Obi, C. O., Ugwunna, O. T., & Oguanobi, C. R. (2025). The Impact Of Climate Change On Food Security In Nigeria. International Journal of Innovative Finance and Economics Research 13(1),375-388. https://:10.5281/zenodo.15011838.

[11] Ezeokoye, L.I.,Mbaeri, N.C., & Imoagwu, C. P. (2024). Impact of small scale fish farming in poverty reduction in south-East zone of Nigeria. International Journal of advanced economics,6(7),251-263. https://:10.51594/ijae.v6i7.1279.

[12] FAO,(2020). Nigeria: Climate Change and Food Security Country Profile. http://www.fao.org/3/ca9817en/CA9817EN.pdf.

[13] FAO, (2023). Regional Overview of Food Security and Nutrition: Statistics and Trends. https://www.fao.org/faostat/en/#data/FS.

[14] FAO, AUC, ECA, & WFP. (2025). Africa – Regional Overview of Food Security and Nutrition 2025: Statistics and trends. Accra, FAO. https://doi.org/10.4060/cc8743en.

[15] Gowda, A. (2018). Improving sorghum productivity under changing climatic conditions: A modeling approach. Field Crops Research, 246, 107685. https://doi.org/10.1016/j.fcr.2019.107685.

[16] Hamadjoda, Y.D., Nuamah, P.A., Njong, A.M., & Rumbidzai, M. R. (2024). Does Climate Variability Matter in Achieving Food Security in Sub-Saharan Africa? Journal of Environmental Challenges 15(6):100870. https://doi.org/10.1016/j.envc.2024.100870.

[17] Harnandez, R., & Gabbard, S. (2019). Food systems sustainability, food security and nutrition in the Mediterranean region: The contribution of the Mediterranean diet. In, Encyclopedia of Food Security and Sustainability, Volume 2. Elsevier, Amsterdam. pp. 176-180.https://doi.org/10.1016/B978-0-08-100596-5.21977-X.

[18] IPCC. Climate Change in Eastern and Southern Africa: impacts, Vulnerability and Adaptation (2022) https://www.ipcc.ch/apps/njlitie/srex/njliite_download.php? Accessed 10 September, 2025.

[19] Intergovernmental Panel on Climate change (IPCC), (2018). Global Warming of 1.50C.Summary of Policy makers. Retrieved from https://www.ipcc.ch/sr15/.

[20] Imoagwu, C. P., Nwogwugwu, U. C., Ezenekwe, U. R., &. Kalu, C. U. (2023). Food Production and Life Expectancy: Evidence from the Economic Community of West African States (ECOWAS). International Journal of Research and Innovation in Social Science (IJRISS), 7(9), 2099-2112. https://:10.47772/IJRISS.2023.71071.

[21] Imoagwu, C. P., Kalu,C. U., Uzoechina, B. I., & Nwokoye, E. S. (2024). Food Security and Life Expectancy in Selected Economic Community of West African States (ECOWAS). International Journal of Advanced Research in Public Policy, Social Development and Enterprise Studies (IJARPPSDES) 5(1), 175-189. https://doi.org/10.48028/iiprds/ijarppsdes.v5.i1.4.

[22] James, K. O. (2021). Achieving sustainable development goal two: Establishing the determinants of food security in Nigeria. International Journal of Economics, Commerce and Management, 9(9), 180-193.

[23] Joyo, M., Ram, N., & Magsi, H. (2018).Risk assessment of climate variability on rice productivity in Sindh province of Pakistan. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences, 34(1), 68-77.

[24] Khurshid, S., & Abid, M. (2024). Climate change vulnerability and multidimensional poverty in flood prone rural areas of Punjab, Pakistan: an application of multidimensional poverty index and livelihood vulnerability index, Environment, Development and Sustainability: A Multidisciplinary Approach to the Theory and Practice of Sustainable Development. Springer, 26(5), 13325-13352. https://:10.1007/s10668-023-04207-8.

[25] Mashura, S. (2021). Impact of climate change on food security and health outcomes in West African countries: a co-integration analysis. International Journal of Social Science and Economic Research, 06 (02), 628. https://doi.org/10.46609/IJSSER.2021.v06i02.015.

[26] Nzeh, I.C., Uzoechina, B. I., Imoagwu, C. P., & Ogwuru, H. O. R. (2023). Investigating the Determinants of Cereal Production in Nigeria. International Journal of Advanced Studies in Economics and Public Sector Management, 11(2), 32-48. DOI: http://dx.doi.org/10.48028/iiprds/ijasepsm.v11.i2.04.

[27] Sabola, G. A. (2024). Climate change impacts on agricultural trade and food security in emerging economies: A case of Southern Africa. Discover Agriculture Discover, 2(1), 12. https://doi.org/10.1007/s44279-024-00026-1.

[28] United Nations Economic Commission for Africa (UNECA) (2023). Africa's hunger crisis deepens as war, climate pile on pain. https://www.uneca.org › african-regional-overview-of-food and nutrition-2023.

[29] USDA, ERS, (2022). Climate change and Eastern Africa: A review of impact on major crops. Journal of Food and Energy Security.

[30] Walsh, F.K.(2020). Trend analysis in climatic variables and impacts on rice yield in Nigeria. Journal of Water and Climate Change, 6(3), 534–543.

[31] Wang, J. (2019). Food security, food prices, and climate change in China: a dynamic panel data analysis, International Conference on Agricultural risk and food security 2010. Agriculture and Agricultural Science Procedia 1(2019), 321-324. https://doi.org/doi:10.1016/j.aaspro.2010.09.

[32] World Bank, (2023). World Development Report 2023: Financing the climate Transition: Building the Green, inclusive, Resilient Economies of the Future. www.worldbank.org.

[33] World Development report (2025). Food Security Update. www.worldbank.org.

[34] Ziska, L. H. (2016). The role of climate change and increasing atmospheric carbon dioxide on weed management: Herbicide efficacy. Journal of Agriculture, Ecosystems & Environment, 2(31), 304-309, https://:10.1016/j.agee.2016.07.014.