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# Rainfall and Temperature Trends in Ogbia Local Government Area Bayelsa State, Nigeria from 1993 To 2023

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**ABSTRACT:** The objective of this paper was to examine the rainfall and temperature trends in Ogbia Local Government Area (LGA) Bayelsa State, Nigeria from 1993 to 2023 by obtaining a 30-year dataset from the Nigerian Meteorological Agency (NiMet) using the SARIMA model, which combines seasonal and non-seasonal components to capture periodic variations effectively. The results revealed a significant increase in annual rainfall from 1993 to 2023, with an annual trend of +15.86 mm/year. Rainfall ranged from 2,252.9 mm in 2020 to 4,658 mm in 2021, with an average of 2,962.31 mm, showing notable interannual variability. July was the wettest month (473 mm), whereas December was the driest month (29 mm). Projections indicate annual rainfall will rise from 3,231.95 mm in 2025 to 3,628.49 mm by 2050, reflecting intensified rainfall patterns. Temperature analysis revealed a gradual warming trend, with an average of 31.66°C and extremes ranging from 30.88°C to 32.72°C. February is the hottest month (34.4°C), while May to July sees cooler temperatures due to rainfall. Projections suggest temperatures will rise to 33.4°C by 2050, with a statistically significant warming trend ($R^2 = 0.584$, $p < 0.001$). Temperature anomalies range from -2.0°C to +2.22°C, with moderate variability. The study urges climate adaptation through afforestation, urban planning, and climate-smart agriculture. Policymakers must prioritize renewable energy and public awareness to mitigate risks. Advanced research and stakeholder collaboration are essential to protect ecosystems, agriculture, and livelihoods.

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Agriculture remains a vital part of Nigeria's economy, with staple crops such as yam (*Dioscorea spp.*) and cassava *(Manihot esculenta)* playing crucial roles in ensuring food security and sustaining livelihoods, particularly in rural regions such as the Ogbia Local Government Area (LGA) of Bayelsa State. These crops are central to subsistence farming practices in Ogbia and contribute significantly to the local economy. However, the agricultural sector in this region is increasingly threatened by climate variability, particularly erratic rainfall patterns and rising temperatures, which harm crop yields and productivity. These climatic fluctuations have affected traditional farming practices, leading to food insecurity, economic instability, and reduced resilience in smallholder farmers. In response to the challenges posed by climate variability, there is a growing consensus on the need to promote Climate Smart Agriculture (CSA) practices in regions such as the Ogbia LGA. CSA offers agricultural practices that sustainably increase productivity and resilience to climate change while reducing or removing greenhouse gas emissions (Ali *et al.,* 2021). For yam and cassava farmers in Ogbia, CSA offers a pathway

