Climate Dynamics, Fertilizer use, and Cassava Output in Nigeria: A Four-Decade Trend Analysis (1980 – 2023)

Enoch, O.C[1]. Echebiri, R.N[2]; Amusa T.A[2]; Anyaim, K.H[1]; Aigbokie S.O[3]; Enoch, J.U[2] and Nwankwo, E.N[4]

[1]Department of Agricultural Economics, Federal University of Technology, Imo State,

[2]Department of Agricultural and Vocational Education, Michael Okpara University of Agriculture

[3]Department of Agricultural Economics, Gregory University, Uturu

[4]National Horticultural Research Institute, Ibadan

DOI: https://dx.doi.org/10.51244/IJRSI.2025.1210000327

Received: 02 November 2025; Accepted: 08 November 2025; Published: 21 November 2025

ABSTRACT

This study investigated the trends in climatic variables, fertilizer use, and cassava production in Nigeria from 1980 to 2023, utilizing exponential trend analysis on secondary data sourced from the Food and Agriculture Organization (FAO) statistics, the World Bank database, the National Bureau of Statistics (NBS), and the Nigerian Meteorological Agency (NiMet). Results indicated a slight but significant decline in rainfall (β = -0.0021, $p < 0.01$) and cassava yield (β = -0.0094, $p < 0.01$), alongside significant temperature increases (β = 0.0037, $p < 0.01$), relative humidity (β = 0.0027, $p < 0.01$), solar radiation (β = 0.0154, $p < 0.01$), cultivated land area for cassava (β = 0.0052, $p < 0.01$), and labour force involved in cassava production (β = 0.2599, $p < 0.01$). Fertilizer use showed a negative but statistically insignificant trend (β = -0.0392, $p > 0.05$). These findings suggest that, despite increasing land and labour inputs, as well as expanding solar radiation and humidity, cassava yields are declining, likely due to decreasing rainfall, rising temperatures, and inadequate fertilizer application. The study concluded that climate variability, coupled with limited technological adoption as exemplified in low fertilizer use, threatens cassava productivity in Nigeria. It recommends urgent investment in climate-smart agricultural practices, enhanced access to fertilizers, and the promotion of drought- and heat-tolerant cassava varieties to bolster resilience and sustain production.

Keywords: Cassava output, climate variability, fertilizer use, time-series analysis, Nigeria, 1980–2023

INTRODUCTION

The agricultural sector plays a crucial role in Nigeria's socioeconomic system, providing employment for over 70% of the rural population and making a significant contribution to the country's GDP and national food security (Adofu *et al.*, 2010). In this sector, cassava is one of the most vital staple crops due to its adaptability, low production costs, and widespread consumption across the country (Ajayi, 2014; Dixon & Ssemakula, 2008). Nigeria remains the world's largest cassava producer, yet the crop continues to underperform relative to its full potential due to climate variability, limited access to improved technologies, and other structural inefficiencies (Bentley *et al*., 2017; BlueSense, 2023).

From 1980 to 2023, Nigeria has experienced significant changes in climate factors such as rainfall, temperature, relative humidity, and solar radiation, which are essential to agricultural productivity. Climate variability and change, evident through unpredictable rainfall, rising temperatures, and extreme weather events, have increased risks to farming systems, threatening sustainable cassava production (Adejuwon, 2004; Akande *et al.*, 2017). Studies show that these climate changes directly impact physiological processes in cassava, including growth cycles, tuber development, and resistance to diseases (Alves & Setter, 2016; Agba *et al.*, 2017).

Rainfall, a critical water source for crop growth, has become increasingly unpredictable in timing and distribution, leading to delayed planting and crop failure in rain-fed systems (Akinniran et al., 2013). Cassava, although relatively drought-resistant, still depends on adequate moisture for optimal yields. Similarly, increased average temperatures and the frequency of heat waves have implications for cassava's photosynthetic efficiency and stress tolerance thresholds (Ajetombi & Abiodun, 2010; Ebele & Emodi, 2016). Relative humidity, on the other hand, significantly influences pest and disease dynamics, such as root rot and mosaic virus, which reduce yield and crop quality (Alehile, 2023).

Solar radiation, a crucial component for photosynthesis and dry matter accumulation, has shown spatial and seasonal variability across Nigeria's ecological zones, affecting cassava productivity (Alves & Setter, 2016). Though cassava generally thrives under high light intensity, excess solar radiation in combination with moisture stress can lead to oxidative damage, reduced stomatal conductance, and suboptimal tuberization (Chikezie *et al.*, 2015).

Besides climatic factors, the importance of technology, especially inorganic fertilizer use, cannot be overstated. Fertilizer application is crucial for maintaining soil fertility and increasing cassava yields, particularly as continuous cultivation depletes essential nutrients (Biratu, 2018). However, the trend in fertilizer usage in Nigeria remains inconsistent due to issues related to cost, distribution, and farmers' awareness (Amanchukwu *et al.*, 2015; Anabaraonye, 2019). Despite government programs promoting fertilizer subsidies, adoption levels stay low, limiting the sector's ability to offset climate-related yield losses (Siregar *et al.*, 2017).

Furthermore, the combined influence of technology and climate factors creates complex interactions that affect cassava productivity. For example, while improved fertilizer use can mitigate the adverse effects of poor soils, its effectiveness diminishes under erratic rainfall or drought conditions. Similarly, innovations in planting methods and crop management practices are only beneficial when they align with prevailing agro-climatic realities (Asare *et al.*, 2017; Amanchukwu *et al.*, 2015).

Cassava's performance over the past four decades can be viewed through the dual lens of climate change and technological adaptation. Understanding how these factors have evolved is essential for developing effective policy measures and guiding future research efforts (Agba *et al.*, 2017; Akomolafe *et al.*, 2018). This is particularly crucial given global climate models that predict increased temperatures and rainfall variability in West Africa, which have significant implications for food security (BNRCC, 2011; Butu *et al.*, 2023).

Therefore, this study examines long-term trends in key climatic parameters (rainfall, temperature, relative humidity, and solar radiation), fertilizer use as an indicator of agricultural technology, and cassava output in Nigeria from 1980 to 2023. By analyzing how these variables change over time and relate to each other, the research aims to offer insights into the factors driving cassava productivity and to guide climate-smart and technology-based agricultural planning. This evidence is vital for supporting Nigeria's adaptation efforts and building resilience in its cassava supply chain in the face of an increasingly uncertain climate (Adejuwon, 2004; Alehile, 2023; Dioha & Emodi, 2018).

