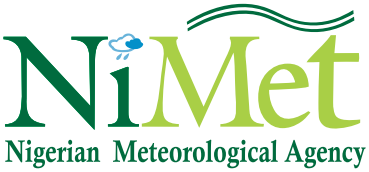

2023
State of the Climate in
NIGERIA

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FORWARD

The year 2023 was yet another defining period as the country continued to experience significant shifts in rainfall and temperatures patterns. The impacts of climate change in Nigeria are far-reaching; affecting critical sectors such as agriculture, water resources, health, and infrastructure. The increasing frequency and intensity of extreme weather events, such as floods, droughts, and heatwaves, have had profound negative impacts on livelihoods and the ecosystems. This is of great concern to individuals, communities and governments at all levels. It is imperative that we acknowledge the pressing need for proactive measures to address these challenges and safeguard the safety and well-being of the populace and the environment.

The World Meteorological Organization (WMO) has formally declared that 2023 stands as the warmest year on record, exceeding all historical benchmarks by a considerable margin. The annual average global temperature approached a noteworthy 1.5°C above pre-industrial levels. This marks a critical milestone, as the Paris Agreement on climate change aims to limit the long-term temperature increase to no more than 1.5°C above pre-industrial levels. The confirmation of the unprecedented high temperature of 2023 underscores the urgency of global and local efforts to address climate change. It also highlights the imperative to tenaciously pursue the attainment of the targets outlined in international agreements and the Nationally Determined Contributions (NDCs) of individual countries under the United Nations Framework Convention on Climate Change (UNFCCC).

Even though climate change impacts are increasing worldwide, progress on reducing carbon emissions from fossil fuels remains extremely slow. According to new research published on 5th December, 2023, by the Global Carbon Project[1], global carbon dioxide emissions from fossil fuel combustion have climbed again to hit record highs in 2023. Emissions have risen by 1.1% compared to the previous year's levels, and sit 1.5% above pre-pandemic volumes recorded in 2019, thus continuing the trend of increasing emissions over the past decade despite a brief decline during COVID-19 pandemic. The concentrations of methane (CH_4) and nitrous oxide (N_2O) in the atmosphere due to human activities have also been increasing globally, giving rise to trapping of more heat energy in the atmosphere. The trapped heat energy invariably fuels the increase in extreme weather events across the world. The long atmospheric lifetimes of CO_2, CH_4 and N_2O means that temperatures will continue to rise for many years to come. The rising concentrations of GHGs in the atmosphere indicate the lack of substantial progress in curbing the emission of CO_2 and greenhouse gases, and this is pushing the world further away from meeting the target of limiting global for rapid decarbonisation, political action continues lagging behind the climate emergency.

[1]Stanford University. https://sustainability.stanford.edu/news/global-carbon-emissions-fossil-fuels-reached-record-high-2023.

The 2023 State of the Climate in Nigeria report presents a sobering picture of weather-induced devastation across the country. The 2023 rainy season in Nigeria was characterized by rainfall-induced hazards, although to a lesser extent than the recorded hazards in 2022. Torrential rains triggered destructive flooding that displaced thousands of people and caused widespread damage to physical infrastructure as well as loss of lives. At the same time, dry spells affected wider areas in the north. The occurrence of frequent high-intensity rainfall led to river overflows and flash floods in various parts of the country. Despite a relative decrease in the overall magnitude of hazards compared to 2022, the impact of these rainfall patterns manifested in increased risks with significant effect on economic sectors, such as agriculture, transportation, energy, education, etc. According to a report released by the National Emergency Management Agency on Tuesday, October 10, 2023, about 171,545 individuals had to be evacuated as a result of the intense rainfall that led to the devastating floods that occurred in different parts of the country in 2023.

Average temperatures across Nigeria increased compared to last year, with some areas seeing record high temperatures. Temperatures above 40°C were reported in various places in the northern parts of the country. In 2023 many Nigerian cities grappled with unprecedented heatwaves. For instance, on 23rd May 2023, Maiduguri recorded its highest-ever daytime temperature, soaring to an alarming 45.2°C. Similarly, Nguru experienced its peak temperature for the year on May 16th, reaching 44.5°C. The intensity of these heatwaves extended to several other cities, surpassing the 40°C mark. Nguru notably reported the most prolonged exposure to temperature above 40°C for 77 days while Maiduguri and Sokoto also experience exceptionally extended periods of intense heat, for 70 and 58 days, respectively.

The 2023 State of the Climate in Nigeria data report presents a sobering picture. Average temperatures across Nigeria increased compared to last year, with some areas seeing record heat. Torrential rains triggered destructive flooding that displaced thousands and caused widespread damage. At the same time, dry spells expanded in the north.

The human impacts from these climate extremes in Nigeria are immense. Lives and livelihoods have been lost, food and water insecurities deepen, while infrastructures crumble. Urgent climate action is therefore needed to strengthen Nigeria's climate resilience and reduce future risks. Efforts to mitigate the increasing climate change impacts must be accelerated by contributing to rapid global greenhouse gas emission reductions.

This bulletin provides a timely update on the climate trends and extremes across Nigeria in 2023. The information presented in this publication is the result of the analyses of observation data collected by NiMet from across Nigeria. It serves as an authoritative reference document for policymakers, planners, researchers and citizens for informed, sound decision-making. Information on the extreme weather events that occurred in the country in the preceding year can also spur appropriate adaptation actions that will reduce the vulnerability of individuals and communities to future weather hazards. Climate change is real, and its impacts are affecting us.

Timely adaptation and mitigation actions are therefore critical. This report is a tool for raising awareness about the pressing issues related to climate change and encourages the implementation of innovative and sustainable solutions. Through knowledge sharing and capacity building, communities can be empowered to adapt to the challenges of a changing climate, while also fostering a sense of collective responsibility for environmental conservation. This bulletin serves not only as a retrospective lens but also as a forward-looking guide, emphasizing the imperative for proactive measures and strategic interventions.

I am honoured to present the State of Climate in Nigeria Bulletin for the year 2023. This document stands as a testament of collective dedication to understanding, analysing, and addressing the intricate interplay of climatic factors affecting our country. It is also a call to action, urging policymakers, communities, and individuals to engage in concerted efforts to combat climate change. By recognizing the inherent connection between human activities and environmental changes, a culture of responsibility and stewardship toward the environment can be fostered. It is my sincere hope that this document will inspire dialogue, drive awareness, and propel everyone toward a future where our actions today contribute to the well-being of generations tomorrow.

Prof. Charles Anosike
Director General/CEO
Nigerian Meteorological Agency

February 2024

PREFACE

The World Meteorological Organization (WMO) has declared 2023 as the warmest year on record globally as the world continued to grapple with the complexities of a changing climate. As the effects of global warming became increasingly apparent in Nigeria, the State of the Climate in Nigeria (2023) provides a comprehensive analysis of the various environmental, social, and economic impacts of climate change across the diverse regions of the country in 2023.

This edition gives information on weather events that occurred within the year and how they affected all aspects of socio-economic activities in the country. It has five (5) Chapters. The observed behaviour of some key Climatic Parameters such as Solar Radiation, Temperature, Precipitation, and other elements that characterized 2023 are presented in Chapter One. Observed Changes in Climate Pattern in 2023, which include trends in Precipitation, Temperature (Mean, Maximum and Minimum) and other weather elements are discussed in Chapter Two. Chapter Three discusses the Observed Climate Drivers such as Surface Pressure and Winds and Global/Regional Interconnections such as ENSO events projections. Extreme weather event experienced in the country in 2023 are discussed in Chapter Four. The socio-economic impacts of extreme weather events on various sectors of the economy such as Agriculture and Food Security, Transportation, Energy, Water Resources and Health, are discussed in Chapter Five. This chapter also discusses the overview of Greenhouse Gas Emission, as well as Early Warning Systems and Disaster Risk Reduction.

This publication is a product of the dedicated efforts of experts within the Agency. Their collective knowledge and expertise have provided valuable insights into the challenges posed by climate change in Nigeria in 2023. The retrospective information on weather events in this publication will help policy makers to design appropriate adaptation and response strategies for the future. The State of the Climate in Nigeria (2023) is therefore a testament to the sustained commitment of NiMet to provide scientific information for combating the challenges of climate change in Nigeria. It is a reminder of the urgent need to prioritize sustainable development, environmental stewardship, and climate action to ensure a prosperous and resilient future for generations.

CHAPTER ONE

1.0 OBSERVED CHARACTERISTICS OF SOME KEY CLIMATIC PARAMETERS IN 2023

1.1 Solar Radiation

The 2023 annual average incident solar radiation over the country ranged from 150 to 288.1 $Wm^{-2}day^{-1}$as shown in Figure 1.1, Jigawa, parts of Kano, Bauchi, Yobe and Borno states experienced the highest mean annual incident of solar radiation of above 270 $Wm^{-2}day^{-1}$. Sokoto, Zamfara, Kebbi, Katsina, Kaduna, Niger, Plateau, Gombe, Adamawa, Taraba, Kwara, Kogi and Benue states as well as the FCT experienced solar radiation between 240 and 260 $Wm^{-2}day^{-1}$, while the other states in the country recorded between 230 $Wm^{-2}day^{-1}$ and 190 $Wm^{-2}day^{-1}$, except for parts of Lagos and Akwa Ibom states that experienced below 190 $Wm^{-2}day^{-1}$, of solar radiation.

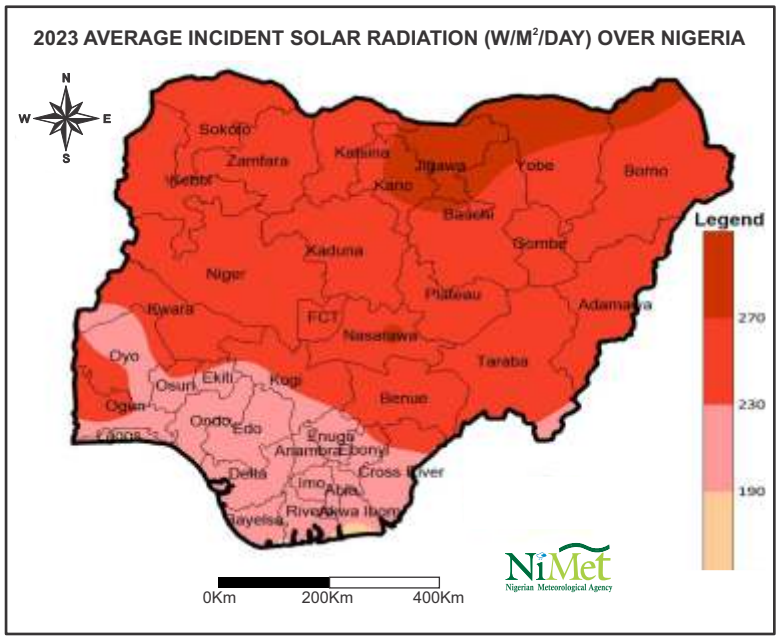


Figure 1.1: Average incident Solar Radiation over Nigeria in 2022

1.1.1 Daily Average Incidence of Solar Radiation

The maximum daily mean incident solar radiation in 2023 ranged from 229.2 to 383.1 $Wm^{-2}day^{-1}$ across the country. The highest value (383.1 $Wm^{-2}day^{-1}$) was recorded in Jigawa followed by 372.7 $Wm^{-2}day^{-1}$ in Yobe, 368.1 $Wm^{-2}day^{-1}$ in Borno, 368.1 $Wm^{-2}day^{-1}$ in Kano, 368.1 $Wm^{-2}day^{-1}$ in Bauchi, and 368.1 $Wm^{-2}day^{-1}$ in Nasarawa states. , as shown in Table 1.0

Table 1.0: Daily Average Incident Solar Radiation

S/N	State	Annual Average (Wm-2day-1)	Highest Daily (Wm-2day-1)	S/N	State	Annual Average (Wm-2day-1)	Highest Daily (Wm-2day-1)
1	Abia	316.0	221.3	19	Kano	368.1	273.5
2	Adamawa	333.3	233.6	20	Katsina	339.1	248.8
3	Akwa Ibom	247.7	158.6	21	Kebbi	358.8	241.8
4	Anambra	310.2	215.0	22	Kogi	336.8	234.7
5	Bauchi	368.1	263.9	23	Kwara	324.1	238.6
6	Bayelsa	321.8	220.3	24	Lagos	292.8	205.0
7	Benue	327.5	232.3	25	Nasarawa	365.7	277.2
8	Borno	368.1	263.9	26	Niger	318.3	235.3
9	Cross River	332.2	229.6	27	Ogun	355.3	270.0
10	Delta	314.8	220.1	29	Ondo	342.6	210.8
11	Edo	305.6	210.6	30	Osun	338.0	233.5
12	Ekiti	343.8	225.2	31	Oyo	307.9	214.8
13	Enugu	324.1	220.4	32	Plateau	335.6	247.0
14	FCT	347.2	239.3	33	Rivers	313.7	214.6
15	Gombe	349.5	240.4	34	Sokoto	350.7	246.0
16	Imo	349.5	221.6	35	Taraba	343.8	237.4
17	Jigawa	383.1	282.1	36	Yobe	372.7	288.1
18	Kaduna	324.1	247.5	37	Zamfara	358.8	249.7

1.2 Temperature

1.2.1 Annual Mean Maximum Temperature

In 2023 the annual mean maximum temperature recorded across the country ranged from 28.0°C to 37.0°C. This range is one degree Celsius (1°C) higher than what was observed in 2022. The highest temperature range of 34.0 to 37.0°C was recorded over the northern and central states. Small parts of Plateau, Kaduna and Bauchi states recorded the lowest temperature range of 28.0 to 31.0°C while the southern states, the FCT and most parts of Plateau, Kaduna and Bauchi states recorded values in the range of 31.0 to 34.0°C (Figure. 1.2).

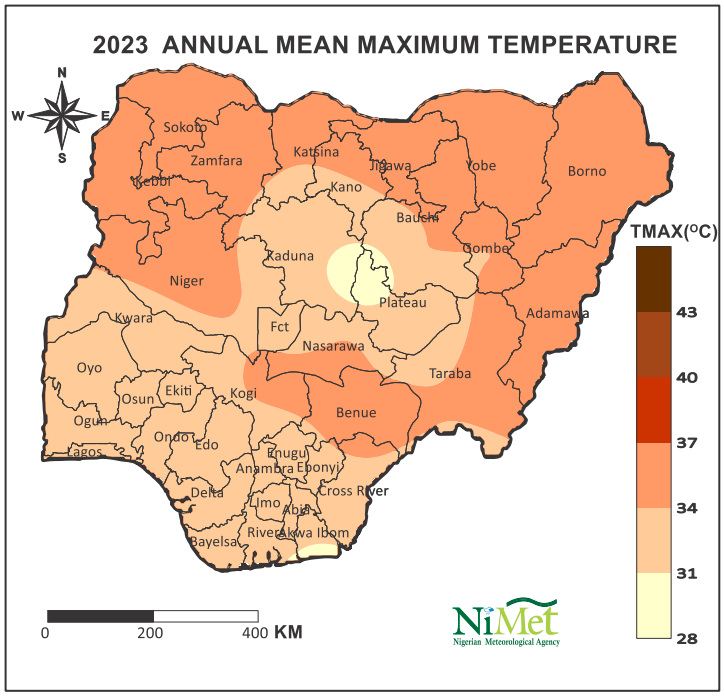


Figure.1.2: Observed Annual Mean Maximum Temperature across Nigeria in 2023

1.2.2 Annual Mean Maximum Temperature Departure (Deviation from Long-term Average)

In 2023, most of the country experienced warmer than normal maximum temperatures when compared to the 1991–2020 average. This aligns with the World Meteorological Organization's report that 2023 was the warmest year on record globally (WMO, 2024). Across the country, no state recorded annual temperature values below the long-term average in 2023 (Figure 1.3). Just a few isolated locations in Delta, Edo, and Yobe states recorded normal annual mean maximum temperatures compared to the 1991-2020 average.

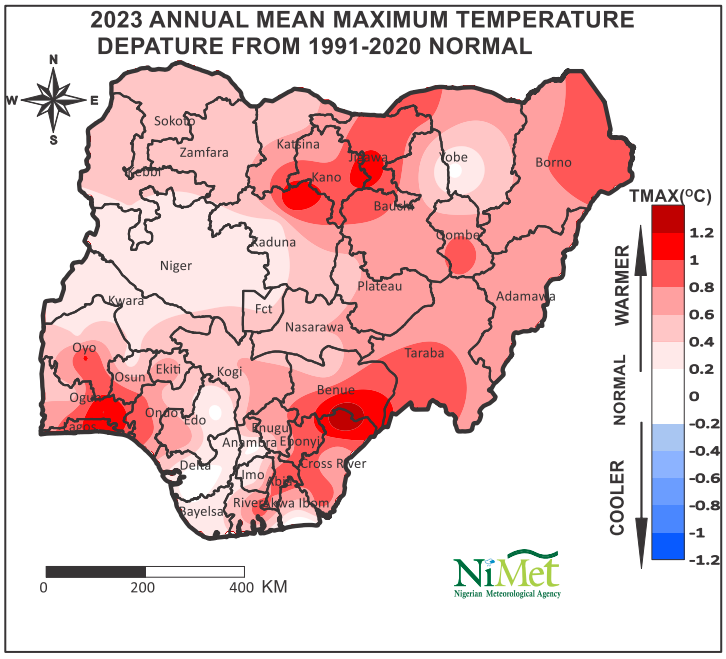


Figure 1.3: Observed annual mean maximum temperature departure from 1991-2020 average (normal) across Nigeria in 2023

1.2.3 Maximum Temperatures and Hot season

The hot season in the country occurs yearly between February and May, when daytime temperatures reach their highest values. This season is characterized by increased solar radiation intensity, longer daily sunshine duration, more frequent heatwaves, and high level of discomfort. The hot season begins earlier in the South, starting in February and lasting through March, while in the North it commences a month later from March through May. Therefore, the duration of the hot season is shorter in the South at two months, compared to three months (March, April and May) in the North. The 2023 hot season was also experienced over the southern states from February to March, and over the North from March to May as in the previous two years. The hot season was generally hotter in the North with highest temperature of 45.2 °C recorded in May over Maiduguri while Umuahia in the southern part of the country recorded highest temperature of 41.6 °C in February.

1.2.3.1 Hot Season in the South in 2023

All the cities in the South attained the highest temperature of the year and hottest period of the season in February, with higher mean monthly values in February than March. The observed mean monthly temperature across the southern states ranged from 31.2°C in Eket (Akwa Ibom state) to 38.2°C in Ogoja (Cross River state) in February and 30.4 to 38.1°C over same stations in March. Similarly mean hot season temperatures were highest over Ogoja (38.2°C) and lowest in Eket (30.8°C), implying that Ogoja in Cross river state was the hottest while Eket experienced the lowest warming during the hot season (Figure.1.4) The observed mean hot season temperatures were higher than long term average values in most of the southern cities. This was similar the observation in the North in the year under review.

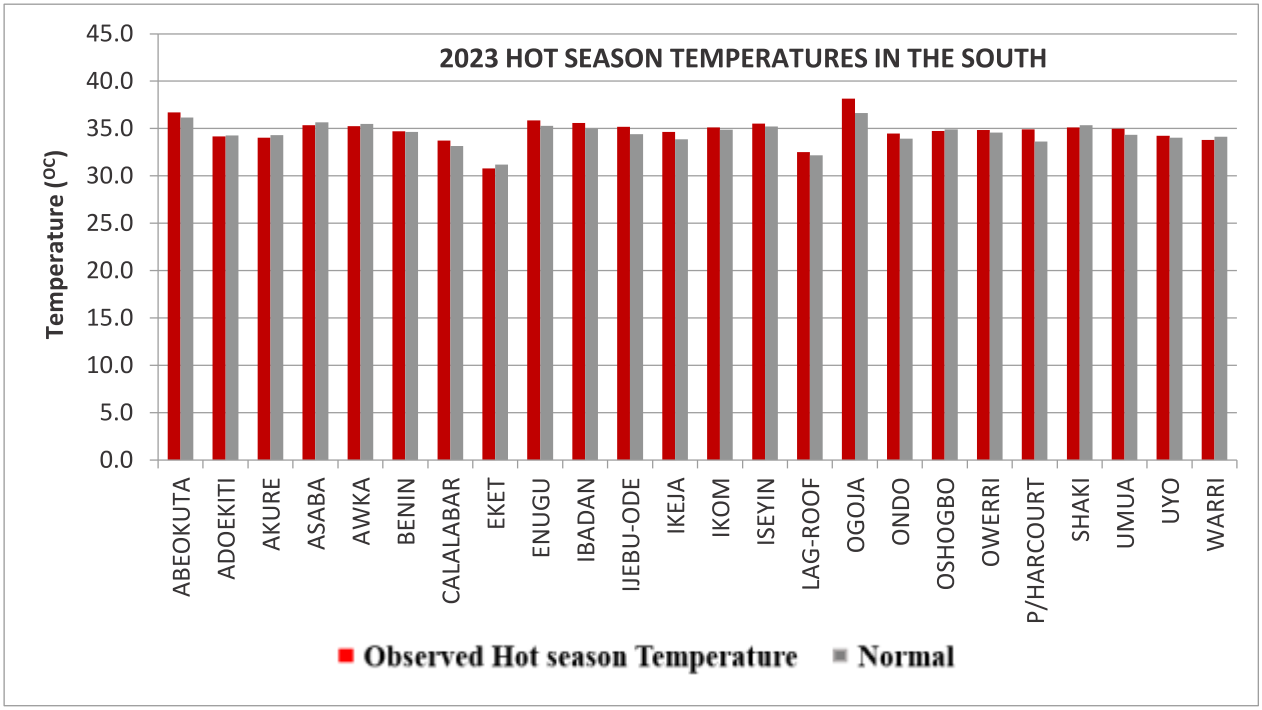


Figure.1.4 Comparison of Southern Nigeria 2023 Hot season mean maximum temperature with 1991 -2020 Normal

1.2.3.2 Hot Season in the North

In 2023, hot season three months mean temperatures in the North ranged from 30.4°C in Jos, Plateau state to 40.6°C in Yobe state (Figure 1.5). The hottest period of the year with the highest day time temperature was experienced in May over Nguru (Yobe state), Maiduguri (Borno state) and Sokoto. Most of the northern states experienced the hottest period of the year and season in March while few states such as Jigawa and Zamfara experienced the hottest period in April. The observed hot season temperatures were higher than normal over most of the states in the North except over Ilorin in Kwara state, Yelwa in Kebbi state and Minna in Niger state where the observed values were below 1991-2020 average values as shown in Figure 1.5.

