NIHSA

NIGERIA HYDROLOGICAL SERVICES AGENCY

Water Resources Data for Sustainable Development

2024

ANNUAL FLOOD OUTLOOK

content

4.1.1
Flooding and Poverty

4.1.2
Health Sector

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

4.1.3
Education

4.1.4
Transportation

HIS EXCELLENCY

BOLA AHMED TINUBU GCFR

PRESIDENT, COMMANDER-IN-CHIEF OF THE ARMED FORCES
FEDERAL REPUBLIC OF NIGERIA

HIS EXCELLENCY

SEN. KASHIM SHETTIMA

VICE PRESIDENT

FEDERAL REPUBLIC OF NIGERIA

ENGR. PROF. JOSEPH TERLUMUN UTSEV FNSE, FNICE, FNIWE, FICEN, FIIA

HONOURABLE MINISTER

OF WATER RESOURCES & SANITATION

FEDERAL REPUBLIC OF NIGERIA

BELLO MUHAMMED GORONYO Esq

HONOURABLE MINISTER OF STATE

FEDERAL MINISTRY OF WATER RESOURCES & SANITATION

SHEHU ALIYU SHINKAFI, FCNA

PERMANENT SECRETARY

FEDERAL MINISTRY OF WATER RESOURCES & SANITATION

ENGR. CLEMENT ONYEASO NZE, FNSE, FNAHS

DIRECTOR GENERAL

NIGERIA HYDROLOGICAL SERVICES AGENCY (NIHSA) and Hydrological Adviser to the Federal Government

FOREWORD

The devastating impact of floods have continued to bedevil the nation. Year in year out, flood management and managing risks associated with flood disasters are becoming a herculean task that government has to cope with. Lives, livelihoods, properties and critical infrastructures are being lost to flood events, agricultural sector is being affected, thus threating food security. From North to South and East to West, the annual flooding of the river banks, coastal areas, farmlands and agricultural produce including the flash flooding of villages, towns, cities and urban centres have continually left untold hardship on the Nigerian citizens.

The Annual Flood Outlook produced by the Nigeria Hydrological Services Agency (NIHSA), an Agency of the Federal Ministry of Water Resources and Sanitation, has been the principal source of information that is deployed by the Federal Government to sensitize the entire populace on the strategies of flood mitigation. The flood outlook provides expected annual and seasonal patterns of flooding for the country with advisories to the States and Local Government Areas on the projected level of flooding in their respective domains and the need for them to put in place early anticipatory actions to counter impacts of flood in their localities, particularly in the most vulnerable communities.

To address the perennial flood disasters in Nigeria, President Bola Ahmed Tinubu, GCFR, inaugurated the National Economic Council Ad-HOC Committee on Flood Mitigation, Adaptation, Preparedness, and Response to proactively develop a roadmap to enhance Nigeria's flood mitigation, adaptation, preparedness and response capabilities. The Presidential directive was predicated on the periodic updates and briefings on situations of flooding in the country by the Nigeria Hydrological Services Agency.

The 2024 Annual Flood Outlook (AFO) is therefore timely and serves as a valuable resource to enriching the work of the Presidential Committee. The 2024 AFO also provides detailed information on the probable flood risk areas in the current year, with their degree of vulnerabilities designed to serve as a working tool for various sectors including governments at all levels, agriculture, water corporations, humanitarian and donor aid organisations, oil and gas companies, town planners, disaster management agencies, health, national planning, security agencies and the general public.

Reflecting on the lessons learnt from the previous flood disasters, the most recent being the 2022 flood disasters, let us use the knowledge gained and information that are provided in 2024 AFO predictions as a vital flood early warning and disaster risk reduction information for improved flood mitigation strategies and preparedness to build a flood-resilient nation.

Engr. Prof. Joseph Terlumun Utsev, FNSE
Honourable Minister of Water Resources and Sanitation
April, 2024.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to the Honourable Minister of Water Resources and Sanitation, Engr. Prof. Joseph Terlumun Utsev, FNSE, FNICE, FNIWE, FICEN, FIA, the Honourable Minister of State, Rt. Honourable Bello Mohammed Goronyo, Esq and the Permanent Secretary of the Ministry, Alhaji Aliyu Shehu Shinkafi, FCNA, for their unwavering support to the activities of the Agency and most importantly on the production of this 12th edition of the Annual Flood Outlook (AFO) for the country.

I acknowledge the immense contributions and commitments of our technical experts, team of consultants, stakeholders as well as staff of NIHSA who worked assiduously towards the production of the outlook.

I also sincerely thank all the relevant agencies namely; Nigerian Meteorological Agency (NiMET), National Emergency Management Agency (NEMA), National Inland Water-ways (NIWA), Nigeria Integrated Water Resources Management Commission (NIWRMC), Office of the Surveyor General of the Federation (OSGOF), National Space Research and Development Agency (NASRDA), National Water Resources Institute (NWRI), River Basins Development Authorities (RBDAs) among others for providing the relevant data and valuable contributions in the preparation of the Outlook.

Furthermore, we acknowledge the huge support received from Agro-Climatic Resilience in Semi-Arid Landscapes (ACReSAL) and Action Against Hunger (AAH) which aided flood forecasting capabilities and improved the capacity of our staff.

Consequently, I hope that this Annual Flood Outlook (AFO) for the year 2024 will serve the purpose of providing flood early warning to Nigerians on flood risks mitigation, adaptation and resilience to the general public, particularly to those living in the flood-prone areas of the country.

Engr. Clement Onyeaso Nze, FNSE
Director-General/CEO &
Hydrological Adviser to the Federal Government
April, 2024.

EXECUTIVE SUMMARY

The 2024 Flood Outlook report offers a comprehensive assessment of flood risk across the country, highlighting critical areas of concern and strategic recommendations for mitigation and preparedness. Through an analysis of historical data, climate forecasts, hydrological modeling and the report identifying varying degrees of flood risk across different regions and timeframes.

The report identifies high-risk areas across three distinct scenarios: April, May and June (AMJ), July, August and September (JAS) as well as October and November (ON). In the AMJ period, 25 states and 72 Local Government Areas (LGAs) are identified as high-risk areas, indicating heightened vulnerability to flooding. This vulnerability persists into the subsequent months, with 33 states and 135 LGAs identified as high-risk areas from July to September, and 19 states and 44 LGAs during October and November. These regions are characterised by erratic rainfall patterns, river basin dynamics and inadequate hydraulic infrastructures, amplifying the potential for devastating flood impacts on communities, agriculture and infrastructures.

The report identifies moderate-risk areas across the same timeframes. In the AMJ period, 24 states and 63 LGAs are categorised as moderate-risk, signaling a need for heightened vigilance and preparedness measures. This risk extends into the following months, with 33 states and FCT as well as 221 LGAs identified as moderate-risk from July to September, and 24 states and 100 LGAs during October and November. While these regions may not face an immediate threat of flooding comparable to high-risk areas, they remain susceptible to adverse impacts during periods of intense rainfall and increased river discharge.

To mitigate the potential impact of flooding in high-risk areas and enhance resilience nationwide, the report recommends series of strategic interventions. These include, implementing robust early warning systems to provide timely alerts to at-risk communities, enabling proactive evacuation and response efforts. Investing in infrastructure improvements such as flood defenses, drainage systems and embankments to mitigate flood risk and protect vulnerable areas. Engaging local communities through awareness campaigns, training programs and participatory planning processes to build

resilience and facilitate community-led response efforts. Promoting sustainable land use planning practices to minimize exposure to flood hazards and preserve natural floodplains and wetlands. Strengthening institutional capacity at all levels of government to effectively coordinate flood response and recovery efforts, including disaster risk management, emergency response and post-disaster recovery planning.

By implementing these recommendations in collaboration with relevant stakeholders, Nigeria can enhance its capacity to manage flood risk effectively, minimize the adverse impacts of flooding as well as build a more resilience and sustainable future for all its citizens. The comprehensive analysis provided in the Flood Outlook 2024 report serves as a valuable resource for policymakers, planners and emergency responders, informed evidence-based decision-making and guiding targeted interventions to reduce flood risks and enhance resilience across Nigeria. Through concerted action and proactive measures, Nigeria can address the complex challenges posed by flooding and work towards a safer, more resilient future for all.

CHAPTER ONE

1.0INTRODUCTION

> ***The recurring floods in Nigeria have exacerbated food and agricultural challenges, submerging over 266,000 acres of valuable farmland annually leading to inevitable food shortages.***

In the face of escalating climate variability and heightened risk of extreme weather events, the importance of early warning systems for the mitigation of natural disasters such as floods and drought among others cannot be overemphasized. Floods are without doubt one of the most devastating natural disasters that strike numerous regions in the world every year. In the last decades, the trend in flood damages has been growing exponentially due to the increasing frequency of heavy rainfall, changes in upstream land use and a continuously increasing concentration of population and assets in flood-risk areas. The certainty of climate change has spurred the need for preventive measures, anticipating exacerbation of existing challenges particularly susceptibility to destructive flood occurrences.

Nigeria is currently experiencing its most severe flooding over a decade, displacing over 1.4 million people, with more than 500 reported fatalities, numerous injuries and diseases (NEMA, 2023). Recurring flood issues during rainy seasons from March to July and Mid-August to October in the South and July to October in the North, leading to rivers and dams overflowing, causing widespread flooding in states such as Anambra, Cross-river, Rivers, Bayelsa, Delta, Edo, Benue, Kogi, Lagos, Adamawa and Niger.

The recurring floods in Nigeria have exacerbated food and agricultural challenges, submerging over 266,000 acres of valuable farmlands annually leading to inevitable food shortages (NEMA, 2023). In response to the ongoing crisis, it is imperative to implement sustainable solutions that will address the socio-economic and food security impacts. The floods have not only highlighted the immediate devastations but also exposed structural and systematic shortcomings within the country.

Despite early flood forecasts, government efforts at both national and state levels to mitigate damages through relief and evacuation have proven largely inadequate.

Fig. 1: **Scene of flooding at Lokoja, 2023**

1.2 Purpose of the Annual Flood Outlook

Contrary to certain natural disasters, floods resulting from rainfall can be managed through effective planning and infrastructural development. Primary contributors to Nigeria's flooding challenges include a deficient drainage system, subpar waste management, poor rural/urban planning and lack of disaster education which are significantly impacting Nigeria's cities and displacing thousands of people.

In addressing flood risks, the Nigeria Hydrological Services Agency (NIHSA) has consistently fulfilled its mandate through its proactiveness by informing the public about flood outlooks. It has also enhanced its data and models for the Annual Flood Outlook (AFO) which has led to improved forecasts, reduced the damaging effects of floods on communities that heed to the warnings. Moreso, AFO offers valuable insights into potential flooding scenarios based on anticipated weather conditions and hydrological factors. It plays a pivotal role in fostering resilience against floods by providing timely and accurate information. The forecast educates communities, governments and organisations to proactively manage risks, protect lives and minimise flood impacts.

The AFO serves as a crucial guide, contributing to economic growth and sustainable development. Additionally, it accelerates integrated approaches (anticipate, early warnings, impacts, search and rescue, rehabilitation, and provision of relief materials) to address interconnected water-related risk management and socio-economic environmental challenges for sustainable flood disaster reduction and management in Nigeria.

1.3 Importance of Flood Preparedness and Response

Flood, being one of the most common and destructive natural disasters in Nigeria, pose significant threats to communities nationwide. Flood preparedness is crucial as it helps minimise risk to lives and properties. Being ready with emergency plans, supplies and awareness can make a significant difference in coping with and recovering from flood events.

