Discovery Agriculture

To Cite:
Alexander CB. The Impact of Rainfall on Maize Production in Nigeria: A 20 Year Empirical Analysis (2005–2024). *Discovery Agriculture* 2026; 12: e17da3193
doi: https://doi.org/10.54905/disssi.v12i25.e17da3193

Author Affiliation:
[1]School of Environmental Sciences, Captain Elechi Amadi Polytechnic Rumuola, Port Harcourt, Nigeria

***Corresponding author:**
Chinago Budnukaeku Alexander,
School of Environmental Sciences, Captain Elechi Amadi Polytechnic Rumuola, Port Harcourt, Nigeria. Email: chinago.alexander@portharcourtpoly.edu.ng;
ORCID: https;//orcid.org/0000-0002-6724-2878

Peer-Review History
Received: 24 November 2025
Reviewed & Revised: 16/December/2025 to 18/May/2026
Accepted: 30 May 2026
Published: 12 June 2026

Peer-Review Model
External peer-review was done through double-blind method.

Discovery Agriculture
pISSN 2347-3819; eISSN 2347-386X

© The Author(s) 2026. Open Access. This article is licensed under a Creative Commons Attribution License 4.0 (CC BY 4.0)., which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. To view a copy of this license, visit http://creativecommons.org/licenses/by/4.0/.

The Impact of Rainfall on Maize Production in Nigeria: A 20 Year Empirical Analysis (2005–2024)

Chinago Budnukaeku Alexander[1] *

ABSTRACT

This study examines the impact of annual rainfall patterns on Nigerian maize (Zea mays) production over a twenty year period (2005–2024). It examines how changes in weather patterns and extreme climatic events like droughts and floods impact on maize production over Nigeria, using historical climate data sourced from the World Bank Climate Change Knowledge Portal and production statistics from FAOSTAT and USDA-FAS. Recent research shows that maize grows better where rainfall is moderate or adequate; however, extreme events such as droughts and floods are inimical to maize yield and productivity. Adverse climatic conditions impacts negatively on national maize output. The findings among other things revealed a positive significant correlation between optimal rainfall distribution and maize yield; similarly extreme climatic fluctuations pose substantial risks and challenges to maize yield and national food security. This study shows that 2011 and 2015 stands out as notable drought years that negatively impacted maize production growth in Nigeria, while 2019 and 2024 recorded excessive rainfall resulting to localized flood, damaging of maize and other crops which triggers low maize production. The study also observed that factors, such as area expansion, improved cultivars and technological knowhow improves the crop cultivation, however, rainfall stands out as the primary exogenous determinant of annual productivity. The work recommended the adaptation of climate-smart agricultural practices, which includes drought-resistant seed varieties and improved drainage systems, to migrate the impacts of climate change.

Keywords: Adaptation Strategies, Climate Change, Drought, Flood, Food Security, Maize Production, Nigeria Agriculture, Rainfall Variability, Smallholder Farmers.

1. INTRODUCTION

Maize (*Zea mays*) is a local staple food crop eaten in all parts of Nigeria. It is referred to locally as corn; it is one of the most dependable cereal crops in Nigerian agricultural sector. Its importance is beyond mere subsistence. It employs a reasonable number of the population and it is a key agricultural export product for the country. In fact it is a key crop for national food productivity and security, besides it is a primary energy source in human nutrition, and provides essential raw materials for the livestock, employment and industrial sectors (IITA, 2023). Due to maize importance in Nigeria, there has been progressive increase in its output for

over six decades. There has been a remarkable shift in the history of maize production over the years. It has evolved from a localized and subsistence backyard crop in the southern Mangrove/Freshwater vegetation and the Rainforests to a major commercial commodity predominantly cultivated in the Guinea savanna and the Sudan savannas in the north part of the country (1AR, 2022). Maize as a crop plays vital role in the production of many consumables, such as cereals, oil for cooking, animal feeds, sweeteners, dairy products and is also use as medication for mumps. It also serves as local delicacies in different part of West Africa. Maize is the most consumed staple food in Nigeria, it also account for about 5% of Nigeria Gross Domestic Product (GDP), (2025).