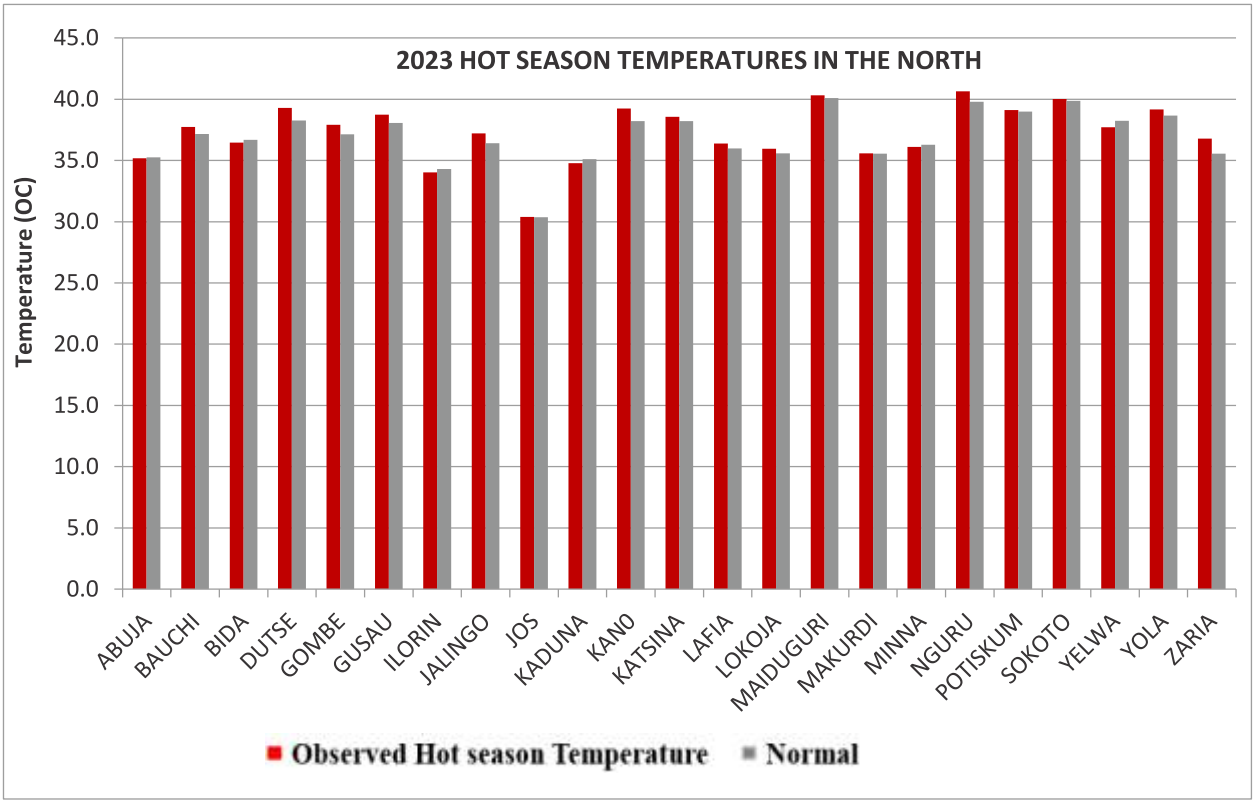


Figure.1.5 Comparison of Northern Nigeria 2023 Hot season mean maximum temperature with 1991-2020 Normal 91-2020 Normal

1.2.3.3 Hot Season Mean Maximum Temperature Compared to Normal

Generally, the country experienced a warmer than normal hot season in 2023 especially over the eastern half and southwestern part of the country (Figure.1.6). The highest degree of warming was over Kano, Katsina, Jigawa, and parts of Benue, northern Cross River and Rivers states where the observed temperatures were 0.8 to 1.5°C above long term average. Other states experienced warming below 0.8°C. Parts of Kebbi, Niger, Kaduna, Kwara, Oyo, Ondo, Edo and Delta states experienced cooler than normal hot season. Normal conditions where however, experienced over the northwest extending from part of Sokoto through Zamfara, Kebbi, Kaduna, the FCT, Kogi to Ekiti, Osun, Ondo, Edo, Delta, Anambra, southern Akwa Ibom states. The warming experienced in the country during the hot season is in line with the increasing global average temperature trend reported by WMO in 2023 (WMO 2024).

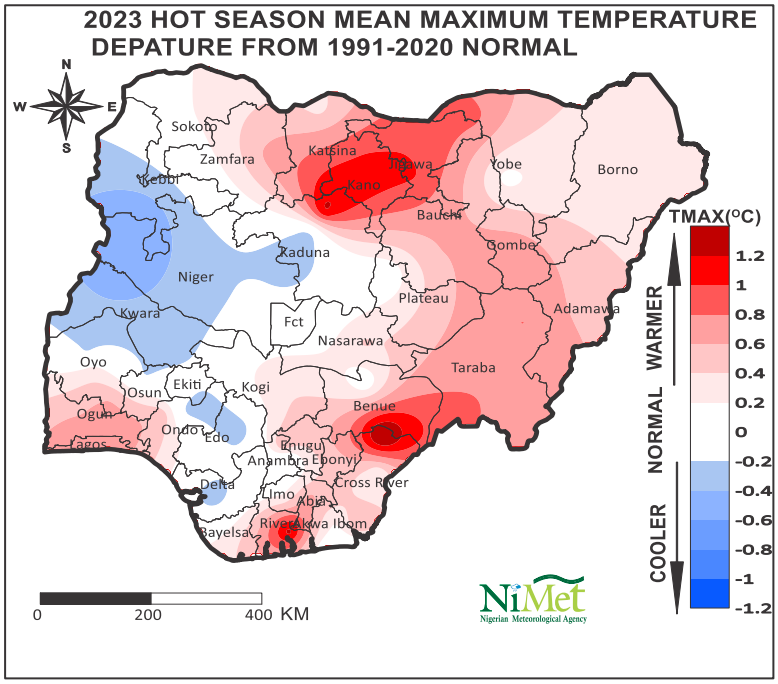


Figure 1.6: Observed Hot season mean maximum temperature Departure from Normal

1.2.4 Annual Mean Minimum Temperature in 2023

The annual mean minimum temperature distribution in 2023 was between 16° and 27°C. The lowest minimum temperature was recorded over parts of Kano, Jigawa, Bauchi, Nasarawa, Kaduna, and Plateau States. Minimum temperatures over most of the country were between 22° and 27° C.

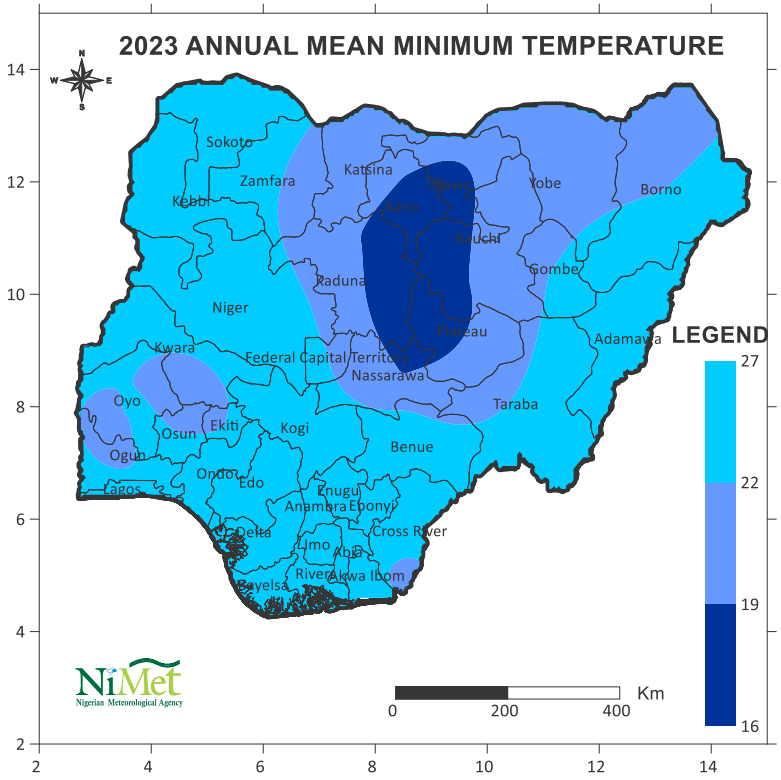


Figure 1.7: 2023 Annual Mean Minimum Temperature

1.2.5. Annual Temperature Departure (Deviation from Long-term Average)

1.2.5.1 Annual Minimum Temperature Departure

Analysis of minimum temperatures and their departure from the long-term average show that cooler than normal temperatures were recorded over parts of Bauchi, Jigawa, Kano, Kaduna, Plateau, Nasarawa, Niger, Kogi, Lagos, Ogun, Oyo, Osun, Ondo, Delta, Bayelsa, Rivers, Imo and Cross River states, as well as the Federal Capital Territory. Warmer than normal minimum temperatures were recorded over much of the north and parts of the inland cities of the south. (See Figure 1.8).

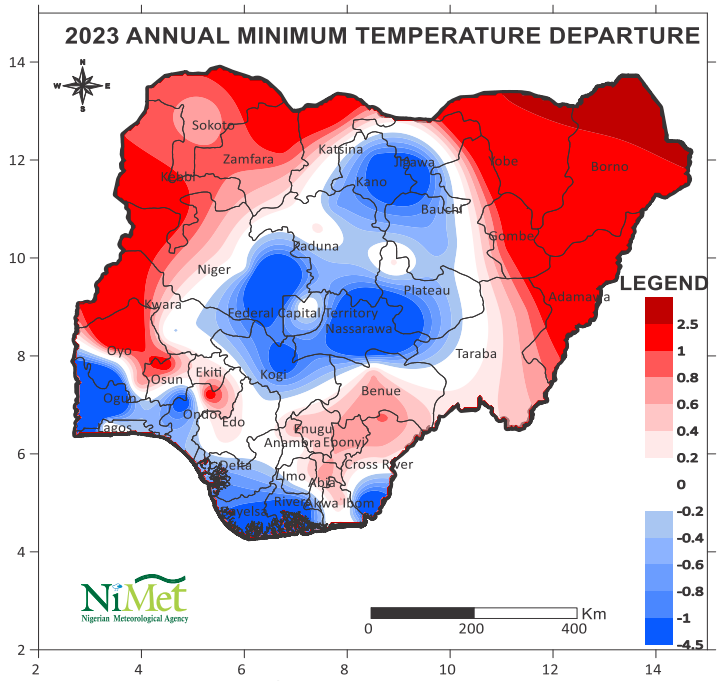


Figure 1.8: Annual Minimum Temperature Departure

1.2.5.2. Annual Mean Temperature Departure (Deviation from Long-term Average)

The mean departure of both the maximum and minimum temperatures from the long-term average is depicted in Figure 1.9. It shows that both maximum and minimum temperatures were generally warmer than their long-term mean over most parts of the country except parts of Nasarawa, Ogun and Jigawa states which are cooler than their long-term averages.

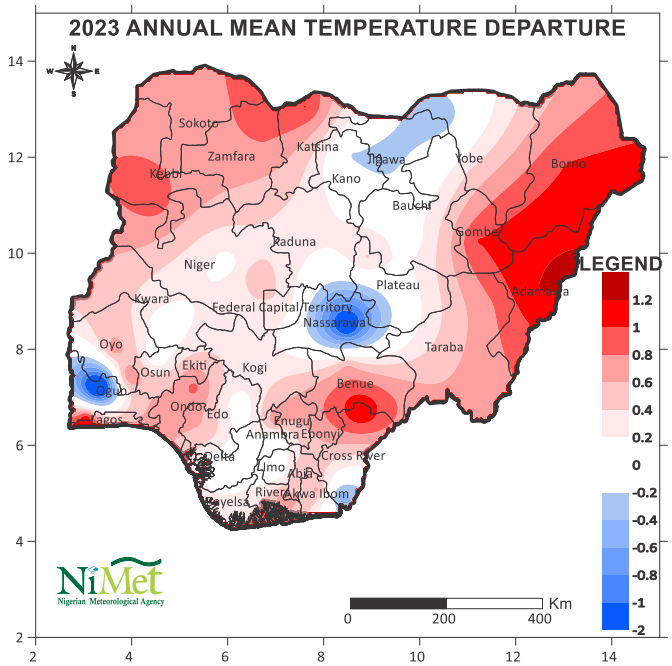


Figure 1.9: 2023 Annual Mean Temperature Departure

1.2.6 Minimum Temperature and Cold Season

The cold season occurs in the months of December and January. It is the period when the country is predominantly under the influence of the cold dry north-easterly winds blowing from the Sahara Desert. Minimum temperatures are lowest within these two months and nights can be slightly chilly.

1.2.6.1 Cold season temperatures over the Northern cities

Minimum temperatures for 2023 cold season were significantly cooler than normal over Bauchi, Kano, Lafia, and Dutse. They were also significantly warmer over Yola, Maiduguri and Makurdi, the season recorded near-normal temperatures over the rest of the northern cities as shown in Figures 1.10 and 1.11. On the whole, a greater proportion of the Northern cities recorded a warmer-than-normal cold season. This agrees with the generally warmer than normal temperatures during the year

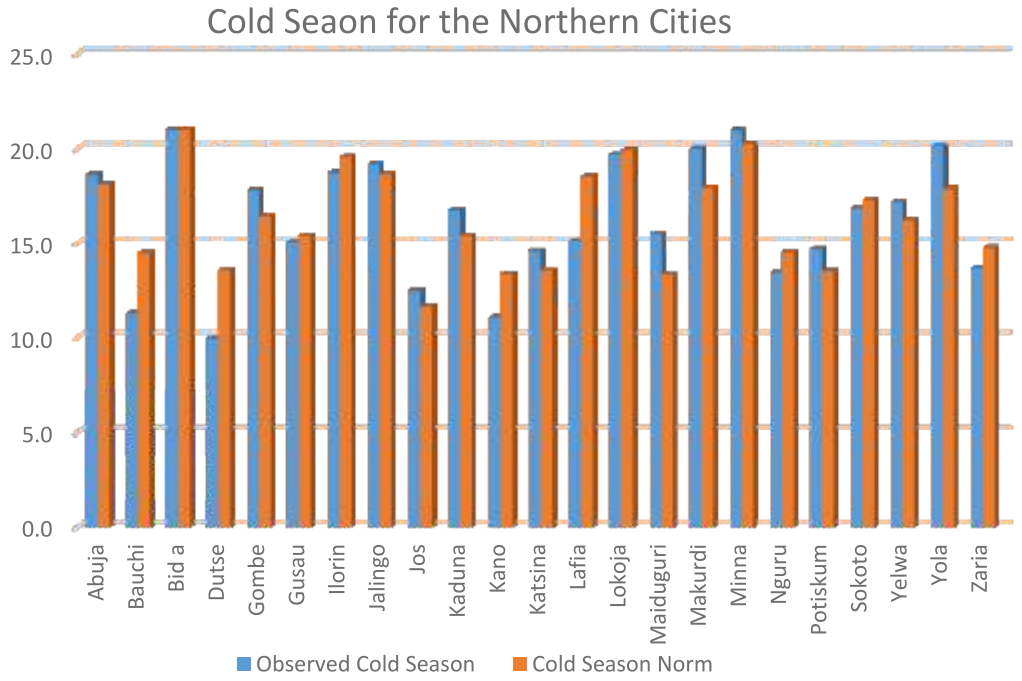


Figure 1.10: Cold season temperatures over the Northern cities in 2023

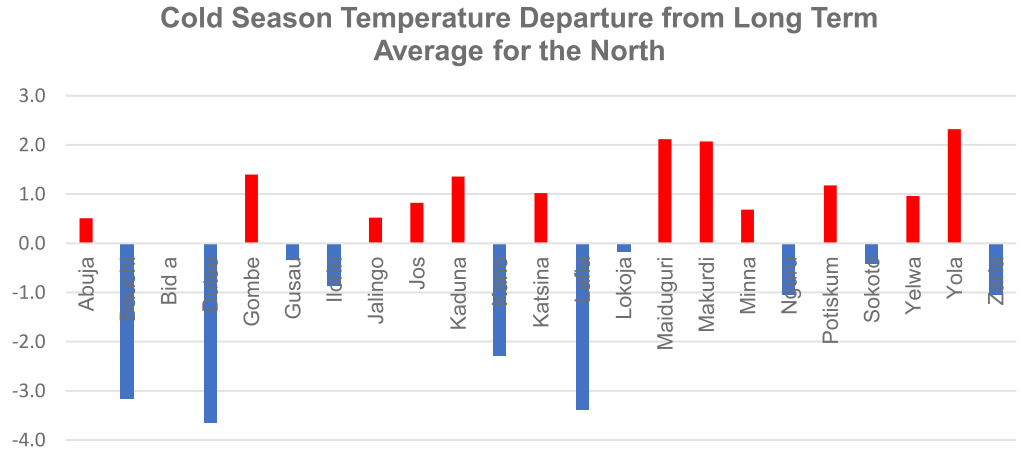


Figure 1.11: 2023 Cold Season Temperatures Departure over the Northern cities

1.2.6.2 Cold season temperatures over the Southern cities

Figures 1.12 and 1.13 show that temperatures during the cold season of 2023 in southern Nigerian cities were generally close to the long-term normal values, indicating a typical cold season overall. However, in some cities, temperatures deviated significantly from their historical averages. Abeokuta was notably cooler than its long-term mean, while Lagos roof located in Lagos Island was significantly warmer than its average cold season temperature.

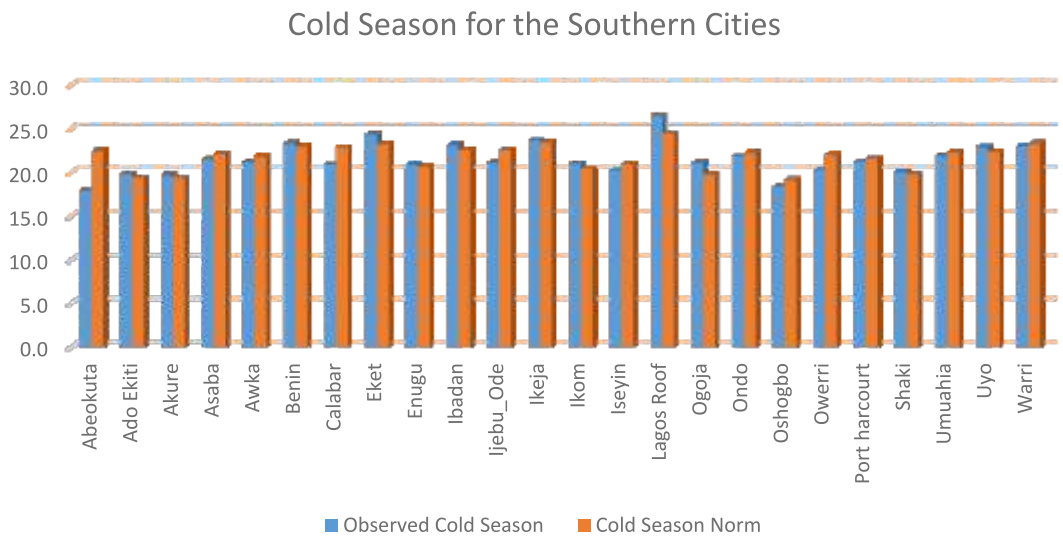


Figure1.12: 2023 Cold season temperatures over the Southern cities

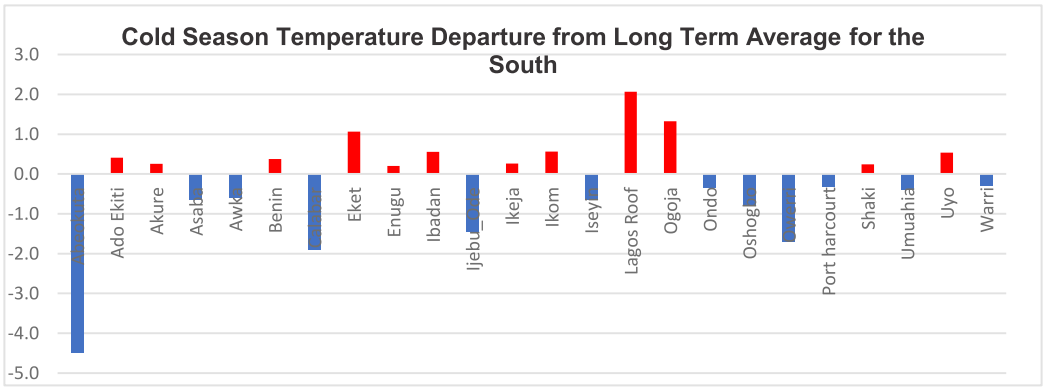


Figure 1.13: 2023 Cold season temperatures departure from long term average over the Southern cities

1.3 Rainfall

1.3.1 Cumulative annual rainfall

Cumulative rainfall amounts over Nigeria in 2023 ranged from 400 to 4200 mm; gradually increasing from north to south (Figure 1.14). The lowest value of 413.2 mm was recorded in Yobe state, while the highest amount of 4065.1 mm was recorded over Bayelsa state. Rainfall amounts were less than 1000mm in the northern states, while the central states recorded 1000 to 2200 mm, and southern parts of the country recorded 2200 to over 4000 mm. Overall, a distinct north-south gradient is evident, with the lowest rainfall totals in the north giving way to progressively higher amounts further south. This is a well-known pattern of rainfall distribution over Nigeria.

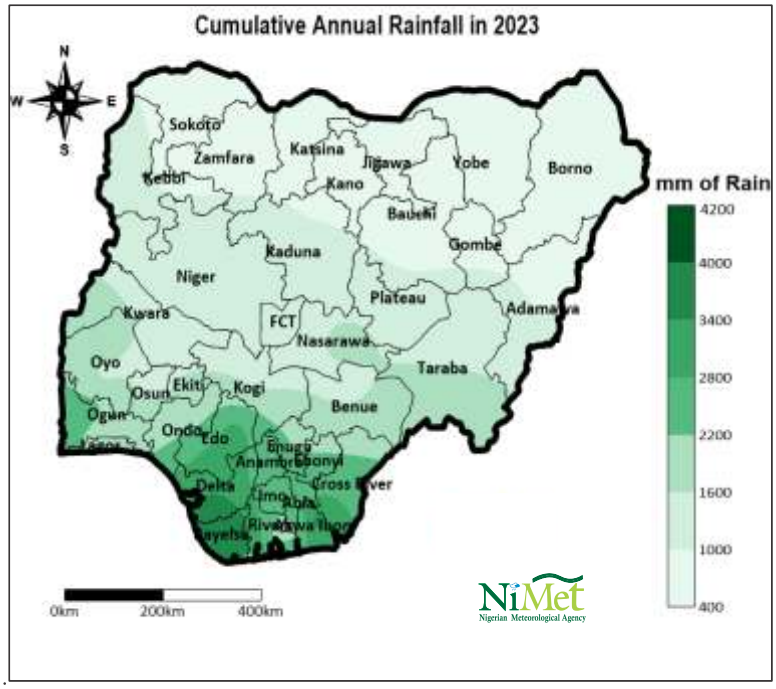


Figure 1.14: Cumulative annual rainfall over Nigeria in 2023

1.3.2 Cumulative Annual Rainfall Departure (Deviation from Long-term average) in 2023

In 2023, the deviation of cumulative annual rainfall from the long-term average (1991–2020) reveals that most parts of the country experienced above-average rainfall (positive departures). In Ogun, Akwa Ibom and Bayelsa states, the observed cumulative rainfall for the year was higher than the normal (i.e., 1991 to 2020 average) by more than 1000mm. However, Jigawa, Bauchi, Gombe, Kano, Zamfara, and River states observed below normal rainfall (negative departures of 100 to 500mm). The rest of the country experienced normal rainfall conditions as shown in Figure 1.15a.