For many decades, flood hazard management has emphasised flood protection based on “Hard” engineering works (e.g. embankments, dykes, etc). Flood control structures have at least one of the following objectives:

- reduce the area of inundation on flood plains,
- reduce flood stage and peak discharge
- reduce flood duration.

These structures, however, can adversely affect the fluvial morphodynamics of the channels and floodplain (Benito &Vazquez-Tarrio, 2022). The river systems adjust to the new conditions imposed by the flood control structures, producing in some cases an unintended geomorphic response. Furthermore, the paradigm for flood management has shifted from the classical river engineering approach and its reliance on structural defenses to a more sustainable environmentally friendly scheme.

In this regard, river corridor management based on hydrogeomorphic process is probably one of the more established approaches today for achieving a more sustainable control of flood hazards. It involves the identification and delimitation of the space needed for the rivers to ensure adequate water, sediment and ecological fluxes. The principle behind this approach relies on allowing rivers the freedom to evolve, wander, rather than developing this area and forcing the rivers to flow into narrow, designated channels shaped by embankments and channelisation. This approach is followed today in many countries and a variety of terms have been applied to these river corridors, e.g., “functional flooding areas”, “fluvial territory”, “river corridors”, “room for the river” and freedom space for river, although the impact on geomorphic processes needs to be carefully assessed.

Other multifaceted aspects of flood preparedness include the following:

1.3.1. Early Warning System: Rapid and accurate information is pivotal in the face of impending flooding. Establishing effective early warning system enables authorities to alert residents promptly, giving them crucial time to evacuate and seek safety. The integration of technology such as flood alert system with high decibel (db.) siren and weather monitoring enhances the accuracy of these warnings by saving lives and properties.

1.3.2 Community Awareness: Educating communities about flood risks and preparedness measures foster a proactive approach to safety. This approach involves understanding local floodplain, recognising evacuation routes and disseminating information on emergency shelters. Public awareness campaigns can instill a sense of responsibility and empower individuals to take necessary precautions.

1.3.3 Emergency Planning: Developing comprehensive emergency plan is a cornerstone of flood preparedness. These plans should cover evacuation procedures, communication strategies and coordination among various response agencies. Regular drills and simulations ensure that communities are well-poised in executing these plans efficiently during an actual flood event.

1.3.4 Infrastructure Resilience: Designing and maintaining resilient infrastructure such as robust levees and flood barriers reduce the impact of flooding. Investment in sustainable infrastructure not only protects against immediate threats but also contributes to long-term community resilience.

1.3.5 Risk Assessment and Zoning: Conducting thorough risk assessments helps to identify areas prone to flooding. Implementing zoning regulations that restrict or guide development in high-risk zones can prevent unnecessary exposure to flood hazards.

1.3.6 Community Partnership and Participation: Flood preparedness is a collective effort that involves collaboration among government agencies, local communities, non-profit organisations and other stakeholders. Establishing strong partnership ensures a coordinated response, efficient resource allocation and a united front against the challenges posed by floods.

1.3.7 Climate Change Adaptation: Recognizing the impacts of climate change on frequency and intensity of floods is crucial for long-term preparedness. Implementing adaptive measures such as sustainable urban planning and environmental conservation help communities become more resilient to the evolving challenges posed by a changing climate.

Flood preparedness is not merely a reactive response but a proactive strategy that encompasses various elements from early warning systems to community engagement and climate change adaptation. By embracing comprehensive preparedness measures, communities can safeguard lives, protect properties and build resilience in the face of one of the nature's most formidable adversaries.

1.4 RIVER BASIN CHARACTERISTICS AND THE RESPONSE TO RAINFALL PATTERNS IN RELATION TO RIVER SYSTEMS NETWORK.

Nigeria experiences distinct wet and dry seasons with peak river flows occurring during the rainy season. Intense and prolonged rainfall events can overwhelm even a well-managed river system triggering floods, particularly in areas with inadequate drainage or compromised land use practices. However, effective management of flood risks requires a deep understanding of Nigeria's unique river basins. These basins with their distinct characteristics influence how they respond to rainfall patterns.

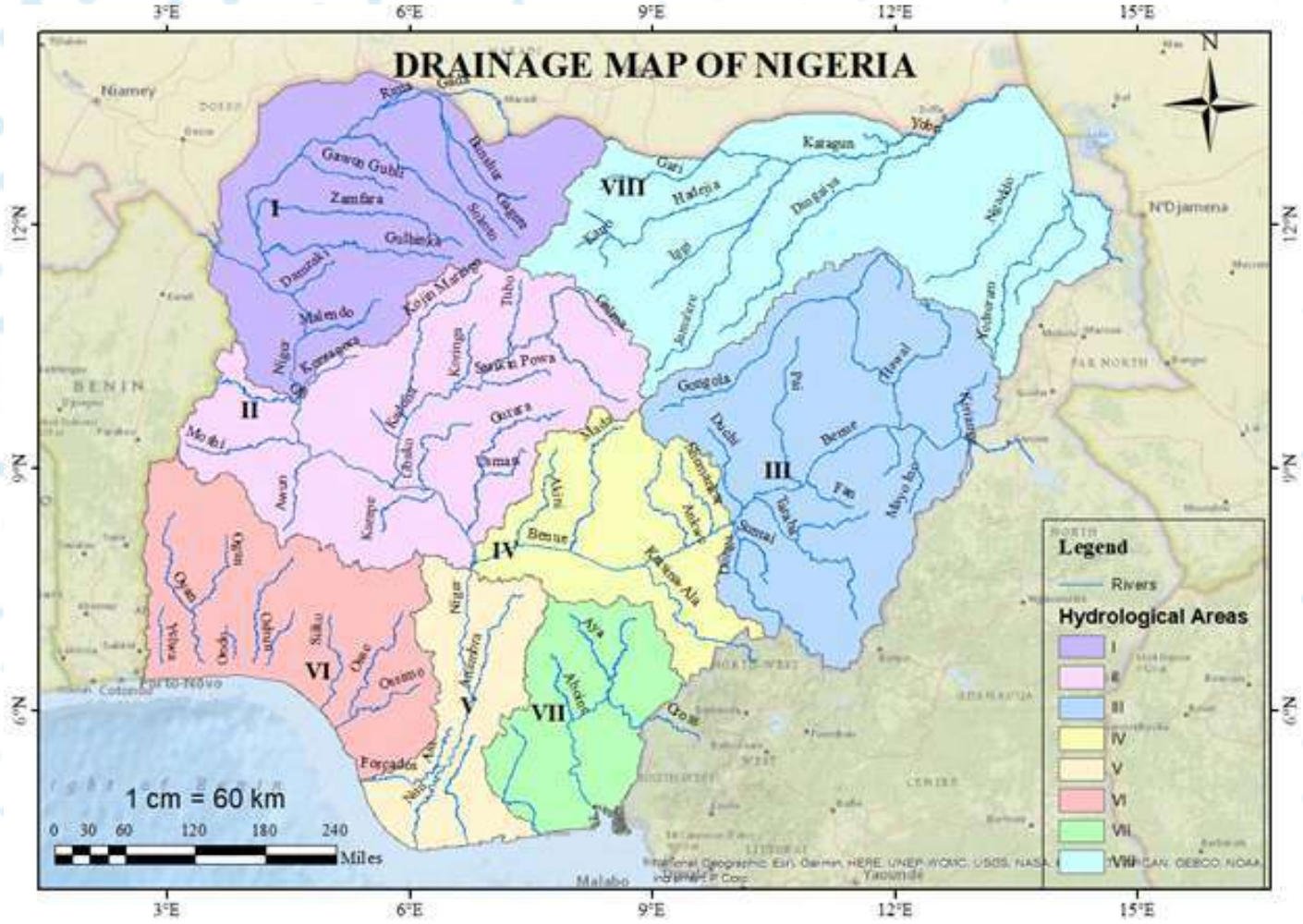


Figure 2: Map of Nigeria Showing Drainage Systems and Hydrological Areas

Moreover, the seasonal nature of rainfall contributes to variations in river flow with peak flows occurring during the rainy season. The management of Nigeria river basins involves a holistic approach, considering the diverse characteristics and responses to rainfall. The Nigeria Hydrological Services Agency (NIHSA) plays a pivotal role in monitoring and predicting river behaviour. Early warning systems informed by an understanding of river basin dynamics are crucial for mitigating the impact of floods and ensuring sustainable water resources development and management. This understanding is essential for developing effective strategies to manage water resources, prevent floods and promote sustainable development in the diverse regions of the country

CHAPTER TWO

2.0.Preamble

> *The aggregate of River Niger and Benue flows downwards where it eventually discharges into the Atlantic Ocean through a board delta. See map showing the Evolution of flow from Rivers Niger and Benue at Jiderebode and Wuroboki respectively.*

FLOOD RISK ASSESSMENT

The River Niger is the largest and longest river in West Africa, it takes its source from the Fouta Djallon Highlands at a location barely 300km from the Atlantic Ocean in the Republic of Guinea. The River is about 4200km long from Guinea to Nigeria. The active basin is about 1,500,000 km2 in the following nine (9) Countries; Guinea, Mali, Cote d'Ivoire, Burkina-Faso, Niger, Benin, Chad, Cameroon and Nigeria.

The River flows generally north-eastwards at its source in Guinea, through Mali forming Inland Delta in the Sahara Desert and flow south-eastwards to Niger Republic. The River passes through a stretch of less than 50km in Benin Republic before entering Nigeria. In Nigeria, River Niger flows southwards to Lokoja confluence in the central part of the Country where it joined River Benue.

The aggregate of the river flows downward and eventually discharges into the Atlantic Ocean through a broad delta. See the flowcharts of Rivers Niger and Benue as they entered Nigeria (figure 2.1 and 2.2).

