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GIS/REMOTE SENSING QUARTERLY EVALUATION BULLETIN

A PUBLICATION OF THE NIGERIAN METEOROLOGICAL AGENCY

4th Quarter 2024

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GIS/REMOTE SENSING QUARTERLY EVALUATION BULLETIN

September - November 2024

A publication of Nigerian Meteorological Agency

Our Mandate

Our core mandate is to observe, collate and analyze meteorological data to provide timely and accurate reporting of weather and climate information for socio-economic development and safety of lives and properties.

Our Vision

To be a World Class provider of Weather and Climate services for safety and sustainable national socio-economic development.

Our Mission

To observe Nigerian Weather and Climate and provide Meteorological, Hydrological, and Oceanographic Services in support of National needs and International Obligations

Who We Serve

Aviation, Agriculture, Building and Construction, Commerce, Health, Hydrology, Marine, Oil and Gas, Sports, Social Events, Power and Energy, Telecommunication and more...

EDITORIAL

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Preface

The Nigerian Meteorological Remote Sensing Bulletin aims to publish high-quality, Open-Access publications to benefit the earth and atmospheric observation community, open to everyone in need of them. The Bulletin focuses on the theory, science, and technology of remote sensing, as well as interdisciplinary research with earth and atmospheric science and information science.

Topics of particular interest include, but are not limited to:

- Agriculture, forestry and range
- Atmospheric science and meteorology
- Ocean and inland water remote sensing
- Remote sensing of energy, water and biogeochemistry cycles
- Natural hazards/ disaster and environmental sciences and
- Bio geosciences remote sensing, etc.

Professor Charles Anosike
Director General/CEO NiMet &
Permanent Representative of Nigeria
with WMO

Introduction

The Nigerian Meteorological Remote Sensing bulletin serves the remote community with the publication of results on theory, science, applications and technology of remote sensing of Earth resources and environment. Thoroughly interdisciplinary, this bulletin focuses on new concepts, new results, new development of remote sensing. The bulletin publishes on basic theory of remote sensing, remote sensing technology and applications. The emphasis of the bulletin is on biophysical and quantitative approaches to remote sensing at local to global scales. Areas of interest include, but are not necessarily restricted to:

- Quantitative and Inversion-agriculture, forestry and range
- Ecology
- Earth and environment science
- Geography and land information
- Geology and geosciences
- Hydrology and water sciences
- Remote sensing image processing and analysis
- Atmospheric science and meteorology
- Oceanography
- Disaster monitoring
- Geographic Information system, GIS etc.

Preamble

The GIS/Remote Sensing Quarterly Review Bulletin for the fourth quarter 2024 reveals the extent of Nigeria's susceptibility to flood and provide insight on the possible locations for fishing activities in Nigerian maritime waters. This assessment relies on monthly rainfall, soil moisture index, relative humidity, chlorophyll concentration, sea surface temperature and other relevant remote sensing data. States prone to flooding are presented in this bulletin by overlaying Nigeria's Digital Elevation Model (DEM) on the spatial rainfall distribution and also carrying out other interpolation and Geospatial analysis such as inverse distance weighted (IDW), kriging amongst others.

CHAPTER ONE
September 2024

1.0 Rainfall Distribution

1.1 RAINFALL DISTRIBUTION OVER NIGERIA IN SEPTEMBER 2024

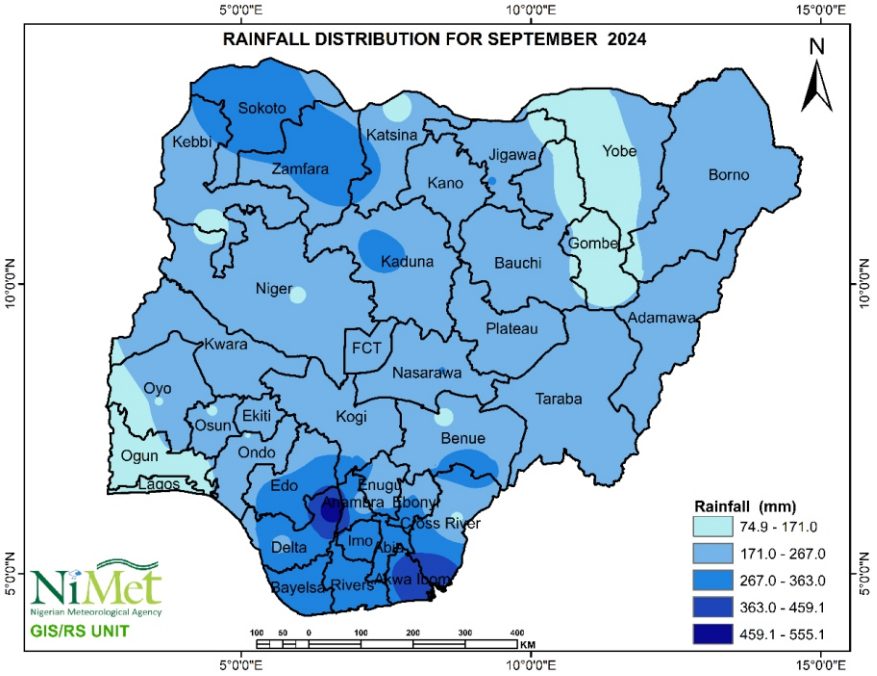

Figure 1: Rainfall Amount for September 2024.

1.1.1 OBSERVED FEATURES: The rainfall distribution in September 2024 shows significant rainfall activities across Nigeria. The northern and central states experienced rainfall amounts ranging between 171mm and 267mm, except parts of Yobe, Gombe, Katsina, Kebbi, Niger and Benue states where the amount of rainfall recorded was between 74.9mm and 171mm was recorded. Also, rainfall amounts ranging from 267mm to 363mm were recorded over parts of Kogi, Benue, Kaduna, Zamfara, and Sokoto states during the period. The South-West, South-East and South-South regions recorded rainfall amounts ranging between 171mm and 555.1mm except Lagos, Ogun and parts of Oyo, Osun, Ondo and Rivers states where rainfall between 74.9mm and 171mm was recorded.

1.1.2 ADVISORIES:

State Emergency Management

Agencies in the North-Central and Southern region of the country are advised to access and disseminate NiMet's rainfall forecasts, NIHSA's Annual Flood Outlook to vulnerable and flood-prone communities to help mitigate the impacts of potential flooding especially the release of water from Lagdo Dam. This proactive approach can significantly reduce the risk to lives and property in these regions.

1.2 RAINFALL DISTRIBUTION OVER NIGERIA IN SEPTEMBER 2024

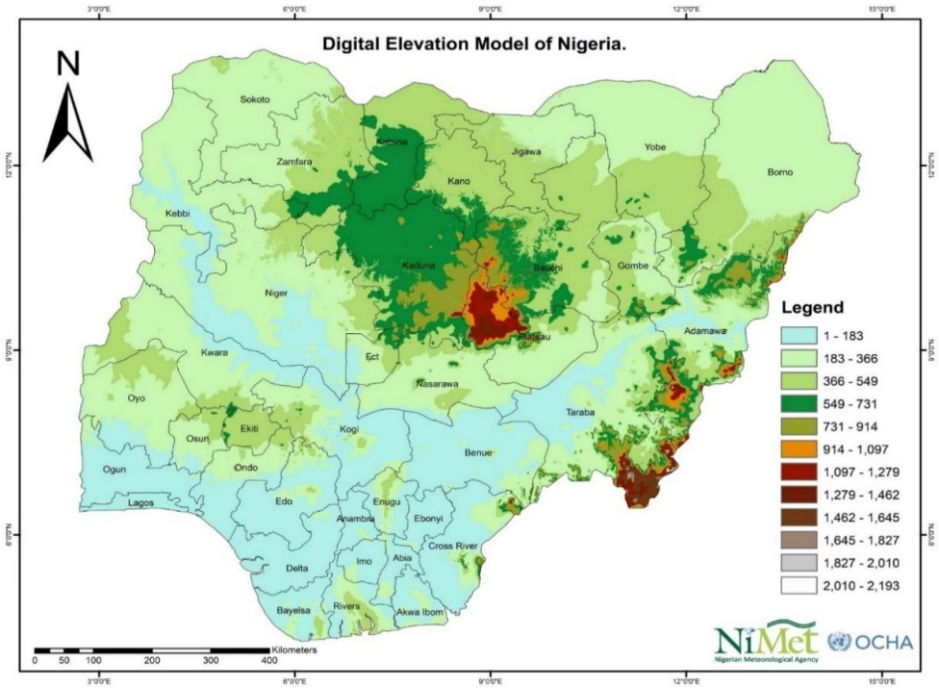

Figure 2: Digital Elevation Model for Nigeria, depicting the geographical positions of high and low areas

1.2.1 OBSERVED FEATURES:

A Digital Elevation Model (DEM) represents the Earth's topographic surface devoid of vegetation, buildings, and other surface structures. DEMs are widely utilized to show the natural terrain without plant cover and human-made features. They consist of a grid of elevation values referenced to a common vertical datum, typically measured in meters, providing a continuous depiction of elevation across a topographic area as illustrated in Figure 2. Elevations across the Nigeria range from 1 meter to 2193 meters. The highest elevations are observed over

parts of Bauchi, Plateau, Kaduna, Taraba, Adamawa, and Cross River States, while the lowest points are located in Lagos, Delta, and sections of Ondo, Edo, Bayelsa, Rivers, and Akwa Ibom states.

1.2.2 ADVISORIES:

Elevated areas above sea level and areas with steep slopes are vulnerable to erosion and landslides. In the event of heavy rainfall, local authorities and residents in these regions are advised to be mindful of these potential risks and take proactive actions to reduce the hazards.

Flooding: Areas with low elevation are naturally at risk of flooding in Nigeria. Lagos, Delta, and portions of Ondo, Edo, Bayelsa, Rivers, and Akwa Ibom states have low elevation and therefore vulnerable to flooding. Preparedness for potential flooding and construction of effective drainage systems are important adaptation measures in such areas.

Infrastructure Development: Thorough planning is crucial when constructing physical infrastructure in areas with varying elevations. In hilly and mountainous terrains, it is imperative to implement adequate engineering measures to ensure stability such as appropriate strength of materials and soil profile analysis.

Ecological Concerns: Mountainous regions often host unique ecological systems. To protect these natural environments, it is essential to implement good ecological practices such as, biodiversity conservation, climate change adaptation and adopt other sustainable environmental practices such as afforestation.