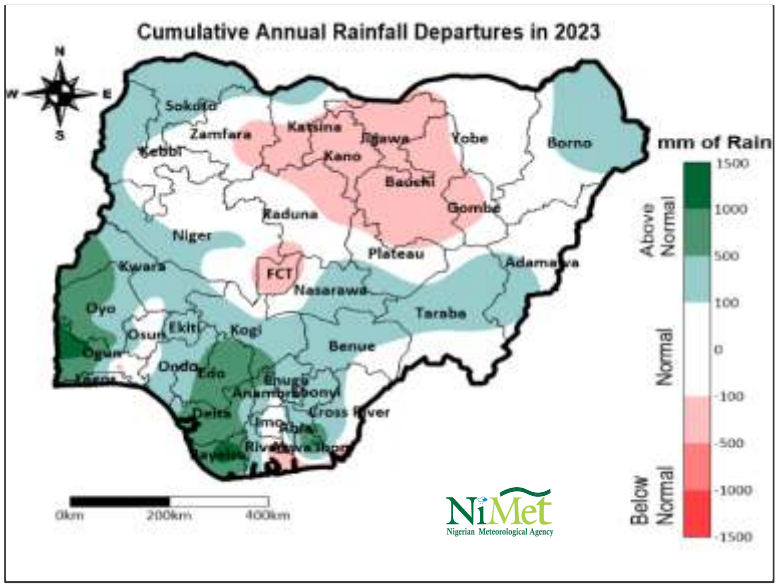


Figure 1.15a: Cumulative Annual Rainfall Departures in 2023

Figure 1.15b shows a comparison of the percentage difference between the long-term (1991 to 2020) average and the observed cumulative rainfall across Nigeria for 2023. The observed cumulative rainfall difference during the 2023 rainfall season indicates surplus (above normal) rainfall of 92% and 82% increase over the cities of Abeokuta and Shaki in Ogun and Oyo states respectively. Other notable above-normal cumulative rainfall was over Uyo (49%), Asaba (48%), Katsina (47%), Yenagoa (44%), Ibadan (41%), Sokoto (37%), Ikeja (35%), Enugu (32%) and Lafia (30%). However, rainfall deficit (i.e., below normal) when compared to the long-term average was recorded over the cities of Abuja (-27%), Gusau (-20%), Kano (-29%), Dutse (-27%), Bauchi (-34%), Nguru (-21%), Zaria (-22%), Gombe (-14%), and Port Harcourt (-13%). The rest of the country observed normal rainfall conditions.

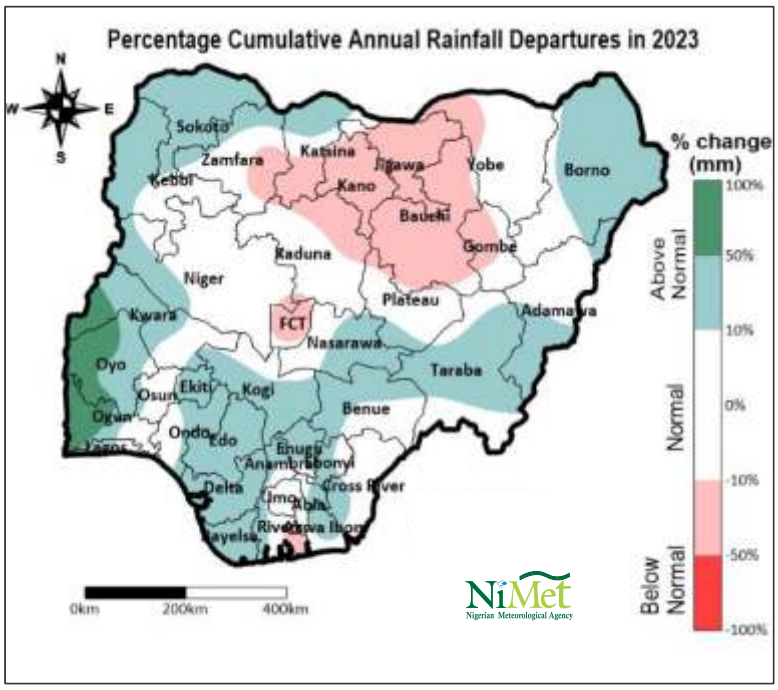


Figure 1.15b: Percentage Cumulative Annual Rainfall Departures from Long term Average in 2023

1.3.3 Number of Rain-days in 2023

The term "rain day" is used to denote a day on which a station has recorded measurable rainfall up to 0.3 mm or more. Cross River (Calabar) in the South recorded the highest number of rain days (187days) while Yobe (Nguru) recorded the least number of 34 rain days. The number of rain-days between 30-70 days were observed over the extreme northern states, while rain-days of between 70-110 days were observed over the central states. The southern parts of the country recorded rain-days of between 130 and 190 days as shown in Figure 1.16.

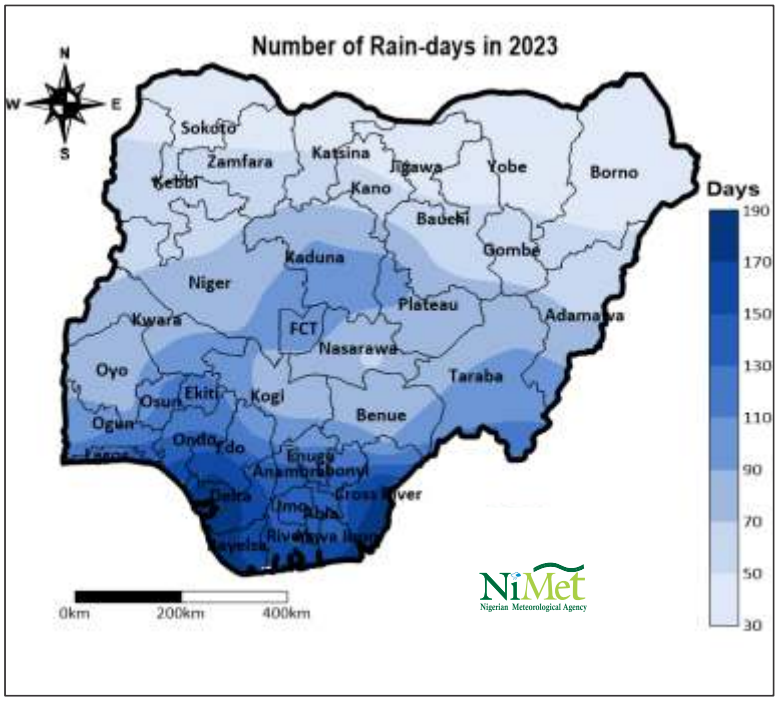


Figure 1.16: Number of rain days over Nigeria 2021

1.3.4 Number of Rain-Days Departures in 2023

Figure 1.17 below presents the analysis of rain-days departure from normal (1991-2020). Most parts of the country (over 70% of cities considered for this analysis cutting across north to south) observed a decrease in the number of rain days compared to normal. However, Kogi, Lagos, Ondo, Edo, Delta, Anambra, Cross Rivers, and Taraba states observed an increase in number of rain-days compared to the normal. The remaining parts of country observed normal rain-days. The highest positive departure of 26 days was recorded over Ado Ekiti while the lowest negative departure of (-25) days was recorded over Ogoja.

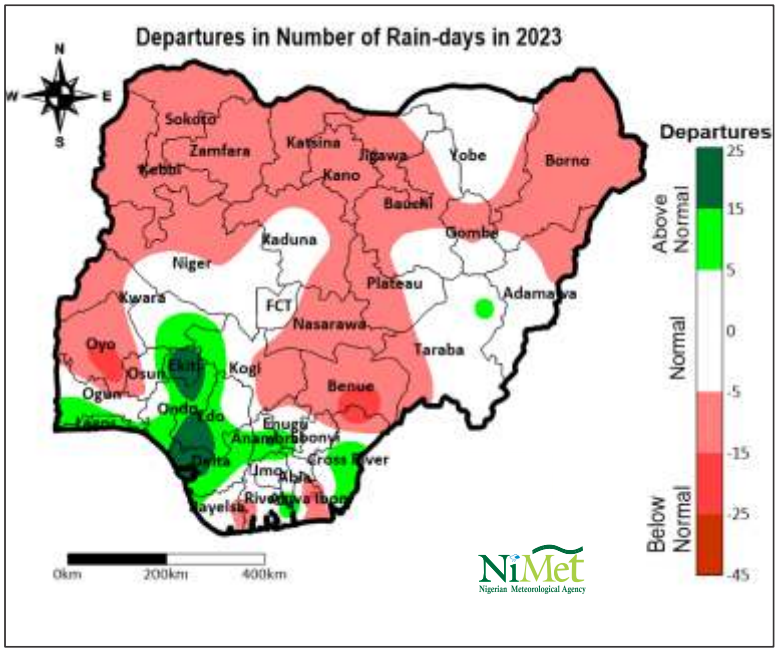


Figure 1.17: Number of Rain-Days Departures in 2023

1.3.5 Cumulative August Rainfall in 2023

As shown in Figure 1.18, illustrates the country rainfall totals for August 2023, ranging from 50 to 500 mm were recorded across the country in August 2023. The lowest rainfall range between 50 and 200 mm was recorded over the southwest, parts of Benue, and Niger states. As the month coincides with the mid-summer drought commonly known as Little Dry season in the southwest, vast portions of the country recorded rainfall between the ranges of 200mm to 400 mm in the month. The lowest and highest rainfall values of 59.8mm and 489.5mm were recorded over Lagos (Ikeja) and Delta (Asaba) respectively. The impact of the LDS was not significant in the year 2023 compared to previous years. Hence, cities within the southwest recorded more rainfall in August compared to the last two years.

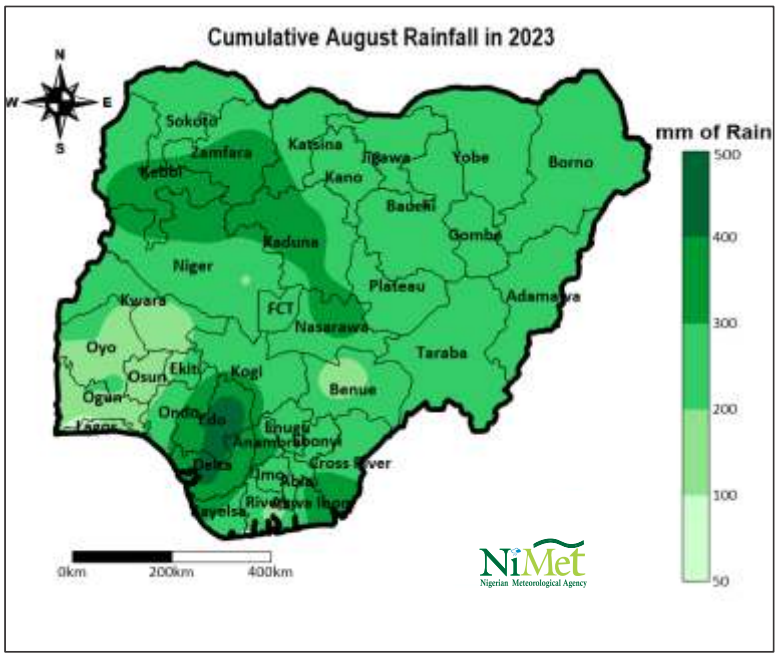


Figure 1.18: Cumulative August rainfall in 2023

1.3.6 Cumulative August Rainfall Departure (Deviation from Normal)

Figure 1.19a depicts a comparison of the difference between the observed 2023 cumulative August rainfall and the long-term average (1991–2020). The analysis shows positive departure (i.e., above normal) rainfall over parts of Borno, Taraba, Adamawa and the western flank of the country. Parts of the FCT, Kwara, Oyo, Benue, Bauchi, Gombe, Kano, Jigawa, Katsina, Yobe and inland and coastal parts of the southeast experienced negative departures from normal (below normal) rainfall. The remaining parts of the country observed normal rainfall amounts in the month of August which normally coincides with the peak of the rainy season in the north and the Little Dry season in the southwest. This period is also characterised by a general reduction in rainfall amount in the entire south of the country. However, in 2023, southwest recorded more rainfall and most parts of north observed deficit rainfall compared to their normal Figure 1.19b shows the percentage deviation of August rainfall from normal.

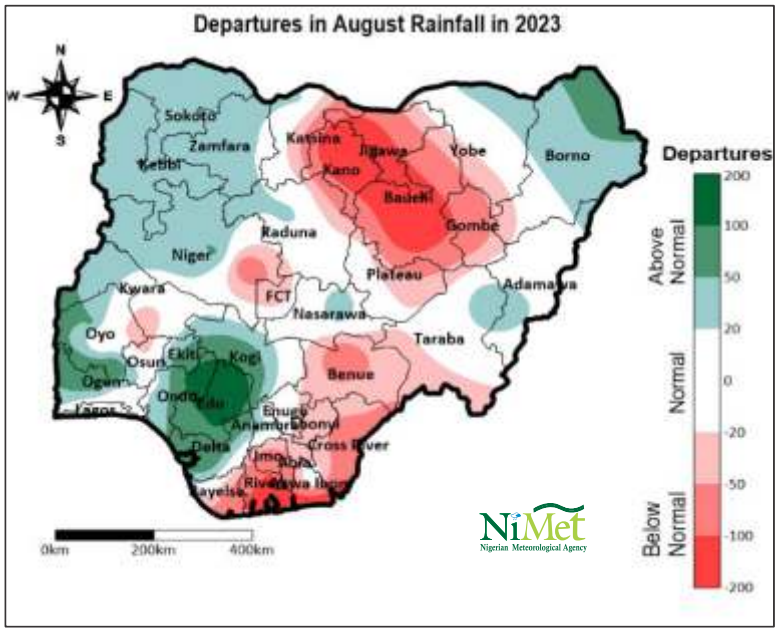


Figure 1.19a: 2023 August Rainfall Departure (Deviation from Long term Average)

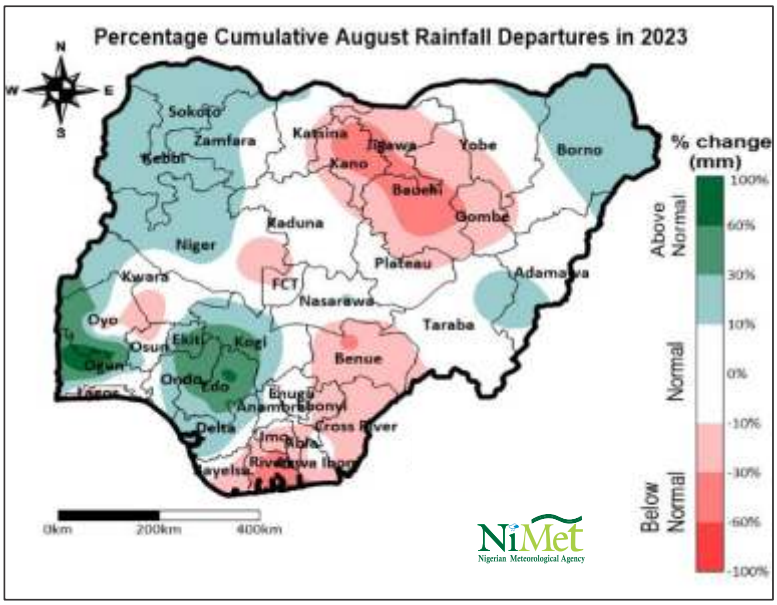


Figure 1.19b: Percentage Cumulative August Rainfall Departure in 2023

1.3.7 Standardized Rainfall Anomaly

The Standardized Precipitation Index (SPI) over Nigeria in 2023 shows normal-to-above normal in most parts of the country, mostly around the South, while below normal rainfall was experienced over parts of Katsina, Kano, Plateau, Zamfara, Jigawa, Bauchi, Gombe, Yobe, Rivers states and the FCT as shown in Figure 1.20.

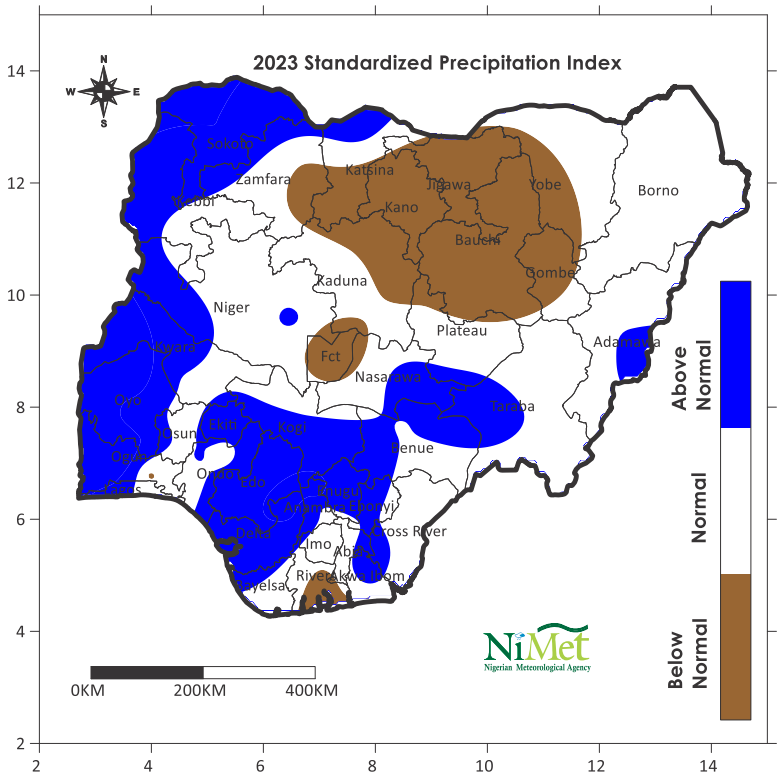


Figure 1.20: Standardized Rainfall Anomaly in 2023

1.3.8 Standardized August 2023 Rainfall Anomaly

In August 2023, rainfall across most of Nigeria was normal to above normal compared to historical averages. However, parts of several northern and southern states recorded below-average rainfall. Specifically, Katsina, Kano, Jigawa, Bauchi, Gombe, Yobe, Kaduna, Niger, Benue, Cross River, Rivers, Imo and Akwa Ibom states received lower rainfall amounts than their long-term August normal as shown in Figure 1.21.

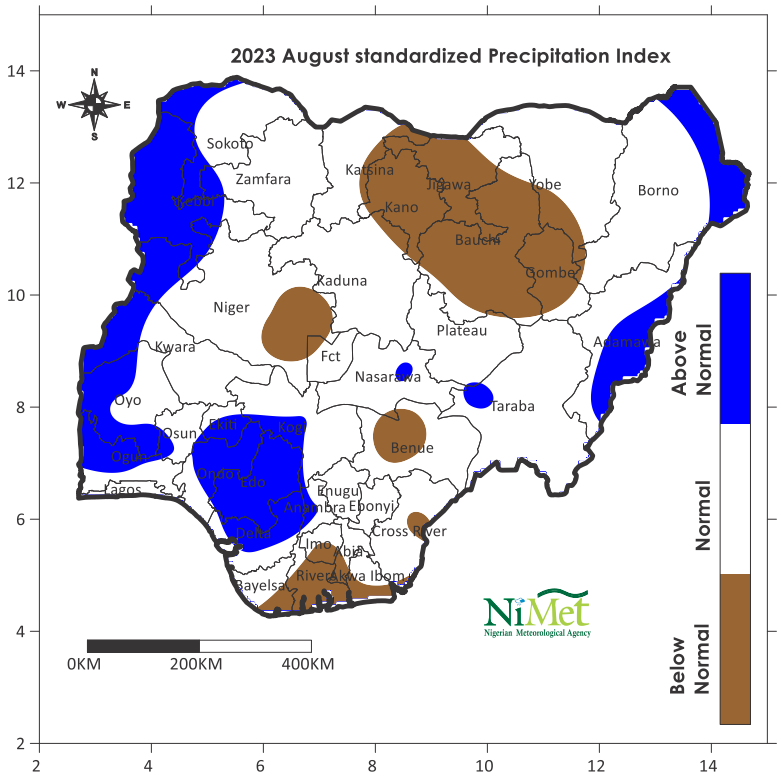
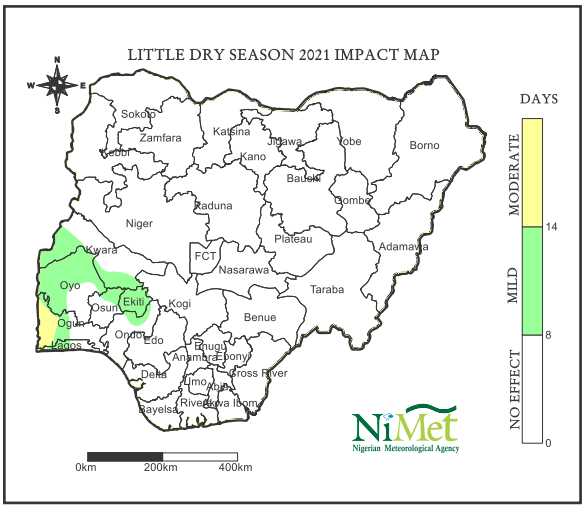
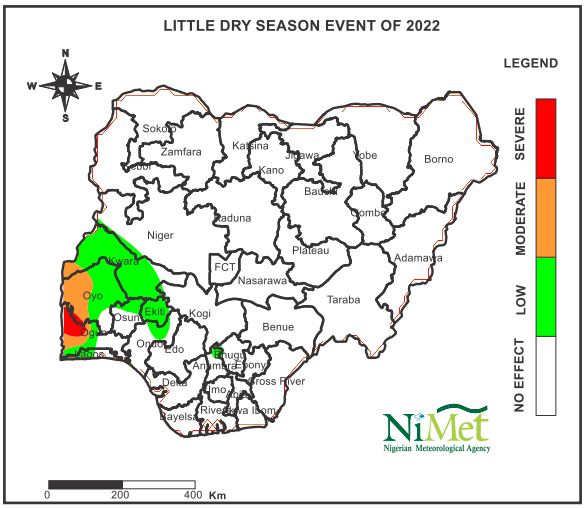


Figure 1.21: Standardized August Rainfall Anomaly in 2023

1.4 Little Dry Season 2023

The Little Dry Season (LDS) is a climatological phenomenon, which manifests itself as a decline in both the frequency and amount of daily rainfall halfway through the rainy season in the southwestern parts (4°–9°N and 3°–7°E) of the country. It usually characterized by a cool cloudy atmosphere. Little or no rains are usually recorded within this period hence the name 'Little dry season'. This event usually occurs between the month of July and August. Distinct variability in the intensity of this phenomenon can be observed looking at historical records, the variability in the event from 2021-2023 is shown in Figure 1.23. It shows that 2023 LDS was mild compared to last two preceding years. Most locations in the southwest recorded a maximum of 7 consecutive days of little or no rain in 2023 except Iseyin which recorded 9 consecutive days of little or no rain. Highlight of the event in 2023 is shown below according to reports from the observing stations.