MATERIALS AND METHODS

The study was conducted in Nigeria. It is located between the Sahel region to the north and the Gulf of Guinea to the south in the Atlantic Ocean. Nigeria shares borders with Niger to the North, Chad to the North-East, Cameroon to the East, and Benin to the West. The country consists of thirty-six (36) States, a Federal Capital Territory (FCT), Abuja, and covers a land area of 923,768 km², with 13.000 km of water borders (NBS, 2023). The country lies between latitudes 3°15' and 13°30' N and longitudes 2°15' and 15°00' E of the Greenwich Meridian (Federal Ministry of Environment, 2020). Nigeria has an estimated population of 214,741,311 as of the second quarter of 2023, with an annual growth rate of 2.5% (World Bank, 2023).

Nigerian agricultural sector have employed more than 36% of the Nigerian labour force, a feat which ranked the sector as the largest employer of labour in the country (Nigeria Bureau of Statistics, 2024). Agricultural output acts as a resource for many processing industries and as a means of foreign exchange earnings for the country. Nigeria's agricultural sector is not immune to the impact of climate change due to dependence on a rain-fed

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

agricultural production system, and a climate outcome reducing output could severely affect the contribution of the sector to the gross domestic product (GDP) (Alehile, 2023).

Food and Agriculture Organization (FAO), World Bank database, National Bureau of Statistics (NBS), and the Nigerian Meteorological Agency (NiMet) data were collected which consisted fertilizer usage rates, cassava output, and climatic variables (rainfall, temperature, solar radiation, and relative humidity) for the study period. Data were analyzed using the log-linear trend equation modeled following Onyenweaku (2004).

Model Specification

The log-linear trend equation for this study was and represented as follows:

$\ln(Y_t) = \alpha + \beta t + \epsilon_t$ - - - Equation (1.0)

where;

$\ln(Y_t)$ = natural log of the variable of interest at time t

α = intercept (baseline log-level of the variable)

β = slope or trend coefficient (average growth rate over time)

t = time in years (from 1980 to 2023)

ϵ_t = error term (captures shocks or deviations)

Each variable will be estimated separately as thus,

$\ln(Rain_t) = \alpha_1 + \beta_1 t + \mu_{1t}$ - - - Equation (1.1)

$\ln(Temp_t) = \alpha_2 + \beta_2 t + \mu_{2t}$ - - - Equation (1.2)

$\ln(RH_t) = \alpha_3 + \beta_3 t + \mu_{3t}$ - - - Equation (1.3)

$\ln(SR_t) = \alpha_4 + \beta_4 t + \mu_{4t}$ - - - Equation (1.4)

$\ln(Tech_t) = \alpha_5 + \beta_5 t + \mu_{5t}$ - - - Equation (1.5)

$\ln(CASSAVA_t) = \alpha_6 + \beta_6 t + \mu_{6t}$ - - - Equation (1.6)

$\ln(LABOURt) = \alpha_7 + \beta_7 t + \mu_{7t}$ --- Equation (1.7)

$\ln(AREAt) = \alpha_8 + \beta_8 t + \mu_{8t}$ --- Equation (1.8)

Where,

$RAIN_t$ = Average annual rainfall in millimeters in period t.

$TEMP_t$ = Average annual temperature in centigrade in period t.'

$RHUM_t$ = Relative humidity in (%) in period t.

$SRAD_t$ = Annual average solar radiation (e.g., MJ/m²/day) in period t.

$RFUCP_t$ = Total quantity of fertilizer used for cassava production (metric tons or kg/ha) for the period, t

$CASSAVA_t$ = Annual cassava production (metric tons) in year t,

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

LABOURt = Labour force in man-days in year t,

AREAt = area of land in hectare in year t,

$\alpha_1 - \alpha_8$ = the constants in the regression line.

$\beta_1 – \beta_8$= the trend coefficient.

t = trend variable measured in years (t = 1, 2, 3...44)

μ_t = the error term.

Multivariate Regression

The functional form of the multivariate regression model can be expressed as:

$$\text{Cassava Yield}_t = \beta_0 + \beta_1 \text{Rainfall}_t + \beta_2 \text{Temperature}_t + \beta_3 \text{Relative Humidity}_t + \beta_4 \text{Fertilizer Usage}_t + \beta_5 \text{Area of Land}_t + \beta_6 \text{Solar Radiation}_t + \beta_7 \text{Labour Force}_t + \varepsilon_t \quad - \quad - \quad - \quad - \quad 1.9$$

Where:

Cassava Yield_t= Cassava yield in year t(tons/ha or appropriate unit)

Rainfall_t= Total rainfall in year t(mm)

Temperature_t= Mean annual temperature in year t(°C)

$\text{Relative Humidity}_t$= Average relative humidity in year t(%)

$\text{Fertilizer Usage}_t$= Fertilizer application in year t(kg/ha)

Area of Land_t= Area of land cultivated for cassava in year t(ha)

Solar Radiation_t= Average solar radiation in year t(MJ/m²/day or equivalent unit)

Labour Force_t= Labor input in cassava production in year t(number of workers or man-days)

β_0= Intercept term

$\beta_1, \beta_2, \ldots, \beta_7$= Coefficients representing the marginal effect of each independent variable on cassava yield

ε_t= Error term capturing all other factors affecting cassava yield not included in the model

RESULT AND DISCUSSION

Table 1: Estimated exponential trend equations for rainfall, temperature, relative humidity, cassava yield, fertilizer usage, area of land, solar radiation, and labour force in Nigeria (1980-2023).

Dependent Variable	β_0	β_1	r^2	Adj. r^2	F-ratio
Rainfall	8.0016***	-0.0021	0.4366	0.4070	8.64
Temperature	3.2140***	0.0037***	0.4901	0.4608	9.86
Relative Humidity	4.1057***	0.0027***	0.9987	0.9986	31756.93

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Cassava Yield	9.3744***	-0.0094***	0.6528	0.6247	19.84
Fertilizer	11.5728***	-0.0392	0.2823	0.2604	3.77
Area of Land	10.9460***	0.0052***	0.9093	0.9072	421.31
Solar Radiation	1.5296***	0.0154***	0.9923	0.9921	5404.17
Labour Force	1.6172	0.2599***	0.5861	0.5762	59.46

Source: Computed from time-series data, 1980-2023. Note: *** implies statistically significant at 0.01 probability levels, respectively. Figures in brackets are t-values

Rainfall exhibited a slight but negative growth trend over the study period, with a β_1 coefficient of -0.0021 and a coefficient of determination (R^2) of 0.4366. Although the trend is statistically significant at the 1% level, the negative coefficient suggests a gradual decrease in rainfall over time in Nigeria between 1980 and 2023. This implies that approximately 43.66% of the variation in annual rainfall is explained by the time trend, as substantiated by the F-ratio of 8.64. This declining trend in rainfall aligns with the growing body of evidence highlighting the effects of climate change in West Africa, particularly in Nigeria. According to Haider (2019), the country has experienced significant shifts in rainfall patterns, with shorter wet seasons and increased unpredictability, a phenomenon that exacerbates the vulnerability of rain fed agricultural systems such as cassava cultivation. Reduced rainfall threatens soil moisture retention, delays planting, and increases the risk of crop failure, especially in regions with poor irrigation infrastructure. The implication is clear: unless adaptive strategies such as efficient irrigation systems, water harvesting technologies, and drought-tolerant cassava varieties are adopted, the declining rainfall trend could undermine long-term cassava productivity and food security in Nigeria (IPCC, 2013; Jarvis *et al.*, 2020).