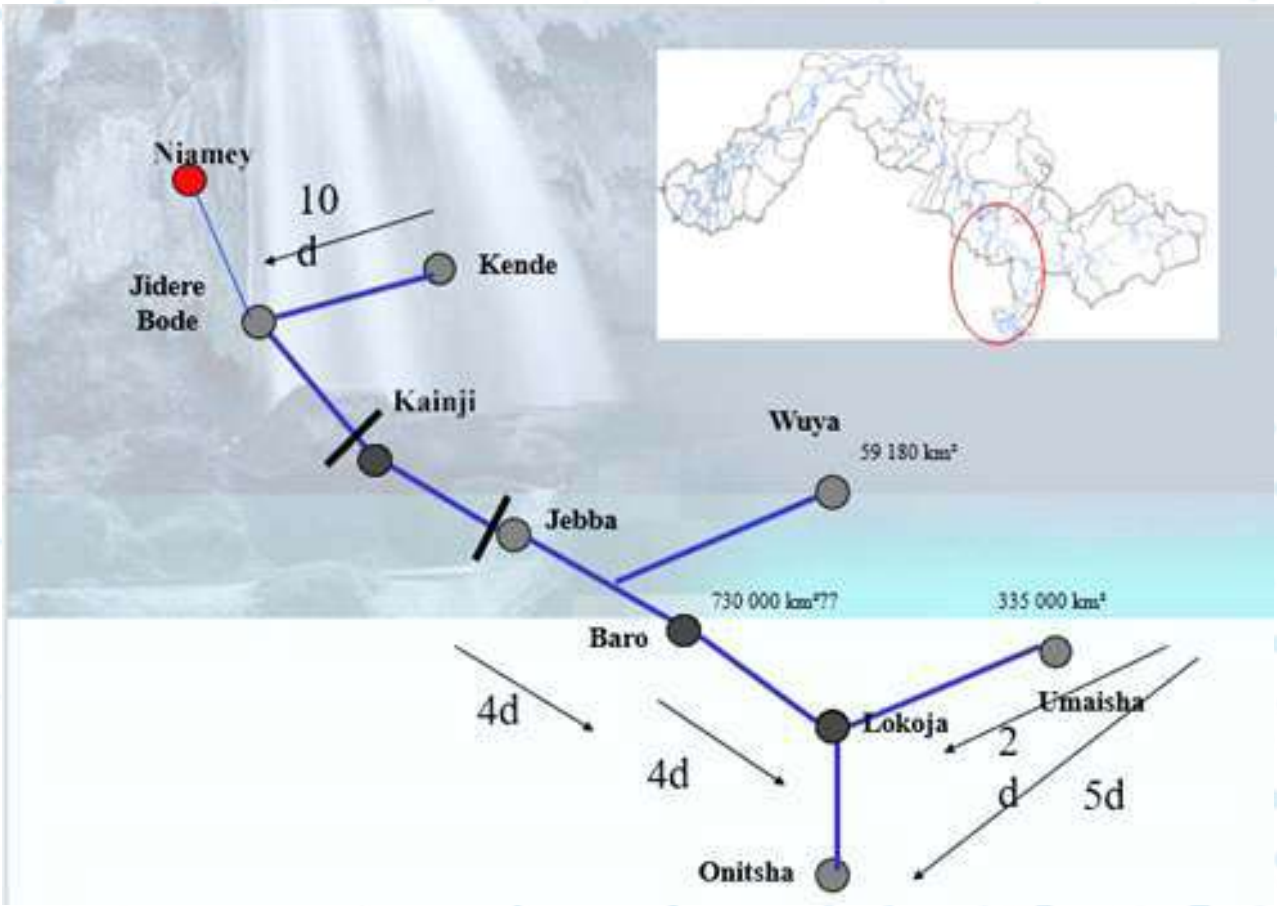


Figure 2.1: Flow Chart of River Niger from Niamey into Nigeria (showing approximate time of concentration)

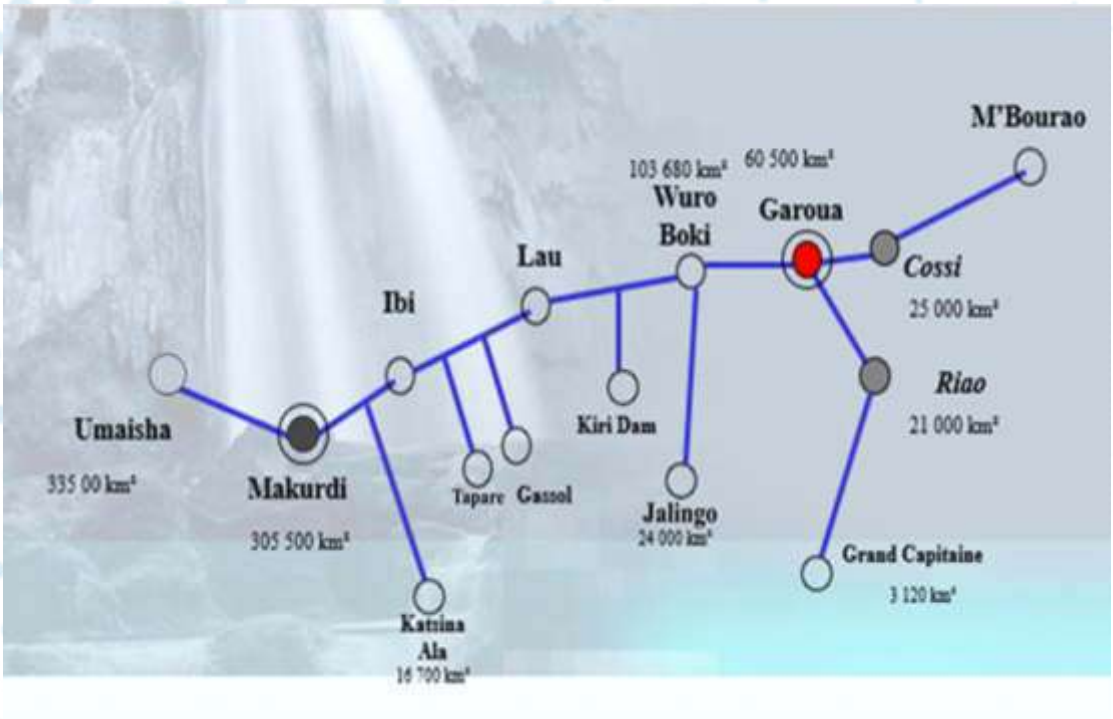


Figure 2.2: Flow Chart of River Benue from Cameroon (Garoua) into Nigeria (showing approximate time of concentration)

2.1. Flow of River Niger at Niamey in 2023

River Niger has two distinct flood flow periods, known as the White and Black Floods. The White flood occurs from June to September during the rainy season while the Black flood arrives Nigeria through Niamey in Niger Republic from Guinea between December and February.

The maximum White Flood flow in Niamey in 2023 was 1,773 m3/s on 1st September, 2023 while the maximum Black flood is 1,588 m3/s on 14th January, 2024. The Hydrographs of River Niger show that flood flow in Niamey in 2023 was lower than those in 2012/2013 and 2020/2021 but higher than that in 2021/2022 as shown in figure 2.3.

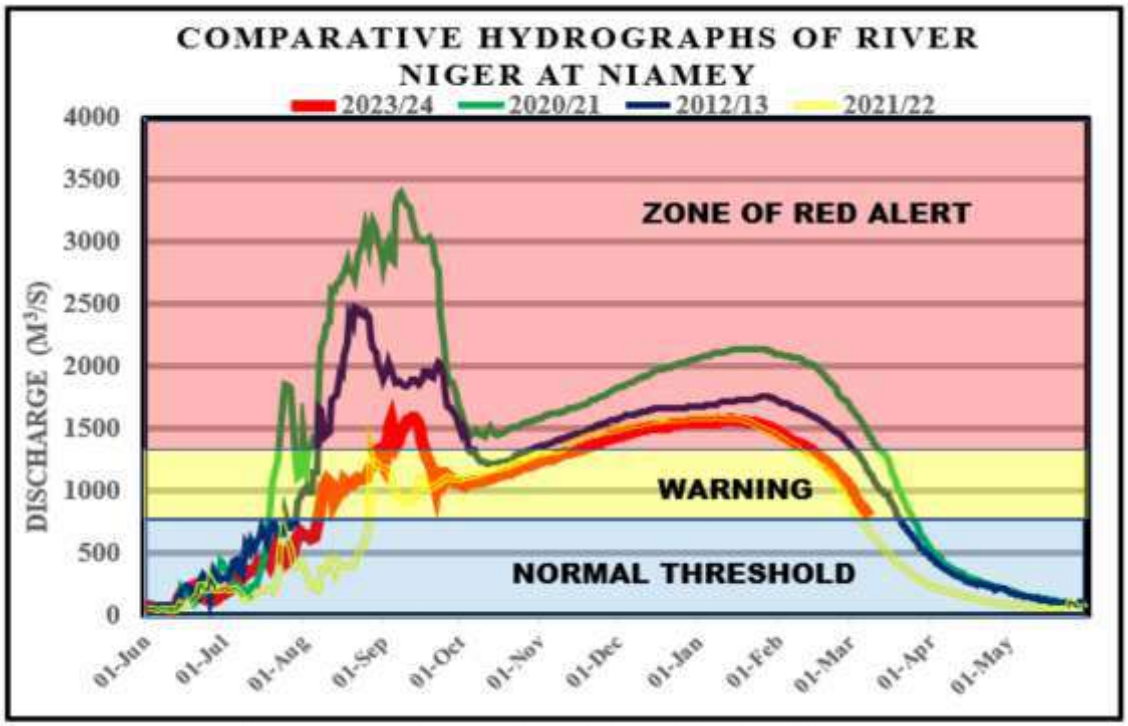


Figure 2.3: Hydrographs of River Niger in Niamey

2.2 *Flow of River Niger at Jiderebode in 2023*

Jiderebode in Kebbi State is the entry point of River Niger into Nigeria. The station is upstream of Kainji and Jebba dams. The maximum discharge at this station was 2,955 m3/s recorded on 9th September, 2023 while the minimum was 42 m3/s recorded on 9th June, 2023 with a mean discharge of 1,570 m3/s.

The Hydrographs of River Niger at Jiderebode from 2020 – 2023 compared with 2012/2013 shows that the discharge recorded in 2023 was only higher than 2021/2022 as shown in figure 2.4 below.

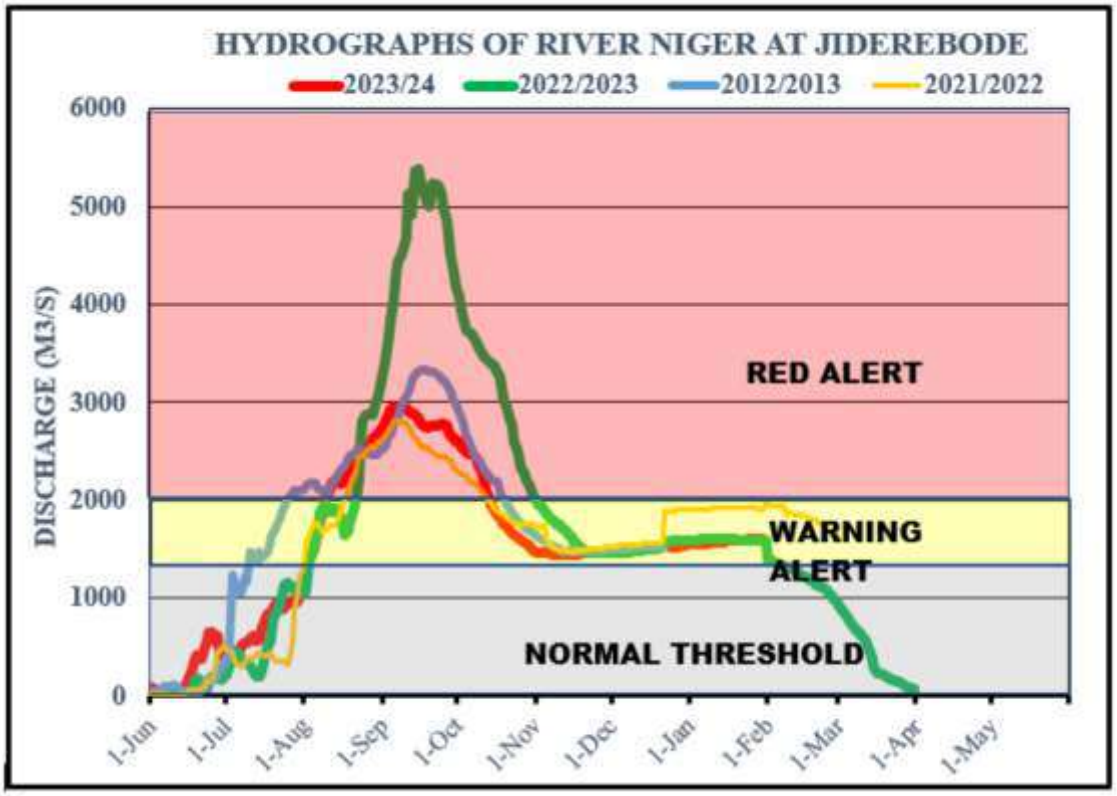


Figure 2.4: Hydrographs of River Niger at Jiderebode

2.3 *Flow of River Niger at Lokoja in 2023*

The flood flow at the confluence of Rivers Niger and Benue at Lokoja (Kogi State), in 2023 has a maximum discharge of 20,578 m3/s recorded on 16th September, 2023 with the minimum discharge of 3,056 m3/s recorded on 1st June, 2023 with the mean discharge of 10,986 m3/s.