As documented in research articles and bulletins, Nigeria is Africa's largest maize producer, and the 13th largest producer in the world, with a consistent annual output of over 12 million metric tons, this indicates a remarkable production growth of nearly 1000% increase since the early 1960s according to (Wossen et al., 2023; PwC Nigeria, 2021). It is important to note that about 90% of maize productions in Nigeria are carried out by smallholder farmers who depend entirely on the vagaries of nature (rain-fed) and are faced with challenges such as seasonal variability in the onset and cessation, duration, intensity, frequency and distribution of rainfall (Adeagbo et al., 2023).

Climate and its elements such as temperature, relative humidity, wind and rainfall are very crucial in agriculture in the tropical region, especially in Nigeria. Rainfall is water droplet from the atmosphere down to the earth surface. It is the commonest type of precipitation in the tropical countries of the world. The importance of rainfall in agriculture is most spectacular in the tropics, because the temperature is always high, except for few mountains like the Kilimanjero. The usual high temperature of the tropics triggers high evapotranspiration which results to loose of water from the soil and the plants. The agriculture calendar of the tropic is determined by rainfall, any shift from the target is a serious challenge to crop productivity and yield. Maize for one is very sensitive to rainfall and water (Alexander, 2015b; Alexander et al., 2015).

Despite this impressive increase in maize production in Nigerian, the fact that the country's agricultural system is dependable on the vagaries of nature makes it vulnerable. The overwhelming dependence on climate and rain-fed practices makes maize production a gamble to vagaries of nature (Alexander, 2015a). The dependability on the dictates of climatic elements makes the sector highly sensitive to climate change and inter-annual rainfall variability. Hence, Nigeria agriculture and the entire sector are vulnerable and at mercy of blind chance. Nigeria weather is not static; it varies over time and space, the variation affect vegetation and its related activities like agriculture and soils. The variability results to distinct vegetation belts across the country, for instance in the south are the Mangrove, Freshwater, and Rainforest vegetation, while in the north, the Sudan savanna and Sahel savanna, between the south and the north we have the Guinea savanna (NiMet, 2024; Ologunorisa and Alexander, 2004, 2007; Alexander, 2025). Each of these vegetation belts has its unique impacts on maize cultivation, with rainfall being the most critical exogenous determinant of yield and productivity.

This study becomes necessary as a result of increasing frequencies and intensities of extreme climatic events in West Africa and its impact on maize production. While adequate rainfall is essential for optimal maize growth and production, it is important to note that insufficient rainfall (droughts) and excessive rainfall (flood) can lead to catastrophic yield losses. Droughts during the critical tasseling and silking stages (the reproductive stage of corn where silk strands emerge to receive pollen) can result to near-total crop failure. At the same time excessive rainfall in the other hand can lead to soil nutrient leaching, waterlogging, and an increased incidence of fungal diseases at any stage of maize life (Ajetomobi, 2016). Scholars has predicted that the global climate is gradually but constantly changing, a situation that can triggers further fluctuation in already unpredictable precipitation (rainfall) occurrence in Nigeria. So, understanding the relationship between rainfall distribution, intensity and frequency in one hand and maize yield and output in the other hand, becomes necessary for developing a resilient agricultural policy that can address yield and productivity issues in Nigeria and indeed the West African sub-region.

This study provides a comprehensive 20 year analysis (2005–2024) of the relationship between rainfall and maize production, aiming to offer data-driven insights into the climatic risks facing Nigerian maize farmers and West Africa sub-region.