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for adapting to the adverse effects of rainfall variability and temperature extremes. The importance of CSA lies in its ability to provide practical solutions to mitigate the effects of climate change on crop production while enhancing food security and livelihoods. CSA practices, such as introducing drought-tolerant yam and cassava varieties and improving water management techniques and agroforestry systems, can help farmers in Ogbia to adapt to changing rainfall patterns and rising temperatures (Adhikari *et al.* 2022). For instance, agroforestry, which integrates trees into crop systems, can improve soil fertility, reduce erosion, and enhance water retention, making farms more resilient to periods of drought or excessive rainfall (Ozor and Nnaji, 2019). Moreover, improved soil management practices, such as mulching and cover cropping, can protect soil from heavy rainfall, prevent waterlogging, and ensure better growth conditions for yams and cassava. Access to timely climate information is essential for farmers to make informed decisions regarding planting, harvesting, and water management. In the Ogbia LGA, where farming is rain-fed and highly vulnerable to unpredictable weather patterns, providing farmers with accurate and localized weather forecasts can help them adapt their practices to changing climatic conditions (Ukpe and Okoli, 2020). Climate information services can alert farmers to the onset of the rainy season, predict dry spells, and provide advice regarding the best time to plant or harvest crops. Integration of climate information services with extension programs can significantly improve the adaptive capacity of smallholder farmers in a region (Ali *et al.* 2021). Rural infrastructure, particularly irrigation systems, storage facilities, and transport networks, are crucial for improving agricultural resilience to climate change. In Ogbia, where farming practices remain largely traditional, the absence of irrigation systems forces farmers to rely entirely on natural rainfall, which makes them vulnerable to periods of drought or excessive rain. Investments in simple, affordable irrigation technologies could help farmers maintain stable production levels even during rainfall variability (Nwosu *et al.,* 2023). In addition, improved storage facilities can reduce post-harvest losses, particularly in the case of cassava, which is highly perishable. Smallholder farmers in the Ogbia LGA are highly vulnerable to the impacts of climate variability owing to their limited resources, access to credit, knowledge of adaptation strategies, limited access to climate information services, and better financing and policy support (Okoro *et al.,* 2020). Many farmers lack the financial capacity to invest in CSA technologies or to recover from crop failures caused by extreme weather events (Adhikari *et al.,* 2022). Addressing this socioeconomic vulnerability requires targeted policies that provide financial support such as microcredit schemes to enable farmers to invest in adaptive practices. Expanding access to agricultural extension services can equip farmers with the knowledge and skills to adopt CSA practices and improve their resilience to climate change (Ozor and Nnaji, 2019). Although numerous studies have been conducted on the impacts of climate change on agriculture in sub-Saharan Africa, the specific effects of recent rainfall and temperature trends on yam and cassava production in the Niger Delta, particularly in the Ogbia LGA, remain underexplored. Most existing research focuses on a broader regional or national scale without delving into localized assessments of climate impacts at the LGA level (Adhikari *et al.,* 2019; Adhikari *et al.,* 2022). This gap in localized research is significant because the Niger Delta has unique agroclimatic conditions, where farming relies heavily on seasonal rainfall and slight shifts in climate can result in substantial disruptions to the agricultural calendars, crop cycles, and overall productivity (Ukpe and Okoli, 2020). Additionally, there is limited research on the adaptive capacity of smallholder farmers in Ogbia to cope with climate change, particularly regarding their access to CSA technologies and resources. This lack of targeted research makes it difficult to develop and implement effective interventions to mitigate the impacts of climate change on yam and cassava farming in the region. The objective of this paper was to examine the rainfall and temperature trends in Ogbia Local Government Area (LGA) Bayelsa State, Nigeria from 1993 to 2023 by obtaining a 30-year dataset from the Nigerian Meteorological Agency (NiMet).

## MATERIALS AND METHODS

*The Study Area:* The study was conducted in the Ogbia local government area (LGA) of Bayelsa State, Nigeria. Bayelsa State is situated in the south-south geopolitical zone of Nigeria and is a prominent oil-producing region. Ogbia is located in the northeastern part of Bayelsa State, between latitudes 4°39' N and 5°02' N and longitudes 6°16' E and 6°35' E. bordered by other LGAs within Bayelsa State, including Nembe to the southeast and Yenagoa to the west. The area is characterized by low-lying, swampy terrain and a network of rivers and creeks. Ogbia LGA encompasses an area of approximately 695 square kilometers. According to the 2006 Nigerian census, the population was approximately 179,926 (NPC, 2006). Given this area and population, the population density was approximately 259 people per square kilometer. The region experiences two distinct seasons: wet and dry. The wet season commences in February–March and persists until October–November, whereas the dry season begins in November–December and continues until January–February. Ogbia LGA in Bayelsa State, situated in the Niger Delta, is characterized by tropical rainforest vegetation, including mangrove swamps, coastal rainforests, and freshwater swamps. These ecosystems support diverse plant species and wildlife, including fishes and birds. Mangroves are critical for coastal protection and the area's vegetation supports agriculture, forestry, and tourism. This vegetation is essential for the local economy and environmental stability as it mitigates erosion and flooding. Historically, the people of Ogbia are predominantly Christian, and their principal occupations include agriculture (cultivating crops such as cassava, yam, and plantains), fishing (both subsistence and commercial), and oil exploration. These sectors constitute the economic foundation of the area.