Graphical Presentation of Trends of Annual Rainfall in Nigeria (1980–2023)

The trend in annual rainfall in Nigeria between 1980 and 2023 is shown in Figure 1.1

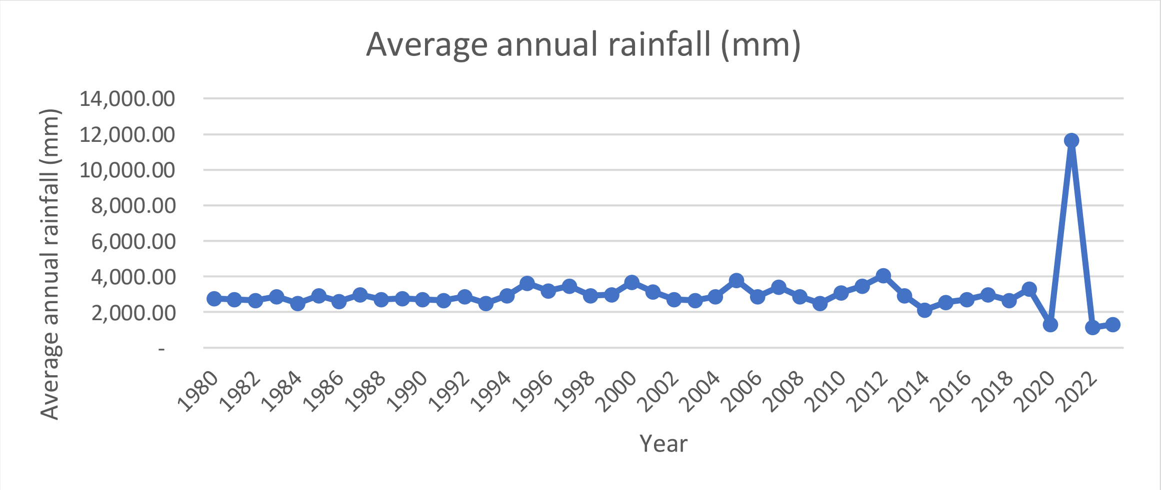

Figure 1.1 Trend in annual rainfall in Nigeria between 1980 and 2023.

Temperature recorded a statistically significant positive growth trend over the reference period, with a β_1 coefficient of 0.0037*** and an R^2 value of 0.4901, indicating that 49.01% of the temperature variation is explained by time. The F-ratio of 9.86 confirms the model's validity. This consistent rise in average temperature mirrors broader global warming trends, which are expected to continue in the coming decades (IPCC, 2007). Rising temperatures can have both beneficial and detrimental effects on cassava. On the one hand, moderate warming may enhance photosynthesis and root development; on the other hand, excessive heat can lead to evapotranspiration stress, impaired tuberization, and shortened growing cycles. According to Hassnain Shah *et al.* (2021), temperature increases are one of the most critical climate risks to agriculture, particularly when not balanced with adequate water availability. As Nigeria continues to experience warming, farmers may need to adapt by shifting planting dates, adopting heat-resistant cultivars, and improving soil organic matter to enhance moisture retention. Failure to adapt could diminish the suitability of cassava cultivation in traditional regions, as noted by Jarvis *et al.* (2020).

Graphical presentation of trends of annual temperature in Nigeria from 1980 - 2023.

The trend in annual temperature in Nigeria between 1980 and 2023 is shown in Figure 1.2

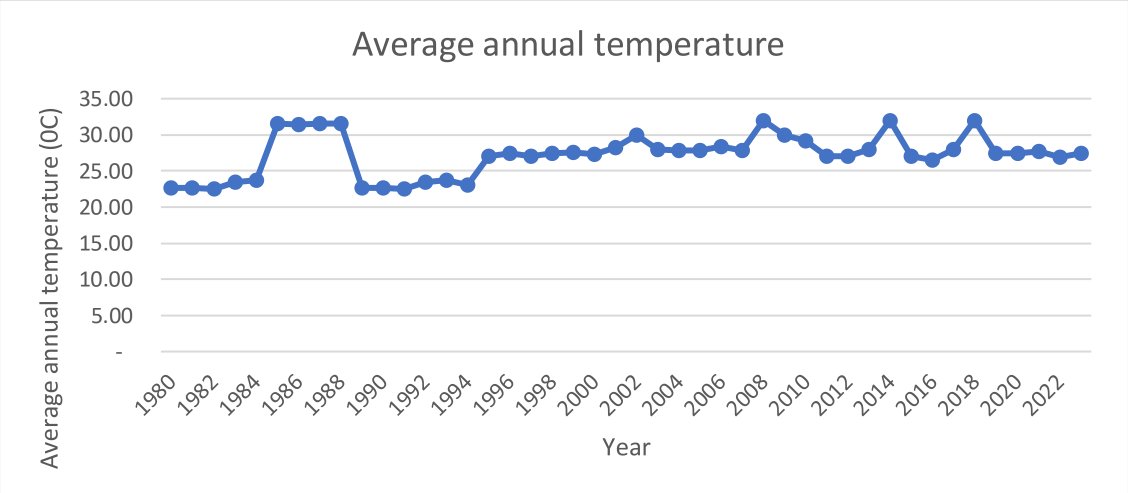

Figure 1.2 Trend in annual temperature in Nigeria between 1980 and 2023.

Relative Humidity exhibited an exceptionally strong and statistically significant positive trend, with a β_1 coefficient of 0.0027*** and a near-perfect R^2 value of 0.9987. The F-ratio of 31,756.93 reinforces the high precision of the model. This trend indicates that relative humidity has increased almost linearly over the past four decades in Nigeria. Increased atmospheric moisture may benefit cassava in water-scarce areas by reducing plant stress; however, excessively high humidity levels can also promote the spread of fungal and bacterial diseases. This is particularly concerning in storage and post-harvest stages, where high humidity can result in rapid spoilage and economic losses. Haider (2019) and Hershey *et al.* (2001) both noted that changes in humidity levels, combined with rainfall and temperature fluctuations, require renewed focus on integrated disease and pest management practices. Therefore, while the rising humidity trend may offer short-term physiological benefits to cassava plants, it poses long-term risks that call for improved drying, processing, and storage innovations.