1.3 PROBABLE FLOOD RISK FOR SEPTEMBER 2024

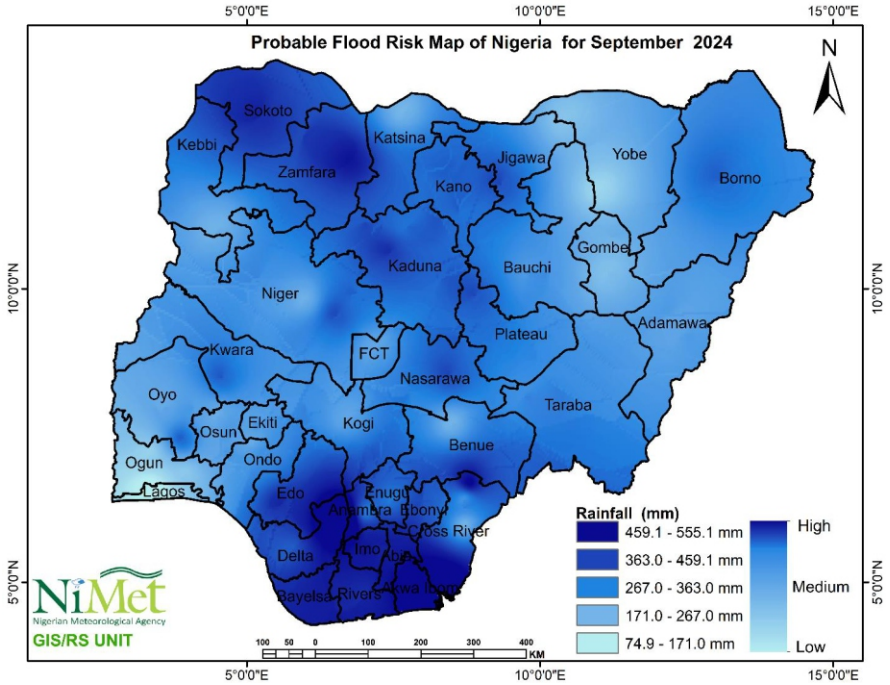

Figure 3: Map indicating Areas of high, medium and low wetness in September 2024.

Table 1: Classification of flood Risk According to Geopolitical zones

S/N	Geo-political Zones	States	Risk Level
South West			
1		Ogun	**Low Risk**
2		Lagos	**Low Risk**
3		Osun	**Low Risk**
4		Ondo	**Low Risk**
5		Oyo	**Low Risk**
6		Ekiti	**Low Risk**
South East			
		Imo	**Medium-High Risk**
1		Ebonyi	**Medium-High Risk**
2		Anambra	**Medium High Risk**
3		Abia	**Medium-High Risk**
4		Enugu	**Medium-High Risk**

South South			
		Delta	**High Risk**
1		Rivers	**High Risk**
2		Akwa Ibom	**High Risk**
3		Bayelsa	**High Risk**
4		Edo	**High Risk**
5		Cross River	**Medium - High Risk**
North Central			
1		Kwara	**Low Risk**
2		Benue	**Low Risk**
3		Kogi	**Low Risk**
4		Kaduna	**Low Risk**
5		Plateau	**Low Risk**
6		Niger	**Low Risk**
7		Abuja	**Low Risk**
8		Nasarawa	**Low Risk**
North East			
1		Taraba	**Low Risk**
2		Borno	**Low Risk**
3		Yobe	**Low Risk**
4		Bauchi	**Low Risk**
5		Gombe	**Low Risk**
North West			
1		Jigawa	**Low Risk**
2		Kano	**Low Risk**
3		Kebbi	**Low Risk**
4		Katsina	**Low Risk**
5		Sokoto	**Medium-High Risk**
6		Zamfara	**Medium-High Risk**

1.4 MAP OF RIVER OVERLAY WITH FLOOD RISK AREAS OF SEPTEMBER 2024.

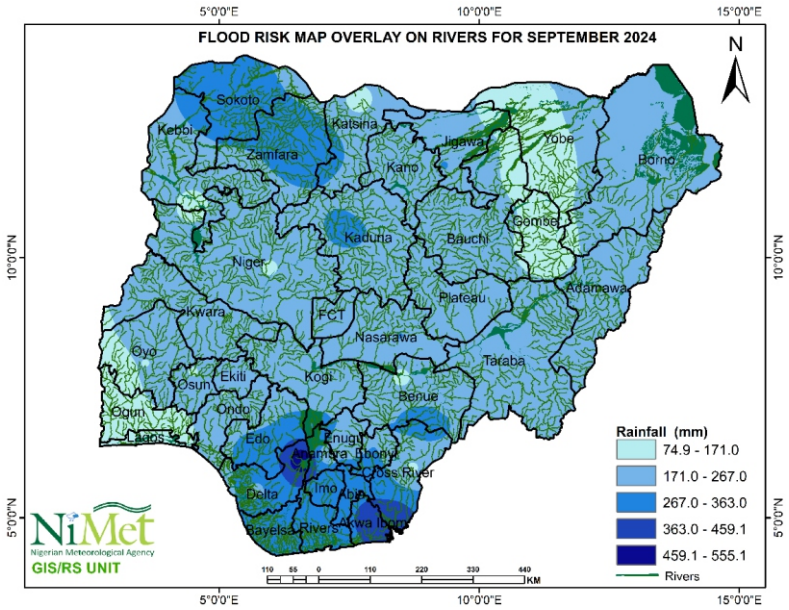

Figure 4: Map of River Overlay with Flood Risk Areas of September 2024.

1.3.1 OBSERVED FEATURES:

Flood risk map overlay on major rivers in Nigeria indicating potential flooding activities in and around rivers in the country. Also, climatic features such as rainfall, rivers shapefile are used to determine these environmental hazards. This is used for identifying rivers that are prone to flooding. Figure 4 shows that in the northern part of Nigeria, Sokoto, Zamfara and parts of Kaduna state are mostly at risk of river flooding.

Considering topographic landscape and rainfall characteristics, Figure 4 indicates the north-central, south-west, south-east and south-south regions have tendencies for river flooding, also impending release of water from Lagdo dam could affect states like Adamawa, Taraba, Edo, Delta, Bayelsa, Rivers, Akwa Ibom, Cross River, Imo, Anambra, Abia, parts of Enugu, Ebonyi, Benue, and Kogi state.

1.3.2 ADVISORIES:

Plans for Evacuation: Local authorities are advised to formulate and share evacuation protocols with residents in vulnerable areas along river banks, identifying secure shelter locations and escape routes. Also, people living in flood-prone areas should ensure proper clearing of debris in and around rivers and other water channels.

1.5 AREAS IN NIGERIA AT HIGH RISK OF FLOODING IN SEPTEMBER 2024

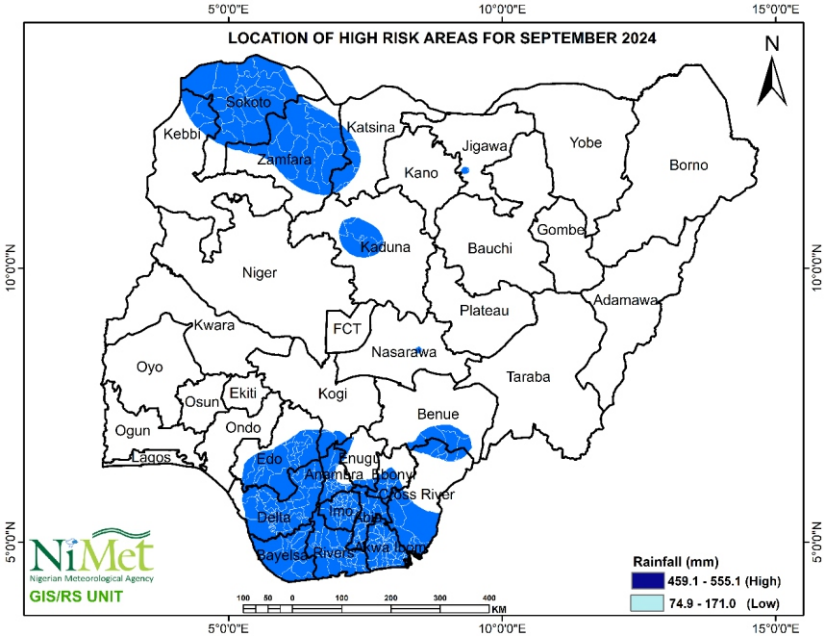

Figure 5: Map Depicting Location of High and Low Risk Areas in September 2024

1.4.1 OBSERVED FEATURES:

With further examination of potential flood risk zones as seen in Figure 5, states and local government areas with likelihood of flood occurrence have been identified. Delta, Bayelsa, Akwa Ibom, Imo, Abia, Cross River including parts of Sokoto, Kebbi, Kaduna, Benue, Edo, Enugu, Ebonyi and Kogi states have shown to be at high risk with their local government areas depicted in Figure 5. The risk levels in term of percentage is outlined in Table 2.

1.4.2 ADVISORIES:

Plans for Evacuation: Local authorities are advised to formulate and share evacuation protocols with residents in vulnerable areas, identifying secure shelter locations and escape routes.

Promoting Community Awareness: Residents are encouraged to follow guidance from local authorities and stay informed about weather forecasts. State Meteorological Inspectors (SMI) should effectively disseminate weather information, ensuring that emergency contact details for local response teams and services are easily accessible to the public.

Residents in high-risk areas should take precautionary measures to protect lives and valuable properties.

Keep Up with the News: Monitor local news and weather reports regularly, paying attention to guidance provided by emergency services and local authorities. It is important to stay updated on weather and flood information from NiMet and Nigeria Hydrological Service Agency (NIHSA). Local authorities should initiate and communicate evacuation plans for vulnerable areas, identifying safe shelters and evacuation routes before flooding occurs.

Table 2: States at High Risk of Flooding in September

SN	STATE	SUSCEPTIBILITY LEVEL (%)
1.	ABIA	97.5
2.	AKWAIBOM	92.58
3.	ANAMBRA	80.65
4.	BAYELSA	93.63
5.	BENUE	12.94
6.	CROSS RIVER	54.62
7.	DELTA	91.39
8.	EBONYI	41.61
9.	EDO	61.46
10.	ENUGU	21
11.	IMO	96.2
12.	JIGAWA	0.84
13.	KADUNA	12.63
14.	KEBBI	11.59
15.	KATSINA	15.8
16.	KOGI	6.61
17.	NASARAWA	0.57
18.	RIVERS	93.57
19.	SOKOTO	80.35
20.	ZAMFARA	70.61

1.6 SOIL MOISTURE INDEX ACROSS NIGERIA IN SEPTEMBER 2024

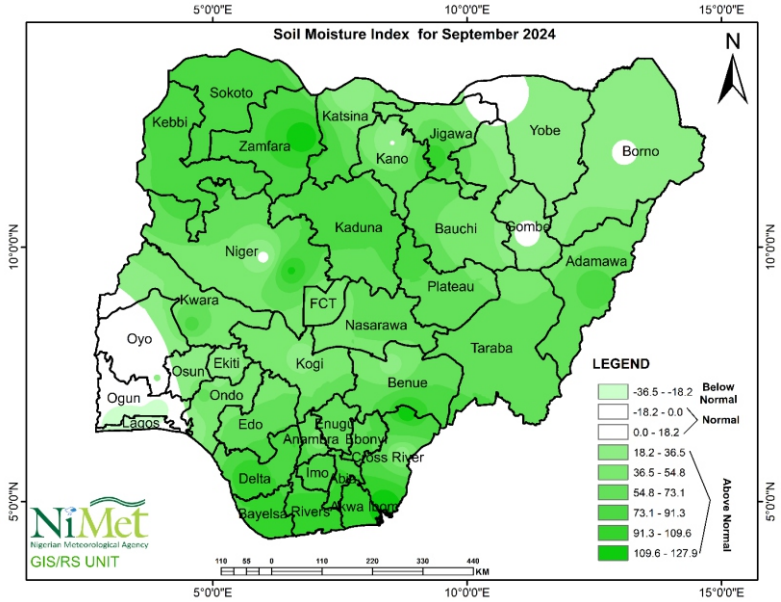

Figure 6: The Soil Moisture Index across Nigeria in September 2024 depicting areas of soil moisture saturation that may be predisposed to flood.