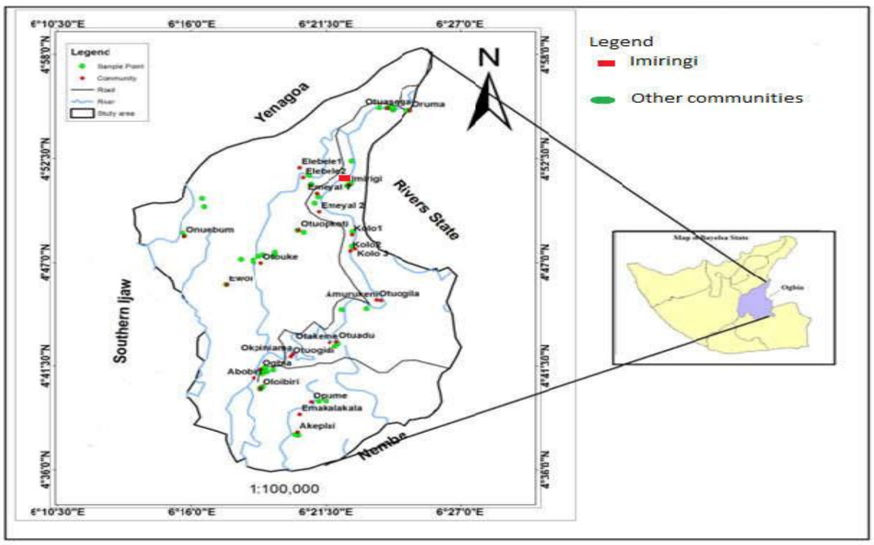


**Fig 1:** Map of Bayelsa Showing Ogbia, LGA Source: Anekwe, and Onoja (2020).

*Method:* Monthly temperature and rainfall data were collected from the Nigerian Meteorological Agency (NiMet) for the period 1993–2023, providing a 30-year dataset suitable for robust climatic analysis. The data were preprocessed using imputation methods such as linear interpolation, ensuring data continuity and reliability. The dataset was formatted and organized for analysis, with time series decomposition applied to separate the data into seasonal, trend, and residual components for enhanced clarity in pattern recognition. The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test was employed to determine the time series. A multiple linear regression model was used to estimate long-term trends in temperature and rainfall. The model treated time as the independent variable and temperature or rainfall as the dependent variable, expressed mathematically as:

$$Y(t) = \beta_0 + \beta_1 t + \mathcal{E}(t) \quad (1)$$

Where: Y(t) is the observed value of temperature or rainfall at time t; $\beta_0$ is the intercept, representing the baseline value of the dependent variable when t=0; $\beta_1$ is the slope coefficient, capturing the rate of change in the dependent variable (temperature or rainfall) over time. A positive $\beta_1$ indicates an increasing trend, while a negative $\beta_1$ reflects a decreasing trend; Ɛ(t) is the error term, accounting for unexplained variability in the dependent variable; Seasonal Autoregressive Integrated Moving Average (SARIMA) Model was employed for forecasting future temperature and rainfall trends. SARIMA is expressed as:

$$SARIMA\ (p,d,q)(P,D,Q)s \quad (2)$$

Where: p,d,q are the non-seasonal parameters: p: Order of the non-seasonal autoregressive (AR) terms.; d: Degree of non-seasonal differencing required to make the time series stationary; q: Order of the non-seasonal moving average (MA) terms; P,D,Q are the seasonal parameters: P: Order of the seasonal autoregressive (SAR) terms. D: Degree of seasonal differencing required to remove seasonal trends. Q: Order of the seasonal moving average (SMA) terms. S=The length of the seasonal cycle (e.g., s=12s = 12s=12 for monthly data, representing a yearly cycle).