The Hydrographs of River Niger at Lokoja from 2020 – 2023 show that the discharge recorded in 2023 was only higher than 2021/2022 as shown in figure 2.5.

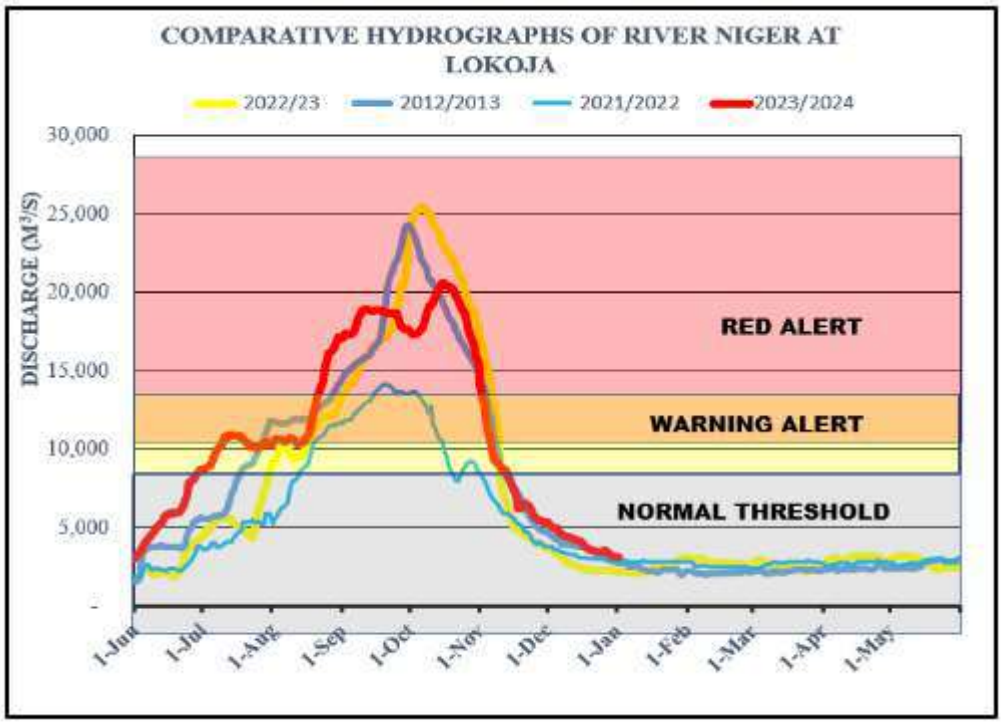


Figure 2.5: Hydrographs of Rivers Niger at Lokoja.

2.4 Flow of River Benue at Makurdi in 2023

River Benue at Makurdi (Benue State) in 2023 recorded a maximum discharge of 11,860 m3/s recorded on 22nd October, 2023 with a minimum discharge of 152 m3/s recorded on 1st July, 2023 with a mean discharge of 4,817 m3/s.

The Hydrographs of River Benue at Makurdi in 2023 from 2020 – 2024 show that the discharge recorded in 2023 was only higher than that of 2021/2022 as shown in figure 2.6.

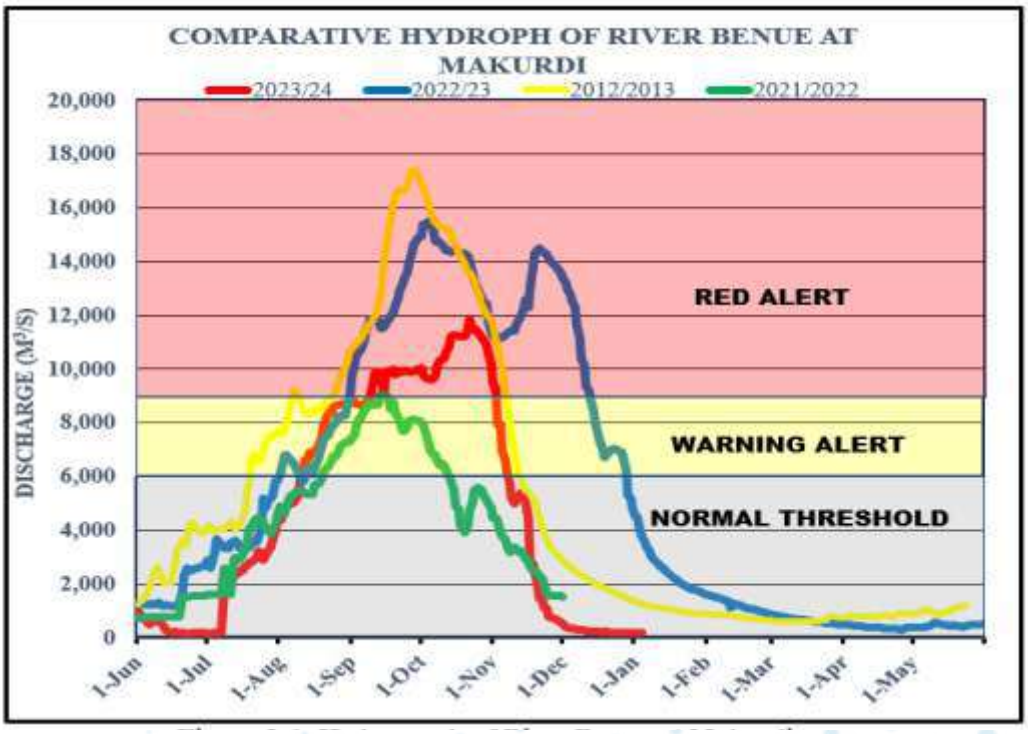


Figure 2.6: Hydrograph of River Benue at Makurdi

2.5 Analysis of Flood Incidences in 2023

Nigeria experienced a notable reduction in 2023 flooding compared to the previous year (2022), yet the impact persisted severely in several states nationwide. The National Emergency Management Agency (NEMA) reported that 642,841 individuals were affected, with 275,984 displaced due to flooding while 9,210 hectares of farmlands were totally damaged in 2023. This crisis underscores the susceptibility of numerous areas in Nigeria to seasonal flooding, mainly during the rainy season from April to October.

NIHSA in 2023 AFO, predicted that 178 Local Government Areas (LGAs) fall within the High-Risk Flood Areas in 32 States and Federal Capital Territory (FCT) while 156 Local Government Areas (LGAs) across 33 states experienced varying degrees of flooding, resulting in widespread devastation and the displacement of numerous communities (see Figure 2.7 for 2023 Flood Impact and Appendix 1 for flood occurrence and forecast matrix). This crisis underscores the vulnerability of many states in Nigeria to seasonal flooding.

Figure 2.7: infographic of 2023 Flood incidence. Source: NEMA (2024)

The states most affected include Anambra, Adamawa, Abia, Akwa Ibom, Edo, Benue, Borno, Delta, Ekiti, Imo, Kwara, Lagos, Ogun, Ondo, Oyo, Niger, River, Taraba, and the Federal Capital Territory (FCT) as shown in figure 2.6 below. These states experienced various degrees of flooding, resulting in casualties, submerged houses, damaged infrastructure, and disrupted livelihoods.

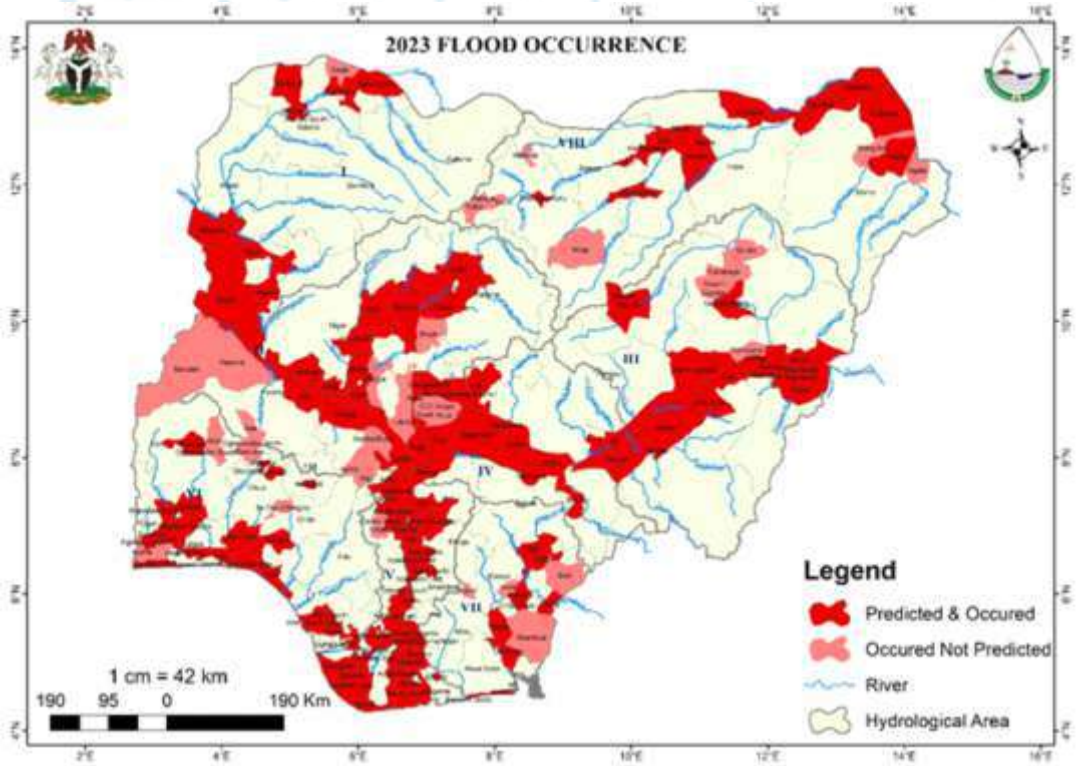


Figure 2.8: Map showing 2023 Flood occurrence and forecast matrix.

In Anambra State, 50 communities across 7 LGAs were submerged, leading to the destruction of buildings and farmlands as well as the outbreak of cholera pandemic. Adamawa State faced severe flooding, causing significant damage to infrastructure such as roads, shelter facilities, health facilities, IDP sites, schools and other community facilities across 14 out of 21 LGAs.

Similarly, Niger State reported flood incidents in 11 LGAs with houses submerged and farmlands washed away which are prominent among the challenges faced. In the FCT, communities such as Lugbe (Trademoore Estate) experienced flooding, resulting in houses submerged and casualties. Other affected areas in the FCT include Jedo, Lokogoma, Kubwa, and Galadimawa.

Addressing these issues such as mitigating the risks to population and infrastructures, education on sustainable urban planning, effective drainage systems and environmental conservation are crucial. By raising awareness and implementing appropriate measures, Nigeria can better prepare and adapt to the recurring threat of flooding, safeguarding both its citizens and infrastructure for the future.