1.5.1 OBSERVED FEATURES:

The soil moisture conditions across the country in September 2024 is illustrated in the Soil Moisture Index (SMI) map (Figure 6). As shown in the map, the soil moisture over most parts of the country was above normal except Parts of Borno, Yobe, Jigawa, Gombe, Niger, Kwara, Oyo, Ogun, Lagos, Osun and Ondo state where normal soil moisture condition was recorded during the period under consideration. While below normal condition was observed mainly over parts of Ogun and Lagos states.

Relating Figure 6 with Figure 1, it is expected that some parts of the south east and south-south regions of the country, especially Delta, Bayelsa, Akwa Ibom, Rivers, Cross River, Imo, Abia, Anambra Enugu and Ebonyi states are likely to experience flood within the period.

1.5.2 ADVISORIES:

Adequate precautions and mitigation measures to reduce the impact of flooding in the South-South, South-East and North-Central region and areas under above normal conditions should be implemented.

1.7 RELATIVE HUMIDITY DISTRIBUTION ACROSS NIGERIA IN SEPTEMBER 2024

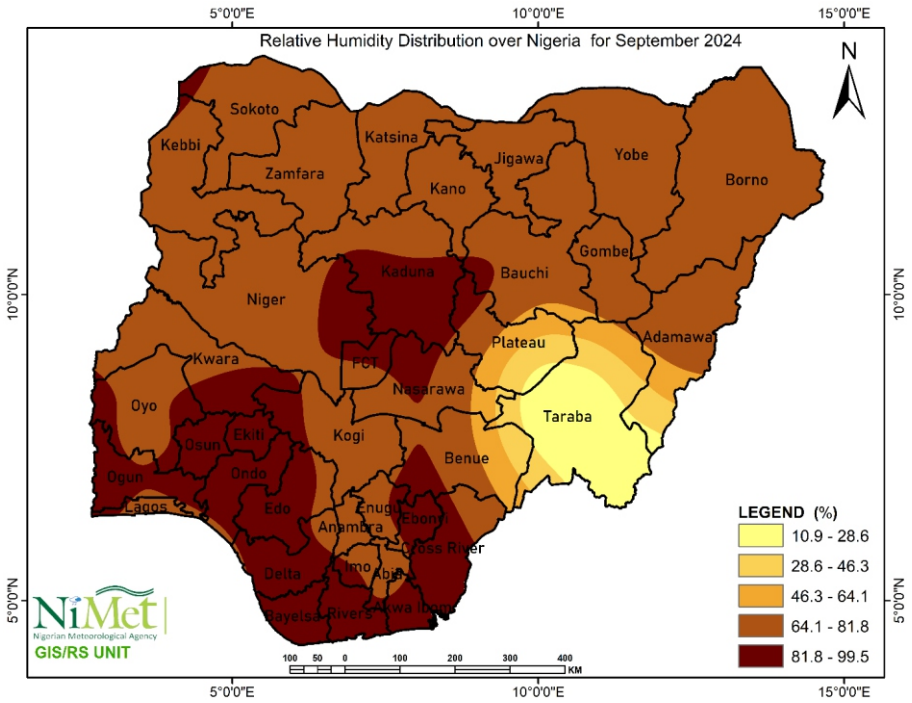

Figure 7: The Relative Humidity Distribution over Nigeria in September 2024

1.6.1 OBSERVED FEATURES:

The following are the features observed concerning relative humidity distribution over the country in September 2024 as seen from Figure 7:

- The Relative Humidity (RH) over the north-eastern part of the country range between 64.1% and 81.8%, except in some parts of Adamawa, Taraba and Bauchi which recorded very low relative humidity range of 10.9% to 46.3%.
- The North-western region experienced relative humidity ranging between 64.1% and 81.8%. However, parts of Sokoto, Kebbi and Kaduna state experienced high relative humidity range between 81.8% and 99.5% during the period.
- Relative humidity range of between 64.1% and 99.5% was observed over most parts of the north-central region except for parts of Benue, Nasarawa and Plateau where relative humidity range between 28.6% and 64.1% was experienced.
- High Relative Humidity ranging between 81.8% and 99.5% was observed mainly over most places in the Southern region apart from parts of Oyo, Lagos, Enugu, Anambra and Abia state which recorded relative humidity range between 64.1% and 81.8%.

1.6.2 ADVISORIES:

With the Inter-Tropical Discontinuity (ITD) line still around latitude 15oN, the country is

still under the influence of the moist southwesterlies and the high relative humidity across the country is still high. Therefore proper planning of day to day activities with relation to disseminated weather information are encouraged

1.8 MASS CHLOROPYHLL CONCENTRATION OVER NIGERIAN COAST

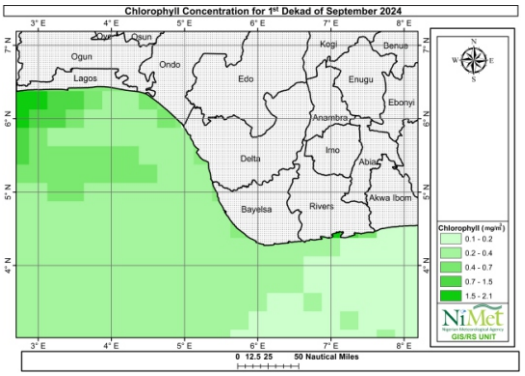

Figure 8: Chlorophyll Concentration for First Dekad of September 2024 (*Data Source: Copernicus Marine*)

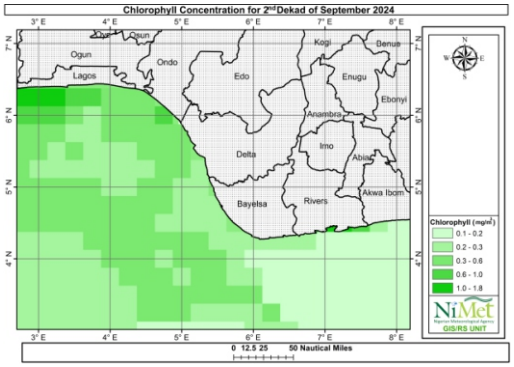

Figure 9: Chlorophyll Concentration for Second Dekad of September 2024 (*Data Source: Copernicus Marine*)

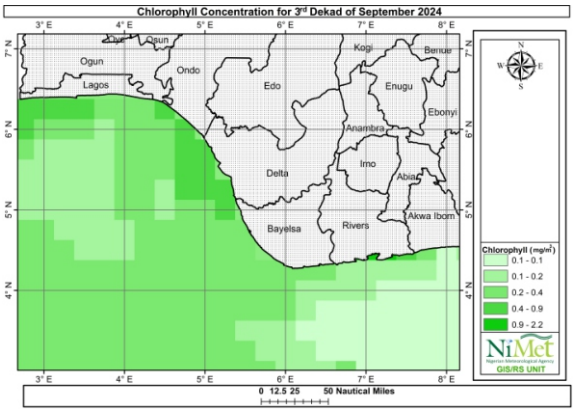

Figure 10: Chlorophyll Concentration for Third Dekad of September 2024 (*Data Source: Copernicus Marine*)

1.7.1 OBSERVED FEATURES: Chlorophyll concentration reveals the dynamic interplay of multiple factors, including nutrient availability, sunlight, and the delicate balance of biomass productivity. Higher chlorophyll values indicate nutrient-rich waters where phytoplankton thrive. Figure 8, Figure 9 and Figure 10 shows surface ocean chlorophyll concentration for the first, second and third dekads of September 2024.

Considering Figure 8, the dark green areas which represent higher chlorophyll concentration ranges between 0.7mg/m3 and 2.1mg/m3 which lies with latitude 5.3 oN and 6.4 oN and longitude 2.7 oE and 3.7 oE mainly over the coast of Lagos state. Light green areas indicate lower concentration of

chlorophyll ranging between 0.1mg/m3 and 0.2 mg/m3. Moderate concentration of chlorophyll ranges between 0.2 mg/m3 and 0.7 mg/m3 within the period.

As seen from Figure 9, the concentration of chlorophyll have extended to the coast of Ondo and Delta during the second dekad with higher values ranging between 0.6 mg/m3 and 1.8 mg/m3. Comparing Figure 10 with Figure 9 it is observed that there is improvement of chlorophyll concentration over the coast of the country covering the coast of Lagos, Ondo, Delta, Bayelsa, Rivers and parts of Akwa Ibom state. However, the highest concentration for the dekad (Figure 10) is over latitude 4.9 oN and 6.4 oN and longitude 4.4 oE and 5.3 oE.

Note that: changes in phytoplankton population may impact fish and other marine life, which can affect economic productivity and food availability. Also, decision makers can use this indicator to understand the health and productivity of marine ecosystem that depend on phytoplankton.

