IJAAR PUBLISHING®

West African Journal of Interdisciplinary Research | ISSN: 3027-1878
Volume 3, Issue 1 (2025) | www.ijaar.org

ANALYSIS OF THE ANNUAL VARIATION OF TEMPERATURE AND RAINFALL OVER A SOLAR CYCLE IN BENUE STATE, NIGERIA

OGWUCHE EMMANUEL[1], IBUKUN AKINSOLA SAMSON[2]
[1]Department of Science Laboratory Technology, NACEST Makurdi
[2]Department of Physics, University of Ilorin, Kwara State, Nigeria

ABSTRACT

This study investigates the annual variation of temperature and rainfall over a solar cycle (2012–2023) Benue State, and examines the correlation between solar activity and local climate conditions. Using historical climate data, the research analyzes temperature and rainfall patterns in relation to solar cycles, revealing significant seasonal fluctuations and long-term trends. The findings show that Benue experiences high temperatures during the dry season, particularly from December to February, with daytime highs exceeding 35°C. Rainfall is concentrated during the wet season (April to October), and is often erratic, with intense rainfall events followed by prolonged dry spells. The analysis further indicates that solar maxima, characterized by heightened solar activity, are associated with increased temperatures and humidity, while solar minima result in cooler temperatures and reduced rainfall. Additionally, the study identifies a gradual increase in average annual temperatures over the study period, suggesting the onset of climate change in the region. These climatic variations have direct implications for agriculture, water resources, and public health in Makurdi. The research concludes by recommending the adoption of climate-resilient agricultural practices, improved water resource management, and public health interventions to mitigate the impacts of extreme weather events.

Keywords: Temperature variation, Rainfall patterns, Solar cycle, Benue State, Nigeria

Ogwuche, E., & Ibukun, A. S. (2025). Analysis of the Annual Variation of Temperature and Rainfall Over a Solar Cycle in Benue State, Nigeria. *West African Journal of Interdisciplinary Research. 3*(2), 57-68. DOI: https://doi.org/10.5281/zenodo.15714890

INTRODUCTION

Understanding the annual variations of rainfall and temperature is crucial for various sectors, including agriculture, water resource management, and urban planning. Benue State is located in the central part of the country and experiences a tropical climate characterized by distinct wet and dry seasons. The study of these variations in Benue provides insights into broader climatic trends, helps predict agricultural productivity, and aids in planning for climate resilience. Benue lies within the Guinea Savanna region, which is marked by a wet season, typically from April to October, and a dry season from November to March. The city's climate is influenced by the Intertropical Convergence Zone (ITCZ), which shifts seasonally and brings varying weather patterns. The annual rainfall in Benue averages between 1200 mm to 1500 mm, with significant inter-annual variability (Adejuwon, 2004). Temperature variations in Benue are also notable, with average temperatures ranging from 24°C to 34°C throughout the year (Ayoade, 2004).

Rainfall and temperature are critical climatic variables that significantly affect the socio-economic activities in Benue. Agriculture, the mainstay of the local economy, is particularly vulnerable to climatic variations. Changes in the timing, intensity, and amount of rainfall can impact crop yields, water supply, and food security (NIMET, 2018). Similarly, temperature fluctuations can affect crop growth cycles, livestock health, and the prevalence of pests and diseases (Odekunle, 2006).

Numerous studies have highlighted the climatic variability in Nigeria and its implications. Odekunle (2004) examined the relationship between climate and crop yield in the country, finding that variations of rainfall and temperature significantly influence agricultural output. Similarly, Oguntunde et al. (2011) analyzed rainfall patterns over the Niger Delta and noted significant seasonal and annual variations, which were attributed to both natural and anthropogenic factors.

In the context of Benue State, specific studies have been conducted to analyze climatic trends. For instance, Tersoo et al. (2016) explored the impact of climate variability on maize production in Makurdi and found that inconsistent rainfall patterns posed a significant challenge to farmers. Additionally, studies by Nyagba (2009) have indicated a noticeable trend towards increased temperature and reduced rainfall in recent decades, suggesting potential implications for water resources and agricultural sustainability.

The study of annual variation in rainfall and temperature in Benue is essential for developing adaptive strategies to mitigate the adverse effects of climate variability. It can inform policy-making, particularly in areas related to agricultural planning, water resource management, and disaster preparedness. Moreover, understanding these climatic patterns can help in predicting future trends and preparing for potential climate change impacts, thereby enhancing the resilience of Benue's socio-economic systems.

Benue State, like many regions in Nigeria, is experiencing significant variations in climatic conditions, particularly in rainfall and temperature patterns. These variations have profound implications for the city’s socio-economic activities, particularly agriculture, which is the primary livelihood for a significant portion of the population. Despite the critical importance of understanding these climatic variations, there is a lack of comprehensive, localized studies that document the annual changes in rainfall and temperature over solar cycle in Benue. This gap in

knowledge hampers the development of effective strategies to mitigate the adverse impacts of climate variability.

The primary problem addressed by this study is the lack of detailed information on the annual variation of rainfall and temperature over solar cycle in Benue. Without this information, it is challenging for policymakers, farmers, and other stakeholders to make informed decisions regarding agricultural planning, water resource management, and urban development. For instance, irregular rainfall patterns can lead to crop failure, affecting food security and the local economy. Similarly, temperature fluctuations can impact crop growth, livestock health, and the prevalence of climate-sensitive diseases.

This study aims to fill this critical knowledge gap by systematically analyzing the annual variations of rainfall and temperature over solar cycle in Benue over an extended period. By doing so, it seeks to provide a foundation for more effective climate adaptation and mitigation strategies in the region. It will also analyze the rainfall/temperature trends over the region of Benue.