Combination of seasonal and non-seasonal components to address regular and periodic variation

$$\Phi p(B^s)\, p(B)(1 - B)^d (1 - B^s)^D\, Yt = \theta_Q(B^s)\theta_q(B)\mathcal{E}t \quad (3)$$

Where: B: Backshift operator; Φp(B): Non-seasonal AR polynomial; $\Phi p(B^s)$: Seasonal AR polynomial; $p(B)$: Non-seasonal MA polynomial; $\theta_Q(B^s)$: Seasonal MA polynomial; $Yt$: Observed value at time ttt; $\mathcal{E}t$: White noise error term.

## RESULTS AND DISCUSSION

The dataset shows an overall increasing trend in annual rainfall from 1993 to 2023, with notable variability between years. The lowest rainfall occurred in 2020 (2,252.9 mm), while the highest was recorded in 2021 (4,658 mm), indicating significant interannual fluctuations. The historical average rainfall is approximately 2,962.3 mm, with recent years (2021–2023) exhibiting unusually high values, suggesting an intensification of rainfall events. Periods of relatively wet years, such as 1995, 1997, and 2021–2023, alternate with drier years, including 1998, 2001, and 2020.

From fig 2, annual rainfall shows an increasing trend (slope) of approximately 15.86 mm per year, with a historical average of 2,962.31 mm, a minimum of 2,252.90 mm in 2020, and a maximum of 4,658.00 mm in 2021. July is the wettest month (473 mm average, the trend line $R^2$ = 0.083, and P value of 0.1162 at 0.05), while December is the driest (29 mm average). The study reveals an increasing annual rainfall trend of 15.86 mm/year, with a historical average of 2,962.31 mm, highlighting significant interannual variability between 2020 (2,252.90 mm) and 2021 (4,658 mm).