1.9 SEA POTENTIAL TEMPERATURE OVER NIGERIAN COAST

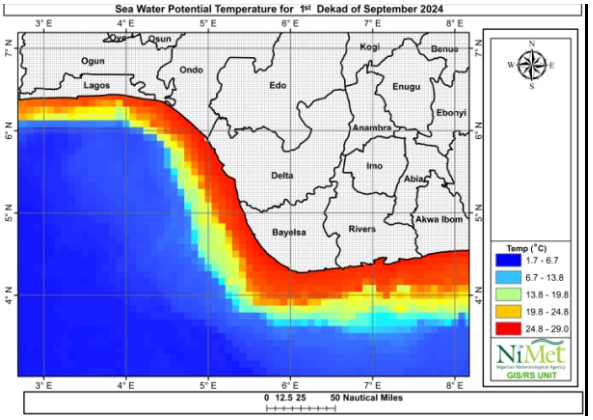

Figure 11; Sea Potential Temperature for First Dekad of September 2024 (*Data Source: Copernicus Marine*)

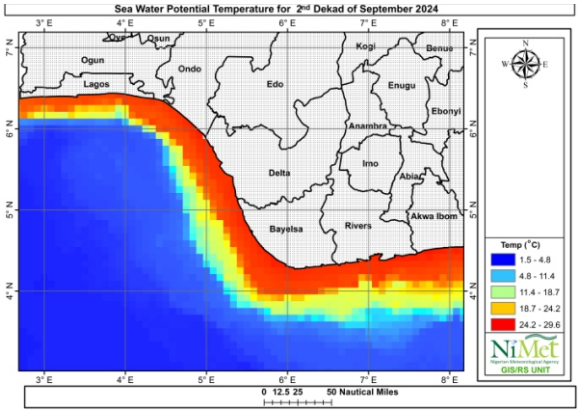

Figure 12; Sea Potential Temperature for Second Dekad of September 2024 (*Data Source: Copernicus Marine*)

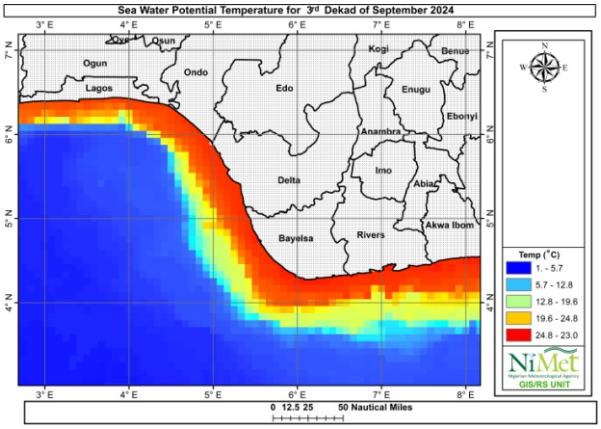

Figure 13; Sea Potential Temperature for Third Dekad of September 2024 (*Data Source: Copernicus Marine*)

1.8.1 OBSERVED FEATURES: Figures 11, 12 and 13 shows the sea surface potential temperature for first, second and third dekads of September 2024 respectively. Evaluation of these temperatures is necessary owing to the fact that it plays a vital role in determining the movement of fish and other species. This temperature directly or indirectly impacts the rate of all physical, chemical, and most biological processes occurring in the ocean.

Figures 11, 12 and 13 depict higher temperatures within the coast of Lagos, Ondo, Delta, Bayelsa, Rivers and Akwa Ibom states. For the first dekad, higher temperatures (represented in red colour) ranges between 24.8°C to 29°C while for the second and third dekad, the higher temperatures ranges between 24.2 °C and 29.6 °C and 24.8 °C to 29 °C respectively. Furthermore, Figures 11, 12 and 13 show that lower temperatures are far away from the coast lines of the country. The values are seen to be in the range of 1.7°C to 6.7°C (Figure 11), 1.5°C to 4.8 oC (Figure 12) and 1.0 °C to 4.7°C (Figure 13) respectively.

1.8.2 ADVISORIES:

With warming temperatures, fish and other marine species at the warmer regions are likely to migrate to cooler regions with high concentration of Phytoplanktons for feeding activities. Fishing vessels, trawlers and fish farmers are advised to operate in areas of cooler temperature for maximum catch.

CHAPTER TWO
October 2024

2.0 RAINFALL DISTRIBUTION

2.1 RAINFALL DISTRIBUTION OVER NIGERIA IN OCTOBER 2024

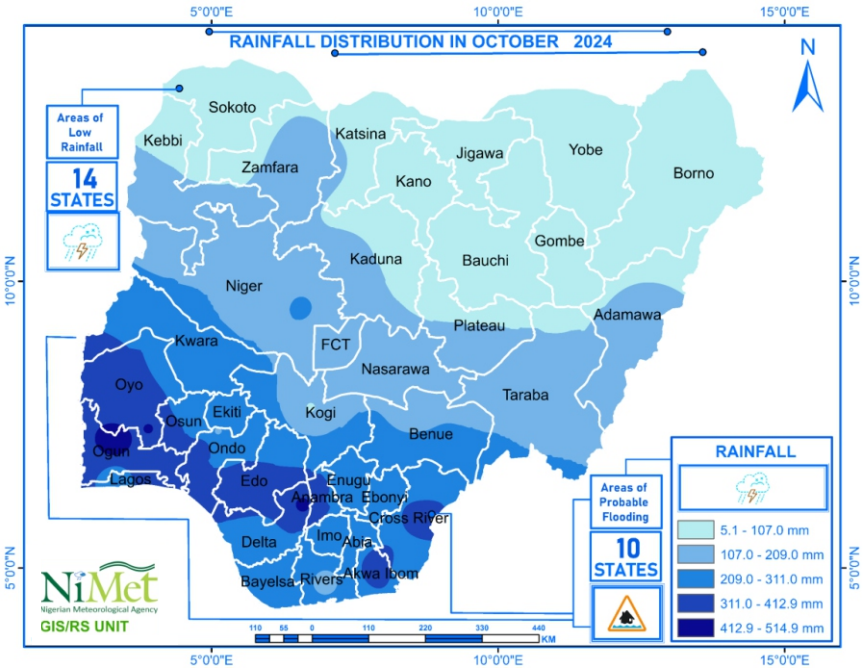

Figure 14: Rainfall Amount in October 2024.

2.1.1 OBSERVED FEATURES: The rainfall distribution in October 2024 shows significant rainfall activities across Nigeria. The northern and central states experienced rainfall amounts ranging between 5.1mm and 107mm, except parts of Kebbi, Zamfara Plateau, Kaduna, Taraba and Adamawa, states where the amount of rainfall recorded was between 107mm and 209mm. Also, rainfall amounts ranging from 209mm to 311mm were recorded over parts of Kwara, Niger and Benue states. The South-West, South-East and South-South regions recorded rainfall amounts ranging between 311mm and 514.9mm.

2.1.2 ADVISORIES:

State Emergency Management Agencies in the North-Central and Southern states of the country are advised to access and disseminate NiMet's rainfall forecasts. The forecasts are helpful for identifying vulnerable and flood-prone communities and enable them mitigate the impacts of potential flooding especially the release of water from Lagdo Dam. This proactive approach can significantly reduce the risk to lives and property in these regions.

2.2 DIGITAL ELEVATION MODEL OF NIGERIA

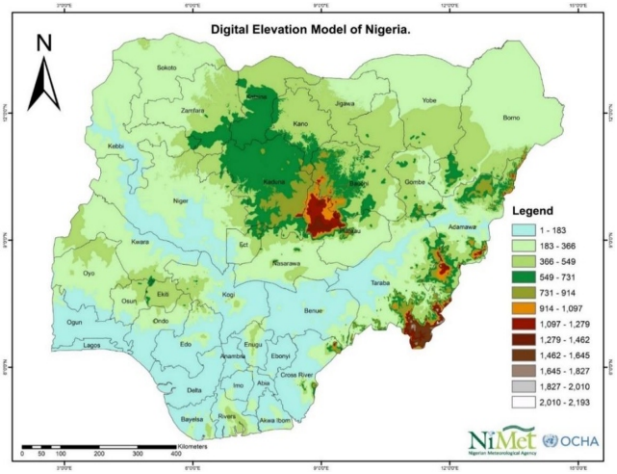

Figure 15: Digital Elevation Model for Nigeria, depicting the Geographical positions of high and low areas

2.2.1 OBSERVED FEATURES:

A Digital Elevation Model (DEM) represents the Earth's topographic surface devoid of vegetation, buildings, and other surface structures. DEMs are widely utilized to show the natural terrain without plant cover and human-made features. They consist of a grid of elevation values referenced to a common vertical datum, typically measured in meters, providing a continuous depiction of elevation across a topographic area as illustrated in Figure 2. Elevations across Nigeria range from 1 meter to 2193 meters. The highest elevations are found in parts of Bauchi, Plateau, Kaduna, Taraba, Adamawa, and Cross River States, while the lowest points are located in Lagos, Delta, and sections of Ondo, Edo, Bayelsa, Rivers, and Akwa Ibom states.

2.2.2 ADVISORIES:

Elevated areas above sea level and areas with steep slopes are susceptible to erosion and landslides. In the event of heavy rainfall, local authorities and residents in these regions are advised to be mindful of these potential risks and take proactive actions to reduce the risks.

Flooding: Areas with low elevation are naturally susceptible to flooding in Nigeria. Lagos, Delta, and portions of Ondo, Edo, Bayelsa, Rivers, and Akwa Ibom states have low elevation and therefore vulnerable to flooding. Preparedness for potential flooding and construction of effective drainage systems are important adaptation measures in such areas.

Infrastructure Development: Thorough planning is crucial when constructing physical infrastructure in areas with varying elevations. In hilly and mountainous terrains, it is imperative to implement adequate engineering measures to ensure stability such as appropriate strength of materials and soil profile analysis.

Ecological Concerns: Mountainous regions often host unique ecological systems. To protect these natural environments, it is essential to implement good ecological practices such as, biodiversity conservation, climate change adaptation and adopt other sustainable environmental practices such as afforestation.

2.3 PROBABLE FLOOD RISK IN OCTOBER 2024

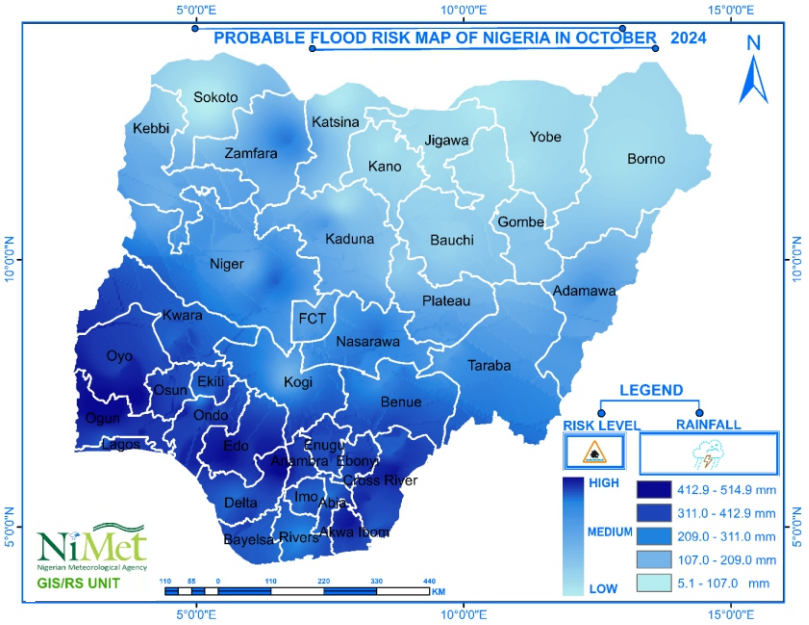

Figure 16: Map indicating Areas of high, medium and low wetness in October 2024

Table 3: Classification of flood Risk According to Geopolitical zones

S/N	Geo-political Zones	States	Risk Level
South West			
1		Ogun	**High Risk**
2		Lagos	**High Risk**
3		Osun	**Medium High Risk**
4		Ondo	**Medium High Risk**
5		Oyo	**Medium High Risk**
6		Ekiti	**Medium High Risk**
South East			
		Imo	**Medium-High Risk**
1		Ebonyi	**Medium-High Risk**
2		Anambra	**Medium High Risk**
3		Abia	**Medium-High Risk**
4		Enugu	**Medium-High Risk**
South South			
		Delta	**High Risk**

1		Rivers	High Risk
2		Akwa Ibom	High Risk
3		Bayelsa	Medium High Risk
4		Edo	High Risk
5		Cross River	High Risk
North Central			
1		Kwara	Medium High Risk
2		Benue	Medium Risk
3		Kogi	Low Risk
4		Kaduna	Low Risk
5		Plateau	Low Risk
6		Niger	Medium Low Rissk
7		Abuja	Low Risk
8		Nasarawa	Medium Low Risk
North East			
1		Taraba	Low Risk
2		Borno	Low Risk
3		Yobe	Low Risk
4		Bauchi	Low Risk
5		Gombe	Low Risk
North West			
1		Jigawa	Low Risk
2		Kano	Low Risk
3		Kebbi	Low Risk
4		Katsina	Low Risk
5		Sokoto	Low Risk
6		Zamfara	Low Risk

Table 4: States Showing High Risk of Flooding in October 2024.