METHODOLOGY

The Study Area

Benue State is located in the sub-tropics within latitude 6.5 to 8.5 ^{0}N; and longitude 7.47 to 10 ^{0}E. The state derives its name from the Benue River initially called *Ber-nor*, a compound word in Tiv language which means river or lake of hippopotamus (*ber* meaning river or lake, while *nor* is the name for hippopotamus) the name *Ber-nor* was corrupted to BENUE by colonial masters, the river is the second largest river in Nigeria after the River Niger. The state borders Nasarawa State to the North; Taraba State to the East; Kogi State to the West; Enugu State to the South-West; Ebonyi and Cross-Rivers State to the South; and has an international border with Cameroon to the South-East. Benue is a rich agricultural region; common crops cultivated in the state include oranges, yams, mangoes, sweet potatoes, cassava, soya bean, guinea corn, flax, sesame, rice, groundnuts and palm trees. The state experiences two distinct seasons, the wet/rainy season and the dry/summer season. The rainy season lasts from April to October with annual rainfall in the range of 100-200mm. The dry season begins in November and ends in March. Temperatures fluctuate between 23 – 37 degrees Celsius during the year. The south-eastern part of the state adjoining the Obudu-Cameroun mountain range, however, has a cooler climate similar to that of the Jos Plateau. The vegetation of the State consists of rain forests which have tall trees, tall grasses and oil palm trees that occupy the state's western and southern fringes while the Guinea savannah is found in the eastern and northern parts with mixed grasses and trees that are generally of average height. Benue's topography is mainly undulating plains with occasional elevations of between 1,500m and 3,000m above sea level.The state's main geological formations are sandy-loam shelf basement complex and alluvial plains. These together with its location in the transition belt between the north and south ecologies and a favorable rainfall pattern account for its support for a wide variety of crops.



Figure 1: Map of the Study Area

Methods

The data obtained for this work include monthly mean of temperature and rainfall spanning a period of eleven years (2012-2023). The data were sourced from the Nigerian Meteorological Agency (NIMET). The collected data were subjected to rigorous statistical analysis using spss and excel. Descriptive statistics, trend analysis, and graphical representations were employed to identify patterns and variations in rainfall and temperature over time. The analyzed data was interpreted to discern long-term trends, seasonal variations, and any anomalies in rainfall and temperature patterns.

RESULT AND DISCUSSION

Examining Rainfall Patterns: Variability and Trends

Figures 1-12 shows the annual variations of minimum and maximum temperatures while Figures 13 – 24 shows the annual pattern of rainfall in Benue State. These Figures shows the intricate tapestry of climate patterns which is associated to rainfall variability. Over the course of a solar cycle, the fluctuations in precipitation not only influence agricultural productivity but also impact water resources and the ecosystem. Analyzing historical data in this research revealed a complex interplay of factors that contribute to these rainfall patterns, shedding light on the region's shifting climate dynamics. Rainfall in Benue is characterized by a distinct wet and dry season, with the majority of precipitation typically occurring between April and October. However, year-to-year variability can lead to significant deviations from this norm. This variability can largely be attributed to broader climatic phenomena, including the El Niño Southern Oscillation, which can alter weather patterns across the globe.

From Figure 13 - 24, the Long-term trends indicate a gradual increase in annual rainfall, although this is accompanied by heightened unpredictability. The data suggests that while the overall volume of rainfall may be rising, the distribution of that rainfall over the year is becoming more erratic. This can lead to intense rainfall events concentrated in shorter time

frames, resulting in increased runoff and soil erosion. Conversely, prolonged dry spells can occur, exacerbating the challenges faced by farmers and communities reliant on consistent weather patterns. Furthermore, the impact of climate change cannot be overlooked. Emerging research suggests that rising global temperatures are altering traditional weather patterns, leading to more extreme weather events. In Benue, this might manifest as an increase in the frequency and intensity of heavy rains, as well as prolonged dry periods, both of which have implications for water management and agricultural practices. Therefore, understanding these rainfall patterns - both their variability and underlying trends - is crucial for developing effective adaptation strategies.

Correlation between Temperature and Rainfall over the Solar Cycle

Understanding the correlation between temperature and rainfall over a solar cycle is crucial for comprehending climate dynamics. This relationship reveals how varying temperatures can influence precipitation patterns, impacting both the environment and local agriculture. Over the solar cycle, observed data indicates a nuanced interplay between temperature fluctuations and rainfall amounts. For instance, warmer years often correlate with increased evaporation rates, which can lead to more intense, albeit sporadic, rainfall events. This phenomenon is particularly evident in the height of the rainy season, where higher temperatures can result in more moisture-laden air, subsequently leading to heavier downpours. Conversely, periods of cooler temperatures may see a decline in rainfall, as the atmospheric conditions become less conducive to cloud formation and precipitation.

From Figures 12 – 24, the analysis of temperature rainfall in Benue showcases these trends vividly. During years marked by elevated temperatures, the region often experiences a bimodal rainfall pattern, characterized by two distinct peaks of precipitation. This pattern not only enhances soil moisture levels but also influences the growing season for local farmers, ultimately affecting crop yields. On the other hand, years with lower average temperatures frequently coincide with prolonged dry spells, creating challenges for agricultural practices and water resource management. By meticulously analyzing these correlations, researchers can forecast future climate scenarios and better prepare for the impacts of climate variability. Therefore, understanding how temperature influences rainfall not only aids in agricultural planning but also informs community resilience strategies, ensuring that the people of Benue are equipped to adapt to changing climate patterns over the next solar cycle.