Graphical presentation of trends of relative humidity in Nigeria from 1980 - 2023.

The trend in relative humidity in Nigeria between 1980 and 2023 is shown in Figure 1.3

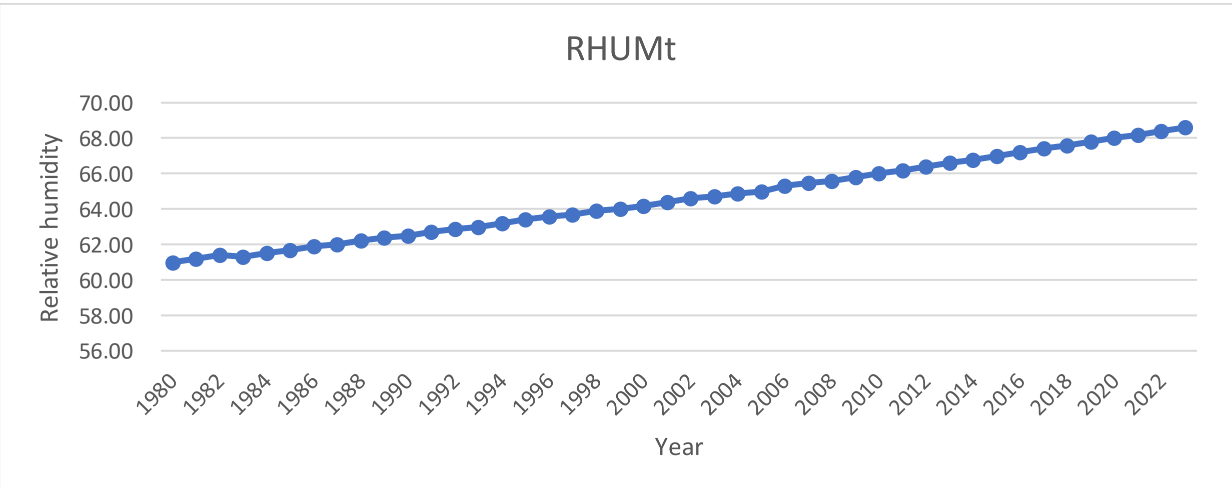

Figure 1.3 Trend in relative humidity in Nigeria between 1980 and 2023.

INTERNATIONAL JOURNAL OF RESEARCH AND SCIENTIFIC INNOVATION (IJRSI)
ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Cassava Yield, the principal focus of the study, displayed a worrisome negative and statistically significant trend, with a β_1 coefficient of -0.0094*** and an R^2 of 0.6528. This means that 65.28% of the variation in cassava yield can be attributed to the passage of time. Despite advancements in research, policy interventions, and increased labour and land allocation, yields have declined steadily. The F-ratio of 19.84 validates the strength of the model. This outcome raises critical questions about the sustainability of cassava production systems in Nigeria. Yield declines may result from a combination of climate stressors, declining rainfall, increasing temperatures, and soil nutrient depletion as well as socio-economic constraints such as poor access to quality inputs, limited mechanization, and weak extension services. Howeler *et al.* (2006) found similar yield stagnation in Asian cassava systems due to declining soil fertility and suboptimal agronomic practices. These findings are echoed by Ivan *et al.* (2017), who emphasized that nutrient imbalances and delayed adoption of improved varieties can lead to sharp declines in productivity. The situation calls for urgent investment in research, climate-resilient technologies, and farmer training to reverse the downward trend in yield.

Graphical presentation of trends of cassava (fresh yield) in Nigeria from 1980 - 2023.

The trend in cassava (fresh yield) in Nigeria between 1980 and 2023 is shown in Figure 1.4

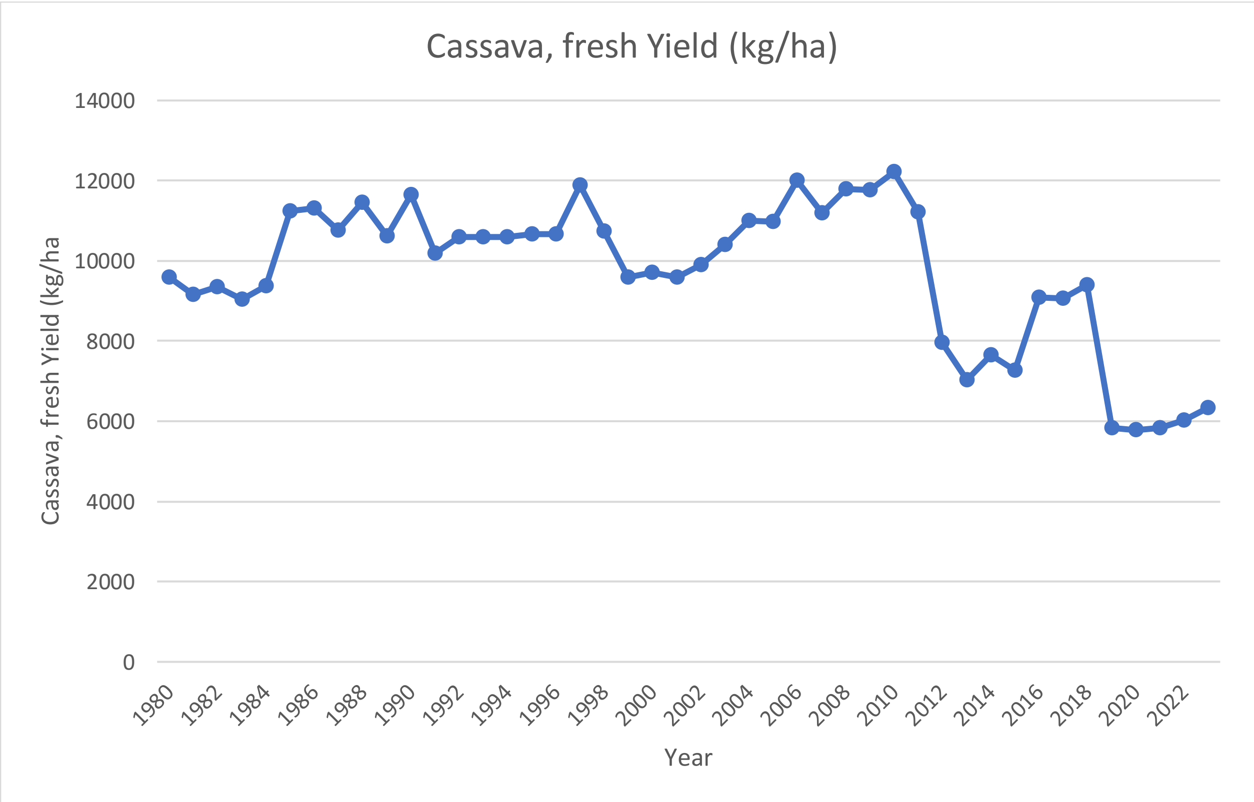

Figure 1.4 Trend in cassava (fresh yield) in Nigeria between 1980 and 2023.