S/N	STATE	SUSCEPTIBILITY LEVEL (%)
1.	ABIA	41.5
2.	AKWA IBOM	50.3
3.	ANAMBRA	60.1
4.	BAYELSA	40.9
5.	BENUE	26.2
6.	CROSS RIVER	39.7
7.	DELTA	68.23
8.	EBONYI	54.30
9.	EDO	70.40
10.	EKITI	55.1
11.	ENUGU	45.0
12.	IMO	40.45
13.	KOGI	20.34
14.	KWARA	44.2
15.	LAGOS	79.78

15.	LAGOS	79.78
16.	NIGER	12.90
17.	OGUN	81.5
18.	ONDO	45.54
19.	OSUN	39.21
20.	OYO	66.6
21.	RIVERS	36.02
22.	TARABA	12.42

2.4 MAP OF RIVER OVERLAY WITH FLOOD RISK AREAS OF OCTOBER 2024.

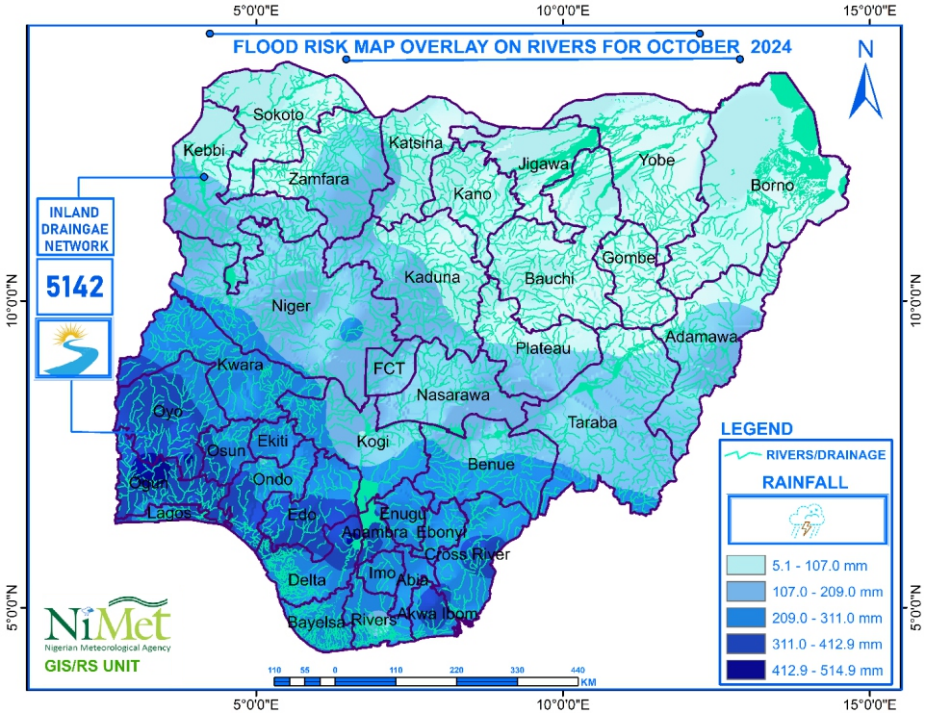

Figure 17: Map of River Overlay with Flood Risk Areas of October 2024.

1.3.1 OBSERVED FEATURES:

Flood risk map overlay on major rivers in Nigeria indicating potential flooding activities in and around rivers in the country. Also, climatic features such as rainfall, rivers shape file are used to determine these environmental hazards. This is used for identifying rivers that are prone to flooding. Figure 4 shows that in the Southern and some western parts of Nigeria, Ogun, Oyo, Edo, parts of Osun Anambra, Akwa Ibom and Cross Rivers state are mostly at risk of river flooding during the month.

Considering topographic landscape and rainfall characteristics, Figure 4 indicates the south-west, south-east and south-south regions are prone to river flooding

1.3.2 ADVISORIES:

Plans for Evacuation: Local authorities are advised to formulate and share evacuation protocols with residents in vulnerable areas along river banks, identifying secure shelter locations and escape routes. Also, people living in flood-prone areas should ensure proper clearing of debris in and around rivers and other water channels.

2.5 AREAS IN NIGERIA AT HIGH RISK OF FLOODING IN OCTOBER 2024

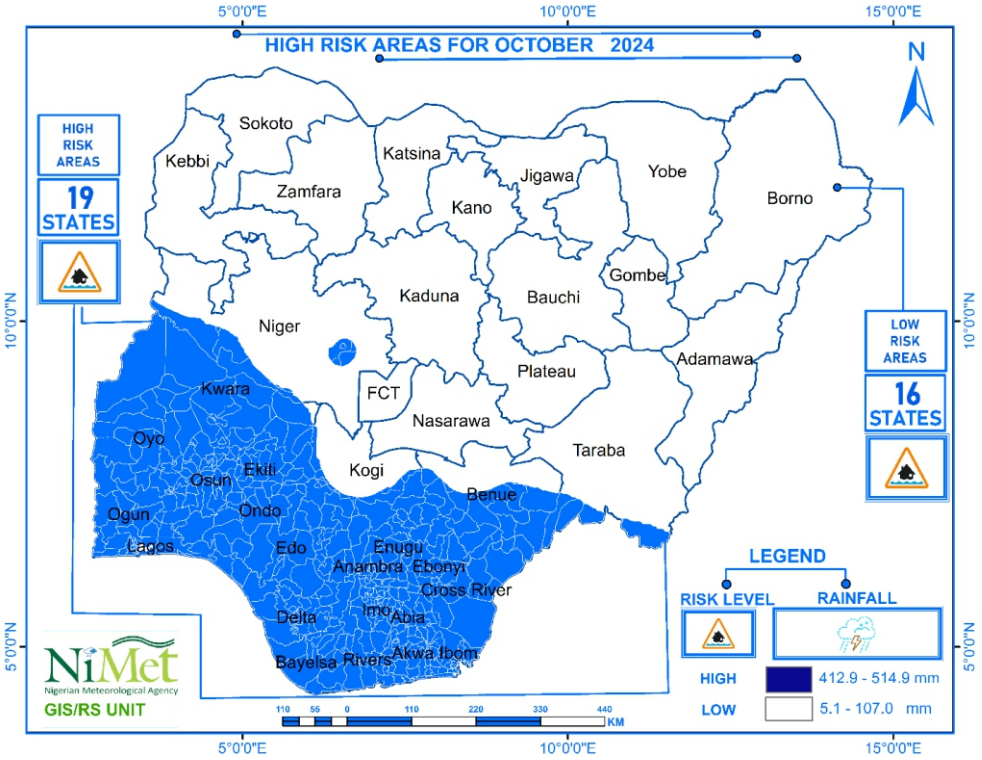

Figure 18: Map Depicting Location of High and Low Risk Areas in October 2024

1.4.1 OBSERVED FEATURES:

With further examination of potential flood risk zones as shown in Figure 5, states with likelihood of flood occurrence have been identified. Kwara, Oyo, Ogun, Lagos, Osun, Ondo , Edo, Delta, Bayelsa, Enugu, Ebonyi , Cross River ,Akwa Ibom, Imo, Abia, Rivers including parts of Benue, Kogi and Niger states are at high risk areas. The flood risk levels in term of percentage is outlined in Table 2.

1.4.2 ADVISORIES:

Plans for Evacuation: Local authorities are advised to formulate and share evacuation protocols with residents in vulnerable areas, identifying secure shelter locations and escape routes.

Promoting Community Awareness: Residents are encouraged to follow guidance from local authorities and stay informed about weather forecasts. State Meteorological Inspectors (SMI) should effectively disseminate weather information, ensuring that emergency contact details for local response teams and services are easily accessible to the public.

Residents in high-risk areas should take precautionary measures to protect lives and valuable properties.

Keep Up with the News: Monitor local news and weather reports regularly, paying attention to guidance provided by emergency services and local authorities. It is important to stay updated on weather and flood information from NiMet and Nigeria Hydrological Service Agency (NIHSA). Local authorities should initiate and communicate evacuation plans for vulnerable areas, identifying safe shelters and evacuation routes before flooding occurs.

2.6 SOIL MOISTURE INDEX ACROSS NIGERIA IN OCTOBER 2024

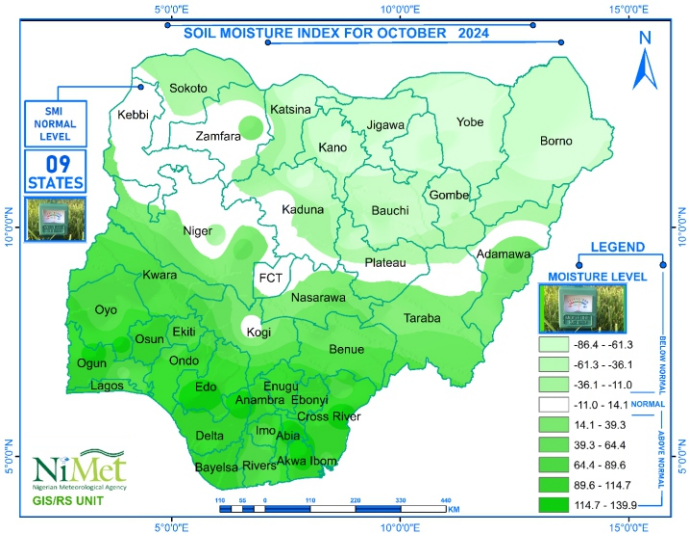

Figure 19: The Soil Moisture Index across Nigeria depicting areas of soil moisture saturation that may be prone to flood in October 2024.