1.1. The Evolution of Maize Production in Nigeria

Maize as a crop in Nigeria has a rich history; however, its importance as a source of foreign exchange is marked by significant technological and geographical shifts. Some decades ago, maize played secondary role to traditional staples like sorghum and millet in the north and yams and cassavas in the south. However, the introduction of high-yielding, early-maturing, and disease-resistant maize varieties by research institutes (such as the International Institute of Tropical Agriculture (IITA) and the Institute for Agricultural Research (IAR)) catalyzed a "maize revolution" (Fakorede et al., 2003; IAR, 2022). Wossen et al. (2023) stated that between 1961 and 2020, the area cultivated and harvested for maize in Nigeria have increased by 450%, while the total production surged by 984%, indicating a shift toward more intensive cultivation practices in certain regions.

1.2. Rainfall Variability and Agricultural Productivity

Rainfall variability is widely acknowledged and accepted as the single most significant factor influencing crop yields in Sub-Saharan Africa. This is because in the tropics there is always high temperature, which triggers high rate of evaporation or evapotranspiration, this high demand of water determines the agriculture calendar in the tropics and in Nigeria in particular (Alexander, 2015a, 2015b).

In Nigeria, the movement of the Inter-Tropical Discontinuity (ITD) dictates the duration and intensity of the rainy season (Olanrewaju, 2021; Chinago, 2020; Ologunorisa and Alexander, 2004, 2007). Studies by Ujoh et al. (2024) in the Middle Belt region have shown that variability in rainfall characteristics, such as the date of onset, the number of rainy days, and the frequency of dry spells explains over 60% of the variance in annual maize yields. The "Maize belt" of the Guinea Savanna is particularly sensitive to these fluctuations and variability, to the extent that just a two-week delay in the onset of rains can significantly shortens the growing window, thereby forcing farmers to adopt shorter-duration varieties that may have lower yield potential.

1.3. Impact of Climatic Extremes: Droughts and Floods

Studies have shown that the impact of extreme rainfall events on maize is non-linear and often devastating. It has been observed that drought (prolonged period of moisture deficit) affects the physiological processes of maize plant, leading to reduced leaf area, stunted growth, and poor grain filling (Baffour-Ata et al., 2023). Similarly, the adverse effects of excessive rainfall (flooding) have historically been understudied but are equally important as it affects maize productivity. Budnukaeku and Emmanuel (2024) and Li et al. (2019) stated that excessive rainfall can reduce crop yields by as much as 30% through oxygen stress in the root zone and can physical destroy of crops.

In Nigeria, the devastating floods of 2012 and 2022 serve as stark reminders of how extreme precipitation which many people see or think as always a blessing; can wipeout years of production gains in a single season.

1.4. Adaptation and Resilience Strategies

In response to climatic challenges, Nigerian farmers have adopted various adaptation strategies to cope. These ranges from traditional methods such as mulching and crop diversification, to modern approach like drought-tolerant (DT) maize varieties. Adeagbo et al. (2021) stated that the adoption of these strategies is heavily influenced by socio-economic factors, which includes access to credit, extension services, and the level of formal education among farmers. Furthermore, recent discovery by Matthew et al. (2025) suggested that farmers who proactively adopt climate-smart adaptation strategies can achieve yields up to 57% higher than those who do not, highlighting the critical role of policy intervention in promoting resilience in maize output.

2. MATERIALS AND METHODS

2.1. Research Design

This study adopts a longitudinal, quantitative research design to examine the relationship between rainfall and maize production in Nigeria over a twenty year period (2005–2024). The approach allows for the identification of long term trends and the assessment of the impact of specific extreme climatic events on maize output.

2.2. Data Sources and Collection

To ensure that a reliable, trusted and standard researchable data were used for the work, the study utilizes data from globally recognized repositories and agencies:

- *Climatic Data*: Annual precipitation data (measured in millimeters) were extracted from the Nigerian Meteorological Agency (NiMet) and World Bank Climate Change Knowledge Portal (CCKP). The dataset used is the CRUTS 4.09 (Climatic Research Unit Time-Series), which provides high-resolution, gridded historical climate data aggregated at the national level for Nigeria (World Bank, 2024).
- *Agricultural Production Data*: National maize production figures (measured in Metric Tons) were sourced from the Nigerian Bureau of Statistics (NBS) and Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) and supplemented with reports from the United States Department of Agriculture Foreign Agricultural Service (USDA-FAS) PSD. Online database (FAOSTAT, 2024; USDA-FAS, 2024)

- *Geospatial Information*: Information regarding maize producing States and ecological or vegetation zones were extracted from recent peer-reviewed geospatial studies and reports from the Nigerian Meteorological Agency (NiMet) and the Federal Ministry of Agriculture and Rural Development (FMARD), Nigeria.