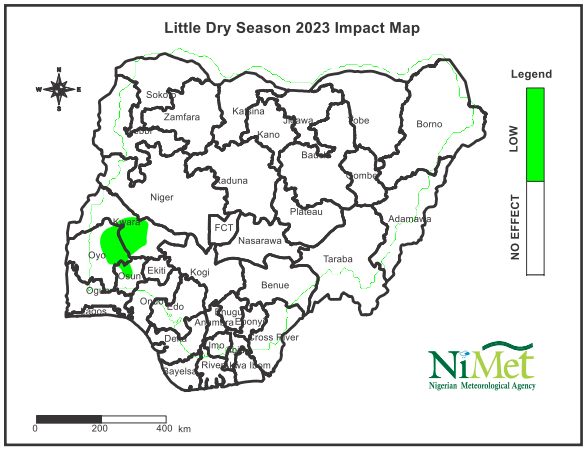


Figure 1.23: Little Dry season impact in 2023, compared to 2022 and 2021

Table 1.2: Comparison of the 2023 LDS with the two preceding years (2022 and 2021)

S/N	City	Date of Consecutive Dry Days in 2023	Number of dry days in 2023	Number of dry days in 2022	Number of dry days in 2021
1	Abeokuta	2 - 8 August	7	8, 24	10
2	Akure	Nill	0	9	10
3	Ikeja	2 – 14 August	13	10, 7, 12	21
4	Ijebu Ode	20 – 27 August	8	12	5
5	Iseyin	1 – 7 August	7	13, 9	14
6	Ondo	19 – 26 August	8	10	14
7	Oshogbo	2 – 8 August	7	9	9
8	Shaki	24 - 30 July	7	13, 10	12
9	Ibadan	2 – 8, & 17 – 23 August	7, 7	13, 12	6
10	Usi Ekiti	Nil	0	7	9

1.5 2023 Dry Spell Episode

A dry spell is defined as a period characterized by an extended lack of rain, a drawn-out period where the weather has been dry, for an abnormally long time. Dry spells are usually shorter than, and not as severe as a drought. Figure 1.24 shows that severe dry spell episodes were experienced in parts of Borno, Bauchi, and Yobe states in July and August 2023. Moderate dry spell was experienced over Zamfara, Sokoto, Jigawa, Kano, Katsina, Kebbi, Plateau, Adamawa, Nasarawa, Kogi, Benue, Kwara and Oyo in July. However, the effect of the 2023 dry spell was mild over the remaining parts of the country.

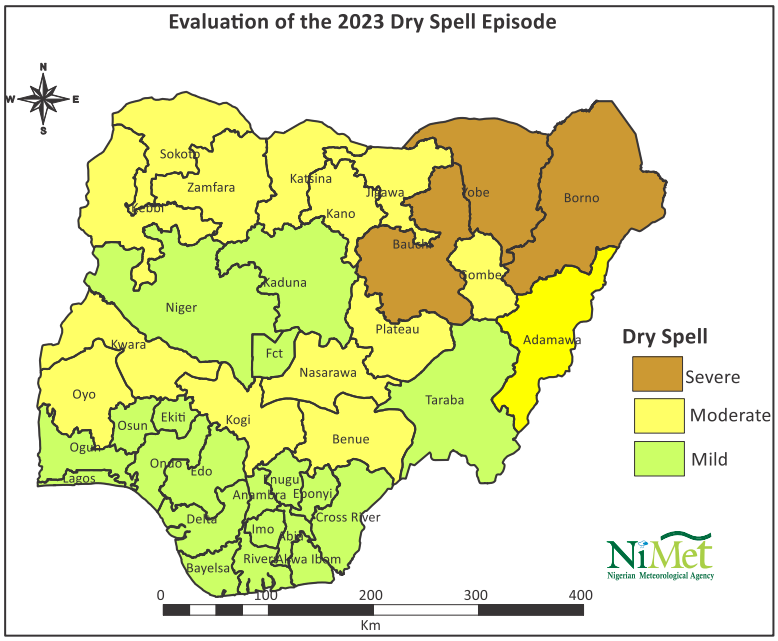


Figure 1.24: Spatial distribution of mild, moderate, and severe dry spells over Nigeria in 2023

CHAPTER TWO

2.0 SYSTEMATIC CHANGES OF CLIMATE PARAMETERS OVER NIGERIA

Some important climate parameters that are used in monitoring changes and variability in the climate over Nigeria are discussed in this chapter. A wide variety of meteorological parameters are available for this purpose. However, temperature and precipitation are deemed to be the most relevant in all parts of the world. These two parameters are categorized as principal climatological surface parameters by the WMO[2]. 43 years of in-situ observation data of rainfall and temperature extracted from the database of the Nigerian Meteorological Agency (NiMet) were used for this analysis. These were taken from 47 meteorological stations with high-quality, consistent, and long-term records spread across Nigeria. Twenty three (23) of these stations are located in the north, while 24 are located in the south, thus providing enough information to carry out regional analyses. To provide a basis for comparison against recent and past observations, 1991-2020 climatological standard normal was used as the benchmark. The new reference period (1991-2020) has been adopted since 2021[3] based on the recommendation by the WMO to reflect changes in the recent climate.

2.1 Rainfall

The rainy season in Nigeria in 2023 was marked by rainfall-induced hazards, even though these were relatively lower than hazards recorded in 2022. High-intensity and high-frequency rainfall resulted in river overflows and flash floods in many parts of the country. The National Emergency Management Agency (NEMA) reported that as of October 2023, 157,159 people were affected country-wide, with 68,000 displaced as a result of flooding across the country[4].

2.1.1 The Standardized Rainfall Anomaly analysis over Nigeria for 2023

The standardized rainfall anomaly analysis over Nigeria in 2023 continues to be on an increasing trend. From the analysis, the Standardized Rainfall Anomaly over Nigeria for 2023 was 1.3 showing that 2023 was placed as the third wettest year in Nigeria since 1981. 2019 and 2012 were the wettest and the second wettest years in Nigeria since 1981, respectively (Figure 2.1, Table 2.1). Furthermore, except for 2021, 2015, and 2013, there have been consistently wet years in the country since 2006 (Table 2.1).

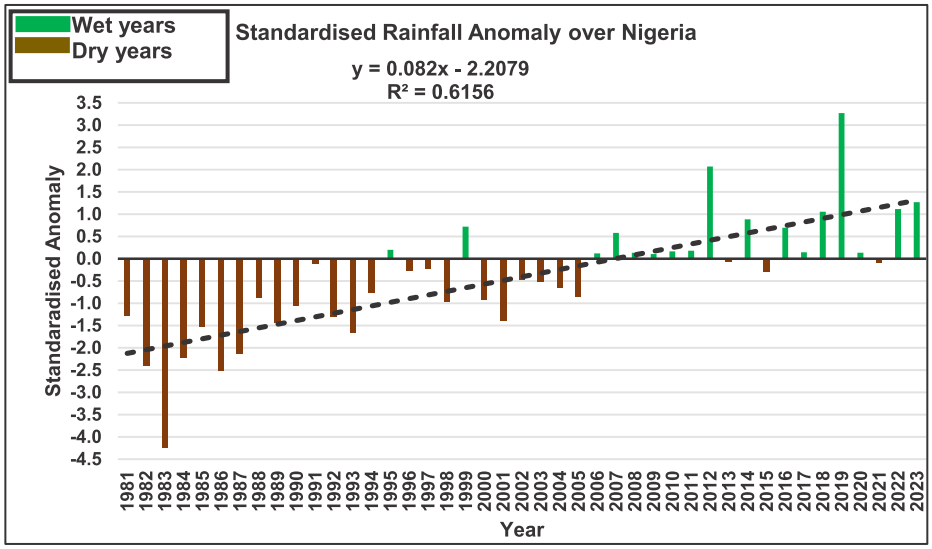


Figure 2.1: Standardised rainfall anomaly and trend over Nigeria for the period 1981-2023 based on data from 47 Meteorological stations and 1991-2020 Climatological Standard Normal

[2]World Meteorological Organization, 'Guidelines on the Calculation of Climate Normals (WMO-No. 1203). Geneva.', 2017

[4]Reliefweb https://reliefweb.int/report/nigeria/unicef-nigeria-humanitarian-situation-report-adamawa-flood-response-31-october-2023

A regional analysis of rainfall places the year 2023 as the most neutral year in northern Nigeria, with a standardised Rainfall anomaly of -0.06 since 1981 in this region.

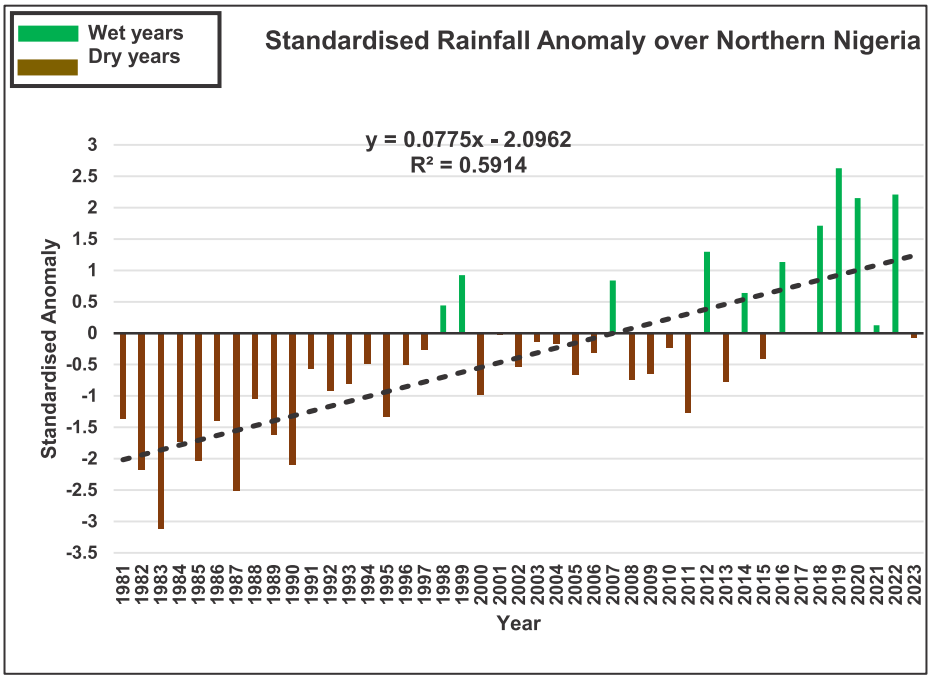


Figure 2.2: Standardised rainfall anomaly and trend over northern Nigeria for the period 1981-2023 based on data from 23 Meteorological stations and 1991-2020 Climatological Standard Normal

In the south, however, 2023 was the third wettest year since 1981 (Figure 2.2). The wettest year in the south remains 2019 and 2012 respectively (table 2.1). Moreover, there has been steady wetness in the south since 2006, except for the years 2015, 2020, and 2021.

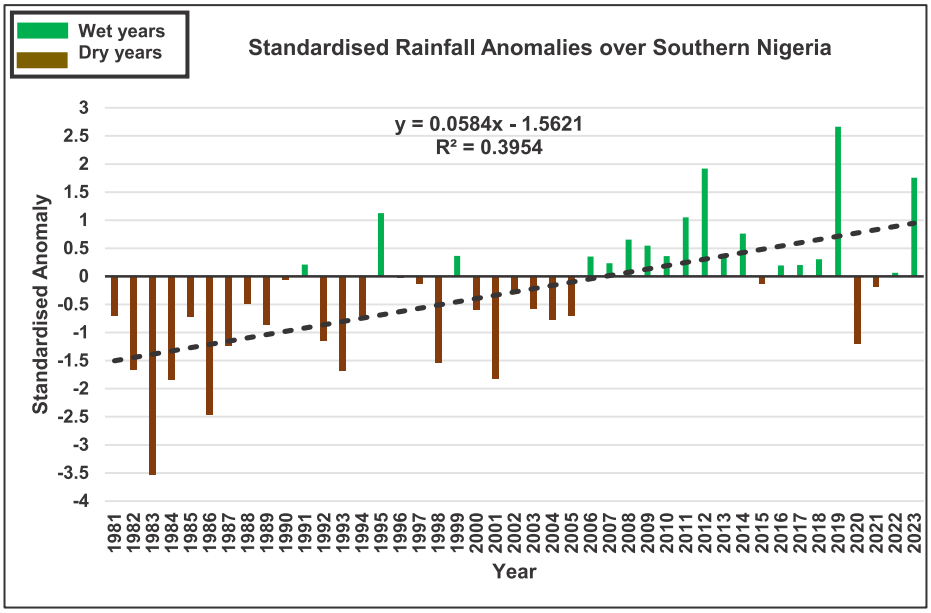


Figure 2.3: Standardised rainfall anomaly and trend over southern Nigeria for the period 1981-2023 based on data from 24 Meteorological stations and 1991-2020 Climatological Standard Normal

Table 2.1 Summary of the wet years and standardised rainfall anomalies from 1981-2023 ranked in descending order of wetness

NIGERIA		Northern Nigeria		Southern Nigeria	
Wet Years	Standardized Anomalies	Wet Years	Standardized Anomalies	Wet Years	Standardized Anomalies
2019	3.3	2019	2.6	2019	2.7
2012	2.1	2022	2.2	2012	1.9
2023	1.3	2020	2.2	2023	1.8
2022	1.1	2018	1.7	1995	1.1
2018	1.1	2012	1.3	2011	1.1
2014	0.9	2016	1.1	2014	0.8
1999	0.7	1999	0.9	2008	0.7
2016	0.7	2007	0.8	2009	0.5
2007	0.6	2014	0.6	2013	0.4
++++ 1995	0.2	1998	0.4	1999	0.4
2011	0.2	2021	0.1	2010	0.4
2010	0.2			2006	0.4
2017	0.1			2018	0.3
2020	0.1			2007	0.2
2008	0.1			1991	0.2
2006	0.1			2017	0.2
2009	0.1			2016	0.2
				2022	0.1

Table 2.2 Summary of the dry years and standardised rainfall anomalies from 1981-2023 ranked in descending order of dryness

NIGERIA		Northern Nigeria		Southern Nigeria	
Wet Years	Standardized Anomalies	Wet Years	Standardized Anomalies	Wet Years	Standardized Anomalies
1983	-4.2	1983	-3.1	1983	-3.5
1986	-2.5	1987	-2.5	1986	-2.5
1982	-2.4	1982	-2.2	1984	-1.8
1984	-2.2	1990	-2.1	2001	-1.8
1987	-2.1	1985	-2.0	1993	-1.7
1993	-1.7	1984	-1.7	1982	-1.7
1985	-1.5	1989	-1.6	1998	-1.5
1989	-1.4	1986	-1.4	1987	-1.2
2001	-1.4	1981	-1.4	2020	-1.2
1992	-1.3	1995	-1.3	1992	-1.2
1981	-1.3	2011	-1.3	1989	-0.9
1990	-1.1	1988	-1.1	2004	-0.8
1998	-1.0	2000	-1.0	1985	-0.7
2000	-0.9	1992	-0.9	2005	-0.7
1988	-0.9	1993	-0.8	1981	-0.7
2005	-0.8	2013	-0.8	1994	-0.7
1994	-0.8	2008	-0.7	2000	-0.6
2004	-0.7	2005	-0.7	2003	-0.6
2003	-0.5	2009	-0.6	1988	-0.5
2002	-0.5	1991	-0.6	2002	-0.3
2015	-0.3	2002	-0.5	2021	-0.2
1996	-0.3	1996	-0.5	2015	-0.1
1997	-0.2	1994	-0.5	1997	-0.1
1991	-0.1	2015	-0.4	1990	-0.1
2021	-0.1	2006	-0.3	1996	0.0
2013	-0.1	1997	-0.3		
		2010	-0.2		
		2004	-0.2		
		2003	-0.1		
		2023	-0.1		
		2001	0.0		
		2017	0.0		

2.2 Temperature

2.2.1 Maximum Temperature

The highest attainable air temperature recorded for each day is the maximum temperature for that day. Maximum temperature analysis was performed from 1981 to 2023. The analysis of maximum temperature data reveals a warming trend over Nigeria since 1981, with persistent warmer-than-normal years since 2015. The standardised maximum temperature anomaly of 3.1 places 2023 as the second warmest year after the year 2021, which is the warmest year so far in Nigeria since 1981 (Figure 2.5). It is worth mentioning that the last 9 years (2015-2023) are among the 10 warmest years observed. This is comparable to what was obtained globally by WMO, the mean temperature in 2023 is currently estimated to be 1.40 ± 0.12 °C above the 1850-1990 average and the last nine years (2015 to 2023) are likely to be the nine warmest years on record, with 2023 being the warmest[5].

The standardised maximum temperature anomaly of 2.9 was found over northern Nigeria (Table 2.4).

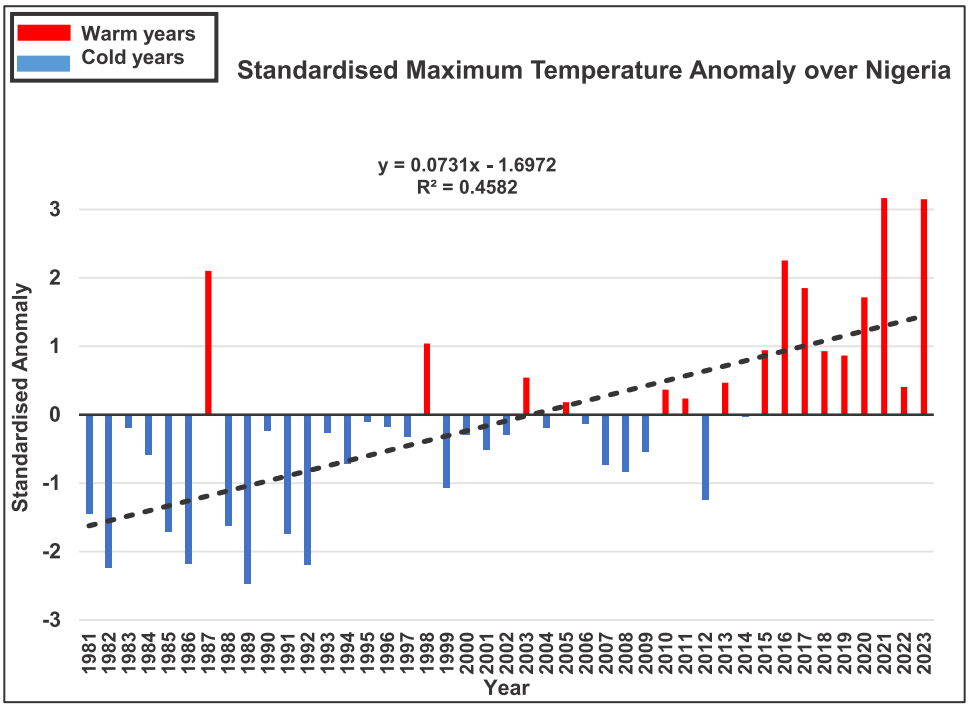


Figure 2.4: Standardised maximum temperature anomaly and trend over Nigeria for the period 1981-2023 based on data from 47 Meteorological stations and 1991-2020 Climatological Standard Normal

[5] World Meteorological Organization (WMO) and World Meteorological Organization (WMO), WMO Provisional State of the Global Climate 20223 WMO (Geneva: WMO, 2023).

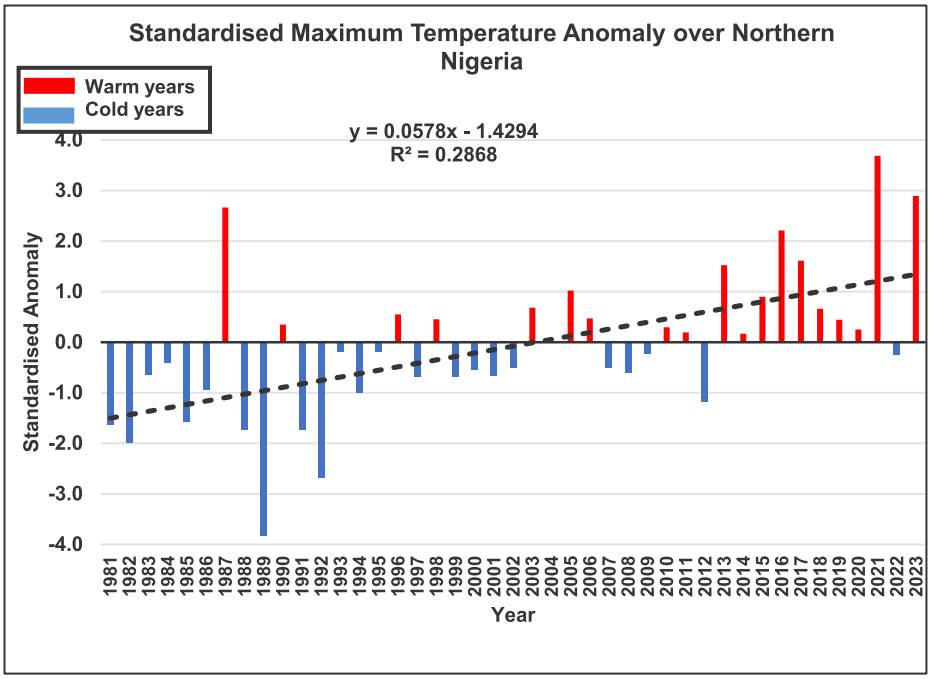


Figure 2.5: Standardised maximum temperature anomaly and trend over northern Nigeria for the period 1981-2023 based on data from 23 Meteorological stations and 1991-2020 Climatological Standard Normal

In the south, the standardised maximum temperature anomaly over southern Nigeria was found to be 2.8, making 2023 the warmest year in the south since 1981 (Figure 2.6). Moreover, the last nine (9) years (2015-2023) were among the 10 warmest years since 1981.