CHAPTER THREE

3.1 Preamble

MODELING AND PREDICTION

> *The integration of altimetry and satellite data into flood forecasting models marks a significant advancement. Altimetry provides precise information about water surface elevation, while satellite data contribute valuable insights into land cover changes and other environmental factors*

Hydrological models are essential tools for simulating streamflow and water level in riverbeds and floodplains. However, the reliability of flood forecasts is often affected by uncertainties arising from input data, model parameters, initial conditions and the model structure itself. The first source of uncertainty lies in input data, which includes variables such as weather data, land cover maps, elevation and soil properties. Inaccuracies in these data inputs can significantly impact the model's ability to replicate actual conditions. Furthermore, uncertainties used in equation contribute to the potential divergence between model prediction and actual observations.

Recent studies have recognised the limitations associated with water level assimilation and have shifted focus towards techniques that directly assimilate flood extent. This approach aims to improve the representation of inundation areas by considering spatial variation beyond traditional water level data. By directly assimilating flood extent, models can better capture the dynamic nature of floodplains and enhance the accuracy of prediction.

The integration of altimetry and satellite data into flood forecasting models marks a significant advancement. Altimetry provides precise information about water surface elevation, while satellite data contribute valuable insights into land cover changes and other environmental factors. Combining this information with weather forecasts, hydrological data and hydrodynamics models create a comprehensive and multidisciplinary approach.

This holistic integration enables a more accurate representation of the flood dynamics, allowing for improved early warning systems and mitigation strategies. By addressing uncertainties through direct flood extent assimilation and incorporating diverse data sources, the synergy of these models enhances our ability to anticipate and manage the negative impacts of floods, contributing to more effective disaster preparedness and response efforts.

3.2 Data Collection and Analysis

For the 2024 Annual Flood Outlook, NIHSA utilised the Soil Water Assessment Tools (SWAT) and Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) models to simulate hydrological processes in basins. The SWAT model is specifically chosen for its ability to capture floods generated by excessive rainfall within Nigeria's boundaries and account for external inflows from Jiderebode (River Niger) and Wuroboki (River Benue). These external inflows are meticulously routed through the river system to enhance flood prediction accuracy. The SWAT model is globally recognized for its versatility and effectiveness in simulating streamflow over time. Its ease of use, leveraging other Geographic Information Systems (GIS) applications ensures the accuracy of prediction.

The HEC-HMS model excels in representing rainfall-runoff processes and the transformation of weather data into runoff. Its contribution lies in its ability to simulate the intricate dynamics of watershed responses to various meteorological conditions, allowing for a detailed analysis of how precipitation translates into streamflow. This level of detail is instrumental in predicting and understanding the potential flooding scenarios in different states.

Furthermore, HEC-HMS incorporates a range of hydrological parameters, including soil properties, land use and topography to create a detailed representation of the watershed. By considering these factors, the model enhances the accuracy of flood predictions.

3.2.1 Data Used and Sources

The input data for the 2024 AFO includes:

- Daily flow records from NIHSA's Hydrological stations.
- Grided daily rainfall data.
- dn1.nsc.liu.se/search/cordex. Scenarios: RCP 4.5 and 8.5. Year 2023.
- Measured daily rainfall and temperature data (NiMet).
- 2024 NiMet Seasonal Climate Prediction (SCP).
- Soil and Landuse Map.
- DEM with vertical accuracy of +/-5meters (SRTM).

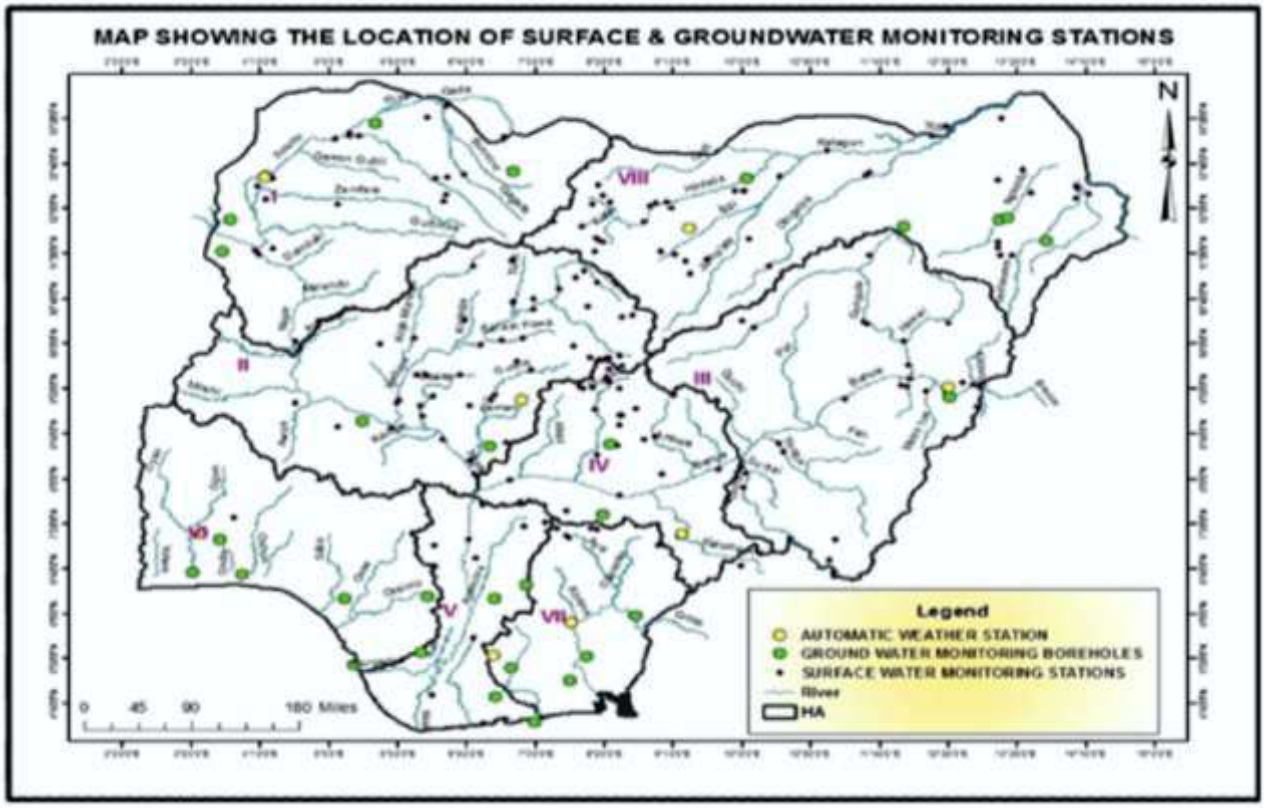


Figure 3.2: Network of NIHSA Surface/ Groundwater and Weather Stations

3.3 Ensemble Forecast

Ensemble forecasting acknowledges the inherent uncertainties in predicting floods by running multiple simulations of the same hydrological model. Each simulation incorporates slightly different starting conditions or alternative model configurations, creating a diverse ensemble of potential flood scenarios. This ensemble offers unique interpretations of the river's future dynamics, accounting for variations in rainfall amounts and timing, diversifying simulations to identify potential biases or strengths in each model.

The resulting ensemble provides a nuanced depiction, presenting not only a singular prediction but a spectrum of possibilities for flood severity and timing. Hydrologists derive valuable insights from this diverse ensemble, gauging the level of uncertainty associated with the forecast based on the spread of ensemble members. A closely clustered ensemble suggests high confidence in a specific flood level while significant dispersion prompts caution and acknowledging the full range of possibilities.

Analyses of the frequency of specific flood levels across ensemble members enables hydrologists to estimate their relative likelihoods. This facilitates the issuance of targeted flood warnings with calibrated confidence levels. Additionally, the presence of extreme flood scenarios in the ensemble should not be overlooked, ensemble forecasting reveals the possibility of outliers, allowing for proactive measures in anticipation of rare but impactful floods.

While ensemble forecasting is not a comprehensive solution, it equips hydrologists with a robust framework for comprehending and communicating the inherent uncertainties in flood prediction. This spectrum of possibilities enables the issuance of more nuanced and informative flood forecasts, fostering improved preparedness, decision-making across communities and emergency response agencies.

3.4 2024 Seasonal Flood Outlook

The 2024 Annual Flood Outlook (AFO) has been categorised to depict seasonal variations in flood patterns in Nigeria by consolidating flood outlooks from three distinct scenarios, each encompassing specific periods during the rainy season in Nigeria. These scenarios are as follows:

- Scenario I: Flood Outlook for the Months of April - June (AMJ).
- Scenario II: Flood Outlook for the Months of July - September (JAS).
- Scenario III: Flood Outlook for the Months of October - November (ON).

The comprehensive outlook for 2024 is a combined assessment derived from these three scenarios. The objective is to transition into having a dynamic flood forecast, and Early Warning System (EWS) that reflects the flood situation. This system is designed to provide spatial-temporal insights that can significantly enhance planning and decision-making across various sectors in Nigeria.

Furthermore, an overview of the eight (8) Hydrological Areas with their hydrological and hydrogeological features, as well as flood simulations for 2024 will be examined and discussed in this section.

3.4.1 Hydrological Area I (Niger North)

Hydrological Area I comprises Kebbi, Zamfara, Sokoto, and parts of Niger and Katsina States. This is drained mainly by the Rivers Niger, Sokoto, Rima, Gulbin Ka and Zamfara. It has two distinct geological features, mainly the Precambrian Crystalline Basement which covers 30% of the area and Sedimentary terrain which covers 70%.

The states that are categorized as High-Risk in HA I are Kebbi, Sokoto and part of Niger. The details of the High and Moderate Risk flood areas in Hydrological Area I are shown below in Figure 3.1.

Flood-risk Areas in HA I (Niger North)