2.3. Data Analysis Techniques

The collected data were processed and analyzed using a multi-step framework:

- Descriptive Statistics: Mean, standard deviation, and coefficient of variation were calculated for both rainfall and production to assess the degree of inter- annual variability.
- Extreme Event Identification: Extreme rainfall years were identified using a percentile-based approach. A "Drought Year" was defined as any year where annual rainfall fell below the 10th percentile of the 20-year series, while a "Flood Year" was defined as any year exceeding the 90th percentile.
- Correlation Analysis: Pearson's correlation coefficient was employed to determine the strength and direction of the relationship between annual rainfall and maize output.
- Visualization: Time-series plots and scatter diagrams were created using Python's Matplotlib and Seaborn libraries to provide clear and intuitive visualizations of trends and correlations.

3. RESULTS & DISCUSSION

3.1. Maize Producing Areas and Ecological Zones in Nigeria

Maize is cultivated in almost all the ecological zones of Nigeria; however productivity varies greatly across the different ecological zones. Understanding these vegetation zones is critical for interpreting the impact of rainfall variability on maize output.

Table 1. Major Maize Producing Areas and Ecological Zones in Nigeria

Ecological Zone	Characteristics	Major Producing States	Production Role
Humid Rainforest	High rainfall (>2000mm), high humidity, short dry season.	Edo, Delta, Ondo, Ogun, Osun, Rivers.	Early season maize; high pest pressure.
Derived Savanna	Transition zone; rainfall 1300-1500mm.	Oyo, Kwara, parts of Kogi	Significant commercial production; two planting seasons.
Southern Guinea Savanna	Rainfall 1000-1300mm; distinct wet/dry seasons.	Benue, Niger, Nasarawa, Taraba	The "Maize Belt"; high yield potential.
Northern Guinea Savanna	Rainfall 900-1000mm; shorter wet season.	Kaduna, Katsina, Kano, Bauchi	Largest commercial output; high solar radiation.
Sudan/Sahel Savanna	Low rainfall (<800mm); high drought risk.	Gombe, Borno, Sokoto, Jigawa	Increasing production due to early-maturing varieties.

Source: Synthesized from IITA (2023) and NiMet, (2024).

The Guinea Savanna accounts for over 60% of Nigeria maize production. The vegetation belt is located between the rainforest of the South and the Sudan Savanna of the North. This region benefits from the movement of Inter Tropical Discontinuity (ITD), moderate rainfall and solar radiation, optimal for maize's physiological development (Zhang et al., 2022). However, this area is prone to erratic and unreliable rainfall onset/cessation and mid-season dry spells, which are inimical to maize production and national food security at

large. The Sudan/Sahel Savanna has low rainfall and a high risk of drought. States like Gombe, Jigawa, Sokoto, and Borno are having more production due to early maturing seeds.

3.2. Analysis of Production and Rainfall Trends (2005–2024)

This 20 year empirical data reveals a progressive growth in maize production output over the years; however, climatic instability occasionally affects not just the yield but also the crop output. National maize production in Nigeria grew from approximately 7.0 million MT in 2005 to a peak of 12.75 million MT in 2022, a 5.75 million MT increase. This represents an 82% increase over two decades. However, this growth has not been linear. Significant dips (unexpected maize output base on extremes in rainfall) in production were observed in years corresponding to rainfall anomalies (when observed rainfall is far away from the region mean rainfall).