Fertilizer Use showed a negative trend with a β_1 coefficient of -0.0392, but it was not statistically significant, and the model's R^2 was relatively low at 0.2823. This indicates that only 28.23% of the variation in fertilizer use is explained by the time trend variable, with an F-ratio of 3.77. The non-significant downward trend suggests weak, inconsistent, or declining use of fertilizers over the years. This could be attributed to high input costs, subsidy inefficiencies, poor farmer education, or declining government investment in fertilizer distribution systems. Ihtisham *et al.* (2020) and IFAD (2001) both highlighted that inadequate access to fertilizers and inappropriate application practices remain major barriers to productivity in low-income countries. Given the central role of balanced nutrient supply in boosting cassava yield—particularly under climate stress—this finding points to a critical gap in Nigeria's agricultural policy. Scaling up fertilizer access through subsidy reform, agro-dealer networks, and extension support is essential for long-term yield sustainability.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Graphical presentation of trends of cumulative fertilizer usage in Nigeria from 1980 - 2023.

The trend in cumulative fertilizer usage in Nigeria between 1980 and 2023 is shown in Figure 1.5

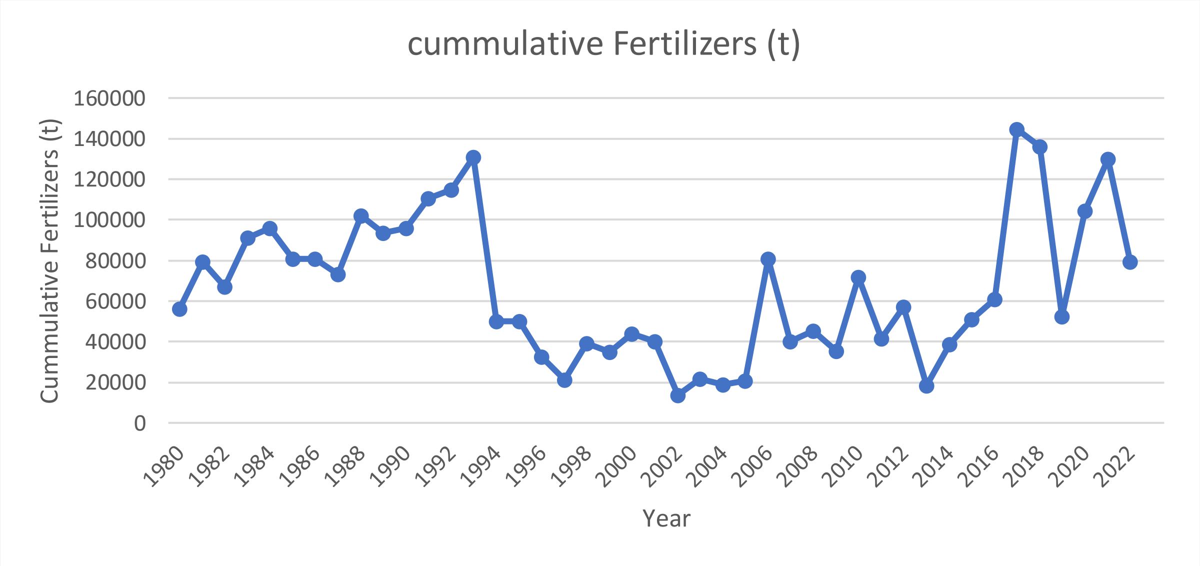

Figure 1.5 Trend in cumulative fertilizer usage in Nigeria between 1980 and 2023.

Area of Land Cultivated for cassava showed a strong, positive, and statistically significant growth trend, with a β_1 coefficient of 0.0052*** and an R^2 of 0.9093, indicating that over 90% of the variation in land area is explained by the time trend. The F-ratio of 421.31 supports the reliability of the model. This suggests that Nigerian farmers have continually expanded the area cultivated with cassava, likely as a response to falling yields in an attempt to maintain or increase total production. While this land extensification strategy may sustain short-term output, it raises significant environmental and economic concerns. Expansion into marginal lands can lead to deforestation, land degradation, and reduced ecosystem services (Howeler *et al.*, 2017; Haider, 2019). The finding highlights the need to transition from extensive to intensive farming practices, emphasizing input optimization, mechanization, and precision agriculture to enhance land productivity without expanding the farm frontier.

Graphical presentation of trends of the area of land harvested in Nigeria from 1980 - 2023.

The trend in the area of land harvested in Nigeria between 1980 and 2023 is shown in Figure 1.6

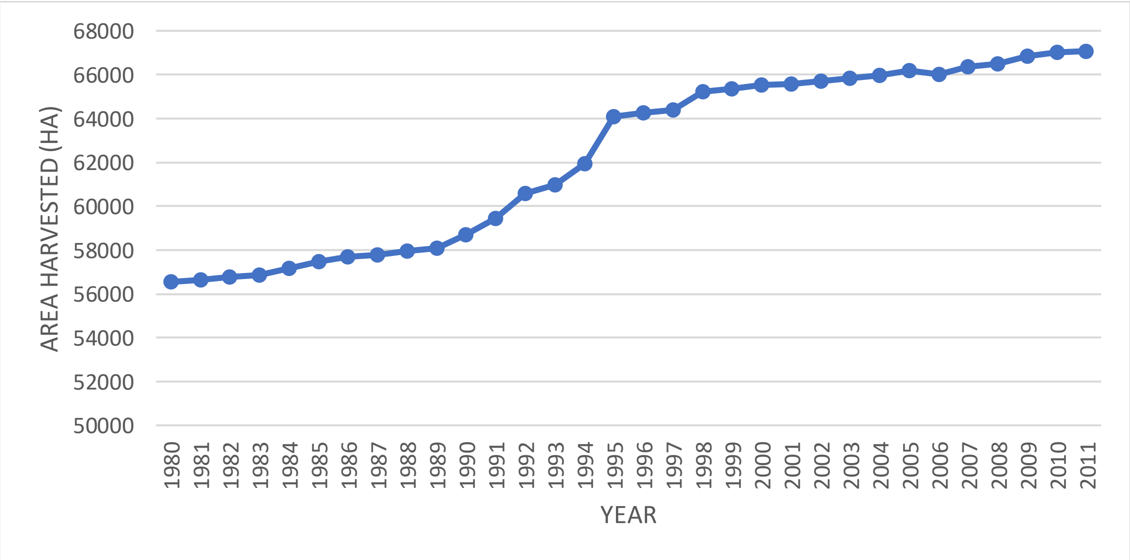

Figure 1.6 Trend in area of land harvested in Nigeria between 1980 and 2023.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