1.5.1 OBSERVED FEATURES:

The soil moisture conditions across the country in October 2024 is illustrated in the Soil Moisture Index (SMI) map (Figure 6). As shown in the map, the soil moisture over most parts of the country was above normal except in Kebbi, Zamfara, parts of Niger, Plateau, FCT, Adamawa, Kaduna, Kogi, states where normal soil moisture condition was recorded during the period under consideration. Below normal soil moisture was observed mainly over parts of Katsina, Kano, Jigawa, Yobe , Borno, Gombe , Bauchi, part of Zamfara and Niger States.

It is expected that some parts of the south east and south-south regions of the country, especially Delta, Bayelsa, Akwa Ibom, Rivers, Cross River, Imo, Abia, Anambra, Enugu and Ebonyi, Osun, Lagos states are likely to experience flood within the period.

1.5.2 ADVISORIES:

Adequate precautions and mitigation measures to reduce the impact of flooding in the South-South, South-East and North-Central region and areas that have above normal soil moisture should be implemented.

2.7 RELATIVE HUMIDITY DISTRIBUTION ACROSS NIGERIA IN OCTOBER 2024

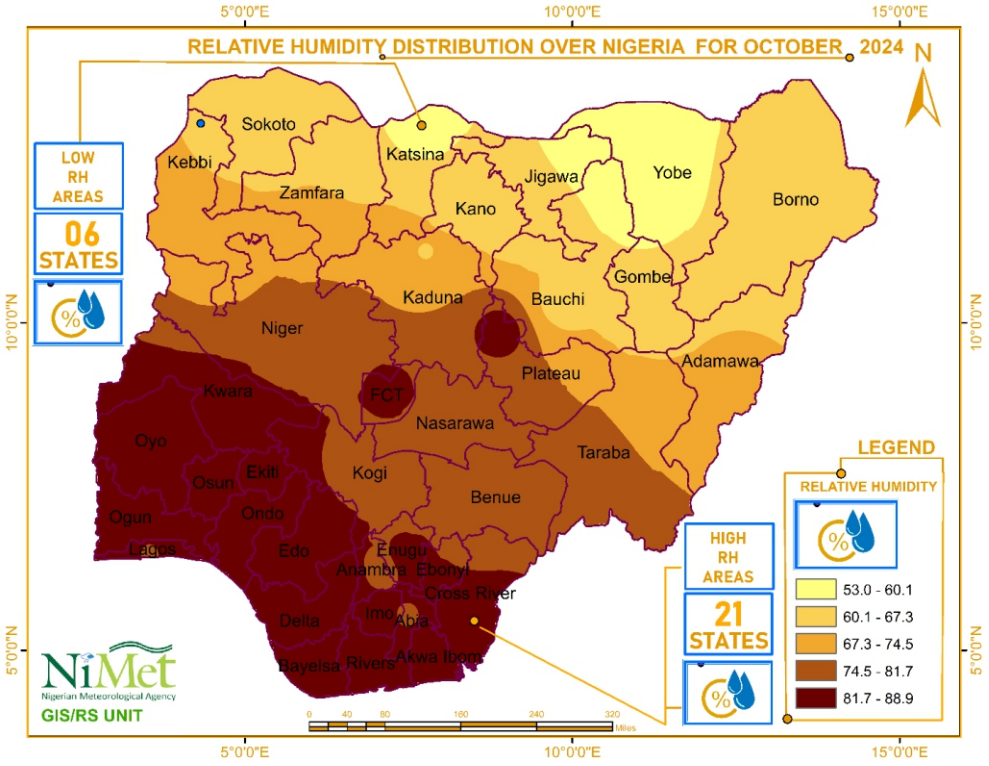

Figure 20: The Relative Humidity Distribution over Nigeria in October 2024

1.6.1 OBSERVED FEATURES:

Figure 6: shows the relative humidity over Nigeria in October 2024. The distribution across the country is characterized by the following features:

- The Relative Humidity (RH) over the north-eastern part of the country range between 60.1% and 67.3%, except for parts of Katsina, Jigawa and Yobe states which recorded 53% to 60.1%.
- The North-western region including parts of Bauchi, Adamawa and Plateau experienced relative humidity ranging between 67.3% and 74.5% during the period.
- Relative humidity ranges between 74.5% and 81.7% was observed majorly over Nasarawa, Kogi, Benue, parts of Taraba, Plateau, and Kaduna states.
- High Relative Humidity ranges between 81.7% and 88.9% was observed mainly over most places in the South- Western, South – Eastern and South-South region apart from parts of Anambra, Abia and Enugu states which experience relative humidity ranges between 74.5% and 81.7%.

1.6.2 RECOMMENDATIONS:

Maintaining optimal RH levels Prevents issues like mold, corrosion, dehydration, and structural damage, so it's crucial to monitor and adjust RH according to specific needs.

2.8 POST FLOOD LAND USE COVER MAP OF MAIDUGURI IN OCTOBER 2024

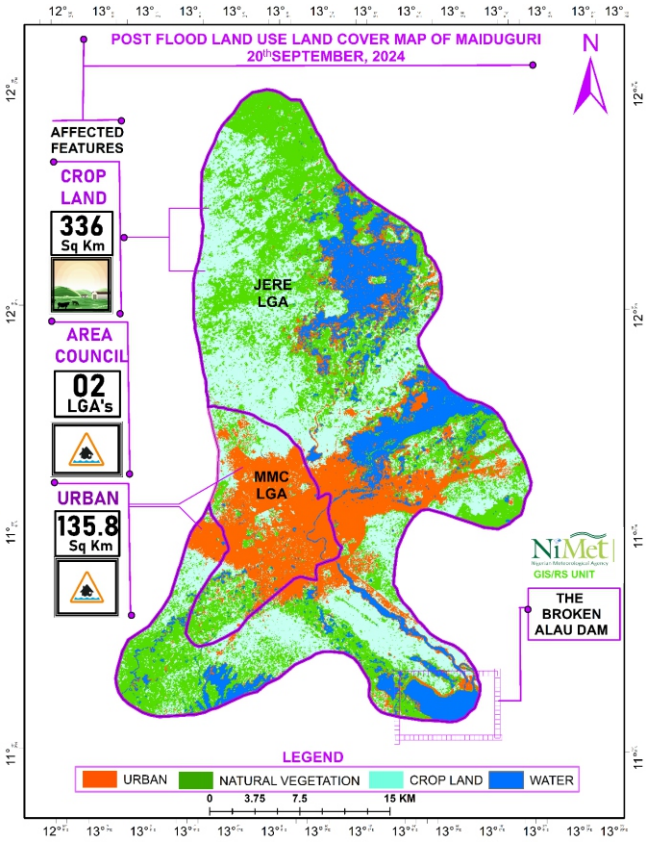

Figure 21: Post Flood Land Use Cover Map of Maiduguri in 20th October 2024

1.7.1 OBSERVED FEATURES: The post-flood land use map of Maiduguri from September 20, 2024, reveals the following key features and areas impacted by the flooding:

Urban and Agricultural Land Cover:

Urban Areas: The map shows urban areas (highlighted in orange), primarily concentrated in the Maiduguri Metropolitan Council (MMC) Local Government Area (LGA). The total urban area affected by the flood measures approximately 135.8 square kilometers.

Crop Land: Extensive cropland (in green) is also highlighted, particularly around Jere LGA, covering about 336 square kilometers. This area has likely suffered substantial agricultural losses, as floods can severely damage crops, impacting local food production.

Natural Vegetation and Water Bodies:

Natural Vegetation: The green areas on the map denote regions with natural vegetation, indicating preserved or uncultivated lands, which may provide some resilience against soil erosion and flooding.

Water Bodies: Significant portions of land (in blue) show water-covered areas resulting from the broken Alau Dam, which is marked in the southeastern region of the map. This water inundation covers both agricultural and possibly some residential areas, creating challenges for land recovery and agriculture.

Administrative Boundaries:

The map encompasses two LGAs: Jere and MMC, which have both been affected by the flood. This division aids in understanding the administrative regions impacted and the scale of displacement and infrastructure needs in each area.

Flood Impact Summary:

The flooding, caused by the Alau Dam's collapse, has led to substantial land cover changes. Floodwaters have inundated both urban and rural areas, affecting homes, farmlands, and infrastructure. The flood impact is extensive, as shown by the areas marked in blue and the scattered distribution of waterlogged regions across MMC and Jere.

This map visually represents the aftermath of the flood, revealing the widespread impact on urban spaces in Maiduguri, agricultural lands, and natural environments. It underscores the importance of developing infrastructure to manage floodwaters and safeguard both urban and agricultural zones against future flooding events.

1.7.2 ADVISORIES:

The advisories for post-flood recovery in Maiduguri focus on five key areas:

1. Urban and Infrastructure Recovery: Plan reconstruction with flood-resistant designs and address debris management to restore urban areas effectively.
2. Agricultural Restoration: Support cropland recovery through soil

treatments, resilient crops, and resources for farmers to reduce food insecurity.

3. Environmental and Water Management: Enhance natural vegetation as a flood buffer and reinforce water infrastructure like the Alau Dam to mitigate future flood risks.
4. Health and Sanitation: Provide clean water and sanitation solutions to prevent disease outbreaks and strengthen healthcare support.
5. Community Engagement and Disaster Preparedness: Educate the community on flood preparedness and establish early warning systems for future events.

These steps aim to rebuild Maiduguri's urban, agricultural, and environmental resilience following the devastating flood.

CHAPTER THREE
November 2024

3.0 RAINFALL DISTRIBUTION

3.1 RAINFALL DISTRIBUTION OVER NIGERIA IN NOVEMBER 2024

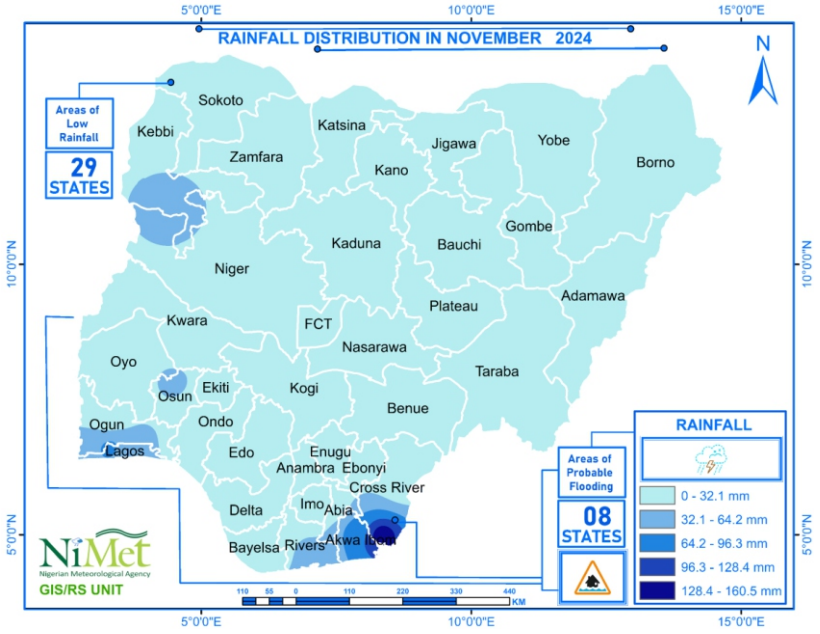

Figure 22: Rainfall Amount in October 2024.