The Guinea Savanna regions are made up of the Derived Savanna, the Southern Savanna and the Northern Savanna. The Guinea Savanna ecological zone sits between the southern rainforests and the northern Sudan savanna. The location offers moderate rain and sunlight that maize requires to grow well. The Mangrove and the Forest ecological zones of the south produce early maize. But most often rainstorm and pest reduces the output within the zone.

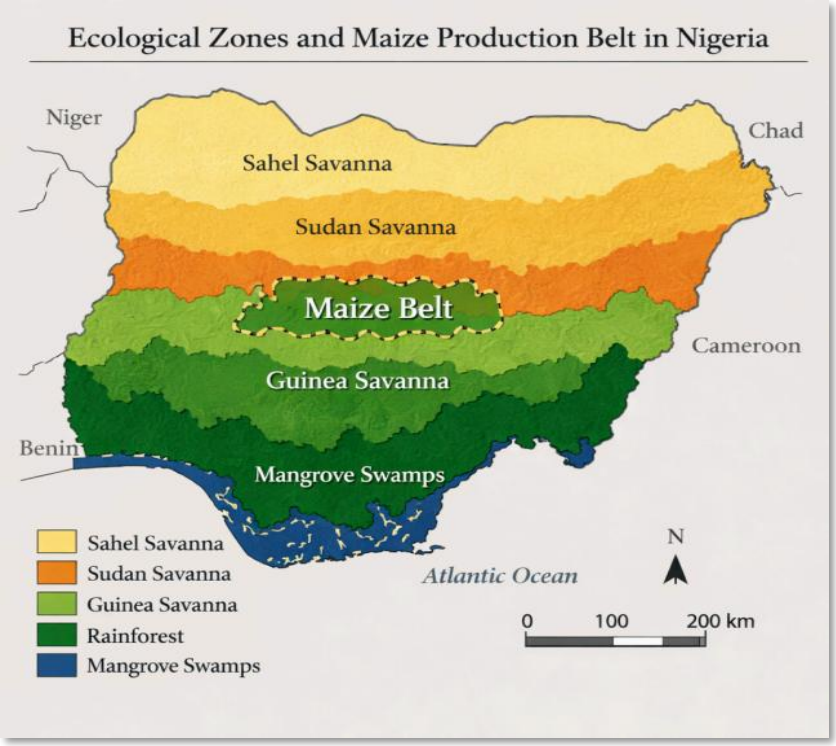

Figure 1. Ecological Zones and Maize Production Belt in Nigeria (Source: Google Map)

3.3. The Impact of Drought: 2011 and 2015

The study identified 2011 and 2015 as critical drought years in Nigeria, in 2011, annual rainfall dropped to 1050.74 mm, and in 2015, it reached a 20-year low of 1032.60 mm. During drought periods, lack of moisture, especially during the vegetative and reproductive stages of the maize crop led to stunted growth and poor cob development. This has serious implications for Nigeria's overall food security. Remarkably, in 2015, despite an impressive expansion in the area under cultivation, the national maize output fall below the previous year, unequivocally highlighting that rainfall remains the primary constraint on maize yield. These findings strongly agreed with previous research, which noted that drought-induced yield losses in Nigeria are often exacerbated by the pervasive lack of irrigation infrastructure (Ajetomobi, 2016).

3.4. The Impact of Excessive Rainfall and Flooding: 2019 and 2024

The years 2019 and 2024 recorded 1296.63 mm and 1293.20 mm rainfall respectively, these amounts of rainfall are characterized as excessive rainfall. While high rainfall is often intuitively perceived as beneficial for agriculture, our data, however, suggested

otherwise, as shown in Figure 2. In 2019, heavy flooding in the Niger and Benue River basins destroyed thousands of hectares of maize farmland. Excessive moisture also leads to soil nitrogen leaching, which is particularly detrimental to maize, a crop with high nutrient requirements. The 2024 season similarly showed that while total production remained high, the yield per hectare in flood prone regions was significantly lower than in years with moderate, well-distributed rainfall. Figure 2 shows that both drought and flooding years recorded a noticeable fall in output compared to the previous year and the preceding year. It was also observed that drought has more drastic impact on maize productivity than flooding.