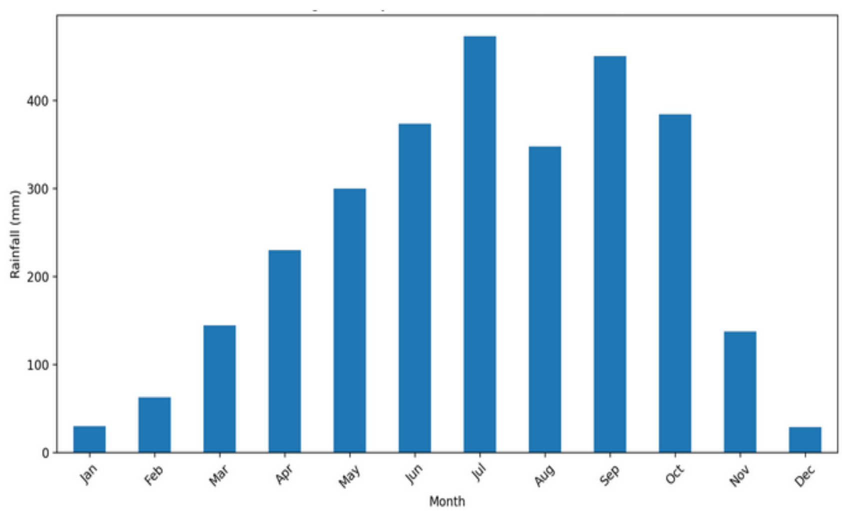


**Fig. 2**: Annual Rainfall distribution of Bayelsa from 1993 to 2023

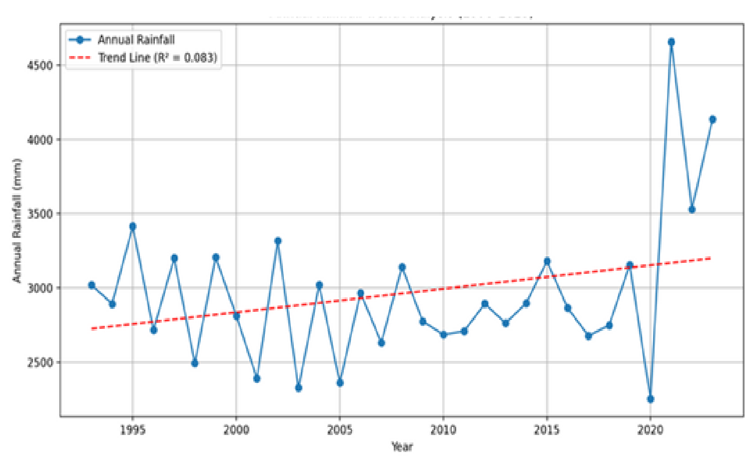


**Fig. 3:** Annual Rainfall Trend Analysis of Bayelsa from 1993 to 2023

This aligns with Agbonaye, and Izinyon (2021) findings, where rainfall variability ranged from an increase of 14.08 mm/decade in the driest decade (1976–1985) to 61 mm/decade in the wettest (1986–1995). The sharper trend in the study suggests an acceleration of rainfall increases in recent years, possibly linked to climate change and greenhouse gas effects. July, with an average of 473 mm, is the wettest month is consistent with Bayelsa's wet-season dominance, while December, with 29 mm, reflects the dry Harmattan period. The relatively low variability ($R^2$ = 0.083) indicates significant interannual differences. The result when compared to Southeast Nigeria, where annual rainfall averages 1,800–2,500 mm, the South-South shows more pronounced increases, surpassing Enugu's annual trend of 8–10 mm/year (Okoro *et al.*, 2022). Overall, the findings underscore regional coherence in increasing rainfall trends and the urgent need for adaptive strategies to mitigate climate change impacts. The findings indicate that the South-South region may be experiencing stronger climate-driven rainfall variability compared to Southeast Nigeria, likely due to its proximity to the Atlantic Ocean and associated climatic drivers.