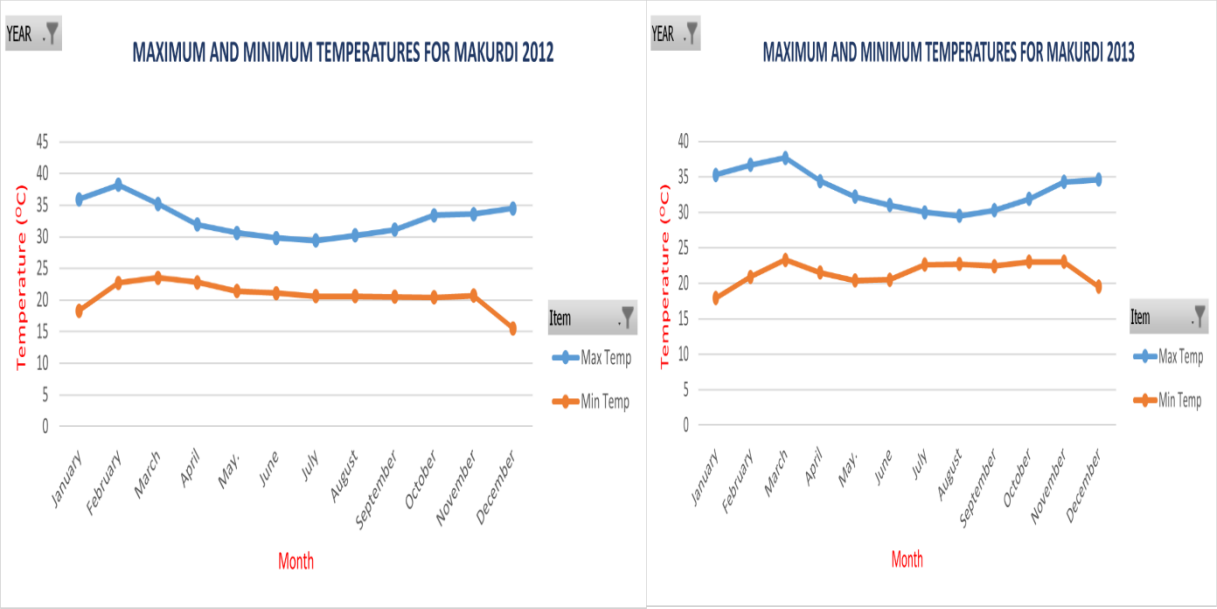
Seasonal Changes: How Temperature and Rainfall Differ Throughout the Year

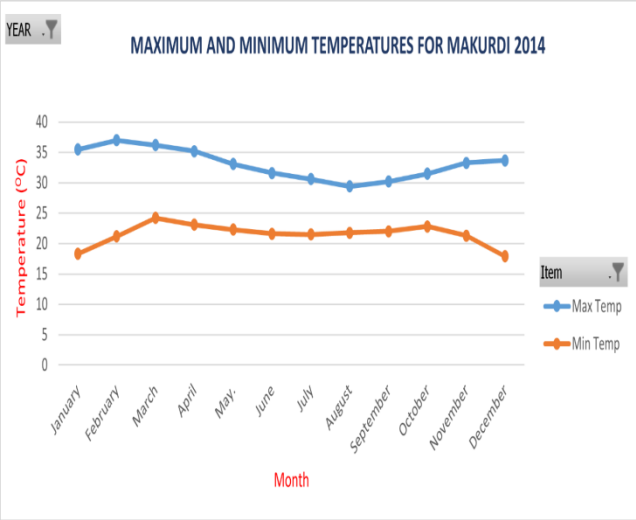
Figures 1 – 24 show the seasonal trends of temperature and rainfall in Benue. It was noted from these Figures that, from December to February, Benue experiences the dry season, characterized by lower humidity and significantly cooler temperatures. During these periods, average daytime temperatures can soar to around 35°C while nighttime temperatures dip to a more comfortable range, often falling below 20°C. This is the period when the Harmattan winds blow, bringing dry air and dust from the Sahara, creating a stark contrast from the humid months that follow. The clear skies and lower rainfall make it an ideal time for outdoor activities and agricultural preparations. As the calendar transitions into March and April, the city begins to warm (as observed from the trends), heralding the approach of the rainy season. This time, temperatures often peaks, reaching well above 34°C, while the first rains start to fall, signaling a shift in the

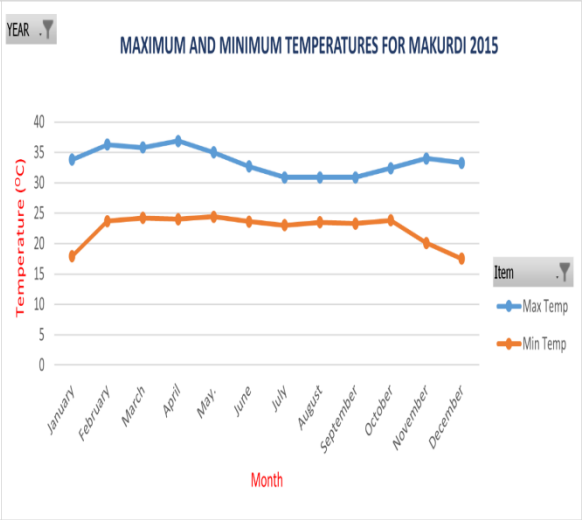
atmospheric conditions. The arrival of rain is crucial for the local farmers, marking the beginning of the planting season. This period witnesses a gradual increase in humidity, and the landscape transforms as greenery emerges and revitalizes the environment.