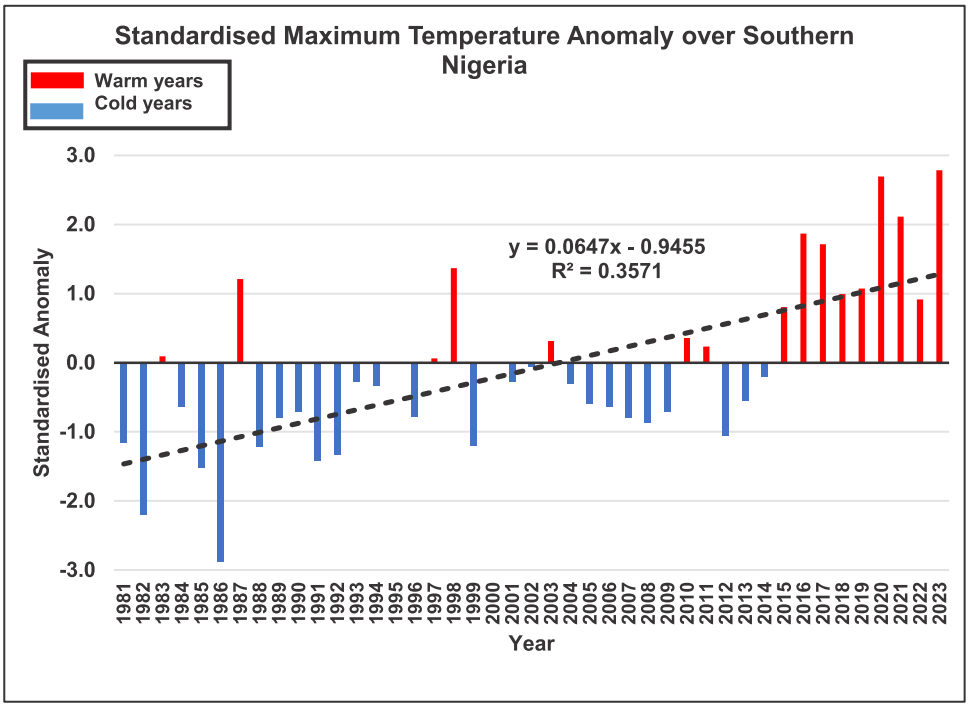


Figure 2.6: Standardised maximum temperature anomaly and trend over southern Nigeria for the period 1981-2023 based on data from 24 Meteorological stations and 1991-2020 Climatological Standard Normal

Table 2.3 Summary of the warm years and standardised maximum temperature anomalies from 1981-2023 ranked in descending order of warming

NIGERIA		Northern Nigeria		Southern Nigeria	
Warm Years	Standardized Anomalies	Warm Years	Standardized Anomalies	Warm Years	Standardized Anomalies
2021	3.2	2021	3.7	2023	2.8
2023	3.1	2023	2.9	2020	2.7
2016	2.3	1987	2.7	2021	2.1
1987	2.1	2016	2.2	2016	1.9
2017	1.8	2017	1.6	2017	1.7
2020	1.7	2013	1.5	1998	1.4
1998	1.0	2005	1.0	1987	1.2
2015	0.9	2015	0.9	2019	1.1
2018	0.9	2003	0.7	2018	1.0
2019	0.9	2018	0.7	2022	0.9
2003	0.5	1996	0.6	2015	0.8
2013	0.5	2006	0.5	2010	0.4
2022	0.4	1998	0.5	2003	0.3
2010	0.4	2019	0.4	2011	0.2
2011	0.2	1990	0.3	1983	0.1
2005	0.2	2010	0.3	1997	0.1
		2020	0.3		
		2011	0.2		
		2014	0.2		

Table 2.4 Summary of the cold years and standardised maximum temperature anomalies from 1981-2023 ranked in descending order of cooling

NIGERIA		Northern Nigeria		Southern Nigeria	
Cold Years	Standardized Anomalies	Cold Years	Standardized Anomalies	Cold Years	Standardized Anomalies
1989	-2.5	1989	-3.8	1986	-2.9
1982	-2.2	1992	-2.7	1982	-2.2
1992	-2.2	1982	-2.0	1985	-1.5
1986	-2.2	1991	-1.7	1991	-1.4
1991	-1.7	1988	-1.7	1992	-1.3
1985	-1.7	1981	-1.6	1988	-1.2
1988	-1.6	1985	-1.6	1999	-1.2
1981	-1.5	2012	-1.2	1981	-1.2
2012	-1.2	1994	-1.0	2012	-1.1
1999	-1.1	1986	-0.9	2008	-0.9
2008	-0.8	1999	-0.7	2007	-0.8
2007	-0.7	1997	-0.7	1989	-0.8
1994	-0.7	2001	-0.7	1996	-0.8
1984	-0.6	1983	-0.6	1990	-0.7
2009	-0.5	2008	-0.6	2009	-0.7
2001	-0.5	2000	-0.5	2006	-0.6
1997	-0.3	2002	-0.5	1984	-0.6
2002	-0.3	2007	-0.5	2005	-0.6
2000	-0.3	1984	-0.4	2013	-0.6
1993	-0.3	2022	-0.3	1994	-0.3
1990	-0.2	2009	-0.2	2004	-0.3
1983	-0.2	1995	-0.2	2001	-0.3
2004	-0.2	1993	-0.2	1993	-0.3
1996	-0.2	2004	0.0	2014	-0.2
2006	-0.1			2002	-0.1
1995	-0.1			1995	0.0
2014	0.0			2000	0.0

2.2.2 Minimum temperature

Similar to the maximum temperature in Nigeria, the minimum temperature is also characterized by a positive trend. However, the observed minimum temperature in 2023 is slightly above 1991-2020 climatological standard normal. The minimum temperature has not gone below the climatological normal since 2009. In the north, the minimum temperature was slightly above the climatological normal in 2023, with a standardized minimum temperature anomaly of 0.7. Furthermore, there has been steady increase in minimum temperature since 2001 in northern Nigeria. A similar warming trend in minimum temperature has been observed in southern Nigeria. This warming has been consistent since 2001.

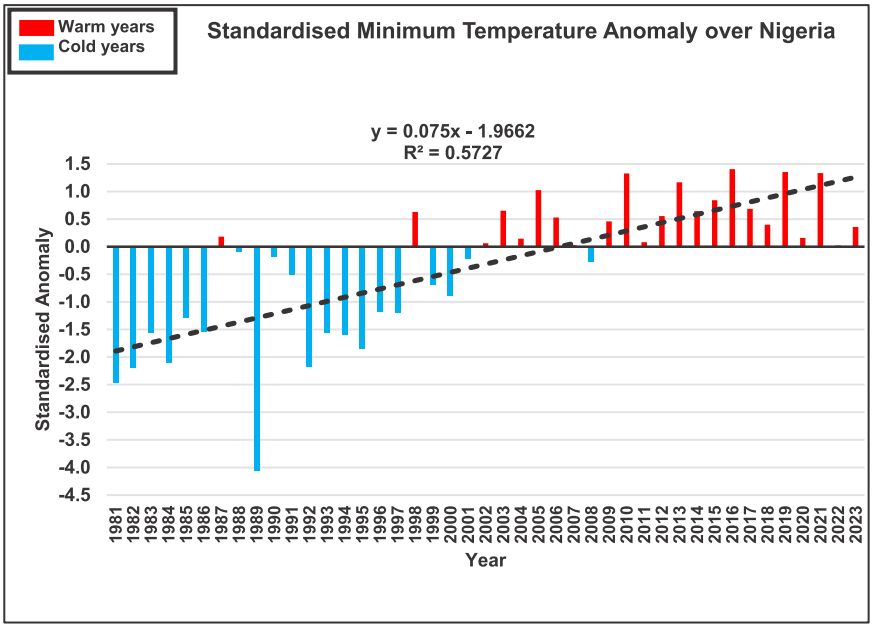


Figure 2.7: Standardised minimum temperature anomaly and trend over Nigeria for the period 1981-2023 based on data from 47 Meteorological stations and 1991-2020 Climatological Standard Normal

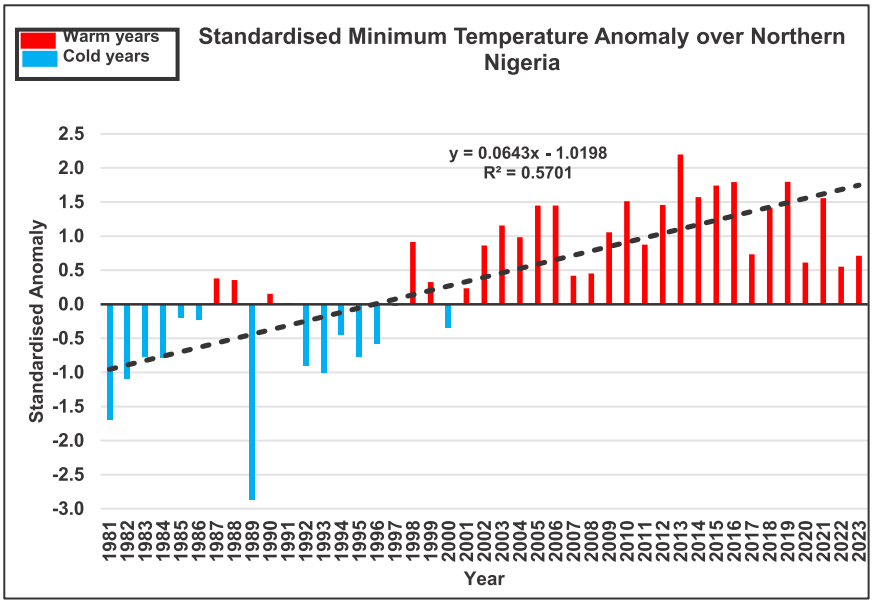


Figure 2.8: Standardised minimum temperature anomaly and trend over northern Nigeria for the period 1981-2023 based on data from 23 Meteorological stations and 1991-2020 Climatological Standard Normal

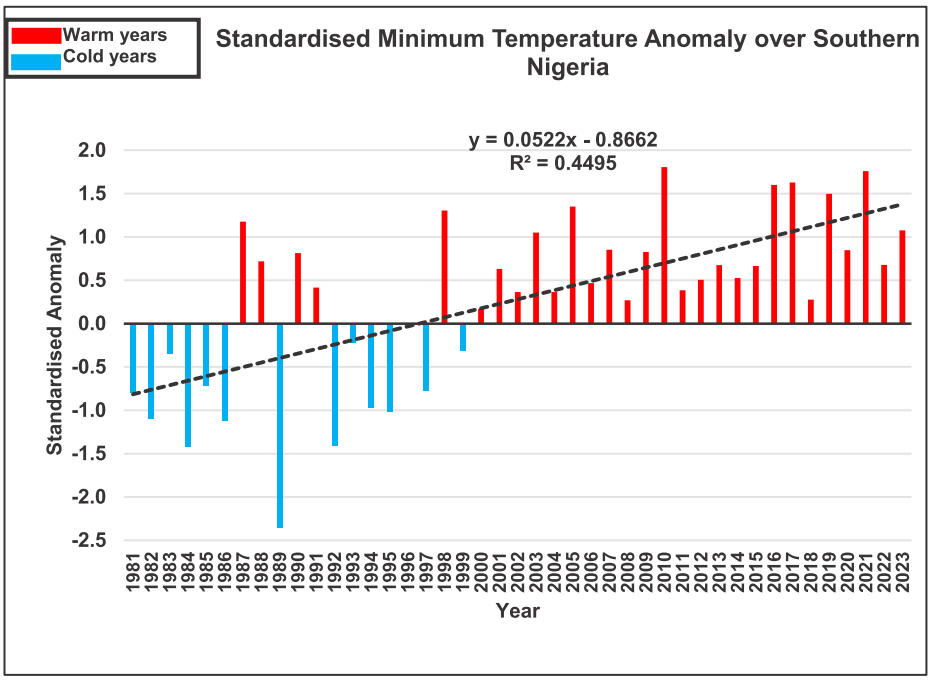


Figure 2.9: Standardised minimum temperature anomaly and trend over southern Nigeria for the period 1981-2023 based on data from 24 Meteorological stations and 1991-2020 Climatological Standard Normal

Table 2.5 Summary of the warm years and standardised minimum temperature anomalies from 1981-2023 ranked in descending order of warming

NIGERIA		Northern Nigeria		Southern Nigeria	
Warm Years	Standardized Anomalies	Warm Years	Standardized Anomalies	Warm Years	Standardized Anomalies
2016	1.4	2013	2.2	2010	1.8
2019	1.4	2019	1.8	2021	1.8
2021	1.3	2016	1.8	2017	1.6
2010	1.3	2015	1.7	2016	1.6
2013	1.2	2014	1.6	2019	1.5
2005	1.0	2021	1.6	2005	1.4
2015	0.8	2010	1.5	1998	1.3
2017	0.7	2012	1.5	1987	1.2
2003	0.7	2006	1.4	2023	1.1
2014	0.6	2005	1.4	2003	1.1
1998	0.6	2018	1.4	2007	0.9
2012	0.6	2003	1.2	2020	0.8
2006	0.5	2009	1.1	2009	0.8
2009	0.5	2004	1.0	1990	0.8
2018	0.4	1998	0.9	1988	0.7
2023	0.4	2011	0.9	2022	0.7
1987	0.2	2002	0.9	2013	0.7
2020	0.2	2017	0.7	2015	0.7
2004	0.1	2023	0.7	2001	0.6
2011	0.1	2020	0.6	2014	0.5
2002	0.1	2022	0.6	2012	0.5
2007	0.0	2008	0.5	2006	0.5
2022	0.0	2007	0.4	1991	0.4
		1987	0.4	2011	0.4
		1988	0.4	2002	0.4
		1999	0.3	2004	0.4
		2001	0.2	2018	0.3
		1990	0.2	2008	0.3
		1991	0.0	2000	0.2

Table 2.6 Summary of the cold years and standardised minimum temperature anomalies from 1981-2023 ranked in descending order of cooling

NIGERIA		Northern Nigeria		Southern Nigeria	
Cold Years	Standardized Anomalies	Cold Years	Standardized Anomalies	Cold Years	Standardized Anomalies
1989	-4.1	1997	0.0	1989	-2.4
1981	-2.5	1985	-0.2	1984	-1.4
1982	-2.2	1986	-0.2	1992	-1.4
1992	-2.2	2000	-0.4	1986	-1.1
1984	-2.1	1994	-0.4	1982	-1.1
1995	-1.8	1996	-0.6	1995	-1.0
1994	-1.6	1995	-0.8	1994	-1.0
1993	-1.6	1983	-0.8	1981	-0.8
1983	-1.6	1984	-0.8	1997	-0.8
1986	-1.5	1992	-0.9	1985	-0.7
1985	-1.3	1993	-1.0	1983	-0.4
1997	-1.2	1982	-1.1	1999	-0.3
1996	-1.2	1981	-1.7	1993	-0.2
2000	-0.9	1989	-2.9	1996	0.0
1999	-0.7				
1991	-0.5				
2008	-0.3				
2001	-0.2				
1990	-0.2				
1988	-0.1				

2.2.3 Diurnal Temperature Range

This section presents the time series of the Diurnal Temperature Range (DTR) over Nigeria from 1981-2023. DRT is the temperature difference between the minimum at night (low) and the maximum during the day (high). The DTR is considered to be an appropriate index for assessing climate change and variability[6]. Over the last 43 years, there has been observed decreasing trend in DTR over Nigeria. The highest variability is observed from the 1980s to the mid-1990s. However, a sharp decreasing trend is found from 1995 to 2012. Thereafter, a period of increasing trend occurred from 2013 to 2023, with dips in 2019 and 2022 (Figure 2.10). The DTR in 2023 was 11.2°C. This was 0.6°C higher than the 1991-2020 climatological average.

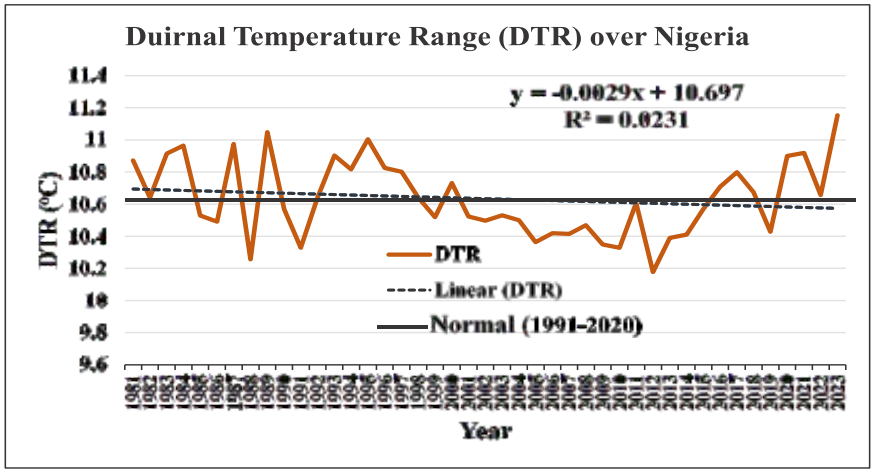


Figure 2.10: Diurnal temperature range (DTR) 1991-2020 climatological average and linear trend over Nigeria during the period 1981-2023 based on data from 47 Meteorological stations

A steeper DTR trend and similar pattern are observed over northern and southern Nigeria (Figures 2.11 and 2.12), compared to the entire country (Figure 2.10). Yet, an increase in DTR is also evident in 2023. With a value of 12.9°C, the DTR in 2023 is 0.6°C higher than the climatological normal for northern Nigeria.

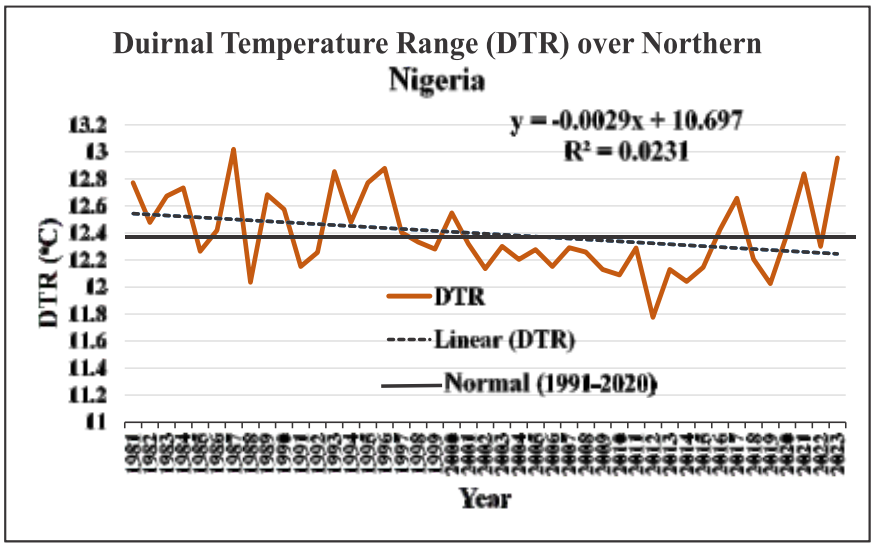


Figure 2.11: Diurnal temperature range (DTR), 1991-2020 climatological average and linear trend over northern Nigeria during the period 1981-2023 based on data from 23 Meteorological stations

[6]Karl Braganza, David J. Karoly, and J. M. Arblaster, Diurnal Temperature Range as an Index of Global Climate Change during the Twentieth Century, Geophysical Research Letters 31, no. 13 (2004), https://doi.org/10.1029/2004GL019998.

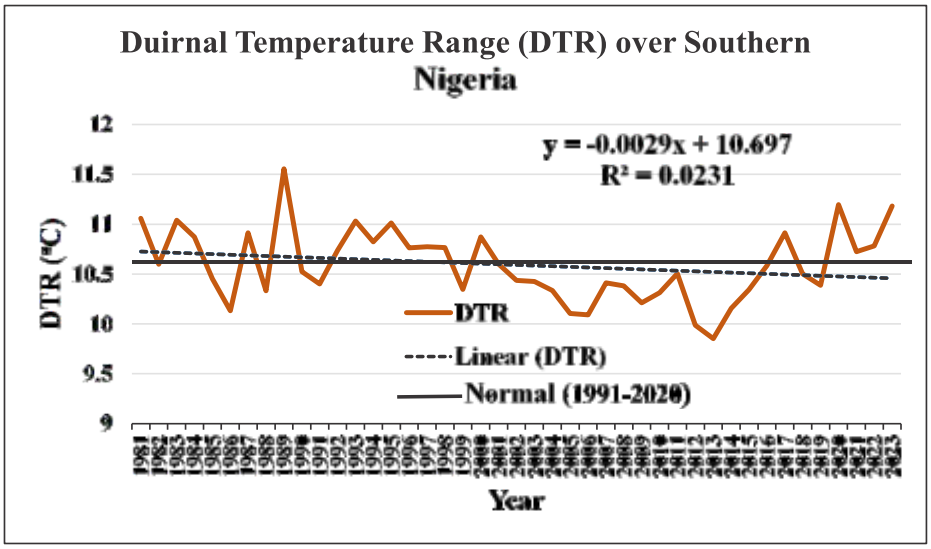


Figure 2.12: Diurnal temperature range (DTR) , 1991-2020 climatological average and linear trend over southern Nigeria during the period 1981-2023 based on data from 24 Meteorological stations

CHAPTER THREE

3.0 OBSERVED CLIMATE DRIVERS

3.1 Inter-Tropical Discontinuity (ITD)

The Inter-tropical Discontinuity (ITD) is the zone, where the moisture laden tropical maritime air mass (MT) from the Atlantic Ocean and dry-dusty tropical continental air mass (CT) from the Sahara Desert meet. Its annual north-south oscillations follow the apparent movement of the sun. This determines the prevailing weather in the country. The latitudinal position of ITD over the country determines the prevailing weather over a particular region within the country. Figure 3.1 depicts the decadal latitudinal positions of the ITD in 2023 compared with its normal (long-term average) position over Nigeria. The position of the ITD was far south early in the year, as shown in Figure 3.1.

However, from the third dekad of January through the third dekad of March, the ITD surged northward of its climatologically normal position. This enhanced moisture influx into the country which resulted in rainfall in the south and false onset of rainy season over many parts of the country during the period. The ITD gradually moved northwards in the second quarter of the year, in June and July, it was 2°N above its normal position (Figure 3.1). The early onset experienced in most parts of the north is attributed to this event. Above normal ITD position (about 1°N) was experienced between first dekad of August and third dekad of September. During the last quarter of the year, the ITD position oscillated north and south about its normal (long term average) position in the month October and November respectively. The ITD was observed to have reached its northernmost position of 19.7°N in August and September and thereafter it started to retreat southward. In the three dekads in December, the ITD was observed to be above north of its climatological mean positions. This explains the late cessation and more rainfall observed in the southern part of the country during the period.

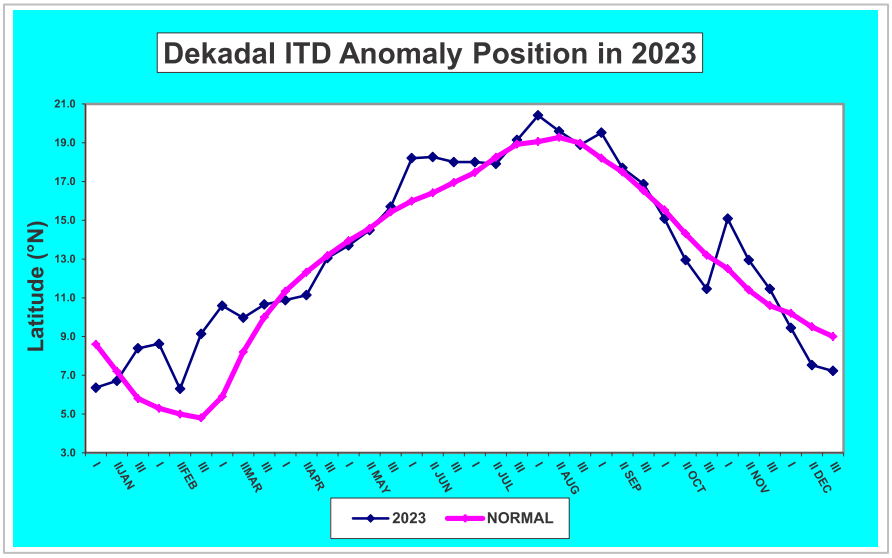


Figure 3.1: Dekadal latitudinal positions of the ITD in 2023 compared with climatological mean over Nigeria

The ITD latituidnal positon began its northwards migration from 8.0°N in March to attain its northernmost position in August before its again started southward retreat in September. The ITD position was at its peak in August at 19.7°N while the south most position of 7.2°N was reached in January 2023 as shown in Figure 3.2.