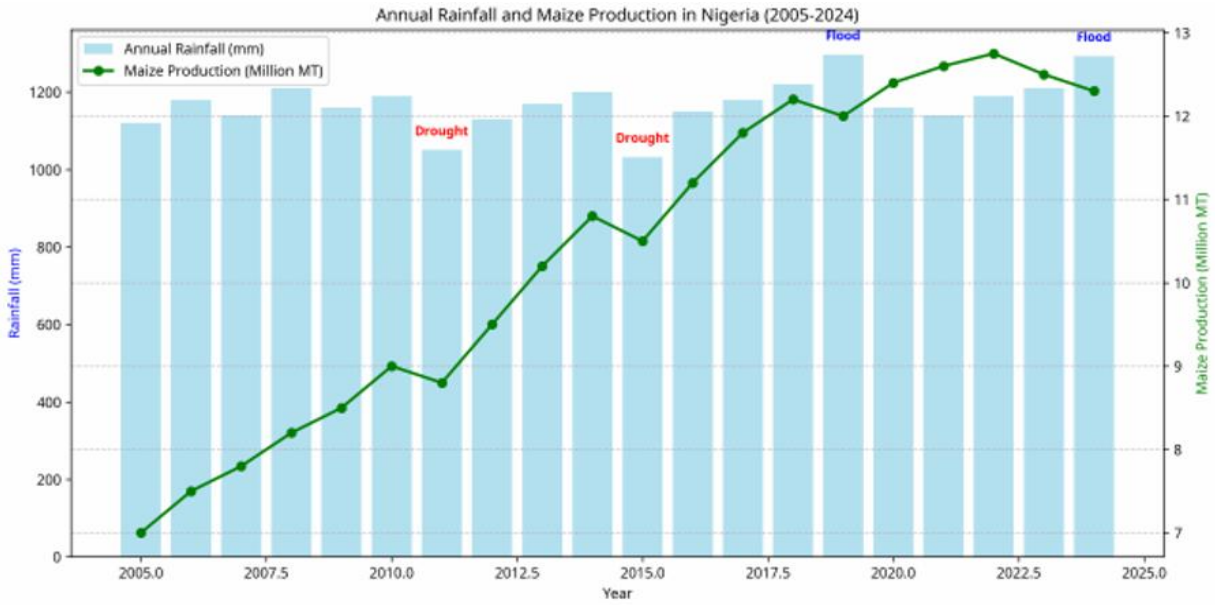

Figure 2. Annual Rainfall and Maize Production in Nigeria (2005-2024)

3.5. Correlation and Productivity Analysis

The correlation analysis for maize productivity and rainfall distribution over the study period show a positive but moderate coefficient, this implies that while rainfall is a significant determinant of output, other factors such as fertilizer application, seed quality, size of cultivated areas, and pest management (e.g., fall armyworm infestations) also play vital roles in determining the final output. The "Productivity Index" (Production per unit of Rainfall) has generally improved over the study period, an indication that Nigerian farmers are becoming more efficient in use of water resources, likely due to the adoption of improved cultivars and better agronomic practices

4. CONCLUSION & RECOMMENDATIONS

This 20 year empirical analysis (2005–2024) highlights the profound and complex impact of rainfall on maize production in Nigeria. The study shows that Nigeria has made significant stride in increasing its total maize output, becoming the leading maize producer in Africa; this growth however, dependent on favorable climatic conditions. The findings shows that extreme rainfall variability; such as droughts and floods are the primary exogenous driver of annual maize output fluctuations in Nigeria. The identification of extreme rainfall years such as the drought of 2011, 2015 and the flood of 2019, 2024, highlights the dual threat posed by climatic extremes. Droughts directly suppress yield through moisture stress during critical growth stages, while excessive rainfall leads to indirect losses through soil nutrient leaching, waterlogging, and physical crop destruction. Furthermore, the analysis of ecological zones shows that the "maize belt" in the Guinea Savanna region is vulnerable to extremes in rainfall, which has significant implications for national food security. Ultimately, the study concludes that the "maize revolution" in Nigeria will remain incomplete and fragile as long as the agricultural system remains predominantly rain-fed and lacks the necessary infrastructure to mitigate climatic shocks.