Solar Radiation exhibited a strong and significant positive trend, with a β_1 coefficient of 0.0154*** and an R^2 of 0.9923. The exceptionally high F-ratio (5,404.17) indicates the robustness of the model. Increased solar radiation suggests that crops now receive more sunlight, which can enhance photosynthesis and potentially increase biomass under ideal conditions. However, in the presence of heat stress and declining rainfall, excessive solar radiation may aggravate water stress and reduce cassava productivity (Ibayashi *et al.*, 2016). Furthermore, increased solar exposure without proper canopy coverage may lead to heat-induced chlorosis, particularly in young plants. Therefore, while solar radiation is generally beneficial, its interaction with other climatic factors must be carefully monitored and managed through shading techniques, mulching, and moisture conservation practices.

Graphical presentation of trends of solar radiation in Nigeria from 1980 - 2023.

The trend in solar radiationin Nigeria between 1980 and 2023 is shown in Figure 1.7

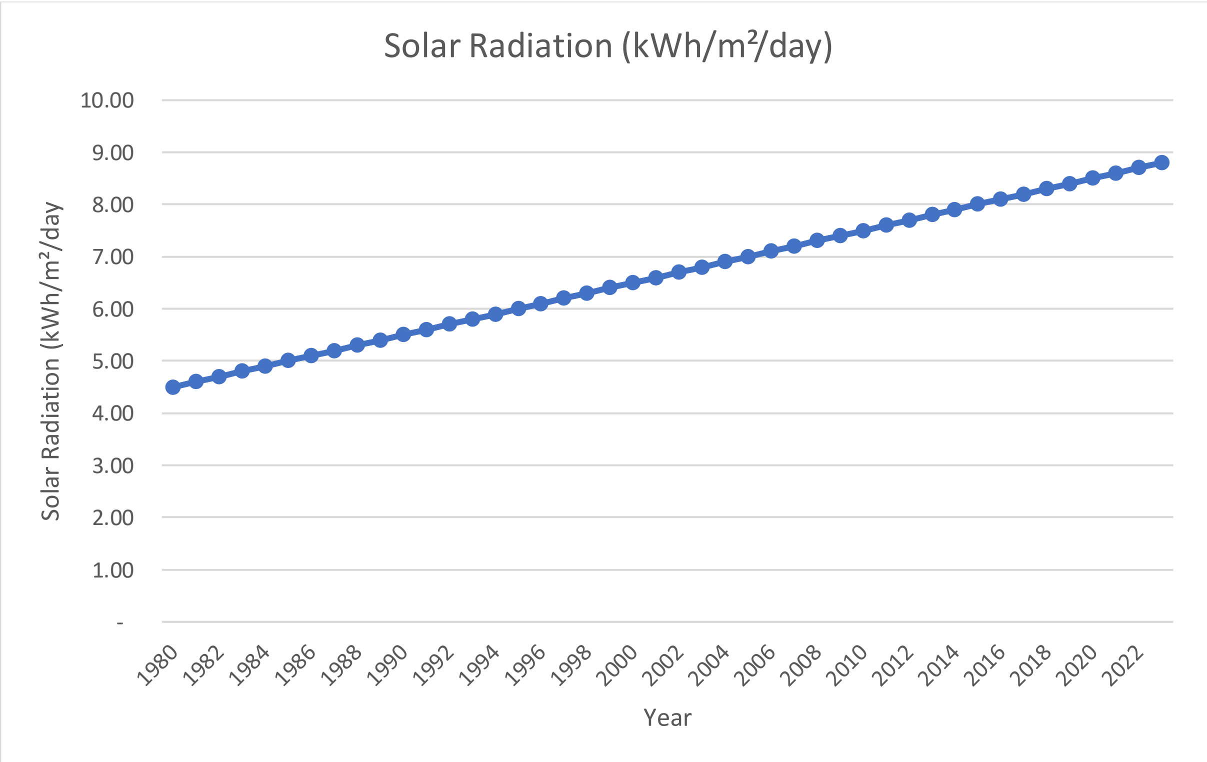

Figure 1.7 Trend in solar radiation in Nigeria between 1980 and 2023.

Labour Force showed a positive and statistically significant trend, with a β_1 coefficient of 0.2599*** and an R^2 of 0.5861, meaning that 58.61% of the variation in the agricultural labour force is explained by time. The F-ratio of 59.46 supports the statistical soundness of the model. This trend reflects a growing labour pool in cassava farming, likely driven by rural population growth and limited off-farm employment opportunities. However, the corresponding drop in yield suggests that labour productivity has not increased proportionally. This calls to question the quality, training, and efficiency of labour utilized. Ismaila *et al.* (2010) emphasize that while labor availability is high in rural Nigeria, its productivity remains constrained by outdated tools, limited training, and a lack of mechanization. Addressing this issue requires not only capacity-building programs but also investments in labor-saving technologies that can improve efficiency and reduce drudgery.

Graphical presentation of trends of the Labour force in Nigeria from 1980 - 2023.