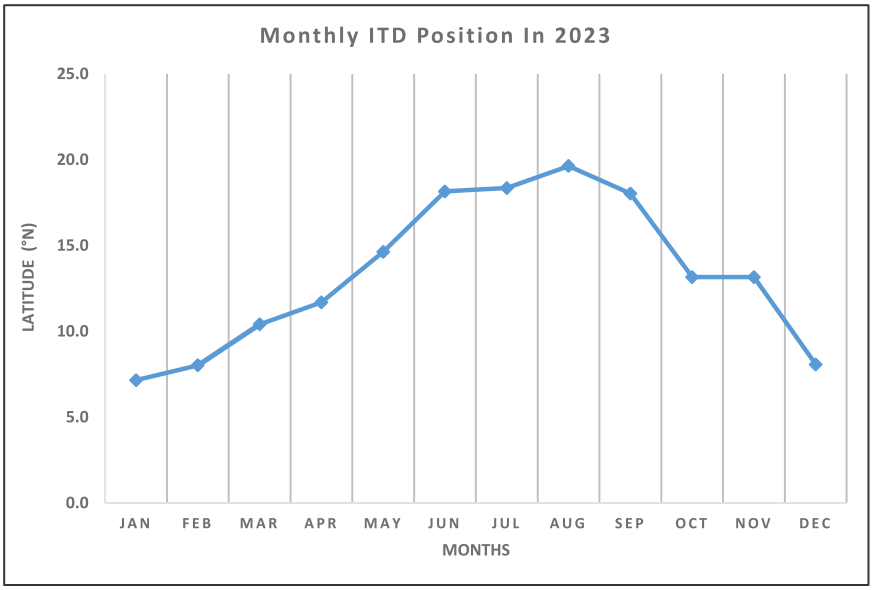


Figure 3.2: Monthly position of the ITD over Nigeria in 2023

Figure 3.3 shows the departure (i.e., deviation from long-term average) of the ITD position in each month of 2023. Above normal (i.e., northward displacement) positions of the ITD were observed in February, March, June, July, August, September, and November. However, below normal (i.e., southward displacement) position of the ITD occurred in the months of April, October, and December in the year. In January and May 2023, the ITD maintained the normal monthly positions. By implication, there was more incursion of the moisture-laden southwesterly winds, and consequently, more rains in those months when the ITD positions were above normal over the country.

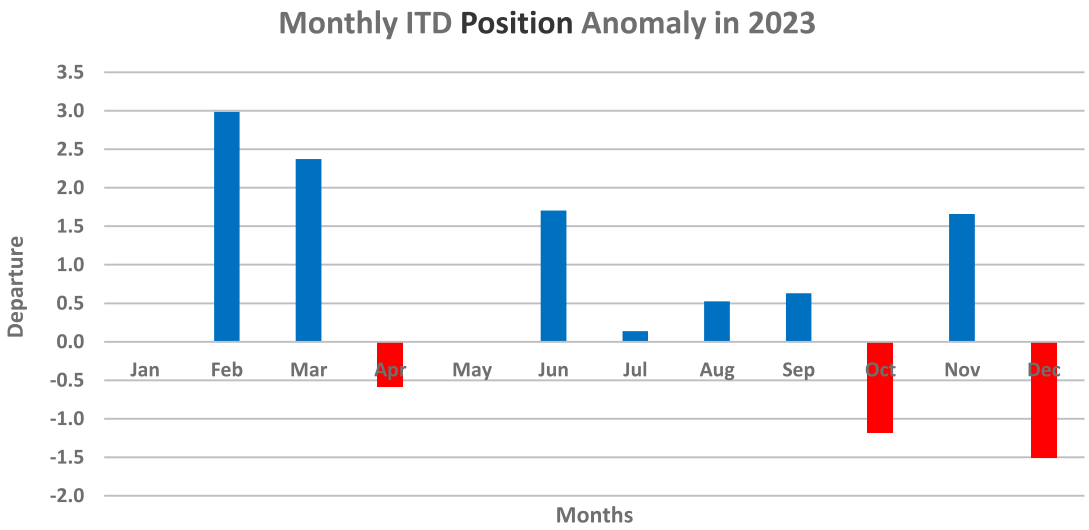


Figure 3.3: Monthly ITD Position Anomaly over Nigeria in 2023

3.2 Surface Pressures

The movement of moisture-laden southerly winds from the Atlantic Ocean and dry, dusty cold north-easterly winds from the Sahara Desert in the atmosphere over the country is determined by two subtropical high-pressure systems. These are the Southern Sub-Tropical High-Pressure Cell (St. Helena) and Northern Sub-Tropical High-Pressure Cell (Azores) respectively. There is an inverse relationship between both pressure systems (i.e. as the St. Helena high intensifies the Azores high weakens and vice versa). The average monthly values of both the Azores and St. Helena high pressure systems are depicted in Figure 3.4.

In the first quarter of 2023, the Azores High Pressure Cell located at about 30°N latitude, strengthened during this period, which is the dry season. The Figure showed that Azores high pressure cell was stronger than the St. Helena high pressure cell and attained peaked value of 1032hPa in January. Its intensification caused extension of large-scale deep ridges over West African sub-region. The subsidence caused by the ridges accounted for the raising of dust over the source regions in Niger and Chad Republic. The dust was then advected into the country by the north-easterly wind.The dust episodes of 2023 lasted till March. The persistence of the dust can be attributed to the persistence of high values of Azores pressure belt in the first quarter of the year.

During the second quarter, steady intensification of St. Helena high commenced and reached a peak value of 1036 hPa in July (Figure 3. 4). These led to increased influx of moisture into the country through south westerly wind trajectory and also increase in the frequency of convective activities. These events heralded the commencement of the rains over most of the country. The peak of rainy season was observed over the north during the third quarter of the year as the moisture laden south westerly winds transversed the entire country and penetrated deeper.

In the fourth quarter of the year, there was a noticeable reversal in the average monthly values of the St. Helena and Azores highs (Figure 3.4). This indicated the commencement of rainfall cessation. The cessation, which also signifies the beginning of the dry season, steadily progresses from the North in October to the South.

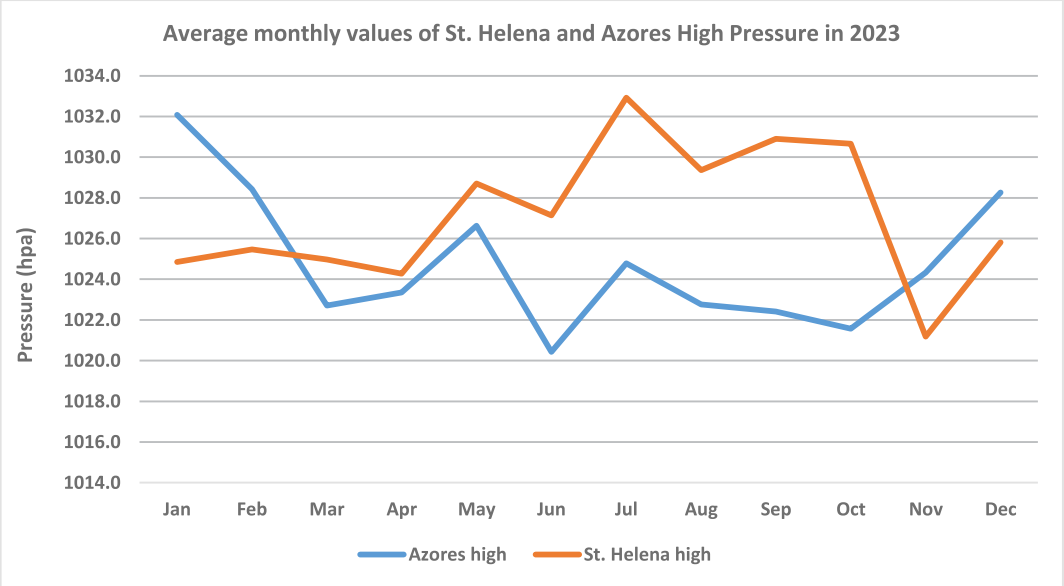


Figure 3.4: Average monthly values of Azores and St. Helena high pressure systems in 2023

3.3 Winds

Continental (CT) wind dominated the entire country in January and February 2023. The observed mean wind speed at 10 meters above Mean Sea Level Pressure (MSLP) ranged from 5 to 20 knots. During this period, at 925 hPa (900 m), the maritime and continental wind speeds varied from 5 to 35 knots and 5 to 15 knots, respectively. The prevalent winds at the surface and at 925 hPa aid the transport of dust from the Sahara Desert into the northern parts and later to the south, during the month of January and February. This resulted in considerable reduction in the horizontal visibility.

In March, the continental winds ranged in speed from 10 to 15 knots at 925 hPa, while the maritime winds ranged from 10 to 35 knots. The rains observed in this month were associated with strong maritime winds which assisted in bringing more moisture from the Atlantic Ocean into the country. The predominant winds at 850 hPa were continental winds, with speed ranging from 10 to 35 knots.

Later into the year, from April to October, average winds of 5 to 10 knots maritime winds were observed on more days than continental winds. Most of the winds were maritime, ranging from 5 to 30 knots at 925 hPa. Nonetheless, simultaneous observations of continental and maritime winds were recorded throughout the country at 850 hPa. At 925 and 850hpa levels, the monsoon trough was observed to be oscillating between 15.0°N and 23.0°N. In November, strong and dust-laden north-easterly winds originating from the Sahara Desert increasingly prevailed, signalling the onset of the Harmattan season across northern parts of the country. However, coastal cities of the country more frequently experienced milder maritime winds from the ocean during this period.

3.4 GLOBAL & REGIONAL TELECONNECTION

3.4.1 OCEANIC NINO INDEX (ONI)

Oceanic Nino Index is a primary indicator for monitoring the ocean part of the seasonal climate pattern called El Nino Southern Oscillation (ENSO). Oceanic Nino Index tracks the 3-month average Sea Surface Temperature (SST) in the east central Tropical Pacific between 120-1700W near the international dateline. El Niño is the warm phase of ENSO and occurs when sea surface temperatures in the key Nino 3.4 region of the

east-central Tropical Pacific exceed 0.5°C above average, as measured by the Oceanic Niño Index (ONI). This indicates a warming of at least 0.5°C compared to the long-term average in the Nino 3.4 zone bounded by 5°N-5°S, 120°-170°W. Conversely, La Niña (the cold phase of ENSO) exist when the ONI drops to 0.5°C below average or cooler, signaling a cooling in the same Tropical Pacific region. A neutral state resides between El Niño and La Niña thresholds, from -0.4 to 0.4°C ONI variation.

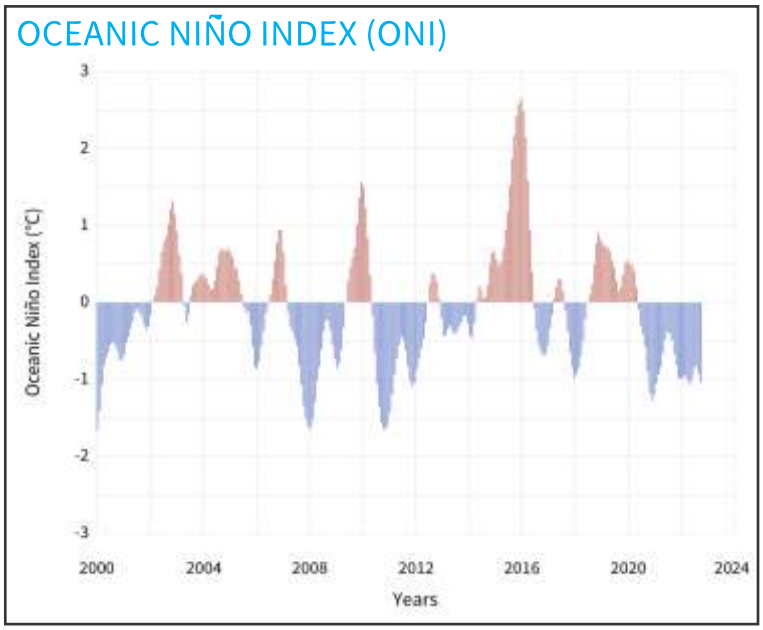


Figure 3.5: Oceanic Nino Index (Sea Surface Temperature Anomaly)[7]

3.4.2 ENSO PROJECTION

El-Nino/La-Nina Southern oscillation is one of the most important indicators in climate prediction globally. It occurs naturally and it is caused by changes in atmospheric dynamics and varying ocean temperatures in central and eastern equatorial pacific. In 2023, the year started with strong El Nino in April till December. El Nino is expected to continue through Northern hemisphere winter, with a transition to ENSO-neutral expected during April-June 2024 at 60% chance as shown in Figures 3.6 and 3.7. The most recent IRI plume favours El Nino to continue through the Northern hemisphere winter 2023-2024. Based on the forecast, there is a 54% chance of a historically strong El Nino during the November-January season (≥2.00C in Nino 3.4). An event of this strength would potentially be in the top 5 of El Nino events since 1950 with implication of below-normal rainfall across Nigeria

[7] Graph-Dashboard: Oceanic Nino Index (ONI) | NOAA Climate.gov

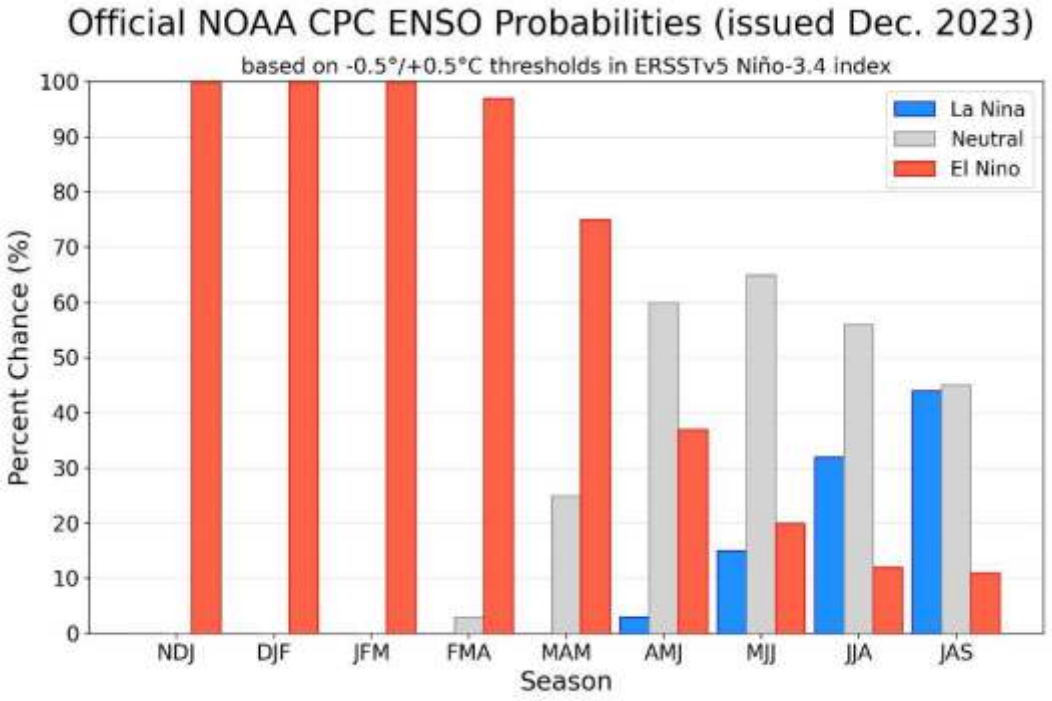


Figure 3.6: Official CPC ENSO Probabilistic ENSO Forecast

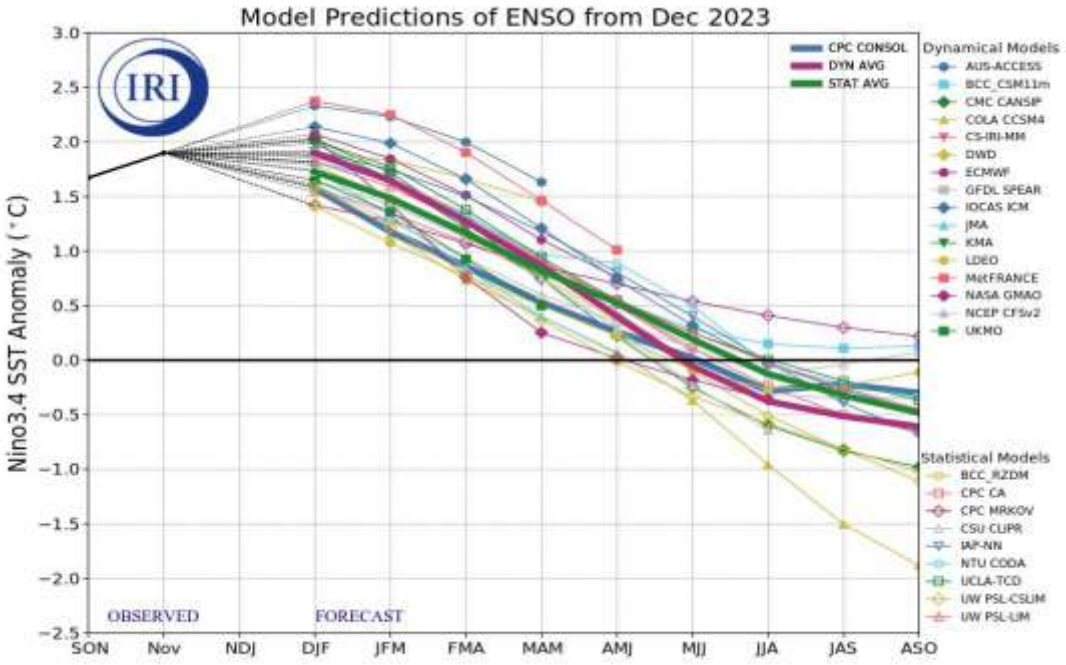


Figure 3.7: Model Predictions of ENSO[8] from December 2023

[8]Climate Prediction Center: ENSO Diagnostic Discussion (noaa.gov)

3.4.3 GLOBAL EXTREME TEMPERATURE RECORD IN 2023

According to WMO, the past nine years 2015-2023 were the warmest on record. The warming El Nino event, which emerged during the Northern hemisphere Spring(March to May) in 2023 and developed rapidly during summer is likely to further increase the temperature in 2024. El Nino typically has its impact on global temperature after its peak. Global temperatures in 2023 were exceptionally high. The Copernicus climate change service monitored several key climate indicators through the year. This reported record breaking conditions such as the hottest months on record and daily global temperature averages briefly surpassing pre-industrial level by more than 20C in 2023. With the unprecedented high global temperatures that were observed from June to December, 2023 became the warmest year on record, surpassing 2016 by margins higher than the previous warmest year.

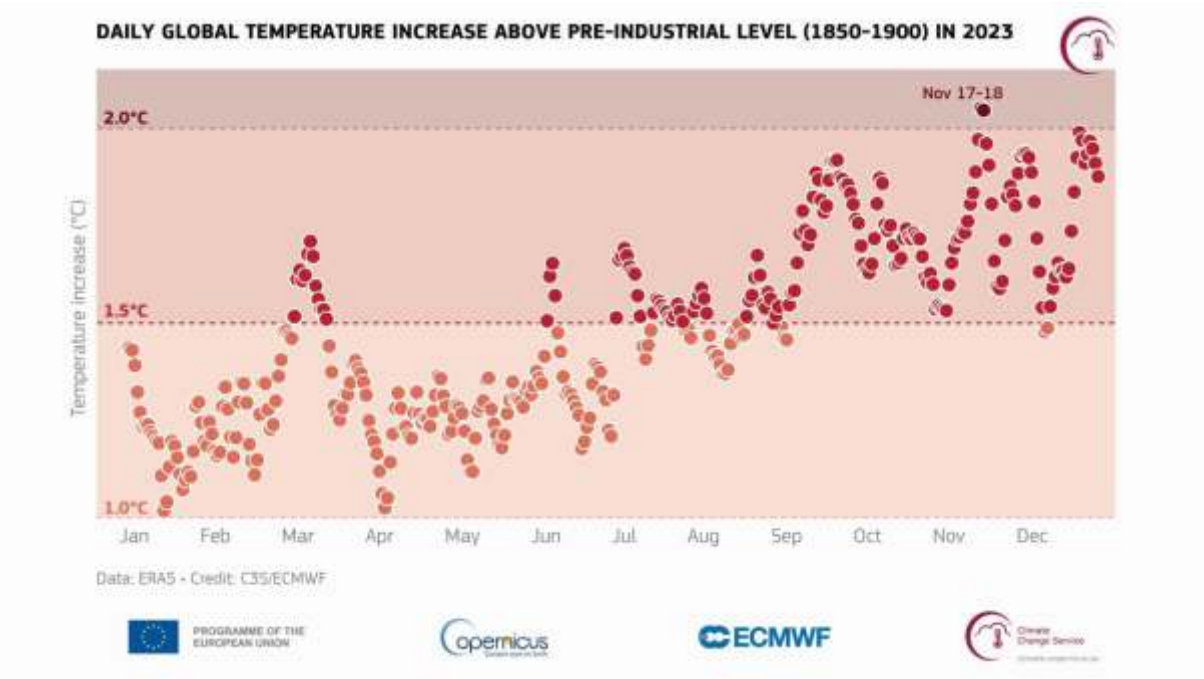


Figure 3.8: Daily Global Temperature[9] in 2023

[9]Copernicus: 2023 is the hottest year on record, with global temperatures close to the 1.5°C limit | Copernicus

CHAPTER FOUR

4.0 EXTREME WEATHER EVENTS IN 2023

Highlights

- 2023 is confirmed as the warmest calendar year in global temperature data records going back to 1850
- 2023 had a global-average temperature of 14.98°C, 0.17°C higher than the previous highest annual value in 2016
- 2023 was 0.60°C warmer than the 1991-2020 average and 1.48°C warmer than the 1850-1900 pre-industrial level
- It is likely that 12 months ending in January or February 2024 will exceed 1.5°C above the pre-industrial level
- Each month from June to December in 2023 was warmer than the corresponding month in any previous year
- July and August 2023 were the warmest two months on record. Boreal summer (June-August) was also the warmest season on record
- In September 2023, the temperature deviation above the 1991–2020 average was larger than in any month in any year in the ERA5 dataset (0.93°C higher than the 1991-2020 average)
- October, November and December 2023, each with a temperature of 0.85°C above average, ranked all joint second-largest in terms of temperature deviation above the 1991–2020 average

4.1 Temperature

The World Meteorological Organization (WMO) has confirmed that 2023 was the hottest year since record-keeping began, exceeding previous highs by a significant amount. Last year's global average temperature approached 1.5°C above pre-industrial levels. This temperature milestone is concerning because the Paris Agreement aims to limit long-term warming to 1.5°C. According to six major international temperature datasets analyzed by the WMO, 2023 was 1.45 ± 0.12°C warmer than pre-industrial levels (1850-1900). Notably, each month from June to December set new record highs, with July and August being the hottest months on record.

Moreover, each decade since the 1980s has been warmer than the previous one, and the past nine years have been the warmest overall. Before 2023, 2016 and 2020 were the hottest years at 1.29 ±0.12°C and 1.27 ±0.12°C above pre-industrial levels, respectively. The ten-year average temperature from 2014-2023 was 1.20 ±0.12°C above 1850-1900 laverages. With this new data, 2023 has surpassed 2016 as the hottest calendar year since records began. Specifically, the ERA5 dataset showed 2023's global average at 14.98°C, exceeding 2016 by 0.17°C.