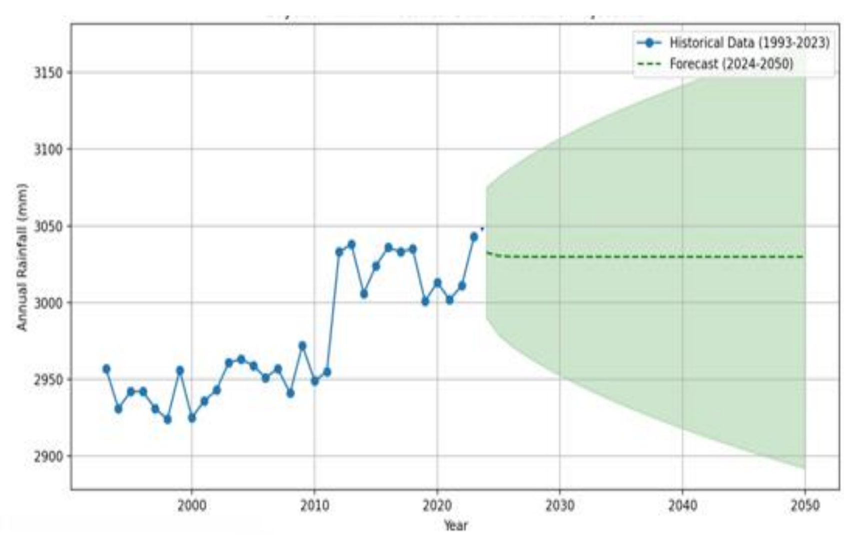


**Fig. 4:** Bayelsa Rainfall: Historical data an d Future projections from 2024 to 2050

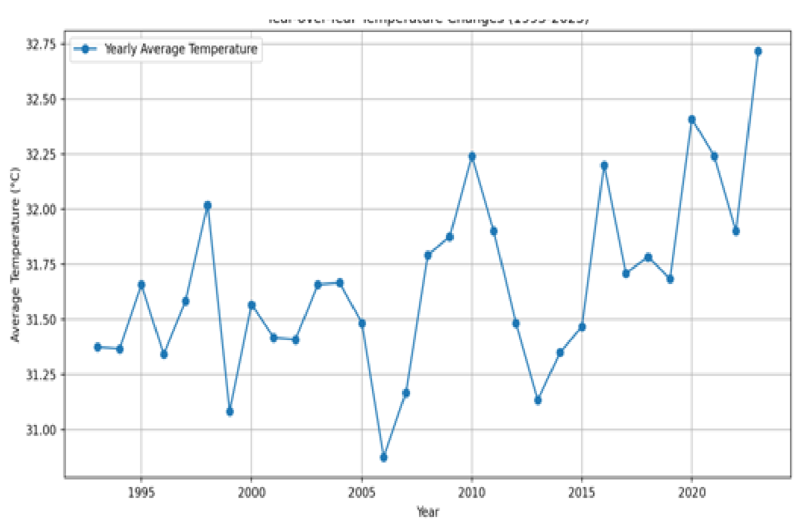


**Fig. 5:** Year over year temperature changes (1993 – 2023)

The projected rainfall data for Bayelsa indicates a steady increase in annual rainfall from 2025 to 2050, with values ranging from 3,231.95 mm in 2025 to 3,628.49 mm in 2050. This trend suggests a rise of nearly 400 mm over 25 years, reflecting the potential intensification of rainfall patterns due to climate change. The maximum projected rainfall is 3,032.64 mm, and the minimum is 3,029.82 mm, indicating a relatively narrow range of variability for individual years. These projections align with observed trends in the South-South region, where increasing rainfall is linked to enhanced monsoonal activity and ocean-atmosphere interactions.

The data reveals a slight warming trend in average temperatures from 1993 to 2023, suggesting a gradual increase in heat levels over time. February is consistently the hottest month, with an average temperature of 34.4°C, likely influenced by reduced cloud cover and intensified solar radiation during the dry season. Conversely, the cooler temperatures observed from May to July align with the peak rainy season, where increased cloud cover and rainfall reduce surface heating. The historical average temperature of 31.66°C reflects a generally warm climate typical of tropical regions like South-South Nigeria.