The trend in the Labour force in Nigeria between 1980 and 2023 is shown in Figure 1.8

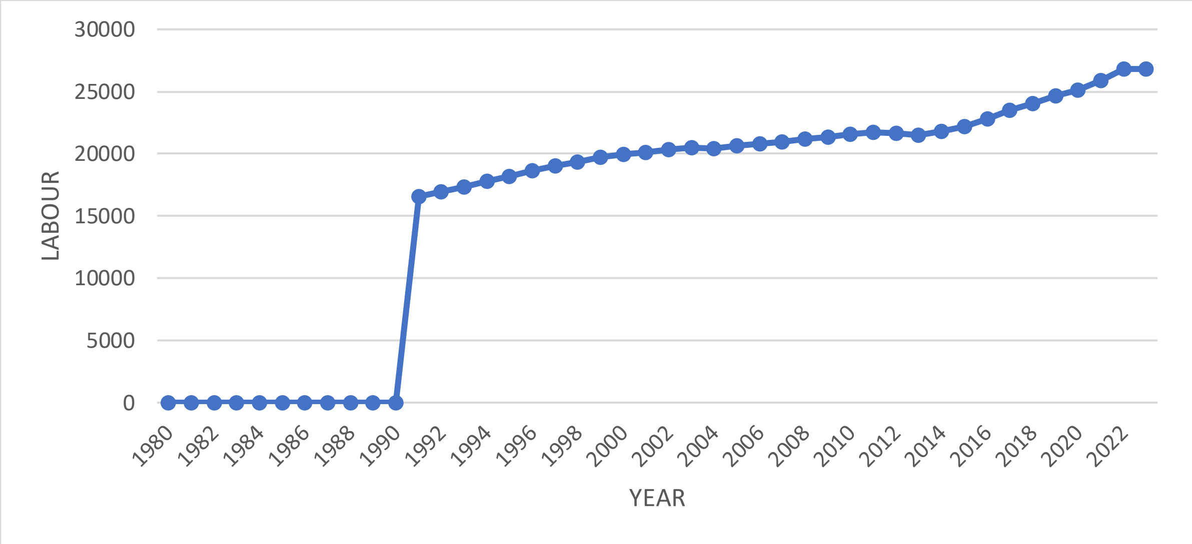

Figure 1.8 Trend in the Labour force in Nigeria between 1980 and 2023.

Table 2: Multivariate Regression Results for effect of climate variables on Cassava Yield in Nigeria (1980–2023)

Variable	Coefficient (β)	Std. Error	t-Statistic	p-Value
Intercept	2.315	1.024	2.26**	0.029
Rainfall	0.0058	0.0021	2.76***	0.008
Temperature	-0.0134	0.0072	-1.86*	0.067
Relative Humidity	0.0021	0.0010	2.10**	0.041
Fertilizer Usage	0.0875	0.0346	2.53**	0.014
Area of Land	0.0453	0.0081	5.59***	0.000
Solar Radiation	0.0219	0.0097	2.26**	0.029
Labour Force	0.1126	0.0435	2.59**	0.012
R^2	0.812			
Adjusted R^2	0.794			
F-statistic	45.36			<0.001
Durbin-Watson	1.92			

Source: Computed from time-series data, 1980-2023. Note: *** Significant at 1%, ** Significant at 5%,*significant at 10%

The multivariate regression results indicate that both climatic variables and farm inputs significantly influence cassava yield in Nigeria over the period 1980–2023. The model as a whole is robust, explaining 81.2% of the variation in cassava yield ($R^2 = 0.812$) with an adjusted R^2 of 0.794. The F-statistic of 45.36 ($p < 0.001$) confirms overall model significance, while the Durbin-Watson statistic of 1.92 indicates minimal autocorrelation in the residuals, supporting the reliability of the estimates. The multivariate regression results show that rainfall has a positive coefficient of 0.0058, significant at the 1% level ($p = 0.008$), indicating that higher rainfall is associated with increased cassava yield. This finding aligns with Ebele and Emodi (2016), who noted that rainfall is a key determinant of agricultural productivity in Nigeria, as adequate moisture supports crop growth and tuber development. Relative humidity also has a positive effect ($\beta = 0.0021$, $p = 0.041$, significant at 5%), suggesting that increased humidity contributes to higher cassava yields. This supports Ebele and Emodi's (2016) observation that favorable moisture conditions, including humidity, are critical for crop performance, especially in tropical climates where cassava is grown. Temperature shows a negative effect on cassava yield ($\beta = -0.0134$, $p = 0.067$, marginally significant at 10%), indicating that higher temperatures may slightly reduce productivity. This is consistent with Dioha and Emodi (2018), who highlighted that rising temperatures under climate change can stress crops and reduce their efficiency, emphasizing the vulnerability of staple crops like cassava to warming conditions. Fertilizer usage positively influences cassava yield ($\beta = 0.0875$, $p = 0.014$, significant at 5%), suggesting that increased fertilizer application enhances production. This finding aligns with Dixon and Ssemakula (2008) and Dixon et al. (2010), who emphasized that appropriate nutrient management, including fertilizer application, is essential for improving cassava productivity in Sub-Saharan Africa. The area of land cultivated has a strong positive effect ($\beta = 0.0453$, $p < 0.001$, significant at 1%), indicating that expanding land for cassava cultivation directly increases output. This observation supports Dixon and Ssemakula (2008), who highlighted that adequate land allocation is crucial for achieving higher yields, particularly in regions where cassava is a staple crop. Solar radiation also positively affects yield ($\beta = 0.0219$, $p = 0.029$, significant at 5%), reflecting the importance of sunlight for photosynthesis and biomass accumulation. This finding is consistent with Dixon et al. (2010), who noted that adequate light exposure is essential for tuber growth in improved cassava varieties. Finally, the labor force has a positive and significant effect on cassava yield ($\beta = 0.1126$, $p = 0.012$, significant at 5%), indicating that greater labor input enhances productivity. This agrees with Dixon and Ssemakula (2008), who stressed that sufficient labor is critical for executing proper agronomic practices and ensuring high yields.

RECOMMENDATIONS

1. Implement climate-smart agricultural strategies such as efficient irrigation, water conservation, and soil moisture retention techniques to cushion against rainfall variability and drought conditions.

2. Promote the development and dissemination of drought-tolerant, heat-resistant, and disease-resistant cassava varieties responsive to shifting climatic conditions.

3. Enhance fertilizer access through effective subsidy reforms and farmer education initiatives to ensure efficient nutrient application.

4. Advocate for sustainable intensification by transitioning from expansive land-use practices to intensive farming methods using mechanization and precision agriculture.

5. Invest in labour efficiency programs through training in modern farming techniques and labour-saving technologies aimed at increasing productivity.

6. Strengthen integrated pest and disease management measures by developing better post-harvest standards and innovations that mitigate losses from fluctuating humidity and disease incidents.

7. Support ongoing research efforts to further understand climate impacts, farmer behaviour, and adaptation technologies, coupled with policies that prioritize sustainable cassava production in Nigeria.