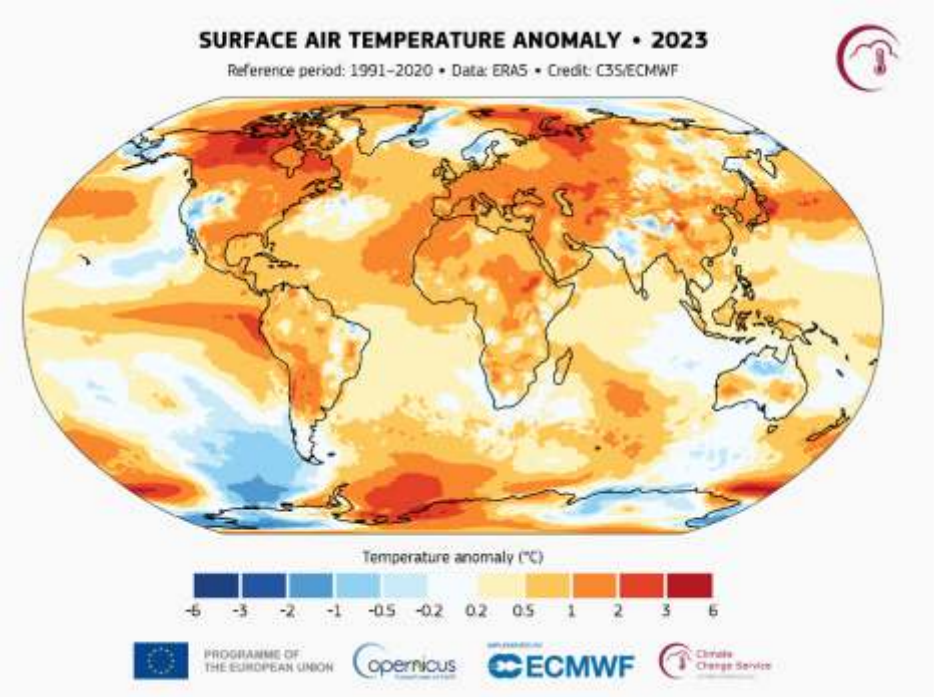


Figure 4.1 Surface air temperature anomaly for 2023 relative to the average for the 1991–2020 reference period. Data: ERA5. Credit: C3S/ECMWF

4.1.1 Maximum Temperature

In 2023, Nigeria experienced unusually high temperatures, with some areas recording temperatures as high as 40°C or higher. These high temperatures were mostly observed in the northern and central states of the country, as well as in Umuahia In the south east from the first week of February to the second week of July. However, some cities such as Maiduguri and Nguru still experienced these high temperatures until October. Maiduguri recorded its highest daytime temperature of 45.2°C on 23 May, while Nguru recorded 44.5°C on 16 May. Other cities that also had daily high temperatures above 40°C are listed in Table 4.1. Nguru had the most days with daytime temperatures of 40°C or higher, with these high temperatures being recorded for 77 days. Maiduguri and Sokoto recorded them for 70 and 58 days each, respectively.

Table 4.1: Cities and the number of days with day-time temperatures > 40°C in 2023 are shown in the table below:

S/N	City	Observed Maximum Value (°C)	Number of Days temperature ≥ 40°C
1	Abuja	40	1
2	Bauchi	41.6	9
3	Bida	41.2	7
4	Dutse	42.8	40
5	Gombe	42	19
6	Gusau	41.6	29
7	Jalingo	41.2	26
8	Kano	42.5	46
9	Katsina	41.6	24
10	Lafia	41.4	7
11	Lokoja	40.5	4
12	Maiduguri	45.2	70
13	Makurdi	40.4	4
14	Minna	40.2	2
15	Nguru	44.5	77
16	Ogoja	40.4	4
17	Potiskum	42.6	40
18	Sokoto	43	58
19	Umuahia	41.6	1
20	Yelwa	42.9	26
21	Yola	43	49
22	Zaria	40.4	3

4.1.2 Minimum Temperature

Lowest night-time temperatures below 12°C were recorded in several cities including Dutse, Zaria, Jos, Kano, Bauchi, and Nguru. The values recorded were 5.0°C, 5.5°C, 6.2°C, 7.0°C, 7.6°C, and 8.0°C respectively. Most of these low temperatures were recorded in January and December. Among these cities, Dutse experienced the highest number of days with night-time temperatures of 12°C or lower, with a total of 78 days. Kano and Bauchi recorded such temperatures for 55 and 45 days respectively as shown in Table 4.2.

Table 4.2: Cities and the number of days with night-time temperatures < 12°C in 2023 is shown in the table below:

S/N	City	Observed Minimum Temperature (^{0}C)	Number of Days with $\leq$ 12°C
1	Abeokuta	12	1
2	Abuja	12	1
3	Bauchi	7.6	45
4	Dutse	5	78
5	Gombe	11.6	1
6	Gusau	10.8	10
7	Jos	6.2	38
8	Kano	7	55
9	Katsina	11.2	6
10	Lafia	11	15
11	Maiduguri	10.8	4
12	Nguru	8	30
13	Potiskum	11.5	5
14	Zaria	5.5	16

4.2 Rainfall

Various parts of the country experienced daily rainfall totals of 100mm and above throughout the year. Ibadan, Shaki, and Katsina had the highest daily rainfall with 203.4mm, 203.2mm, and 190.0mm respectively, followed by Eket with 166.9mm and Sokoto with 162.1mm, cities that observed the highest 1-day rainfall amounts in 2023 are shown in Table 4.3.

Table 4.3: Highest daily rainfall of 100.0mm and above in 2023

S/N	City	Highest 1- day rainfall amount ≥100mm	Number of Days with Rainfall ≥ 100mm	Annual Total
1	Abeokuta	134.5		2395.1
2	Ado Ekiti	124.6		1730.84
3	Akure	103.6		1636.4
4	Asaba	128.4		3011.83
5	Awka	104.1		2247.5
6	Benin	105.4		2874
7	Calabar	115.8		2924.3
8	Eket	166.9		3103.5
9	Enugu	115		2472.99
10	Gusau	102		780.82
11	Ibadan	162.1		2038.2
12	Ikeja	124		2086.8
13	Ikom	120.1		2354.57
14	Katsina	190		877.9
15	Lafia	136.9		1836
16	Lagos Roof (Victoria Island)	103.5		2054.2
17	Makurdi	106.8		1360.7
18	Ogoja	110		2048.1
19	Shaki	203.2		2099.8
20	Sokoto	107		938.3
21	Uyo	104		3629.9
22	Warri	137.9		3449.6
23	Yenegoa	203.4		4065.1

4.3 Extreme Events Witnessed in Nigeria in 2023

4.3.1 Floods

In 2023, Nigeria witnessed much milder flooding than in 2022. The National Emergency Management Agency (NEMA) reported that as of October 2023, 157,159 people were affected nation-wide, with 68,000 displaced due to flooding.

Adamawa State: According to United Nations -Office for the Coordination of Humanitarian Affairs UN-OCHA SITREP (Nov. 20, 2023), over 70 people lost their lives and more than 490 others sustained injuries due to flooding in Adamawa State between May and October 2023, according to the findings of a joint multi sectoral rapid needs assessment. The flooding also displaced more than 57,000 people. Heavy rainfall

coupled with the release of water from Cameroon's Lagdo Dam[10] triggered the flooding that submerged some villages along the banks of the Benue River. The floods damaged schools, health centres, markets, over 19,000 hectares of farmland, and shelters. Areas affected include Lamurde, Yola South, Mayo-Belwa, Numan, Yola North, Fufore, Demsa, and Song local government areas (LGAs) of Adamawa State.

The flood water also contaminated water points in several communities, causing water-borne and vector-borne diseases like cholera, diarrhoea, malaria, and dengue fever. Disease surveillance and notification officers in Yola South LGA reported that 38 cholera cases were confirmed and referred from the Wauro Jabbe community to the Modibbo Adama University Teaching Hospital, Yola. Moreover, an outbreak of scabies, a parasitic skin infestation, was reported in riverine communities like Bawaranji. Figures 4.2 and 4.3 show the impacts of flood on communities in Adamawa state.

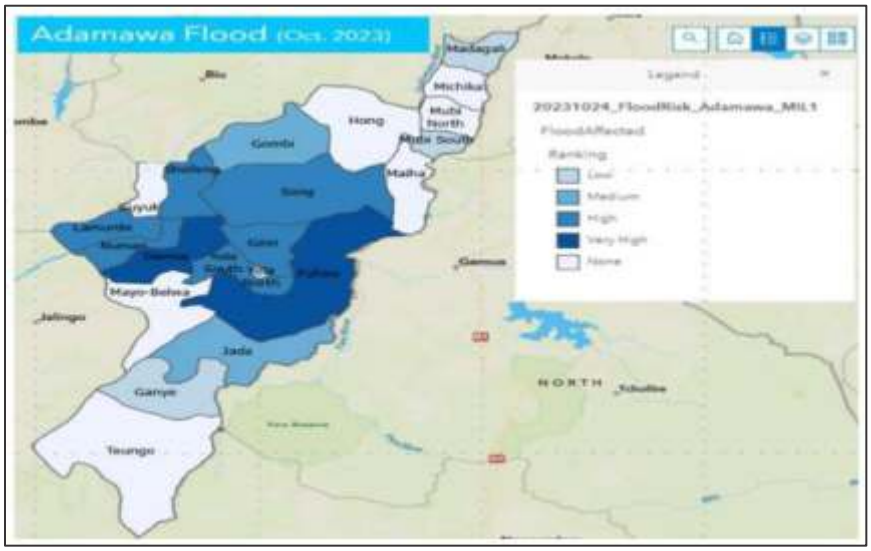


Figure 4.2: Floods affected homes and farmland in over 170 communities. Before the major dam water release, Adamawa had recorded 46 suspected cholera cases, including one death across 5 LGAs (Yola South, Yola North, Mubi North, Shelleng, and Girei. ***Data source****: Adamawa State Emergency Management Agency (ADSEMA)*

Figure 4.3: Affected communities in Adamawa State

Source*: Displacement Tracking Matrix (DTM) of the International Organization for Migration (IOM), Nigeria Mission, October 2023*

[10] Relif web, https://reliefweb.int/report/nigeria/north-east-nigeria-flood-incidents-report-october-2023

Yobe State: Heavy rainfall affected 10 LGAs in Yobe State causing floods which affected a total of 5,496 individuals from 1,032 households. The incidents damaged 585 shelters (IOM UN Migration, Sep. 28, 2023).

Figure 4.4: Sites affected by floods in Yobe state.

Lagos State: A portion of the road that connects the Ikotun roundabout to Ejigbo and nearby communities in Lagos State experienced a collapse due to heavy downpour. Residents said the road close to a canal caved in after the rainfall on Saturday, September 16. Motorists who use this route were forced to alternate the damaged part of the road by filing into a single lane. Residents reported that the road has been gradually damaged by erosion over the years (Source: Tori, September 20 2023).

Figure 4.5: Ikotun/Ejigbo road in Lagos Collapses After a heavy downpour

On Tuesday, October 17, 2023, the residents of Owode Onirin, located in the Kosofe Local Government Area of Lagos State, suffered significant losses when the area was hit by flood. The cause of the flood was the water released from the Oyan Dam. The flood severely affected areas such as Unity Estate, Jehovah Street, Elias Estate, and other nearby sites in the community. Additionally, the flood also displaced some residents who

lived in low-lying areas in Isheri-Olowoora and Alagbole. This information was reported by Fresh Reporters on October 21, 2023.

Figure 4.6: Owode Onirin in the Kosofe Local Government Area of Lagos State

Plateau State: Flood swept through several communities in the Jos North Local Government Area of Plateau State on September 16 and 17, 2023. The affected areas include Anguwan Rogo, Rikkos, Bauchi Road, and Naraguta, destroying at least 150 houses. Although no lives were lost, the flood caused significant damage to properties and washed away valuable items.

Figure 4.7: Impact of Plateau State flood (Leadership News Sep.18 2023)[11]

[11] Leadership News https://leadership.ng/flood-wreaks-havoc-in-plateau-communities-destroys-150-houses/

Taraba State: The residents of Abuja Phase 1 in Jalingo, the capital of Taraba State, suffered losses due to heavy rainfall on Monday, April 24th, 2023. The rain started around 1 a.m. and lasted for several hours, which resulted in flooding in the area and some parts of the Jalingo metropolis. Many houses were submerged and destroyed due to the flooding. (Daily Post, April 24 2023).

Figure 4.8: Jalingo, Taraba State flood

Anambra State: A severe flood struck the Agbobo Umuoga Ossomala community in Ogbaru Local Government Area of Anambra State, resulting in extensive economic damage and hardship for the residents. The flood caused significant destruction of properties, including crops and poultry farms, worth millions of naira. One of the hardest hit businesses was Matucci Farms, a large-scale poultry farm in the community. The flood caused the death of 25,000 birds, leading to a massive loss for the farm. Furthermore, the flood rendered about 400 workers who worked at the farm jobless (Source: bnn, August 16, 2023).

Figure 4.9: Flood Wreaks havoc in Anambra State

Delta State: Two communities, Aboh and Abala-Oshimili in Ndokwa East Local Government Area of Delta State, were submerged by flood due to the rise in the water level of River Niger. According to local sources, the water started encroaching on people's homes in the communities on September 14. While some people have relocated, others were using canoes to access their flooded houses. (The Sun News, September 18, 2023).

Figure 4.10: Delta State flood

Ogun State: Residents and property owners in Agbara, an industrial community located in Ado-Odo/Ota Local Government Area of Ogun State, Nigeria, suffered significant losses due to the perennial flooding that has affected the area. The worst affected residents are those living in Area 8 of OPIC Estate in Agbara, they lamented that the constant rainfall of the previous caused the flooding, it damaged buildings and other possessions. The flooding submerged many properties, leaving residents with no other option than to relocate to safety. (Daily Trust, September 17, 2023).

Figure 4.11: Flood wreaks havoc in Ogun industrial community

Residents of the Lafenwa-Abule Otun community, located in the Abeokuta North local government area of Ogun State, have been forced to evacuate their homes due to severe flooding caused by the release of water from the Oyan Dam. The heavy rainfall on Saturday 14th October 2023 worsened the situation, causing significant damage to the community, which is situated just meters away from the Ogun River.

Figure 4.12: Flood hits Lafenwa-Abule Otun Community in Ogun State

Katsina State: On July 11, 2023, heavy rain caused havoc in Katsina State capital and Bindawa Local Government Area, destroying over 200 houses and the loss of ten lives. The heavy rain began at 4 p.m. and continued late into the night, affecting the Katsina metropolis. The worst-hit area was Ungwan Sabuwa, along the Kofar Kaura axis. Poor drainage was cited as the primary cause of the disaster, with no exit channel for water from the Kofar Kwaya and Kofar Kaura axis (Vanguard July 16 2023).

Figure 4.13: Katsina flood

4.3.3 Windstorms

Yobe State: On the 2nd of May 2023 it was reported that windstorms struck the Boarding Primary School Camp (Transit Camp) in Kala/Balge LGA of Borno State. The windstorms affected a total of 194 individuals from 73 households. The windstorms also damaged 20 shelters and five brick/block latrines (Source: ReliefWeb (IOM) 15 May 2023).

Figure 4.13: Windstorms destroyed properties in Yobe state

Bauchi State: On April 21 and 23, windstorms were reported in the communities of Tsangaya and Kakuma in the Wards Miya West and Kubi East, both located in Ganjuwa LGA of Bauchi State. The windstorms impacted 125 households, affecting 890 individuals in total. One person suffered injuries and over 95 houses sustained damage as a result of the windstorms (Source: IOM 26 April 2023).

Figure 4.14: Damaged shelters in Bauchi wind storms (Source: IOM UN Migration)

Borno State: From May 14–28, strong windstorms affected Bama, Dikwa, Pulka, and Maiduguri. As of the reporting period, a total of 651 shelters were damaged, and 4,143 IDPs were affected by those residing in 20 formal camps, one reception centre, and one informal camp in four locations. The windstorms were an indication of the start of the rainy season in the Northeast. Damaged shelters were emergency shelters, mudbricks, and communal shelters that are used in the reception centre. WASH facilities were also damaged by the windstorms (IOM CCCM Nigeria SITREP, May 30 2023).

[12] IOM UN Migration, https://dtm.iom.int/reports/nigeria-windstorm-and-communal-clash-flash-report-bauchi-state-26-april-2023

Figure 4.15: Windstorm destroyed shelters in Borno state

Delta State: At least six people were killed by a windstorm in Delta State, south-south Nigeria. The incident happened on Thursday April 19 in Oko Community in Oshimili South Local Government Area of the state when a structure collapsed during the windstorm, according to the Delta State Government. It was reported that one person was critically injured while five others sustained various degrees of injuries. A 10-year-old boy was swept away in the Okotomi area of the Okpanam Community in Oshimili North Local Government Area (Premium Times, April 20 2023)

4.3.4 Soil Erosion

Another extreme event caused or aggravated by weather/climate events in 2023 is soil erosion. Some areas affected are:

Yobe State: Residents of Makara Huta-Masakar Makafi in Potiskum Local Government Area of Yobe State experienced the devastating impacts of erosion as many houses and roads collapsed. It was gathered that the erosion claimed the lives of two persons and destroyed more than 10 houses, with many others on the brink of collapse. Many houses were washed on both sides of the gully created by the erosion (Source: Daily Trust, October 11 2023).

Figure 4.16: Erosion destroys houses, and roads in Potiskum, Yobe State
(Source: Daily Trust, October 11 2023)

Bauchi State: Residents of about ten communities in the Alkaleri and Kirfi Local Governments in Bauchi State expressed concern over the threat posed by gully erosion caused by torrential rainfall on their communities. The alarming situation arose after erosion washed away bridges and culverts in the areas. Communities affected are Bulamari, Barambu, Garfatu, Mai'rin Arewa, Katarko and Maciyan Maje).

Figure 4.17: Erosion washes away bridges, threatens houses in Bauchi ***(Source: Premium Times, August 28 2023)***

Anambra State: It was reported that several buildings, structures, and roads were destroyed, while over 100,000 people have been displaced by the menace of gully erosion ravaging communities in Anambra State. Findings showed that some of the communities mostly ravaged by the disaster include the Oba community in Idemili South Local Government Area, Ozubulu in Ekwusigo Local Government Area, Onitsha Inland in Onitsha North Local Government Area, Awada, Nkpor, and Obosi communities in Idemili North Local Government Area, as well as the Atani and Okpoko communities in Ogbaru Local Government Area, among several others.

The Onitsha-Owerri Expressway is an important transportation road that links multiple states in the south-east of Nigeria, along with some areas of the south-south region. In July of 2023, a devastating erosion event occurred in the Oba community, resulting in the closure of one lane of the busy expressway. The Agulu-Nanka Road axis and Alor-Nnobi Road have also been badly affected by the disaster. The Rojeeny Games Village, Tansian University, and a multi-million-naira plastics company are among the structures threatened by erosion.

4.18: Erosion ravages Anambra communities (Source: Punch. December 21) 2023).

4.4 Dust Haze in 2023

Events of dust haze were reported in January, February, March, April and May in the first and second quarter of 2023, as the dry season gradually gave way to the rainy season. Other events were reported in the last quarter of the year, namely in the months of October, November and December 2023. The dry season accompanied by harmattan winds are usually cold, dry dusty while the dust haze episodes are by products of extensive period of dryness and increased sub-tropical high pressure in the Sahara Desert and environs. The major sources of dust that is carried into Nigeria are Faya Largeau, Agadez, Ndjamena, and Zinder in the Niger and Chad. The northern frontier states like Adamawa are the first to feel the impact of dust plumes being transported into Nigeria. These dust particles are then carried by the prevailing winds, settling as haze across the country. Strong winds help disperse the dust downstream, improving visibility after a few days. However, weak or calm winds allow the particles to remain suspended longer, worsening visibility afterwards.

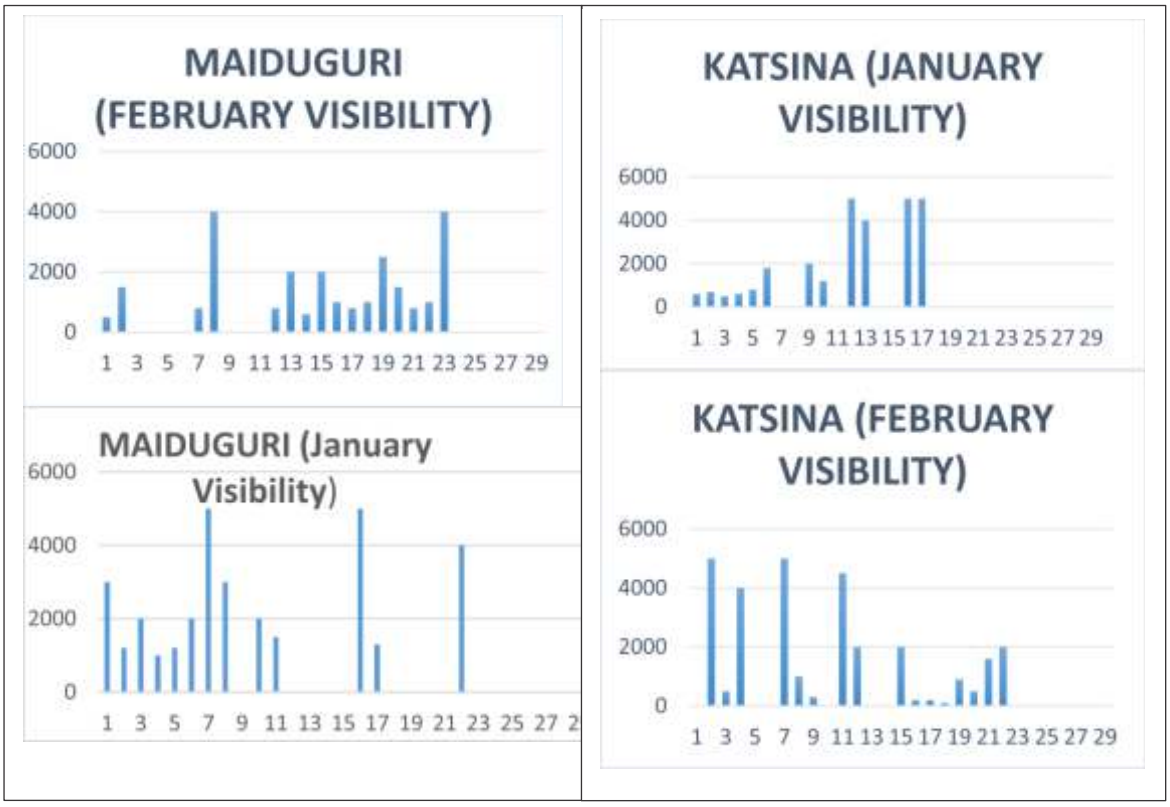


Figure 4.19: Daily visibility over Maiduguri and Katsina in January and February 2023

DUST SPELLS

There were about 10 dust spells in January 2023. These occurred between January 1st and 6th. February had the highest number of dust spells in 2023 with 15 dust spells and the lowest visibility value of 100m over Katsina on February 18th as shown in Table 4.4. Dust propagation into the country is known to lower daytime temperatures and also lower air quality. During the dust outbreaks, increased concentrations of airborne particles consisting mainly of mineral dust and smoke usually affect public health increasing incidences of respiratory illnesses like cough and catarrh during the harmattan dust season. The aviation sector is also impacted negatively during the season. Flights operations are often disrupted when horizontal visibility is reduced to levels that are unsafe for aircraft take-off and landing..