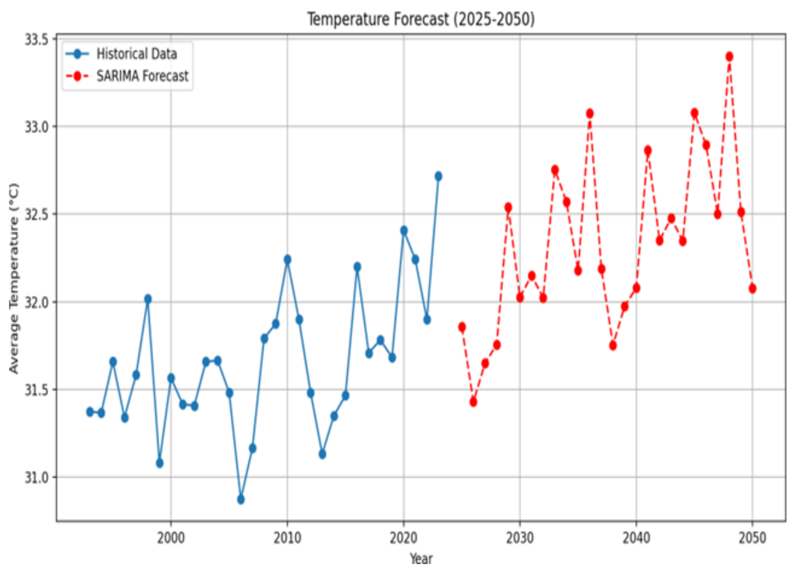


**Fig. 6:** Temperature Forecast 2025 – 2050

The analysis indicates a gradual warming trend in average temperatures from 1993 to 2023, with a historical mean of 31.66°C and relatively low variability (standard deviation of 0.41°C). Temperature extremes range from a lowest yearly average of 30.88°C to a highest of 32.72°C, demonstrating a stable yet slightly increasing trend. The SARIMA model projects temperatures to rise to approximately 33.4°C by 2050, equating to an average increase of about 0.02°C per year. The analysis reveals a statistically significant warming trend ($R^2 = 0.584$, $p < 0.001$) in average temperatures from 1993 to 2023, with 58.4% of the variability explained by the trend. These findings align with studies like Laura *et al.* (2024), highlighting the increase in climate variability impacts on coastal ecosystems. Similarly, Atuma *et al.* (2023) observed a significant upward trend in temperatures throughout the year in Bayelsa State. Their analysis revealed that the temperature variations in Bayelsa are statistically significant when compared to other states in the Niger Delta region. Ofordu *et al.* (2022) reported annual temperature increases of 0.01–0.02°C in urban areas such as Enugu in Southeast Nigeria, attributing these trends to urbanization and changes in land use.

The observed trends align with evidence of widespread warming driven by greenhouse gas emissions and localized heat island effects. However, the slightly faster rate of warming highlighted in this study indicates intensified climate change impacts in recent years, especially in the coastal and lowland areas of South-South Nigeria. The analysis reveals that the most significant warming occurs in February and January, with these months experiencing the highest temperature anomalies. The largest positive anomaly recorded is +2.22°C above the normal temperature, indicating a notable temperature increase during certain periods. On the other hand, the largest negative anomaly is -2.0°C below normal, highlighting periods of cooler temperatures. The standard deviation of anomalies is 0.65°C, suggesting moderate variability in temperature fluctuations around the mean. Agbonaye and Izinyon (2022) identified a significant rise in temperatures, particularly during the decade of 1986-1995, which saw an average temperature increase of 0.14856°C per decade. Similarly, Agu *et al.* (2020) documented a steady increase in temperatures across Southeast Nigeria, with temperature anomalies ranging from +1.5°C to +2.0°C in urban centers of Enugu.