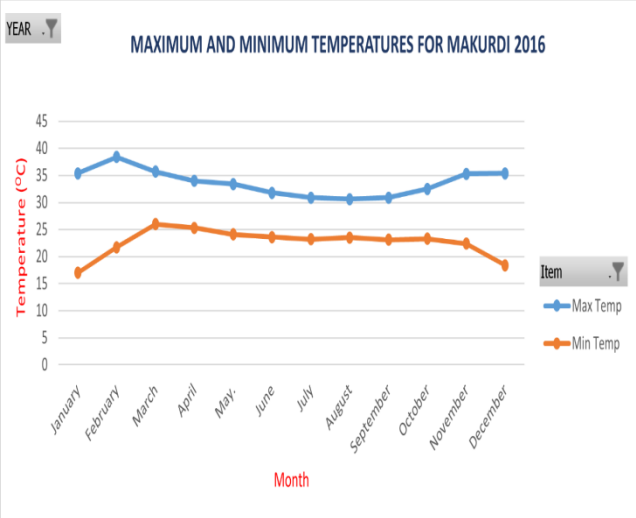
The peak of the rainy season usually occurs between May and September (Figure 13 – 24), when Benue experiences the highest levels of precipitation. Rainfall during these months can be substantial; with monthly averages exceeding 200 mm. Thunderstorms become a common sight, often accompanied by dramatic fluctuations in temperature. Daytime highs may still reach around 31°C, but the frequent rains and overcast skies result in a notable drop in perceived temperatures, providing a refreshing respite from the heat. This season is vital for agriculture, as the abundant rainfall supports crops and sustains the local ecosystem.

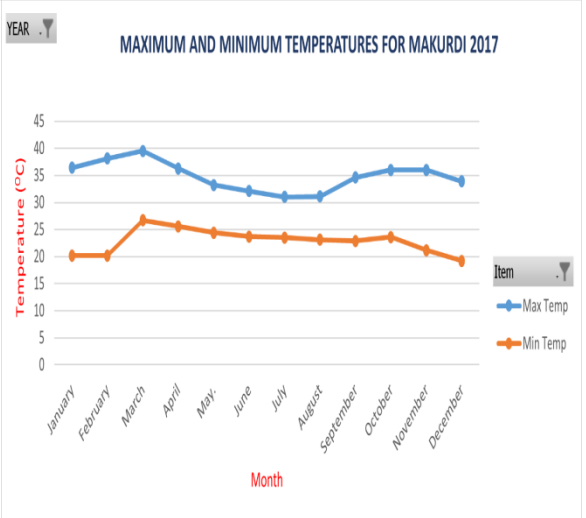
As we move into October and November, the climate begins to transition once again. The frequency of rainfall starts to decrease, and temperatures gradually shift back to the cooler, drier patterns of the early year. This transitional period is often marked by a mix of sunny days and sporadic showers, as the region prepares to bid farewell to the rains. Understanding these seasonal changes in temperature and rainfall not only enriches our appreciation of Benue's climate but also underscores the importance of adapting agricultural practices, water management strategies, and urban planning to align with these natural rhythms.

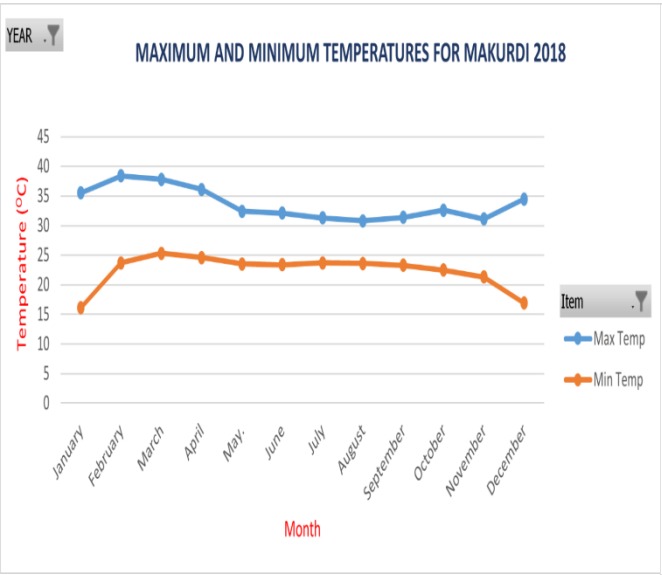


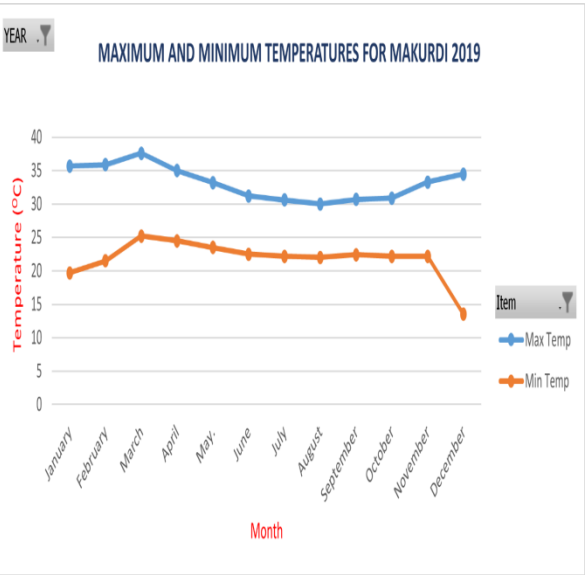

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2014
Temperature (°C)
Item
Max Temp
Min Temp
January
February
March
April
May.
June
July
August
September
October
November
December
Month