Table 4.4: Dust Spells During 2023 Harmattan Season

Spell Period	Number of days	Places affected	Visibility range (m)
January 1st -6th	6	Mostly Northern, central and some Southern states	300-5000
January 10th -11th	2	Entire country	200-5000
January 17th-18th	2	Entire country	800-5000
February 1st – 3rd	3	Northern states	400-5000
February 7th,12th-14th	4	Northern states	600-5000
February 15th-22nd	8	Entire country	100-5000
March 26th – 27th ,31st	3	Mostly Northern and Central states	500-5000
April 1st, 4th -7th	5	Few northern states	600-5000
October 4th ,6th – 7th	3	Few northern states	400-5000
November 2nd -3th ,15th-16th	4	Few northern states	300-5000
November 20th and 21st	2	Few Northern states	800-5000
December 12th -13th	2	Northern states	200-5000
December 25th -29th	5	Entire country	200-5000

CHAPTER FIVE

5.0 SOCIO- ECONOMIC IMPACTS OF EXTREME EVENTS IN 2023

5.1. Transportation and Water Resources in 2023

Climate change is altering precipitation patterns globally, these heavy downpours are likely to increase the risk of flooding, which could substantially disrupt transportation. Prolonged flooding may also delay time-sensitive construction projects. Furthermore, the deluge of floodwaters can erode and wash away the soil substrates and culverts underneath roads, tunnels, bridges, and other infrastructure, potentially destabilizing or severely damaging them. Localized flash flooding from heavy storms may make roads impassable and dangerous for vehicles and pedestrians alike. In 2023, some socio- economic impact of extreme weather events are discussed below.

5.1.1 Inland Water Transportation

There are high concerns about the frequent and deadly boat accidents in Nigeria, because a number of remote and riverine communities do not have access to good roads, leaving rivers as the only available means of transportation.

According to a publication by the Cable News in November, in 2023 alone, over 300 Nigerians died in various boat mishaps across the nation's inland waterways.

- On 12th June, 2023, a vessel capsized in the River Niger near Pategi, Kwara State, Nigeria. The boat was carrying over two hundred people but was stranded due to heavy rain. The National Inland Waterways Authority (NIWA) attributed the boat mishap to turbulent winds which claimed about one hundred and eight (108) lives. In addition, twelve (12) people were also reported to have died in a boat accident at river Kogi Kungra Kamfani, in Arikiya, Lafia LGA of Nasarawa on August 24th 2023.

- On the 9th September, 2023 in Yola South of Adamawa state, another fifteen (15) people lost their lives in a boat mishap as a result of heavy wave. In the same vein, on the 11th September, 2023, it was reported that eleven (11) died as another boat capsized as a result of strong winds and severe thunderstorm in Gurin village, Fufore Local Government Area of Adamawa state.

- Thirty (30) persons were confirmed dead while over thirty (30) were rescued in a boat accident on September 10th, 2023, in the Mokwa LGA of Niger state due to strong waves.

- On 2nd October, 2023, forty (40) people drowned in Kebbi state after a passenger boat capsized due to strong currents.

- On 7th October, 2023, seventy-six people reportedly died following a boat accident in Ogbaru LGA in Anambra state. The people were reportedly escaping from their flooded communities. The boat was said to have lost control when it sailed into a heavy wave.

5.1.2 Air Transportation

Nigeria experiences distinct weather seasons, with harmattan bringing dry and dusty conditions, and the rainy season characterized by thunderstorms. These seasonal variations impact flight operations differently. Low cloud, fog, dust haze and rain may impede visibility at or around an airport while thunderstorms and lightning can cause delays, diversions, rescheduling and cancellation of flight schedules, though, those are

part of safety measures. With all these experienced over Nigeria in 2023. There were widespread flight disruptions across Nigeria, primarily attributable to adverse weather conditions. In February of that year, numerous passengers found themselves stranded for extended periods at various airports nationwide as airlines grappled with the challenges posed by poor visibility weather. The cancellation and disruption of several flights were notably attributed to the harmattan dust haze, reducing visibility to levels ranging between 100 and 2000 meters. The consequences of these disruptions were far-reaching, inflicting a substantial economic toll on both the airlines and the affected travelers. Business schedules were severely impacted, with some passengers missing crucially scheduled meetings, thereby exacerbating the financial strain on both individuals and corporations.

Figure 5.1: Stranded passengers at Murtala Mohammed international Airports

5.1.3 Road Transportation

Road transportation infrastructure such as roads, bridge and culverts are especially susceptible to major disruptions and failures due to extreme weather events, such as heavy rainfall. Similarly high temperatures can cause pavement and bridges to buckle or soften, requiring road closures and repairs. Increased local flooding can affect roadways and tunnels, weaken roadway materials, and cause traffic congestion. Many roads and bridges were impacted in 2023 as shown in figure 5.2

Figure 5.2: Collapsed portion of the bridge linking Maajin Kaji and other communities in Lavun LGA, Niger state due to heavy downpour ***Photo: Sode Mohammed/Radio Nigeria.***

5.2 Water Resources

Rainfall variability, droughts, and desertification are increasing, particularly in the northern Sahelian zone. This will increase competition over increasingly scarce water resources and could increase regional security challenge Climate change poses grave threats to Nigeria's water resources. As an agricultural economy, Nigeria is especially vulnerable to erratic rainfall, in 2023 incidences of floods were reported in several locations, leading to contamination of freshwater supplies and spreading water-borne disease.

During July and August, marked by prolonged dry spells, have been noted in the north-central and north-eastern regions of Nigeria, and traditionally recognized as surplus-producing areas. This poor rainfall performance has reportedly led to the withering of crops such as millet, groundnut, and sorghum in specific localized areas of the northeast. Consequently, there have been instances of replanting in late July to mitigate the impact of these adverse conditions. Extended dry spells also affected water availability sparking conflicts over dwindling water resources. This has negative impacts on agriculture and food security, as well as the livelihoods of many communities

5.3 Education

Extreme weather events such as floods and storms ussually damage schools and infrastructure, making it difficult or impossible for students to attend school. According to Daily Post publication on April 12th, a flood caused by heavy rainfall in Sagamu, Ogun State, resulted in the death of a secondary school student.

On May 23, 2023, a very strong wind caused electric poles and wires in the Ondo State communities of Oke-Odunwo and Akinmarin to collapse, affecting vehicular traffic in the area. According to the Hope Newspaper everyone in the area had to stay at home including school pupils until the poles and wires were taken out of the road and fixed.

Ajegunle and Ikorodu areas in Lagos state had major flooding on September 18, caused by torrential rainfall for over two days thereby resulting to the damage of many homes and the main Lagos-Badagry road. (Source; Getty Images)

Water levels in Adamawa State was said to began rising after several hours of rainfall on Thursday, October 5, 2023, resulting in major floods that severely damaged roads, schools, and other infrastructure in the 14 Local Government Areas of the state. Source; https://reliefweb.int

5.4 Energy

Numerous difficulties are often encountered by the energy sector which could include adverse weather conditions such as intense rain, lightning, and wind gusts.
According to a report by the Hope newspaper, electric poles and wires in the Ondo State towns of Oke-Odunwo and Akinmarin was said to have collapsed on May 23, 2023 due to rain, resulting in a blackout.
Rainfall damaged some high- and low-tension poles in the Southeast on May 29, 2023, causing a blackout that impaired the region's electrical supply. (Daily Post Newspaper report). According to a report by the Vanguard Newspaper on July 4, 2023, low tension wires and poles fell on buildings due to severe downpour in Afaha, Ube Street within Uyo metropolis, Akwa Ibom state.

On October 24, 2023, a heavy downpour in the Adabebe village of Amawbia Community, Awka South Local Government Area, destroyed eight electric poles. This event caused concern for over 2,000 schoolchildren who use this road daily and for those who live nearby, as many of the local students stopped going to school out of fear of being electrocuted. Source: https://newtelegraphng.com

[13] https://reliefweb.int/report/nigeria/nigeria-key-message-update-rainfall-deficits-likely-reduce-harvest-prospects-northeast-and-northcenter-august-2023

Figure 5.3: Fallen poles at Adabebe village in Amawbia Community Awka South Local Government Area[14]

5.5 Particulate matter $PM_{2.5}$ Concentration across Nigeria in 2023

Particulate matter (PM) refers to a mixture of liquid droplets and solid particles suspended in air. PM is categorized based on the aerodynamic diameter of the particles - PM2.5 consists of fine particles less than 2.5 ìm in diameter, while PM10 consists of coarse particles between 2.5 and 10 ìm in diameter. PM can be directly emitted from various sources or formed in the atmosphere through chemical reactions. Major emission sources include Dust particle from Sahara desert during the dry season known as harmattan dust haze, construction sites, power plants, vehicles, residential wood burning, agricultural burning, industrial operations like grinding, and combustion processes that release precursors like nitrogen oxides and sulfur dioxide. Once released into the air, PM can have adverse effects on human health and the environment. Of most concern is the $PM_{2.5,}$ because the particles are small enough to be inhaled deep into the lungs and can even enter the bloodstream, they can also carry a range of toxic substances, including heavy metals and organic compounds. The composition of these particles can further exacerbate their health impacts. Prolonged exposure to elevated levels of $PM_{2.5}$ is associated with various health problems, including respiratory diseases (such as asthma and chronic bronchitis) and cardiovascular issues (like heart attacks and strokes). It stands out as the predominant risk factor among all environmental and occupational hazards[15].

5.5.2 Annual Mean concentration of $PM_{2.5}$ in 2023

Figure 5.4 shows the spatial analysis of the annual mean concentration of particulate matter $PM_{2.5}$. The lowest mean $PM_{2.5}$ concentration ranging from 25 to 30 µg/m3 was reported over southern parts of Cross River, southern Rivers, Bayelsa, Lagos, Ogun, Ekiti, Kogi and southern Akwa Ibom. Most parts of the country reported annual mean $PM_{2.5}$ concentration value of 30 to 35 µg/m3. Parts of Sokoto, Zamfara, southern Kaduna, Bauchi, Gombe, and Imo, recorded mean $PM_{2.5}$ concentration value of 35 to 40 µg/m3. Annual mean PM2.5 concentration range of 40 to 45 µg/m3 was reported over parts of Katsina, Kaduna, Kano, western Bauchi and Jigawa. The highest mean $PM_{2.5}$ concentration of 45 µg/m3 and above was reported particularly over southern Kano, southern Katsina and northern Kaduna.

Notably, throughout the entire year, the $PM_{2.5}$ concentration across Nigeria consistently exceeded the World Health Organization's (WHO) recommended guidelines of 24-hour threshold of 15 µg/m3 and an annual threshold of 5 µg/m3. This persistent elevation raises concerns about potential health risks associated with

[14] www.therazornews.com.
[15] State of Global Air, https://www.stateofglobalair.org/health/pm#major-impacts

prolonged exposure to elevated levels of particulate matter. The collective impact of PM underscores the importance of addressing its adverse effects on both public health and environmental well-being.

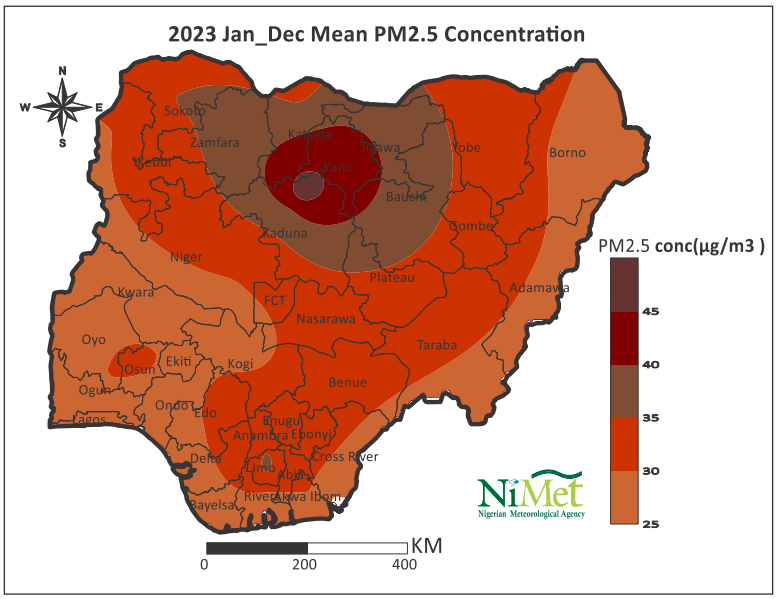


Figure 5.4: Annual Mean Particulate Matter $PM_{2.5}$ Concentration

5.6 2023 Role of NiMet in Early Warning and Disaster Risk Reduction in Nigeria 2023 Overview

According to the United Nations Development Programme (UNDP), Early Warning Systems (EWS) are complex processes that aim to reduce the impact of natural disasters by systematically providing accurate and timely information. If implemented properly, EWS can help and become more resilient to natural disasters and climate-related risks while also supporting the fulfilment of the Sustainable Development Goals (SDGs) by decreasing loss of life and livelihood[16]. Disaster risk reduction aims to prevent new disaster risk, reduce existing disaster risk, and manage residual risk, all of which contribute to increased resilience and, as a result, to the accomplishment of sustainable development.

In the year (2023), the Nigerian Meteorological Agency (NiMet) issued warning and weather alerts for precaution and mitigation measures and early preparedness through its early warnings systems such as Seasonal Climate Prediction (SCP) which consists of the onset of the growing season, length of the season, end of the growing season, annual rainfall amount, dry spell, little dry season, Malaria and Meningitis vigilance and socio-economic implications of some key economic sector in Nigeria. Other EWS includes; the Dekadal Agro-Meteorological Bulletin, Drought and Flood Monitoring Bulletin, Marine Weather Bulletin, High Impact Weather Forecast, Daily Weather Forecast and periodic updates to the Federal and State Government Agencies like the Federal Ministry Of Agriculture and Rural Development (FMARD), National Emergency Management Authority (NEMA), Nigeria Hydrological Services Agency (NIHSA), and States Emergency Management Agencies (SEMAs), among others.

NiMet also conducted a sensitization workshop, downscaled the Seasonal Climate Prediction (SCP) at the Federal and state levels (this includes, Borno, Yobe, Adamawa, Sokoto, Jigawa, Kebbi, Jigawa, Kano, Kwara, Benue, Kaduna, Nasarawa, Oyo, Ogun, Lagos, Enugu, Delta, Ondo, Bayelsa, Edo, Anambra, Abia, Kogi, Cross River states and the FCT among others) as shown in Figures 5.5, 5.6 and 5.7. The SCP document was translated into major Nigeria's official languages (i.e. Yoruba, Hausa, and Igbo) to increase its public awareness and understanding.

[16] UNDP (2018). Five approaches to build functional early warning systems. https://www.adaptation undp.org/sites/default/files/resources/undp_brochure_early_warning_systems.pdf.Accessed 05.01.2024.

Figure 5.5: Sensitization of the 2023 SCP in Federal Capital Territory by NiMet Staff

Figure 5.6: Presentation of the importance of 2023 SCP to the farmers of Global Alliance for Improved Nutrition (GAIN) in Benue state by NiMet staff.

Figure 5.7: Training GAIN farmers at Benue Metropolitan Hotel and Resort Limited in Makurdi

5.7.1 Food security in Nigeria in 2023

The Cadre Harmonisé (CH) is a unifying tool that helps to produce relevant, consensual, rigorous, and transparent analysis of current and projected food and nutrition insecurity in the Sahel and West Africa Region[17]. It enables the classification of the nature and severity of acute food insecurity. It classifies the severity of food and nutrition situations based on an international classification scale through an approach that refers to well-defined functions and protocols.

The Cadre Harmonisé (CH) analysis was conducted in 26 of Nigeria's 36 states, including the Federal Capital Territory. The CH is an analysis of food security led by the Government of Nigeria through the Federal Ministry of Agriculture and Rural Development (FMARD) in partnership with development partners, FAO, UNICEF, and WFP. Results from the CH analysis have become the major yardstick for estimating the geographical areas and populations of vulnerable people in need of urgent humanitarian assistance to prevent food insecurity and malnutrition. However, the result of the CH cycle for October to December 2023 gives an insight into picture of the food security situation in Nigeria for the year 2023. The result of the October to December 2023 analysis indicates that about 18.6 million (8.9%) people including IDPs (416 000 in Borno, Sokoto, and Zamfara states) in 26 states, and FCT of Nigeria are expected to be in food crisis or worse situation from October to December 2023 while in the projected period (June-August, 2024), about 26.5 million (12.6%) Nigerians in Borno, Sokoto, and Zamfara States in 26 states including the FCT of Nigeria are expected to be in food crisis (CH Phase 3) or worse between June and August 2024. unless conscious actions are initiated and implemented to de-escalate vulnerabilities through targeted humanitarian food aid and resilience livelihood support interventions in the worst affected areas.

5.8.2 Hazard and Vulnerability

Protracted insecurity, economic factors such as fuel scarcity and fuel subsidy removal, the acute negative effect of the naira re-design and cashless monetary policy, new naira note have caused consistent soaring above average prices of staple food and basic commodities. In Addition, the slow post-COVID-19 economic recovery in Nigeria coupled with the war in Ukraine continues to impact negatively on livelihoods, agricultural input prices, and supply were among the major hazards reported in 2023. Evidence showed that since October 2022 till date, increases in prices of farm inputs (fertilizer and agrochemicals) have remained

[17] Cadre harmonise food security analysis in Nigeria and consolidation of result workshop FAO, WFP, NPFS November 2023

volatile ranging from 150% to 236%, impacting negatively on households' (HHs) capacity to increase cultivated cropland area (hectares) and apply the recommended fertilizer rate needed for the optimum performance of cultivated crops.

Banditry and kidnapping have also limited households' access to agricultural lands and functional markets to access agricultural farm inputs (fertilizer and agrochemicals) in several communities of Zamfara, Katsina, Niger, Sokoto, and Kaduna States, which impacted negatively on livelihoods. There were also observed incidences of natural and environmental disasters flood and wind storms. Flood incidents in Niger and Kogi states resulted in population displacement, losses of assets, and washing away of ready-to-harvest crops in several communities along river belts. The conflicts between herders and farmers in Benue, Kaduna, and Plateau States, also limited household's access to farmland which led to high livelihood vulnerability in several affected communities. At least 50% of households across the analyzed areas adopted stress-to-crisis coping strategies (begging, debt, and selling of their productive assets) to acquire food which resulted in increased vulnerability among displaced households and disruption of livelihoods in the affected communities. These bottlenecks have continued to impact negatively on the income sources of populations as well as outcomes of food and nutrition security in the affected communities and the country at large.

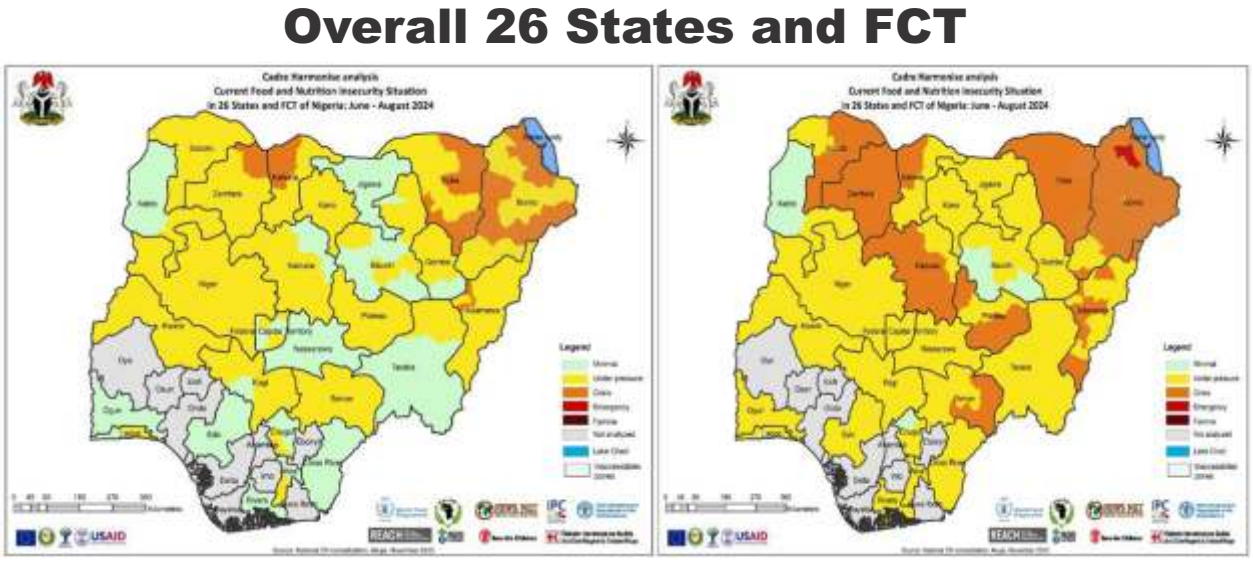


Figure 5.8: Current food insecurity situation in Nigeria[18]

[18] Cadre harmonise food security analysis in Nigeria and consolidation of result workshop FAO, WFP, NPFS November 2023

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ACRONYMS

CPC	Climate Prediction Center
CH	Cadre Harmonisé
CT	Continental Trade wind
DTM	Displacement Tracking Matrix
DTR	Diurnal Temperature Range
ERA5	ECMWF Reanalysis v5
ENSO	El-Niño Southern Oscillation
ECMWF	European Center for Medium-Range Weather Forecasting
EWS	Early Warning Systems
FAO	Food and Agriculture Organisation
FMARD	Federal Ministry of Agriculture and Rural Development
GAIN	Global Alliance for Improved Nutrition
HHs	Households
IDPs	Internally Displaced Persons
IOM	International Organization for Migration
IPCC	Inter-governmental Panel on Climate Change
ITD	Inter-Tropical Discontinuity
IRI	International Research institute for Climate and Society
LDS	Little Dry Season
LGA	Local Government Area
MSLP	Mean Sea Level Pressure
NDC	Nationally determined contributions
NEMA	National Emergency Management Agency
NiMet	Nigerian Meteorological Agency
NIHSA	Nigerian Hydrological Services Agency
NOAA	National Oceanography and Atmospheric Administrator
MT	Maritime Trade wind
UN-OCHA	United Nations -Office for the Coordination of Humanitarian Affairs
ONI	Ocean Nino 3.4 Index SST
SEMAs	State Emergency Management Agencies
SITREP	Situation Report
SPI	Standardized Precipitation Index
SCP	Seasonal Climate Prediction
SDGs	Sustainable Development Goals
SST	Sea Surface Temperature
UNICEF	United Nations Children's Fund
UNDP	United Nations Development Programme
UNFCC	United Nations Framework Convention for Climate Change WASH Water, Satination and Hygiene
WFP	World food programme
WHO	World Health Organisation
WMO	World Meteorological Agency
IOM	International Organization for Migration