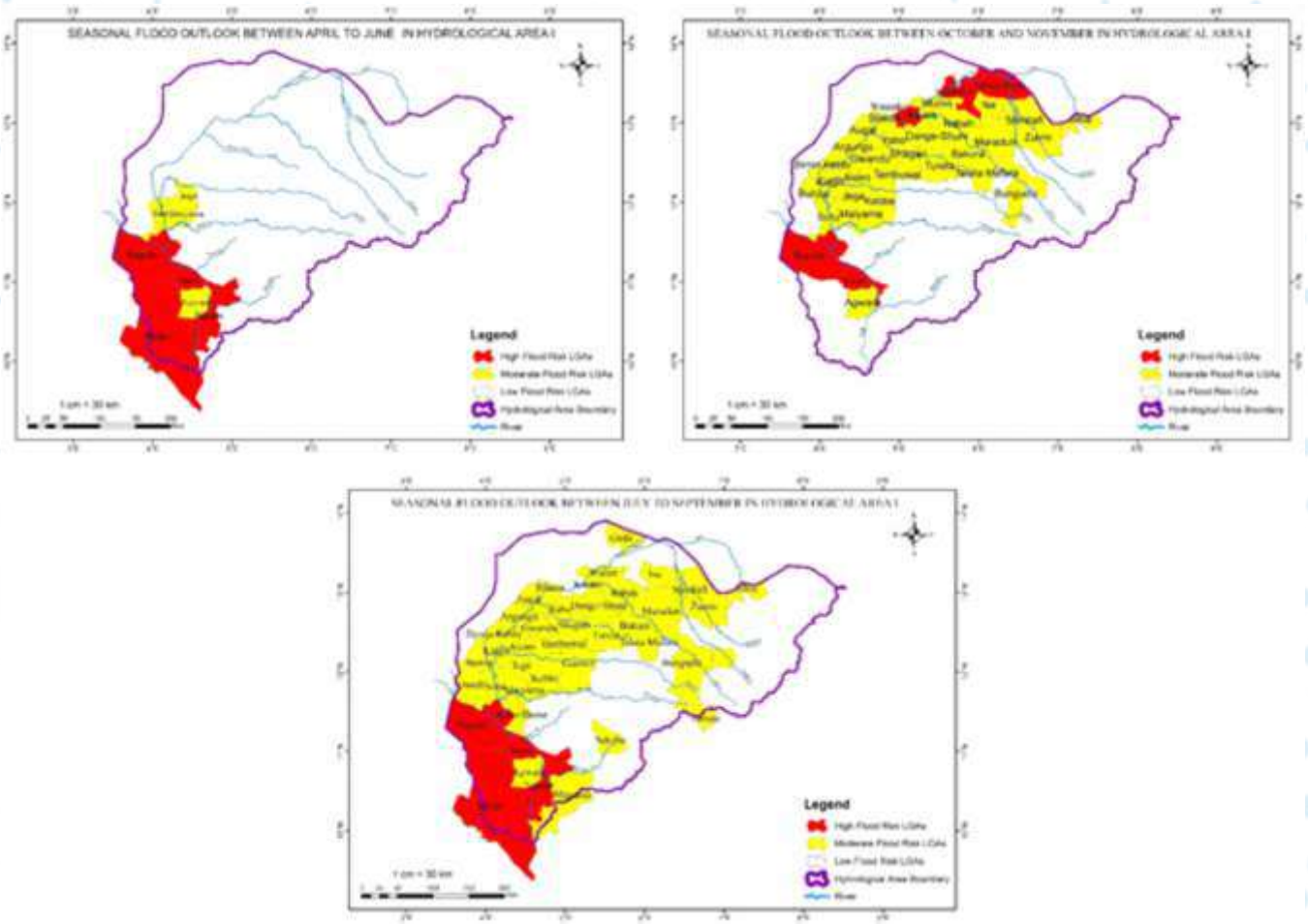
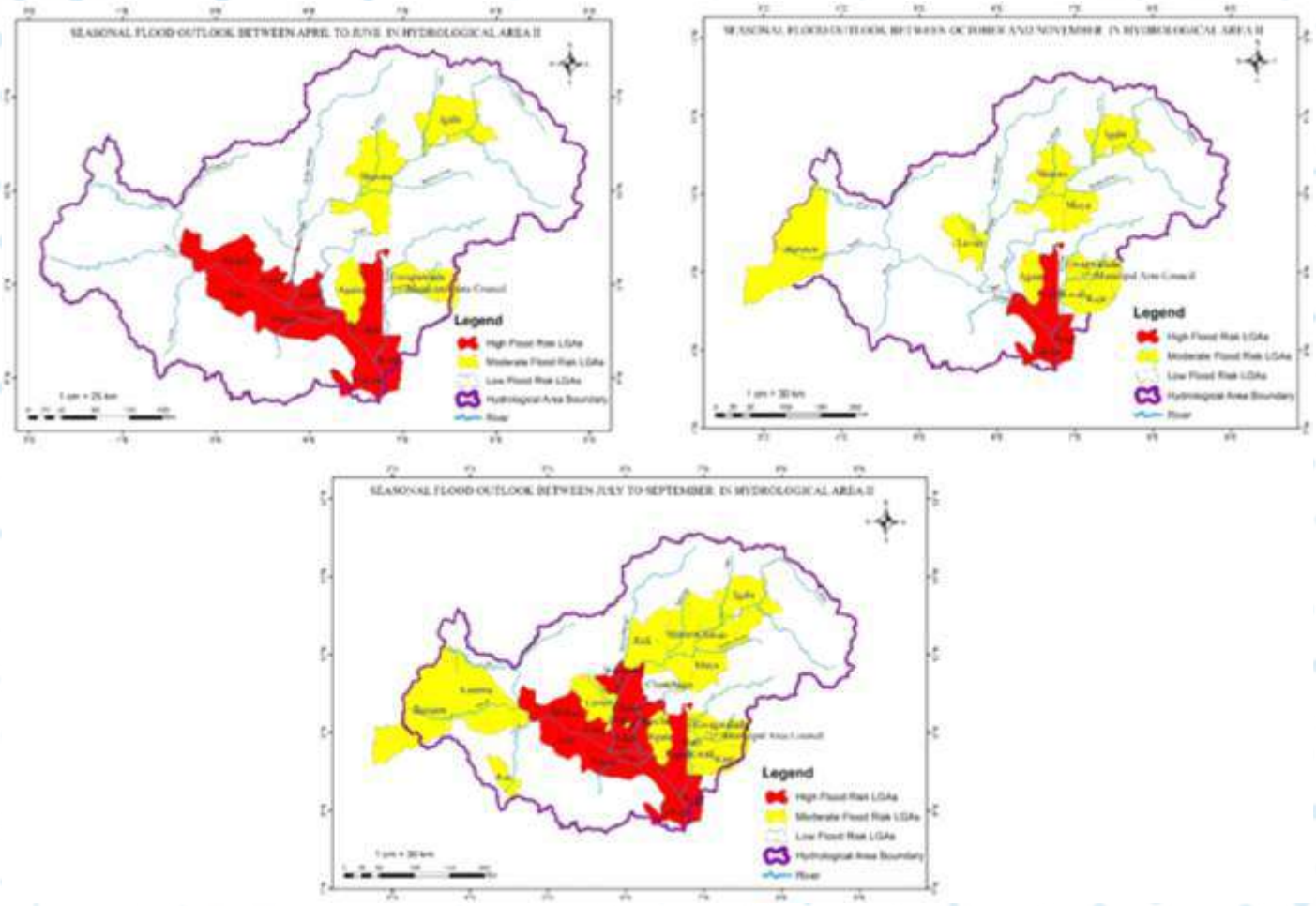


Figure 3.1: Maps showing Flood – Risk Areas in HAI

Hydrological Area II covers Niger, Kwara, Kaduna, FCT and part of Kogi States. The geology of the Hydrological Area II comprises of about 20% Sedimentary rocks and 80% Basement Complex rocks. The main rivers in the area are: Niger, Kaduna, Gurara, Usuma, Kampe and Awun.

In Hydrological Area II, Kwara, part of Kogi and Niger are expected to be in the High-Risk flood area. The details of High and Moderate risk flood areas are shown in Figure 3.2



Flood Risk LGAs in HA II (Niger Central)

3.4.3. Hydrological Area III (Upper Benue)

Hydrological Area III comprises Adamawa, Taraba, Gombe, Bauchi and part of Plateau and Borno States. It is made up of about 70% Sedimentary and 30% Basement. The major rivers are Benue, Gongola, Taraba, Donga, Faro, and Mayo-Kebbi.

The High-Risk States are Adamawa and Taraba, while the States under the Moderate-Risk areas are Adamawa, Bauchi, part of Benue, Borno, Gombe, Taraba and Yobe. The details are shown in Figure 3.3.

Figure 3.2: Maps showing Flood – Risk Areas in HAII

3.4.3. Hydrological Area III (Upper Benue)

Hydrological Area III comprises Adamawa, Taraba, Gombe, Bauchi and part of Plateau and Borno States. It is made up of about 70% Sedimentary and 30% Basement. The major rivers are Benue, Gongola, Taraba, Donga, Faro, and Mayo-Kebbi.

The High-Risk States are Adamawa and Taraba, while the States under the Moderate-Risk areas are Adamawa, Bauchi, part of Benue, Borno, Gombe, Taraba and Yobe. The details are shown in Figure 3.3.

Flood Risk LGAs in HA III (Upper Benue)

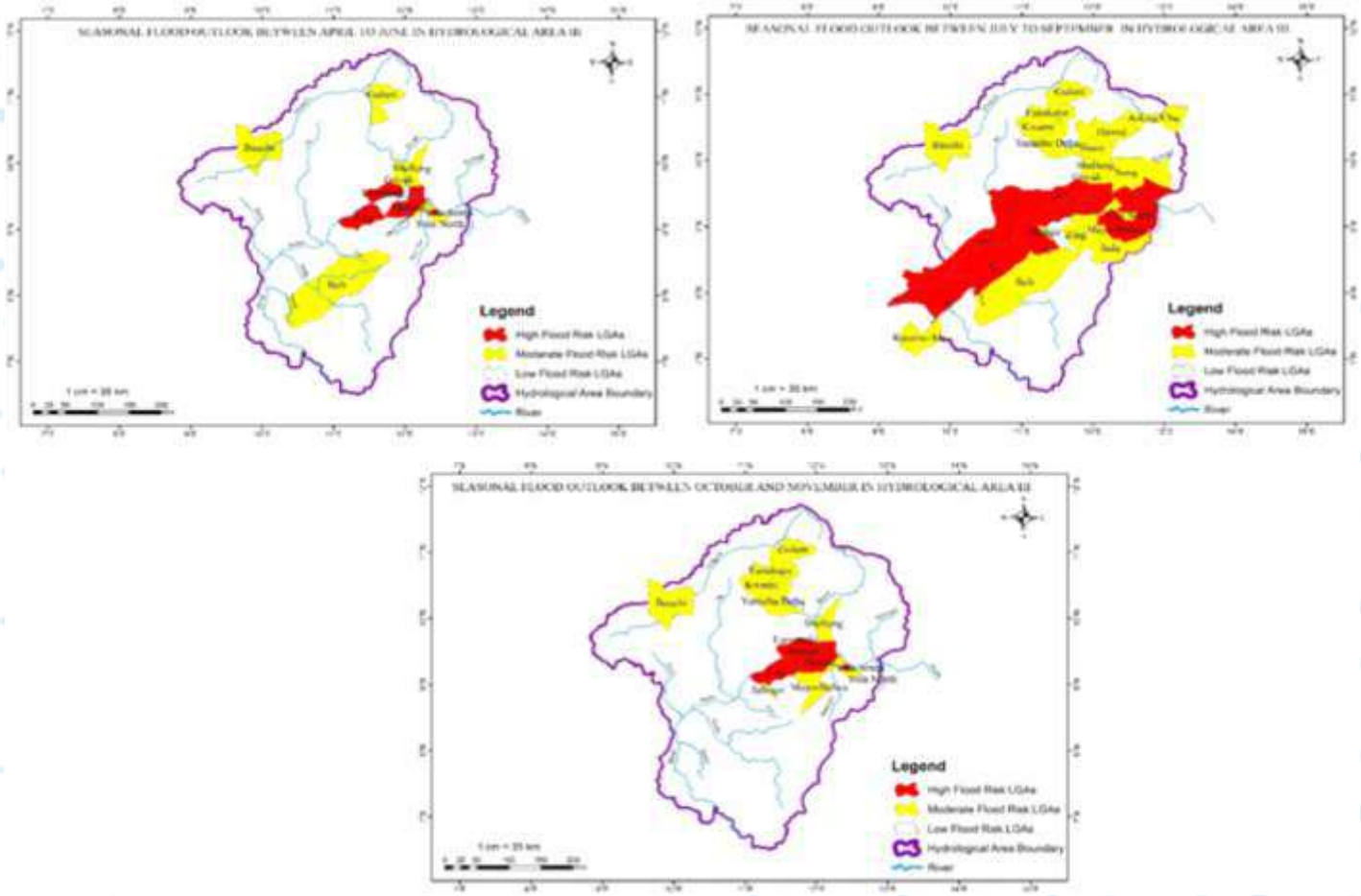


Figure 3.3: Maps showing Flood – Risk Areas in HAIII

3.4.4 Hydrological Area IV (Lower Benue)

Hydrological Area IV covers Plateau, Nasarawa, Benue, Taraba and parts of Kogi. The High-Risk states consist of Benue, Kogi and Nasarawa. The details of High-Risk and Moderate-Risk flood areas in Hydrological Area IV are shown in Figure 3.4 The area is covered by 50% Sedimentary and 50% Basement and is drained mainly by Rivers Benue, Kastina-Ala, Dep and Mada.