Recommendations

To enhance the resilience of the maize sector and transition toward a world-class agricultural system, the following recommendations are proposed:

1. Expansion of Irrigation Infrastructure: The Nigerian government and private sector must prioritize the development of small and large-scale irrigation systems, particularly in the Northern and Middle Belt regions. Decoupling maize production from total reliance on rainfall is essential for ensuring year-round productivity and stabilizing the national food supply.
2. Promotion of Climate-Smart Varieties: Agricultural research institutes should intensify the breeding and distribution of drought-tolerant (DT) and flood-resilient maize varieties. Strengthening the seed value chain to ensure that smallholder farmers have affordable access to these improved cultivars is a key to sustainable maize productivity.
3. Enhanced Weather Forecasting and Extension Services: There is an urgent need for more localized and accurate seasonal climate predictions. Agencies like NiMet should collaborate with agricultural extension services to provide farmers with timely information on planting dates and expected rainfall patterns, enabling them to make informed decisions.
4. Adoption of Soil Conservation and Drainage Management: Farmers should be encouraged to adopt agronomic practices such as mulching, zero-tillage, and the construction of proper drainage channels in flood-prone areas. These practices help in moisture retention during dry spells and prevent waterlogging during periods of excessive rain.
5. Implementation of Climate-Indexed Insurance: To protect smallholder farmers from the financial ruin caused by extreme climatic events, the government and United Nation Agencies should promote and subsidize climate-indexed insurance products. This would provide a safety net and cushion extra cost. This will encourage farmers to invest in higher yielding but more expensive inputs.

Acknowledgments

There is no acknowledgement to disclose.

Author Contributions

This manuscript has been read and approved by the author. The author believe that this manuscript represents honest work done by him.

Funding

This research did not receive any external funding like specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflict of interest

The author declares that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

Ethical approval

Not applicable. This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

Not applicable.

Data availability

All data associated with this study will be available based on the reasonable request to corresponding author.

REFERENCES

1. Adeagbo OA, Bamire AS, Akinola AA, Adeagbo AD, Oluwole TS, Ojedokun OA, Ojo TO, Kassem HS, & Emenike CU. The level of adoption of multiple climate change adaptation strategies: Evidence from smallholder maize farmers in Southwest Nigeria. Scientific African 2023; 22(2): e01971. doi: 10.1016/j.sciaf.2023.e01971
2. Adeagbo OA, Ojo TO, Adetoro A.A. Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. Heliyon, 2021; 7(2021). doi: 10.1016/j.heliyon.2021.e06231