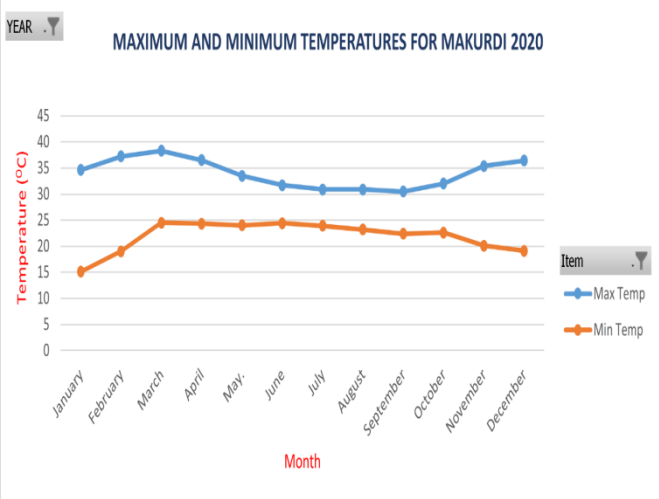

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2015
Temperature (°C)
Item
Max Temp
Min Temp
January
February
March
April
May.
June
July
August
September
October
November
December
Month

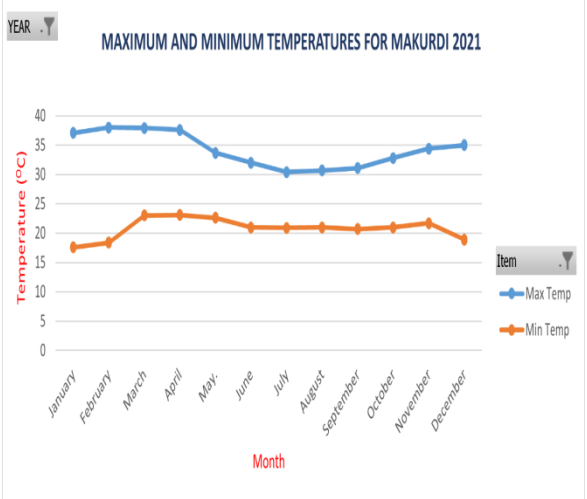

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2016
Temperature (°C)
Item
Max Temp
Min Temp
January
February
March
April
May.
June
July
August
September
October
November
December
Month

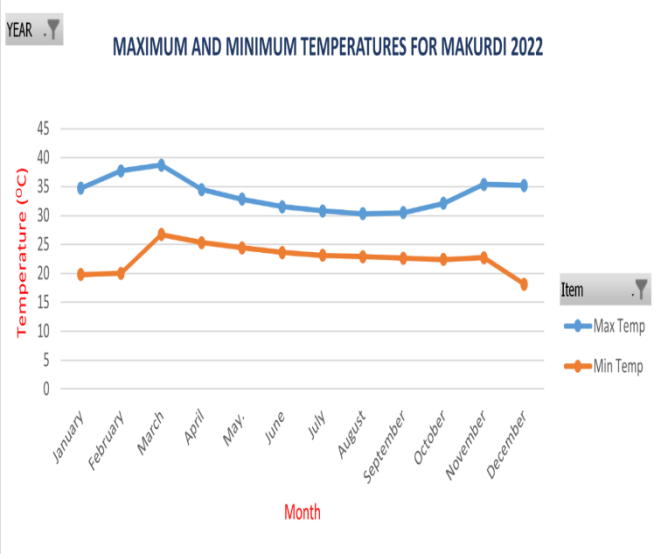

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2017
Temperature (°C)
Item
Max Temp
Min Temp
January
February
March
April
May.
June
July
August
September
October
November
December
Month

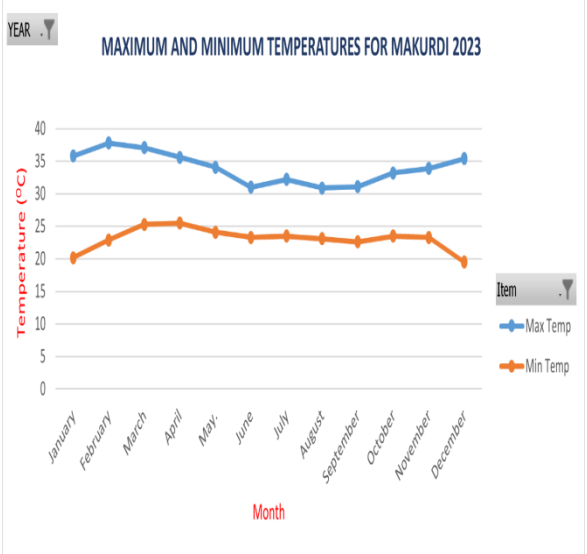

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2018
Temperature (°C)
Item
Max Temp
Min Temp
January
February
March
April
May.
June
July
August
September
October
November
December
Month

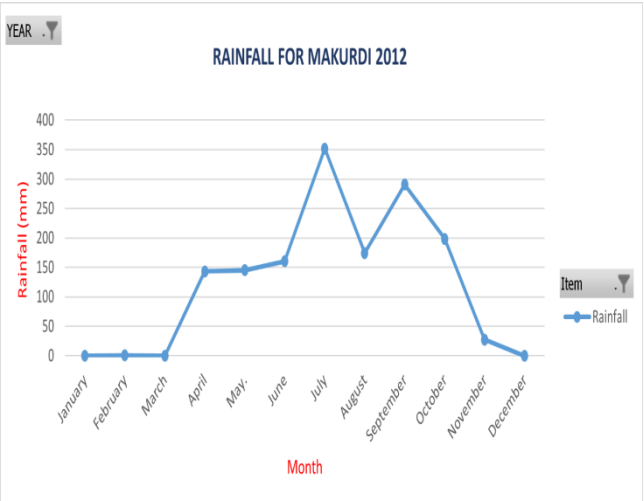

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2019
Temperature (°C)
Item
Max Temp
Min Temp
January
February
March
April
May.
June
July
August
September
October
November
December
Month