Flood Risk LGAs in HA IV (Lower Benue)

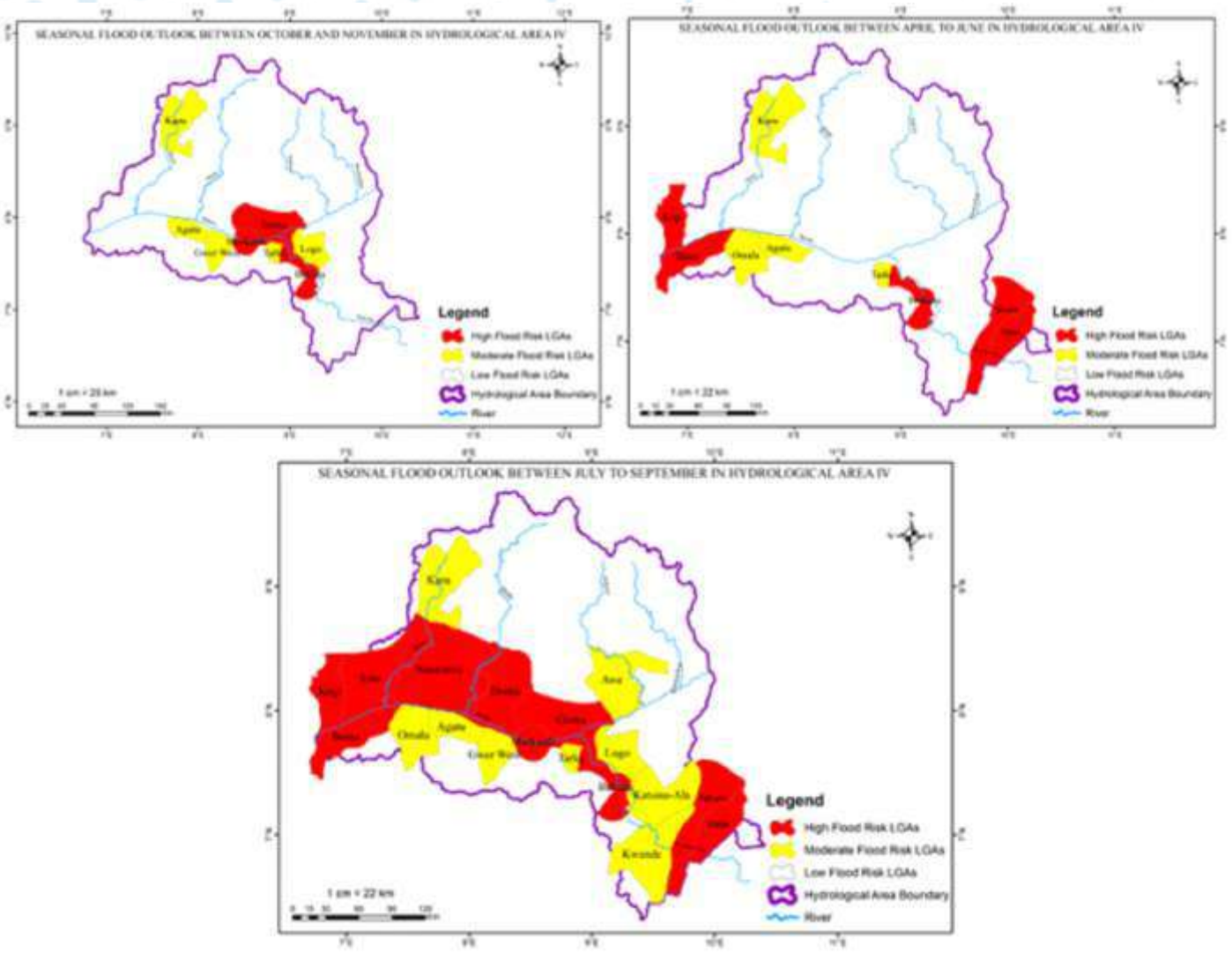


Figure 3.4: Maps showing Flood – Risk Areas in HAIV

3.4.5 Hydrological Area V (Niger South)

Hydrological Area V includes: Anambra, Bayelsa, Delta, Edo, Enugu, Imo, Rivers and part of Kogi State. The geology is 90% Sedimentary and 10% Basement. The major Rivers are: Niger, Anambra, Ase, Orashi, Nun and Forcados.

The States expected to be High-Risk are Anambra, Bayelsa, Delta, Edo, Kogi, Rivers and Imo. Details of High and Moderate-risk flood areas in Hydrological Area V are shown in Figure 3.5

Flood Risk LGAs in HA V (Niger South).

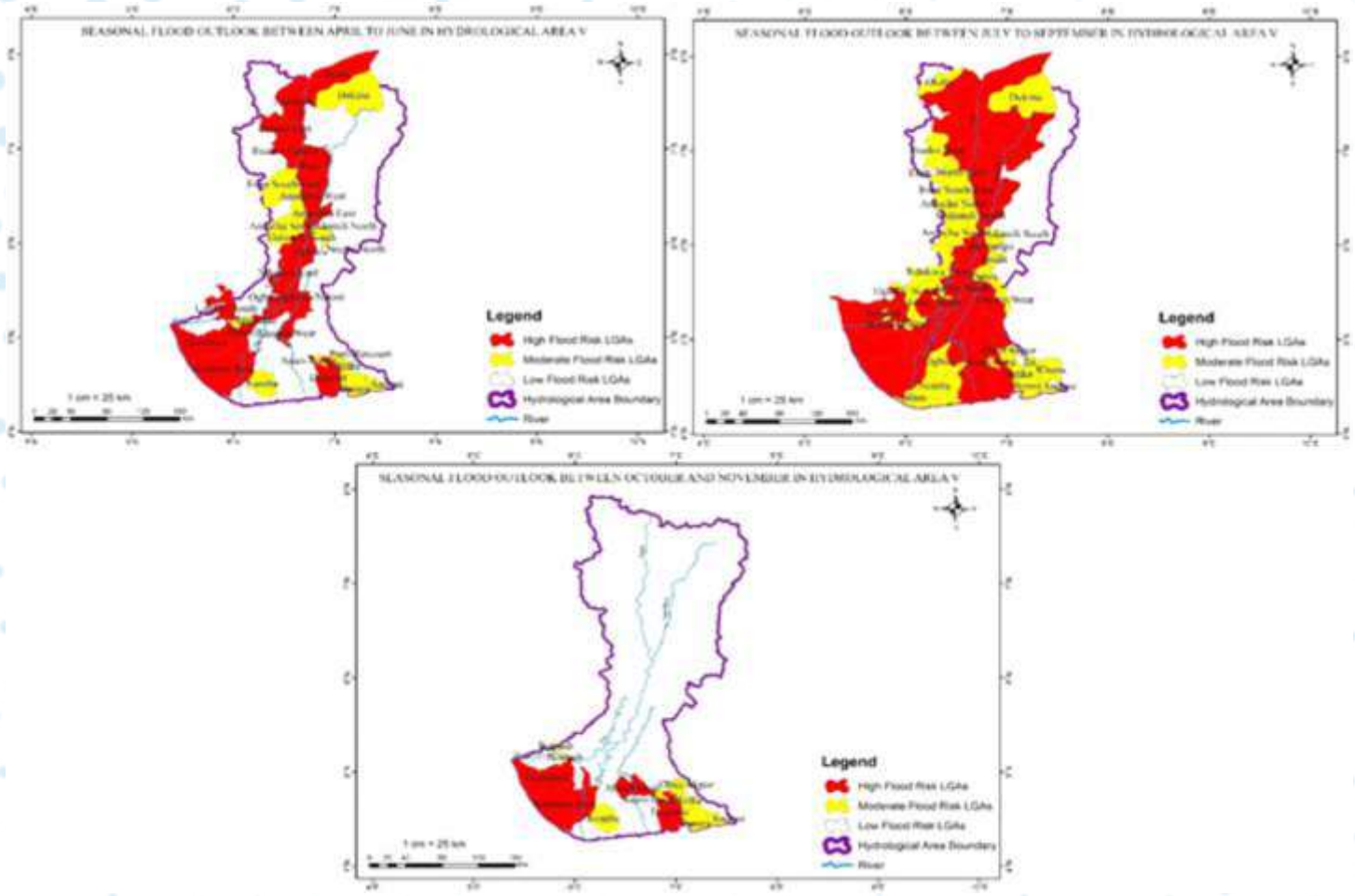


Figure 3.5: Maps showing Flood – Risk Areas in HAV

3.4.6 Hydrological Area VI (Western Lithoral)

Hydrological Area VI comprises of the following States: Lagos, Ogun, Oyo, Osun, Ondo, Edo and parts of Delta and Ekiti States. The Area is 60% Basement and 40% Sedimentary and is drained by Rivers: Yewa, Ogun, Osun, Shasha, Omi, Owena, Osse and Ossiomo.

The High-Risk States are Delta, Lagos, Ogun, Ondo, Osun and Oyo. The details of the High and Moderate-Risk flood areas in Hydrological Area VI are shown in Figure 3.6.