3.1.1 OBSERVED FEATURES: The rainfall distribution in November 2024 shows significant rainfall activities majorly across the southern parts of Nigeria with little or no rainfall activities in the northern and central states. The rainfall amounts Experienced ranged between 1.0mm and 160.8mm in the southern parts of Nigeria with Katsina and Yelwa in the northern states experiencing rainfall amount of 11.9mm and 52.8 mm respectively.

3.1.2 ADVISORIES:

State Emergency Management Agencies in the Southern and the Northern states of the country are advised to access and disseminate NiMet's rainfall forecasts. The forecasts are helpful for identifying vulnerable and flood-prone communities and enable them mitigate the impacts of potential flooding especially the release of water from Lagdo Dam. This proactive approach can significantly reduce the risk to lives and property in these regions.

3.2 DIGITAL ELEVATION MODEL OF NIGERIA

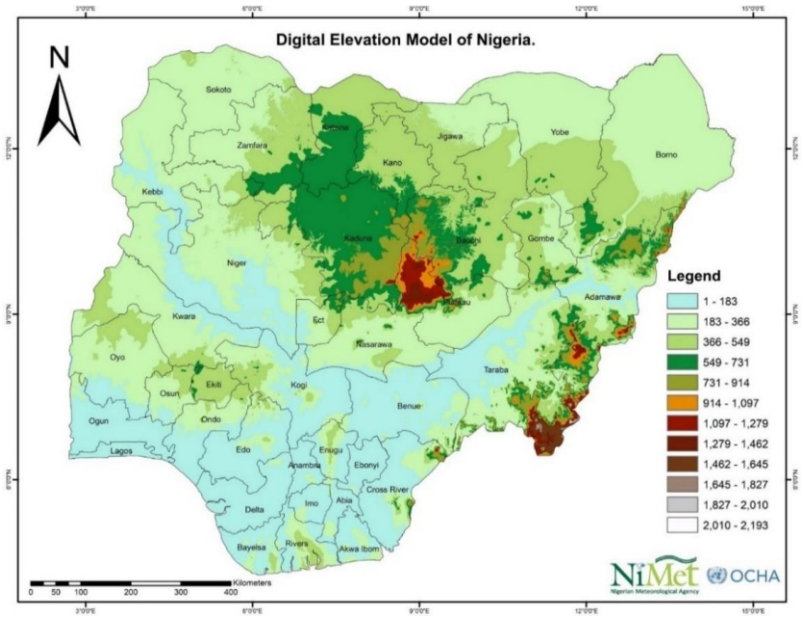

Figure 23: Digital Elevation Model for Nigeria, depicting the Geographical positions of high and low areas

3.2.1 OBSERVED FEATURES:

A Digital Elevation Model (DEM) represents the Earth's topographic surface devoid of vegetation, buildings, and other surface structures. DEMs are widely utilized to show the natural terrain without plant cover and human-made features. They consist of a grid of elevation values referenced to a common vertical datum, typically measured in meters, providing a continuous depiction of elevation across a topographic area as illustrated in Figure 2. Elevations across Nigeria range from 1 meter to 2193 meters. The highest elevations are found in parts of Bauchi, Plateau, Kaduna, Taraba, Adamawa, and Cross River States, while the lowest points are located in Lagos, Delta, and sections of Ondo, Edo, Bayelsa, Rivers, and Akwa Ibom states.

3.2.2 ADVISORIES:

Elevated areas above sea level and areas with steep slopes are susceptible to erosion and landslides. In the event of heavy rainfall, local authorities and residents in these regions are advised to be mindful of these potential risks and take proactive actions to reduce the risks.

Flooding: Areas with low elevation are naturally susceptible to flooding in Nigeria. Lagos, Delta, and portions of Ondo, Edo, Bayelsa, Rivers, and Akwa Ibom states have low elevation and therefore vulnerable to flooding. Preparedness for potential flooding and construction of effective drainage systems are important adaptation measures in such areas.

Infrastructure Development: Thorough planning is crucial when constructing physical infrastructure in areas with varying

elevations. In hilly and mountainous terrains, it is imperative to implement adequate engineering measures to ensure stability such as appropriate strength of materials and soil profile analysis.

Ecological Concerns: Mountainous regions often host unique ecological systems. To protect these natural environments, it is essential to implement good ecological practices such as, biodiversity conservation, climate change adaptation and adopt other sustainable environmental practices such as afforestation.

3.3 PROBABLE FLOOD RISK IN NOVEMBER 2024

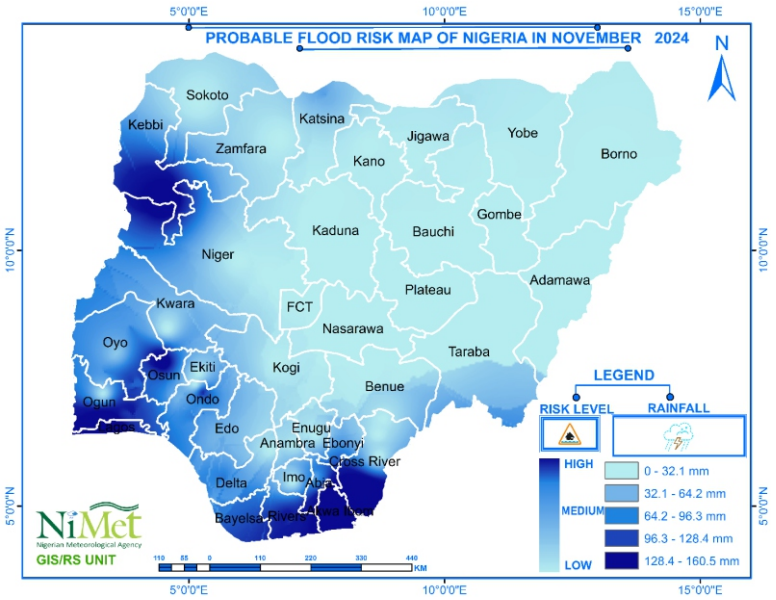

Figure 24: Map indicating Areas of high, medium and low wetness in November 2024

Table 5: Classification of flood Risk According to Geopolitical zones

S/N	Geo-political Zones	States	Risk Level
South West			
1		Ogun	**High Risk**
2		Lagos	**High Risk**
3		Osun	**Medium High Risk**
4		Ondo	**Medium High Risk**
5		Oyo	**Medium High Risk**
6		Ekiti	**Medium High Risk**
South East			
		Imo	**Medium-High Risk**

1		Ebonyi	Medium-High Risk
2		Anambra	Medium High Risk
3		Abia	Medium-High Risk
4		Enugu	Medium-High Risk
South South			
		Delta	High Risk
1		Rivers	High Risk
2		Akwa Ibom	High Risk
3		Bayelsa	Medium High Risk
4		Edo	High Risk
5		Cross River	High Risk
North Central			
1		Kwara	Medium High Risk
2		Benue	Medium Risk
3		Kogi	Low Risk
4		Kaduna	Low Risk
5		Plateau	Low Risk
6		Niger	Medium Low Rissk
7		Abuja	Low Risk
8		Nasarawa	Medium Low Risk
North East			
1		Taraba	Low Risk
2		Borno	Low Risk
3		Yobe	Low Risk
4		Bauchi	Low Risk
5		Gombe	Low Risk
North West			
1		Jigawa	Low Risk
2		Kano	Low Risk
3		Kebbi	Low Risk
4		Katsina	Low Risk
5		Sokoto	Low Risk
6		Zamfara	Low Risk

Table 6: States Showing High Risk of Flooding in November 2024.

S/N	STATE	SUSCEPTIBILITY LEVEL (%)
23.	AKWA IBOM	45.5
24.	CROSS RIVER	38.3
25.	RIVERS	2.5
26.	OSUN	1.8
27.	KEBBI	1.7
28.	NIGER	1.2
29.	OGUN	2.2
30.	LAGOS	15.6

3.4 MAP OF RIVER OVERLAY WITH FLOOD RISK AREAS OF NOVEMBER 2024.

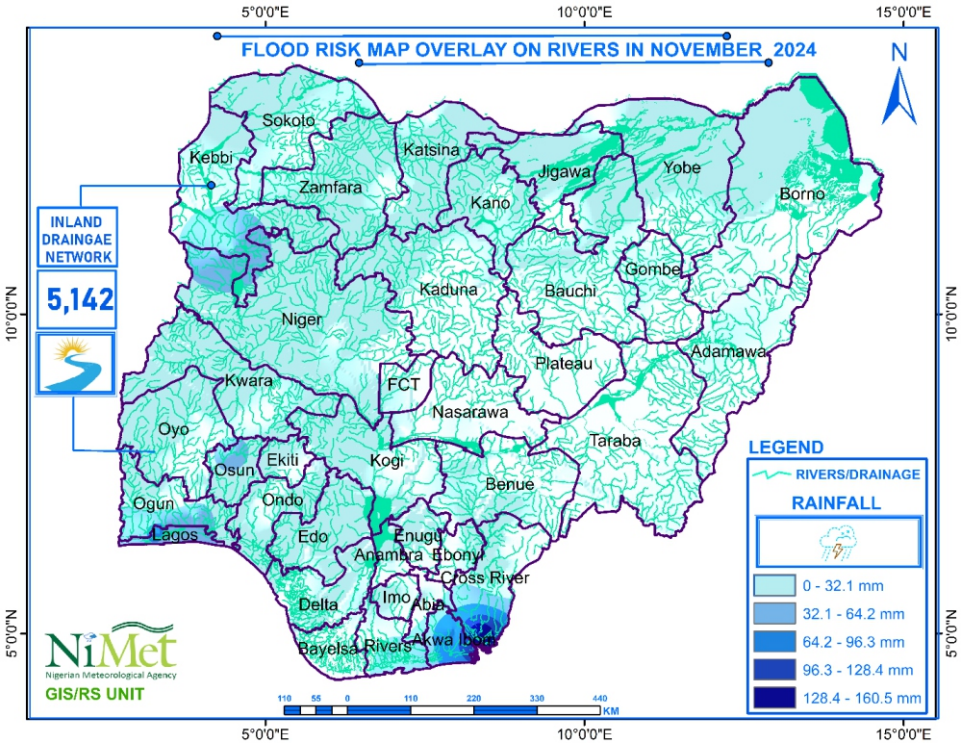

Figure 25: Map of River Overlay with Flood Risk Areas of November 2024.