3. Ajetomobi JO. Effects of weather extremes on crop yields in Nigeria. African Journal of Food, Agriculture, Nutrition and Development, 2016; 16(2), 10731- 10747.
4. Alexander CB, Bakpo MT, and Woke C. Temporal Variation of Rainfall Occurrence: The Effect on Tuber Crop Production in Niger Delta South- South, Nigeria, IOSR-Journal of Agriculture and Veterinary Science 2015; 8(4), 14-18.
5. Alexander CB. Climate Shift Observation in Nigeria: The General Impact on the Climatic Zones. Ournal of rogress in ngneering and hysical cience, 2025; 4(3), 53-59.
6. Alexander CB. Climatological Review of Enugu Rainfall from 1916–2012 and its implications. Global Journal of Science Frontier Research: 2015b; H 15(5), 1-10.
7. Alexander CB. Length of rainfall season and its implication over Enugu soutg-east Nigeria. Global J. Human-Social Sciences: B Georgraphy, Geo- Sciences, Environmental Science and Disaster Management. 2015a; 15(47 – 55).
8. Baffour-Ata F, Tabi JS, Sangber-Dey A, Etu-Mantey EE, & Asamoah DK. Effect of rainfall and temperature variability on maize yield in the Asante Akim North District, Ghana. Current Research in Environmental Sustainability 2023; 5 100222. doi: 10.1016/j.crsust.2023.100222
9. Budnukaeku AC, Emmanuel OS. Historical analysis of climate variability and agricultural production in Nigeria (1931-2020). Climate Change, 2024; 10:e8cc1039.
10. Chinago AB. Analysis of rainfall trend, fl uctuation and pattern over, Port Harcourt, Niger Delta coastal environment of Nigeria. Biodiversity Int.J., 2020; 4(1), 1-8.
11. Emmanuel MA, & Ujoh F. Effect of Variability in Rainfall Characteristics on Maize Yield in Gboko, Nigeria. JournaL of Ennvironmental Protection Science, 2024; 4, 881-887.
12. Fakorede MAB, Badu-Apraku B, Ouedraogo M, Carsky RJ, & Menkir A. (eds), Maize revolution in West and Central Africa. Proceedings of a Regional Maize Workshop, IITA., Ibadan, Nigeria 2003.
13. FAOSTAT. Food and Agriculture Organization Corporate Statistical Database: Nigeria Maize Production. (Online) Available at: https://www.fao.org/faostat/ 2024.
14. IAR. The Evolution of Cereal Production in Northern Nigeria. Institute for Agricultural Research, Ahmadu Bello University, Zaria 2022.
15. IITA. Maize Production in West Africa:Trends and Chalenges. International Institute of Tropical Agriculture, Ibadan, Nigeria 2023.
16. Li Y, Guan K, Schnitkey G, DeLucia EH, & Peng B. Rainfall leads to maize yield loss of a comparable magnitude to extreme drought in the United States. Global Change Biology, 2019; 25(7), 2325-2337. doi: 10.1111/gcb.14628
17. Matthew MD, Timothy E, Olorunshola EO. Adaptation Strategies to Climate Variability Among Maize Farmers in Oyo State, Nigeria. Journal of Agricultural Extension 2025; 29(3), 111-117
18. Nigeria Gross Domestic Product (GDP). Url: https://babbangona.com/maize-farming-in-nigeria-exciting-facts-you-should-know. Retrieve on 28 July, 2025.
19. NiMet. Seasonal Climate Prediction (SCP). Nigerian Meteorological Agency, Abuja 2024.
20. Olanrewaju S. Climate Change and Nigerian Agriculture. University of Ilorin Press 2021.
21. Ologunorisa ET & Chinago AB. Annual thunderstorm fluctuations and trends in Nigeria. Journal of Meteorology 2004; 29 (286), 39-44.
22. Ologunorisa ET. & Chinago AB. The diurnal variation of thunderstorm activity over Nigeria. International Journal of Meteorology 2007; 32 (315), 19-29.
23. PwC Nigeria. Positioning Nigeria as Africa's leader in maize production for AfCFTA. Price water house Coopers Nigeria Report 2021.
24. USDA-FAS. Production, Supply and Distribution (PSD)Online: Nigeria Corn 2024. Available at: https://apps.fas.usda.gov/psdonline/.
25. World Bank. Climate Change Knowledge Portal: Nigeria Historical Data. 2024. Available at: https://climateknowledgeportal.worldbank.org/.
26. Wossen T, Menkir A, Alene A, Abdoulaye T, Ajala S, Badu-Aparaku B, Gedil M, Mengesha W, & Meseka S. Drivers of transformation of the maize sector in Nigeria. Global Food Security, 2023; 38, 100713. doi: 10.1016/j.gfs.2023.100713
27. Zhang N, Qu Y, Song Z, Chen Y, Jiang J. Responses and sensitiveties of maize phenology to climate change from 1971 to 2020 in Henan Province, China. PLoS ONE 2022; 17(1): e0262289. doi: 10.1371/journal.pone.0262289