REFERENCES

1. Adejuwon, S.A. (2004). Impacts of Climate Variability and Climate Change on Crop Yield in Nigeria. Lead Paper Presented to the Stakeholders. Workshop on Assessment of Impacts and Adaptation to Climate Change, Conference Center, Obafemi Awolowo University, Ile-Ife, 20-21 September 2004.
2. Adofu I., Abula M., and Audu S.I. (2010). An assessment of the effects of interest rate deregulation in enhancing agricultural productivity in Nigeria. Current Research Journal of Economic Theory 2(2): 82-86,

3. Agba, D. Z., Adewara, S. O., Adama, J. I., Adzer, K. T., Atoyebi, G. O. (2017). Analysis of the Effects of Climate Change on Crop Output in Nigeria. American Journal of Climate Change. 6, 554 – 571. DOI: 10.4236/ajcc.. 2017.63028
4. Ajayi, JO (2014). Comparative Economic Study of Mixed and Sole Cassava Cropping Systems in Nigeria. J. Agris online Papers in Economics and Informatics, 6 (4): 15-23
5. Ajetombi, J. and A. Abiodun (2010). Climate Change Impacts on Cowpea Productivity in Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 10(1): 2258-2271.
6. Akande, A. et al., (2017). Geospatial Analysis of Extreme Weather Events in Nigeria (1985–2015) Using Self-Organizing Maps. Advances in Meteorology. https://doi.org/10.1155/2017/8576150
7. Akanmu, Adejare & Johnson (2016). How effective is the Nigerian senior school agricultural science curriculum? A survey of Evidence from content development to product. European Scientific Journal February 2016 edition, 2, No.4
8. Akinniran, T. N., Ezekiel, A. A., Ganiyu, M.O., and Adeyemo, S. A. (2013). Effect of Rainfall Variability on Crop Production in Oyo State, Nigeria (1990 - 2009). International Journal of Scientific and Engineering Research, 4 (9), 1737 – 1745.
9. Akomolafe, K. J., Awoyemi, O. B and Babatunde, A. (2018). Climate Change and Its Effects on Agricultural Outputs in Nigeria. Asian Journal of Agricultural Extension, Economics and Sociology, 25 (2), 1 – 11.
10. Alehile, K.S. (2023). Climate Change Effects on Employment in Nigeria's Agricultural Sector. Chinese Journal of Urban and Environmental Studies Vol. 11, No. 3, 1-24.
11. Allem, A.C. (2002), "The origins and taxonomy of cassava", Chapter 1, in: Hillocks, R.J., J.M. Thresh and A.C. Bellotti (eds.), Cassava: Biology, Production and Utilization, CABI, Wallingford, United Kingdom, 1-16, http://ciatlibrary. ciat.cgiar.org/Articulos_Ciat/cabi_04ch1.pdf.
12. Alves, A. A. C., & Setter, T. L. (2016). Response of cassava to water deficit: from the whole plant to the cellular level. Field Crops Research, 186, 24-34.
13. Alves, A. A. C., & Setter, T. L. (2016). Response of cassava to water deficit: from the whole plant to the cellular level. Field Crops Research, 186, 24-34.
14. Amanchukwu, R. N. et al. (2015). Climate change education in Nigeria: The role of curriculum review. Education, 5(3): 71 - 79.
15. Anabaraonye, B., (2019). Educating farmers and fishermen in rural areas in Nigeria on climate change mitigation and adaptation for global sustainability. International Journal of Scientific & Engineering Research, 10(4), 1391-1398.
16. Asare, P. A., Osei, E. K., & Agyarko, K. (2017). Effect of planting methods and nitrogen fertilizer on yield and yield components of cassava (Manihot esculenta Crantz) in the semi-deciduous forest zone of Ghana. Soil Use and Management, 33(1), 131-139.
17. BBC News (2023). Nigeria floods: 'Overwhelming' disaster leaves more than 600 people dead. Retrieved (16-10-2023) from https://www.bbc.com/news/world-africa-63280518
18. Bentley, J., A. Olanrewaju, T. Madu, O. Olaosebikan, T. Abdoulaye, T. Wossen, V. Manyong, et al. 2017. Cassava farmers' preferences for varieties and seed dissemination system in Nigeria: gender and regional perspectives. IITA Monograph, Ibadan: IITA Monograph 90p. https://cgspace.cgiar.org/handle/10568/80554?show=full
19. Biratu, G.K. (2018). Integrated soil fertility management options to improve cassava (manihot esculenta Crantz) productivity in Zambia, in: Center for Environmental Science, Addis Ababa University, Addis Ababa, Ethiopia, 2018.
20. BlueSense (2023). Cassava production in Nigeria. Retrieved (31-09-2023) from https://www.linkedin.c om/pulse/nigeria-biggest-cassava-producer-world-why-isnt-cashing-global
21. BNRCC (2011). National adaptation strategy and plan of action on climate change for Nigeria (NASPA-CCN). Prepared for the Federal Ministry of Environment Special Climate Change Unit.
22. Butu, H., M., Okeke, C., U., and Okereke, C. (2023). Climate Change Adaptation in Nigeria: Strategies, Initiatives, and Practices. Working Paper No. 3. APRI: Berlin, Germany.
23. Chikezie, C. Ibekwe, U. C., Ohajianya, D. O., Orebiyi, J. S., Ehirim, N. C., Henri-Ukoha, A., Nwaiwu, I. U. O., Ajah, E. A., Essien, U. A., Anthony, G and Oshaji, I. O. (2015). Effect of Climate Change on Food Crop Production in Southeast Nigeria: A Co-integration Model Approach. International Journal of Weather, Climate Change and Conservation Research, 2 (1), 47 – 56.

24. Chikowo, R., Mapfumo, P., Nyamugafata, P., & Giller, K. E. (2016). Maize yield response to conservation agriculture practices and nitrogen fertilizer in Southern Africa. Field Crops Research, 198, 173-181.
25. Chikowo, R., Mapfumo, P., Nyamugafata, P., & Giller, K. E. (2016). Maize yield response to conservation agriculture practices and nitrogen fertilizer in Southern Africa. Field Crops Research, 198, 173-181.
26. Chikowo, R., Mapfumo, P., Nyamugafata, P., & Giller, K. E. (2016). Maize yield response to conservation agriculture practices and nitrogen fertilizer in Southern Africa. Field Crops Research, 198, 173-181.
27. Dioha, M. O. and Emodi, N. V. (2018). Energy-climate dilemma in Nigeria: Options for the future. IAEE Energy Forum.
28. Dixon A. G. O. and Ssemakula G. (2008). Prospects for cassava breeding in Sub-Saharan Africa in the next decade. Journal of Food, Agriculture & Environment Vol.6 (3&4)
29. Dixon, R. U., et al. (2010). Improved Cassava Variety Handbook. Ibadan, Nigeria: International Institute of Tropical Agriculture
30. Ebele, N. E. and Emodi, N. V. (2016). Climate change and its impact on the Nigerian economy. Journal of Scientific Research & Reports, 10(6), 1-13. http://www.journaljsrr.com/index.php/JSRR/article/view/21917/40737