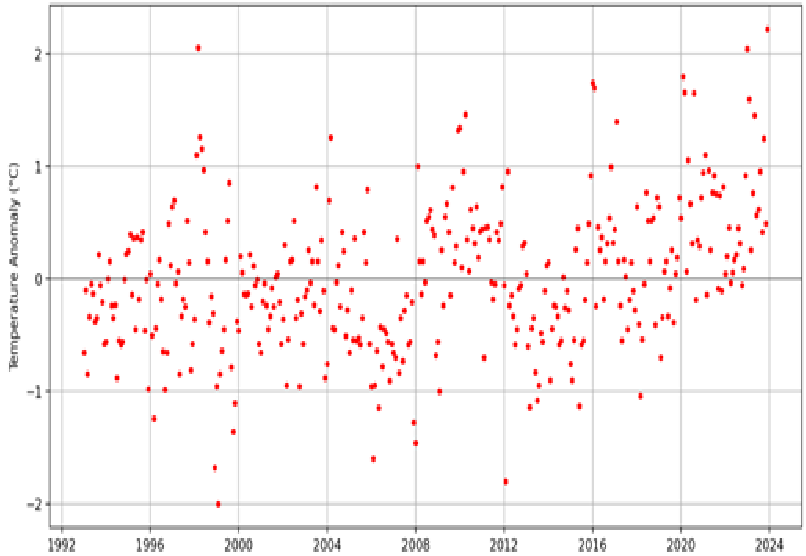


**Fig. 7:** Temperature Anomaly 1993 – 2023

*Conclusion:* The study underscores the pressing issue of climate change in South-South Nigeria, highlighting the region's vulnerability due to urbanization, land-use changes, and greenhouse gas emissions. The findings emphasize the urgent need for climate action, particularly in coastal and lowland areas. Policymakers should focus on implementing climate adaptation measures, such as afforestation, urban planning reforms, and the adoption of climate-smart agricultural practices to mitigate the effects of warming. Public awareness campaigns and investments in renewable energy are also essential in reducing emissions and building resilience. Future research should expand spatial and temporal coverage and employ advanced climate models to deepen understanding. Collaborative efforts among stakeholders will be crucial in addressing climate challenges and protecting ecosystems, agriculture, and human livelihoods in Nigeria.

*Declaration of Conflict of Interest:* The authors declare no conflict of interest

*Data Availability:* Data are available upon request from the first author or corresponding author or any of the other authors

## REFERENCE

Adhikari, U; Nejadhashemi, AP; Woznicki, SA (2022). Climate change and its impact on agricultural productivity in sub-Saharan Africa. *Agric. Systs***,** 177, 102-117.

Agbonaye, AI; Izinyon, OC (2021). Using Time-Series Analysis to Assess the Extent of Climate Variability and Climate Change in Bayelsa State, Nigeria. *J. Applied Sci. Enviro. Manage.***,** 25(10), 1807-1820.

Agu, CC; Amarachi, I; Tukur, K; Omede, H; Nwadike, BK (2020). An Assessment of Heatwave Impact in Enugu Metropolis of Enugu State, 04 September 2020, PREPRINT (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-36863/v1].

Ali, A; Mohammed, S; Iyamabo, AS (2021). Climate-smart agriculture in Nigeria: Lessons from case studies. *J. Agric. Food Security***,** 10(3), 215-227.

Anekwe, UL; Onoja, RA (2020). Assessment of Environmental Radioactivity Level and its Health Implication in Imiringi Community Bayelsa State, Nigeria. *J. Applied Sci. and Enviro. Manage.***,** 24(6), 1045-1050.

Atuma, IM; Efe, SI; Ndakara, OE (2023). Temperature trend in Niger Delta Region, Nigeria. *J. Manag. Social Sci. Research***,** 4(1), 29-39. doi: 10.47524/jmssr.v4i1.30.

NationalPopulationCommission(NPC)(2006).Nigeria NationalCensus.www.population.gov.ng/index.php/publication.

Nwosu, CN; Ibe, CO; Okoro, DO (2023). Smallholder farmers and climate change: Assessing the impacts on cassava and yam productivity in southern Nigeria**.** *Intern. J. Climate Resilience***,** 12(4), 98-112.

Ofordu, CS; Agbor, CF; Oseyomon, JA; Aigbokhan, M; Audu, ED; Adedoyin, OM; Ogoliegbune, M (2022). Urban Heat Island and Land Use/Cover Dynamics Evaluation in Enugu Urban, Nigeria. *J. Geosci. Env. Prot.***,** 10(12), 354-372. doi: 10.4236/gep.2022.1012020.

Okoro, EO; Omergie, AE; Nwankwagu, JO (2022). Temperature and Rainfall Trend in Agbani, Enugu State, Southeastern Nigeria. *J. Meteorol. Clim. Sci.* 21(1), 184-194.

Okoro, EO; Okwu, Delunzu, VU; Ofordu, SC (2020). Issues in Climate Smart Agriculture in Southeastern Nigeria. *Intern. J. Environ. Clim. Change***,** 10(9), 190-200. doi: 10.9734/IJECC/2020/V10I930240.

Ozor, N; Nnaji, CE (2019). Climate change and sustainable food production in Nigeria. *Afri. J. Agric. Res.* 14(12), 659-668.

Ukpe, IK; Okoli, UC (2020). Rainfall variability and its impact on yam production in the Niger Delta. *Nig. J. Agric. Econos.* 14(2), 143-152.