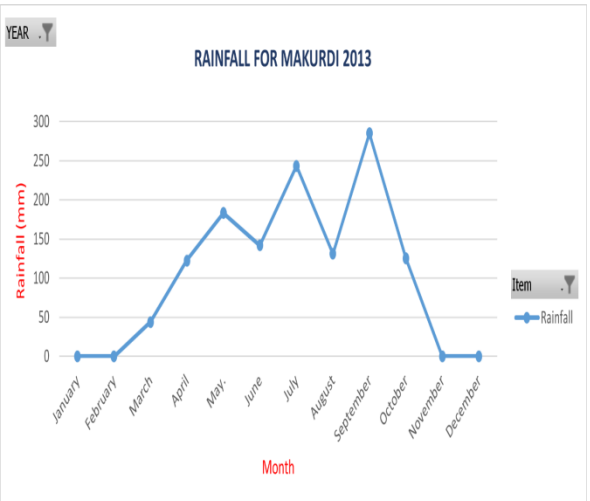

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2020
Temperature (°C)
45
40
35
30
25
20
15
10
5
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Max Temp
Min Temp

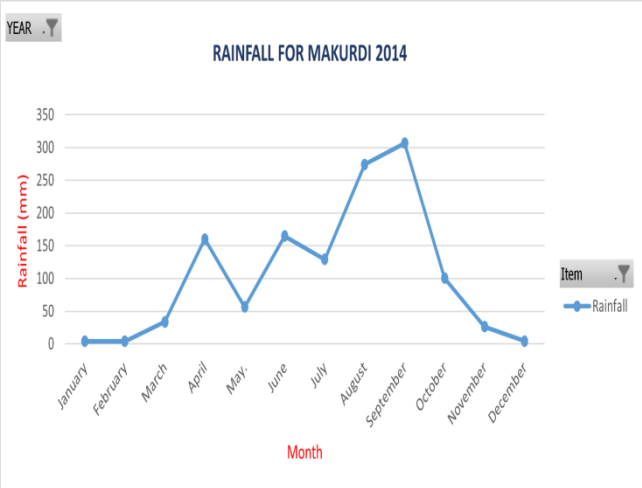

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2021
Temperature (°C)
40
35
30
25
20
15
10
5
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Max Temp
Min Temp

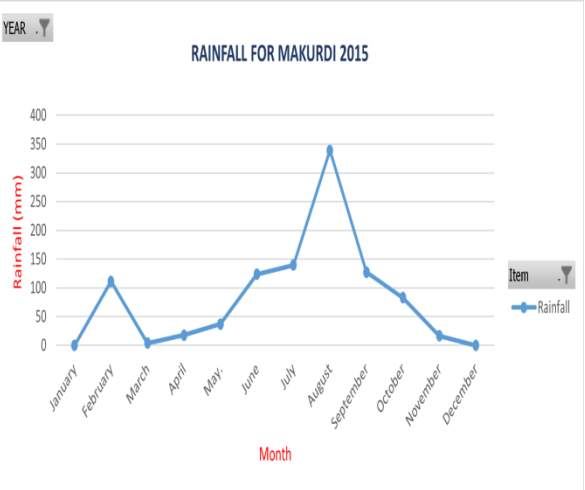

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2022
Temperature (°C)
45
40
35
30
25
20
15
10
5
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Max Temp
Min Temp

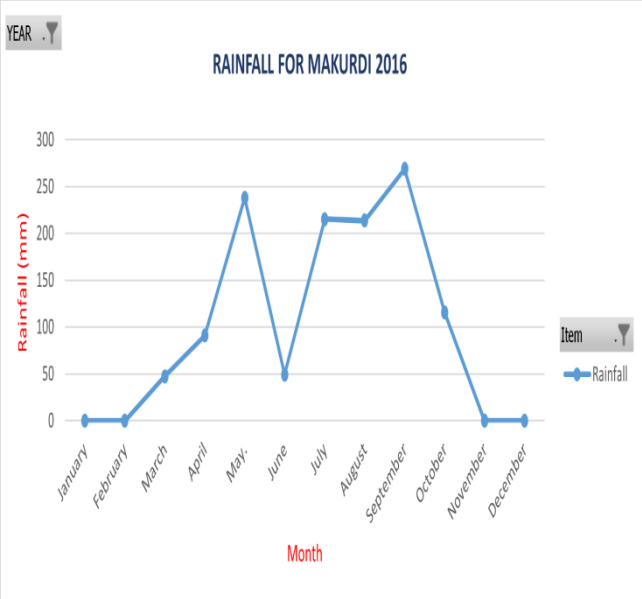

YEAR
MAXIMUM AND MINIMUM TEMPERATURES FOR MAKURDI 2023
Temperature (°C)
40
35
30
25
20
15
10
5
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Max Temp
Min Temp

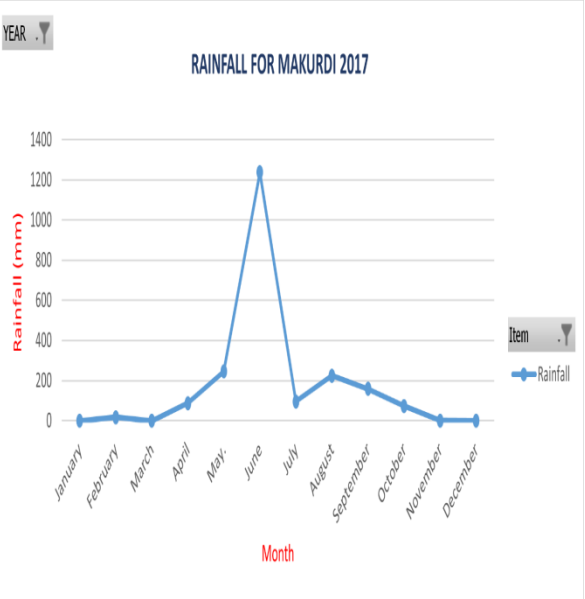

YEAR
RAINFALL FOR MAKURDI 2012
Rainfall (mm)
400
350
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall

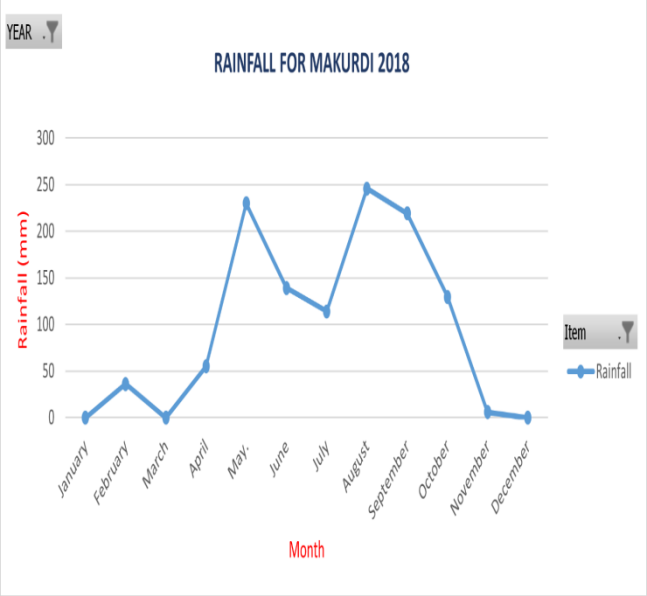

YEAR
RAINFALL FOR MAKURDI 2013
Rainfall (mm)
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall

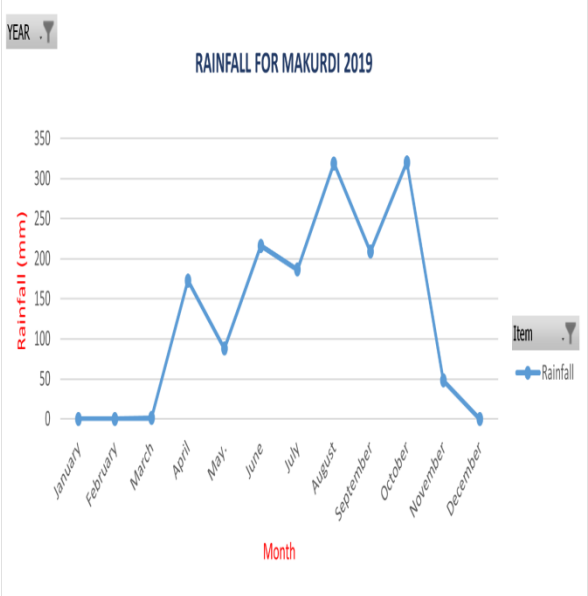

YEAR
RAINFALL FOR MAKURDI 2014
Rainfall (mm)
350
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall

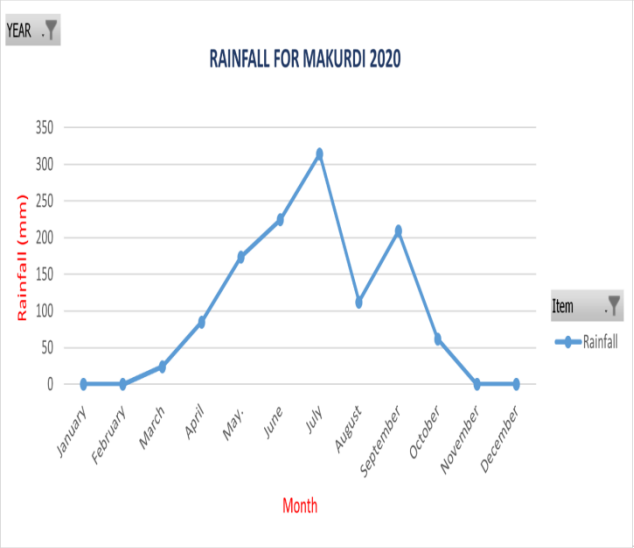

YEAR
RAINFALL FOR MAKURDI 2015
Rainfall (mm)
400
350
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall

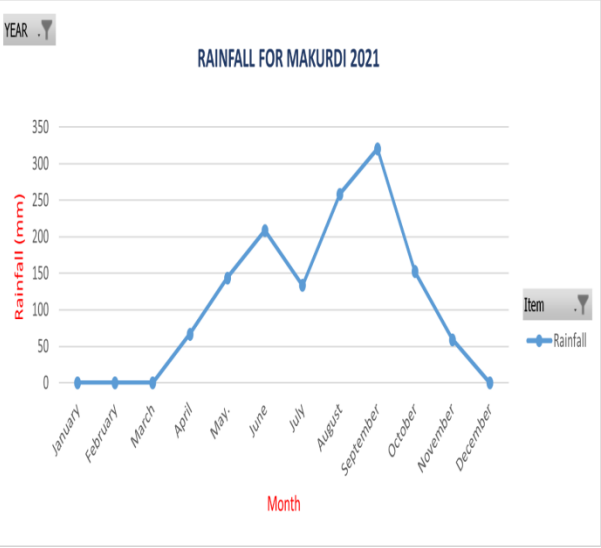

YEAR
RAINFALL FOR MAKURDI 2016
Rainfall (mm)
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall

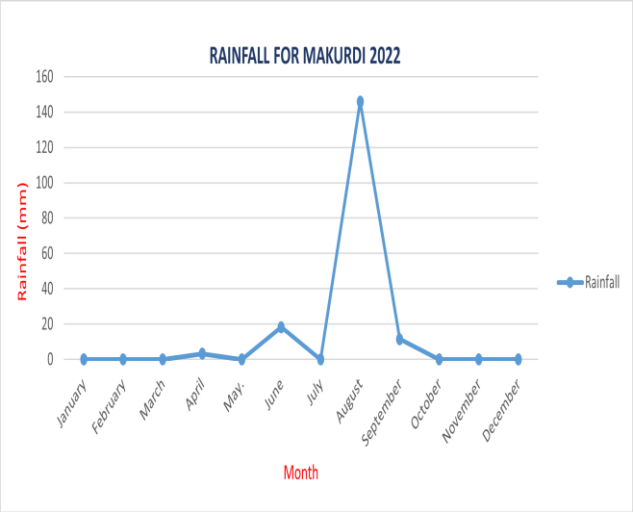

YEAR
RAINFALL FOR MAKURDI 2017
Rainfall (mm)
1400
1200
1000
800
600
400
200
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall

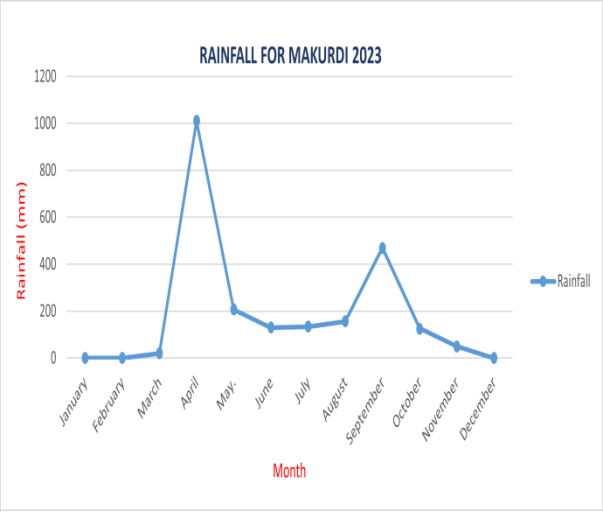

YEAR
RAINFALL FOR MAKURDI 2018
Rainfall (mm)
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall


YEAR
RAINFALL FOR MAKURDI 2019
Rainfall (mm)
350
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall


YEAR
RAINFALL FOR MAKURDI 2020
Rainfall (mm)
350
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall


YEAR
RAINFALL FOR MAKURDI 2021
Rainfall (mm)
350
300
250
200
150
100
50
0
January
February
March
April
May.
June
July
August
September
October
November
December
Month
Item
Rainfall





CONCLUSION

A comprehensive analysis of the annual temperature and rainfall trends in Benue over a solar cycle has revealed significant insights into the region's climate patterns. The data indicates a clear warming trend, with average temperatures gradually rising over the years, a phenomenon that mirrors global climatic changes. This increase in temperature not only affects the local ecosystem but also has broader implications for agriculture, water resources, and public health in the area. The trend indicates an intricate relationship between climate patterns and environmental sustainability. By analyzing these trends, we have not only unveiled the shifts in temperature and precipitation that have shaped the region's ecological landscape but also emphasized the importance of understanding these patterns in the context of climate change and its potential impacts. As we move forward, it is crucial for policymakers, researchers, and the community to consider these findings when developing strategies for climate resilience and sustainable resource management.

REFERENCES

Adejuwon, J. O. (2004). Impacts of climate variability and climate change on crop yield in Nigeria. Climate Research, 27, 83-94.

Amah, C. J., et al. (2019). Urbanization and its impact on local climate: A case study of Makurdi Metropolis, Nigeria. International Journal of Urban Climate, 12(3), 215-230.

Ayoade, J. O. (2004). Introduction to Climatology for the Tropics. Ibadan: Spectrum Books Limited.

Egbule, C. L. (2015). Influence of topography on the distribution of rainfall over Nigeria. International Journal of Climatology, 35(7), 1269-1282.

Ibrahim, I., & Iornumbe, N. E. (2017). Climate change and agriculture in Benue state, Nigeria: Impacts, vulnerability, and adaptation. Journal of Environmental Studies and Policy Analysis, 2(3), 45-58.

NIMET (2018). Nigerian Meteorological Agency Annual Report. Abuja: Nigerian Meteorological Agency.

Nyagba, S. G. (2009). Climate Change and Water Resources Management in Nigeria. Journal of Environmental Science and Policy, 2(3), 23-34.

Odekunle, T. O. (2006). Determining rainy season onset and retreat over Nigeria from precipitation amount and number of rainy days. Theoretical and Applied Climatology, 83(1-4), 193-201.

Oguntunde, P. G., Abiodun, B. J., & Lischeid, G. (2011). Rainfall trends in Nigeria, 1901-2000. Journal of Hydrology, 411(3-4), 207-218.

Okoro, N., & Omeje, M. (2017). Trends in extreme weather events in Makurdi, Nigeria: Implications for climate resilience. Journal of Climate Change, 5(2), 67-78.

Okonkwo, C., &Nnoli, N. (2018). Influence of Atlantic Multidecadal Oscillation on Nigerian rainfall variability. Climate Dynamics, 50(9-10), 3679-3692.

Okwori, A. I., et al. (2018). Impacts of climate change on maize production in Benue State, Nigeria. Journal of Agricultural Science and Food Technology, 4(2), 89-95.

Olayemi, J. K., & Ogundeji, A. A. (2018). Policy interventions for enhancing climate resilience and agricultural sustainability in Nigeria. African Journal of Agricultural Research, 13(32), 1623-1632.

Onyekwelu, J. C., et al. (2015). Climate variability and agricultural productivity in Nigeria: Implications for rural poverty. International Journal of Climate Change Strategies and Management, 7(1), 123-137.

Tersoo, K., Uji, P. A., & Shabu, T. (2016). Climate variability and maize production in Makurdi Local Government Area of Benue State, Nigeria. International Journal of Scientific and Research Publications, 6(4), 225-231.