3.3.1 OBSERVED FEATURES:

Flood risk map overlay on major rivers in Nigeria indicating potential flooding activities in and around rivers in the country. Also, climatic features such as rainfall, rivers shape file are used to determine these environmental hazards. This is used for identifying rivers that are prone to flooding. Figure 4 shows that the south-west regions such as Lagos, Osun, Ogun and some South-East states like parts of Edo, Uyo,Akwa-Ibom, Warri and Cross Rivers state are mostly at risk of river flooding during the month.

Considering topographic landscape and rainfall characteristics, Figure 4 indicates the south-west, south-east and south-south regions that are prone to river flooding

3.3.2 ADVISORIES:

Plans for Evacuation: Local authorities are advised to formulate and share evacuation protocols with residents in vulnerable areas along river banks, identifying secure shelter locations and escape routes. Also, people living in flood-prone areas should ensure proper clearing of debris in and around rivers and other water channels.

3.5 AREAS IN NIGERIA AT HIGH RISK OF FLOODING IN NOVEMBER 2024

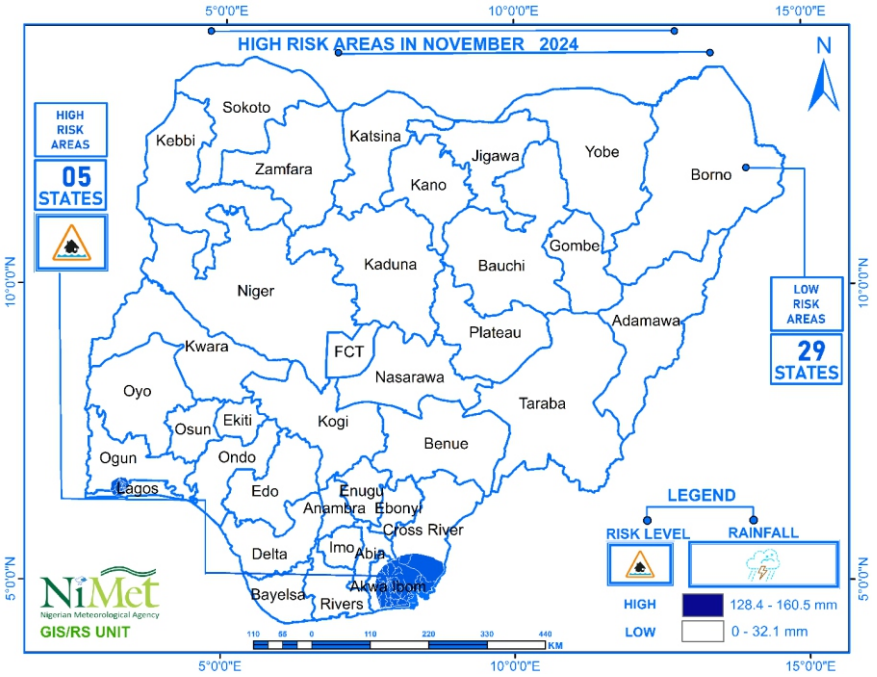

Figure 26: Map Depicting Location of High and Low Risk Areas in November 2024

3.4.1 OBSERVED FEATURES:

With further examination of potential flood risk zones as shown in Figure 5, states with likelihood of flood occurrence have been identified. Akwa-Ibom, Cross River,Rivers,Osun,Uyo and Lagos states are at high risk areas. The flood risk levels in term of percentage is outlined in Table 2.

3.4.2 ADVISORIES:

Plans for Evacuation: Local authorities are advised to formulate and share evacuation protocols with residents in vulnerable areas, identifying secure shelter locations and escape routes.

Promoting Community Awareness: Residents are encouraged to follow guidance from local authorities and stay informed about weather forecasts. State Meteorological Inspectors (SMI) should effectively disseminate weather information, ensuring that emergency contact details for local response teams and services are easily accessible to the public.

Residents in high-risk areas should take precautionary measures to protect lives and valuable properties.

Keep Up with the News: Monitor local news and weather reports regularly, paying attention to guidance provided by emergency services and local authorities. It is important to stay updated on weather and flood information from NiMet and Nigeria Hydrological Service Agency (NIHSA). Local authorities should initiate and communicate evacuation plans for vulnerable areas, identifying safe shelters and evacuation routes before flooding occurs.

3.6 SOIL MOISTURE INDEX ACROSS NIGERIA IN OCTOBER 2024

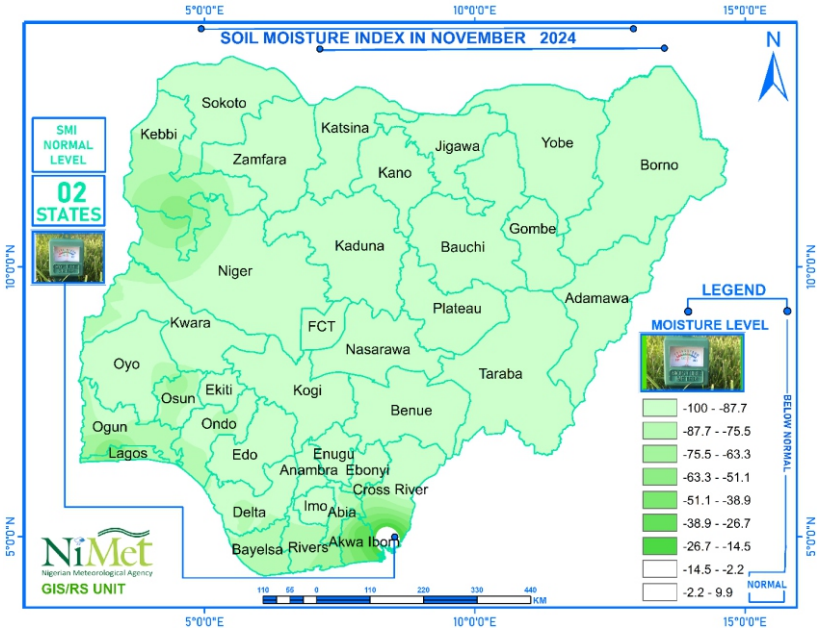

Figure 27: The Soil Moisture Index across Nigeria depicting areas of soil moisture saturation that may be prone to flood in November 2024.

3.5.1 OBSERVED FEATURES:

The soil moisture conditions across the country in November 2024 is illustrated in the Soil Moisture Index (SMI) map (Figure 6). As shown in the map, the soil moisture over most parts of the country were below normal except in parts of Uyo, Cross Rivers and Akwa-Ibom states that had normal soil moisture condition during the period under consideration.

It is expected that some parts of the south east region like Uyo, Rivers and Akwa ibom that are experiencing normal soil moisture index are still likely to experience flood within the period.

3.5.2 ADVISORIES:

Adequate precautions and mitigation measures to reduce the impact of flooding in the South-South, South-East and areas that have above normal soil moisture should be implemented.

3.7 RELATIVE HUMIDITY DISTRIBUTION ACROSS NIGERIA IN NOVEMBER 2024

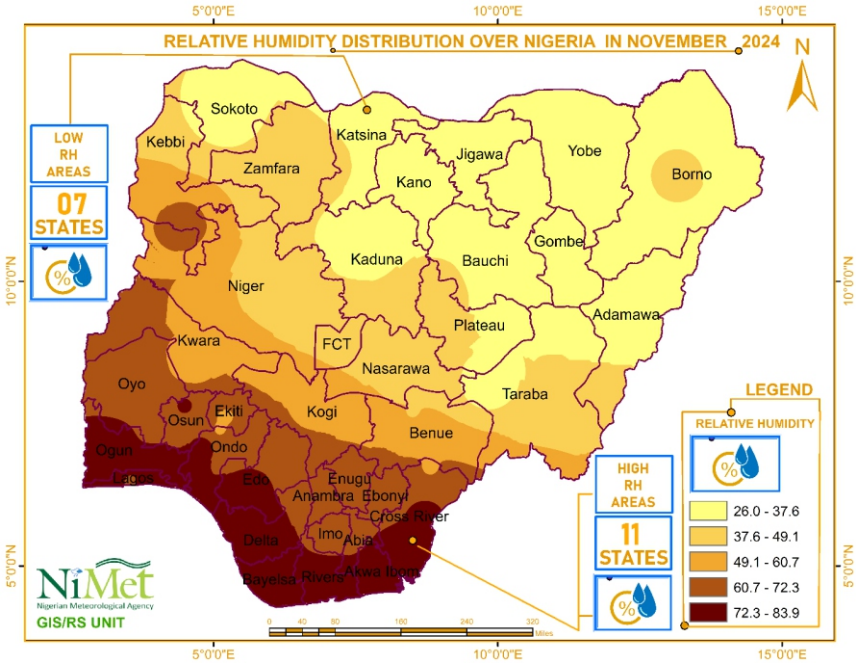

Figure 28: The Relative Humidity Distribution over Nigeria in November 2024

3.6.1 OBSERVED FEATURES:

Figure 6: shows the relative humidity over Nigeria in November 2024. The distribution across the country is characterized by the following features:

- The Relative Humidity (RH) over the north-eastern part of the country range between 26.0% and 37.6%, except for parts of Borno state which recorded 37.6% to 49.1%.
- The North-western region including parts of Kebbi and Zamfara experienced relative humidity ranging between 37.6% and 49.1% during the

period.

- Relative humidity ranges between 49.1% and 60.1% was observed majorly over Kwara, Kogi, Benue and parts of Niger states.
- High Relative Humidity ranges between 72.3% and 83.9% was observed mainly over most places in the South-Western, South – Eastern and South-South region apart from parts of Anambra, Abia and Enugu states which experience relative humidity ranges between 60.7% and 72.3%.

3.6.2 RECOMMENDATIONS:

1. For south-west, South-south and south-eastern parts of the country, the following are recommended:
   - Improve ventilation: Open doors between rooms to increase circulation. You can use fans or move furniture to promote air flow.
   - Use an air conditioner: Air conditioners reduce humidity by cooling the air.
   - Dry clothes: Use a dryer or dry clothes outdoor.
   - Keep surfaces dry: Keep surfaces dry to reduce humidity.
   - Use descants: Decants can help reduce humidity.

2. For north-eastern parts of the country and pockets of areas in the north-western parts of Nigeria, the following are recommended:
   - o Use a humidifier: You can install a humidifier directly to your heating and cooling system or purchase individual units for rooms. Portable humidifiers are a quick and easy to manage low humidity.
   - o Add houseplants: Houseplants can help increase humidity
   - o Cook on the stovetop: Cooking on the stovetop can help increase humidity.
   - o Leave the door Open when showering: Leaving the door open when showering can help increase humidity
   - o Place bowls of water on register: This can help increase humidity

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