Flood Risk LGAs in HA VI (Western Littoral)

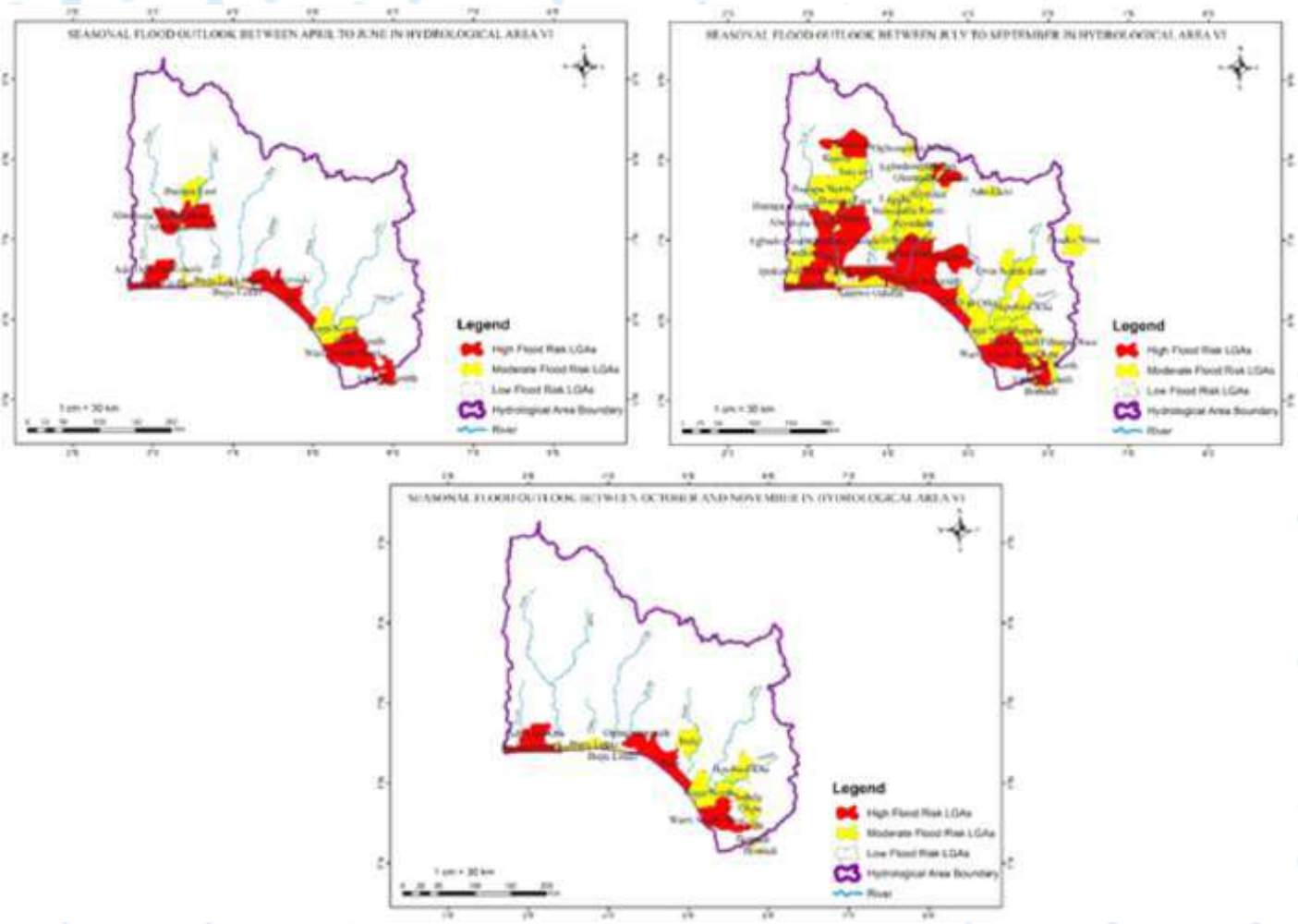


Figure 3.6: Maps showing Flood – Risk Areas in HAVI

3.4.7 Hydrological Area VII (Eastern Littoral)

Hydrological Area VII comprises of Abia, Anambra, Imo, Enugu, Ebonyi, Cross-River, Akwa-Ibom and Rivers States. The area is covered by 90% Sedimentary, 10% Basement Complex rocks and drained by Imo, Qua-Iboe, Calabar, Ivo, Asu, Cross River and Ebonyi River.

The States under the High-Risk category are Akwa-Ibom, Cross River, Ebonyi, and Rivers. The details of High and Moderate-Risk flood areas in Hydrological Area VII are shown in Figure 3.7

Flood Risk LGAs in HA VII (Eastern Lithoral).

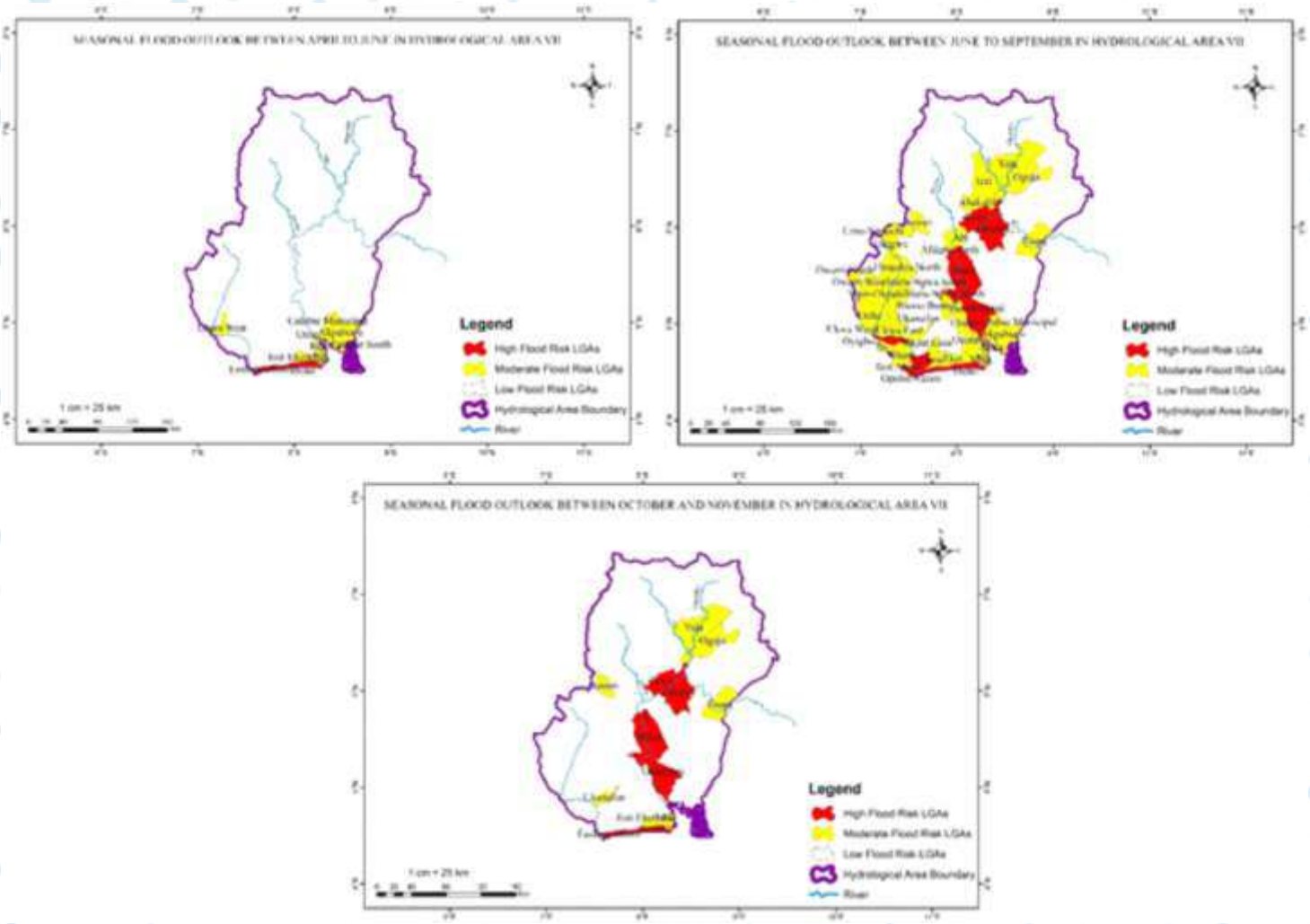


Figure 3.7: Maps showing Flood – Risk Areas in HAVII

3.4.8 Hydrological Area VIII (Chad Basin)

Hydrological Area VIII (Figure 3.10) comprises of Bauchi, Borno, Kano, Jigawa, and Yobe. The geology is made up of 80% Sedimentary and 20% Basement Complex rocks. Major Rivers in the area are: Hadejia-Jama'are, Komadugu-Yobe, Yedseram, Ngadda and Dingaiya.

The States under the High-Risk category are Bauchi, Borno, Jigawa, Kano and Yobe. The details of High and Moderate-Risk flood areas in Hydrological Area VIII are shown in Figure 3.8

Flood Risk LGAs in HA VII (Eastern Lithoral).

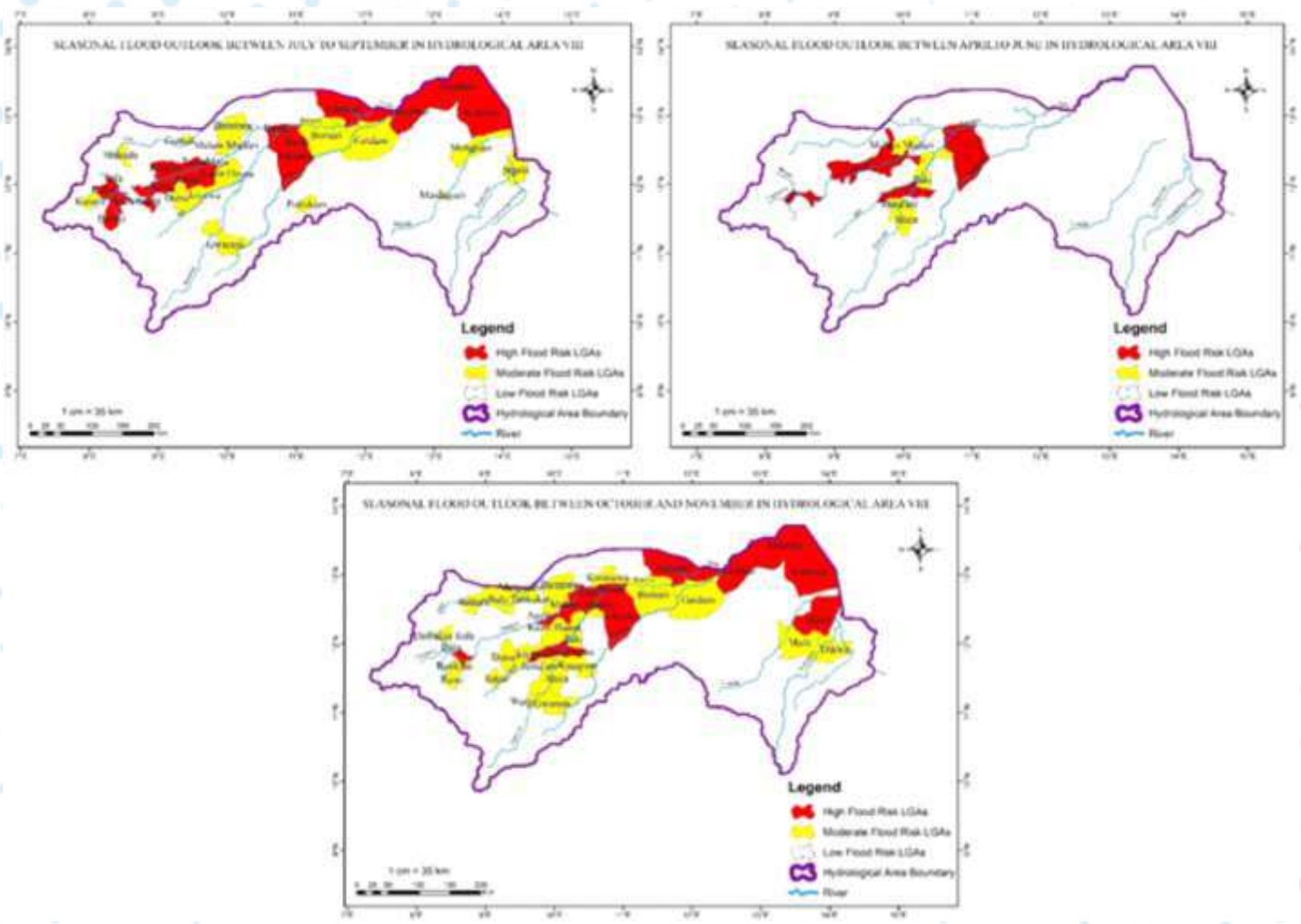


Figure 3.8: Maps showing Flood – Risk Areas in HA VIII

Figure 3.9: Map of Nigeria Showing Flood Risk LGAs in 2024

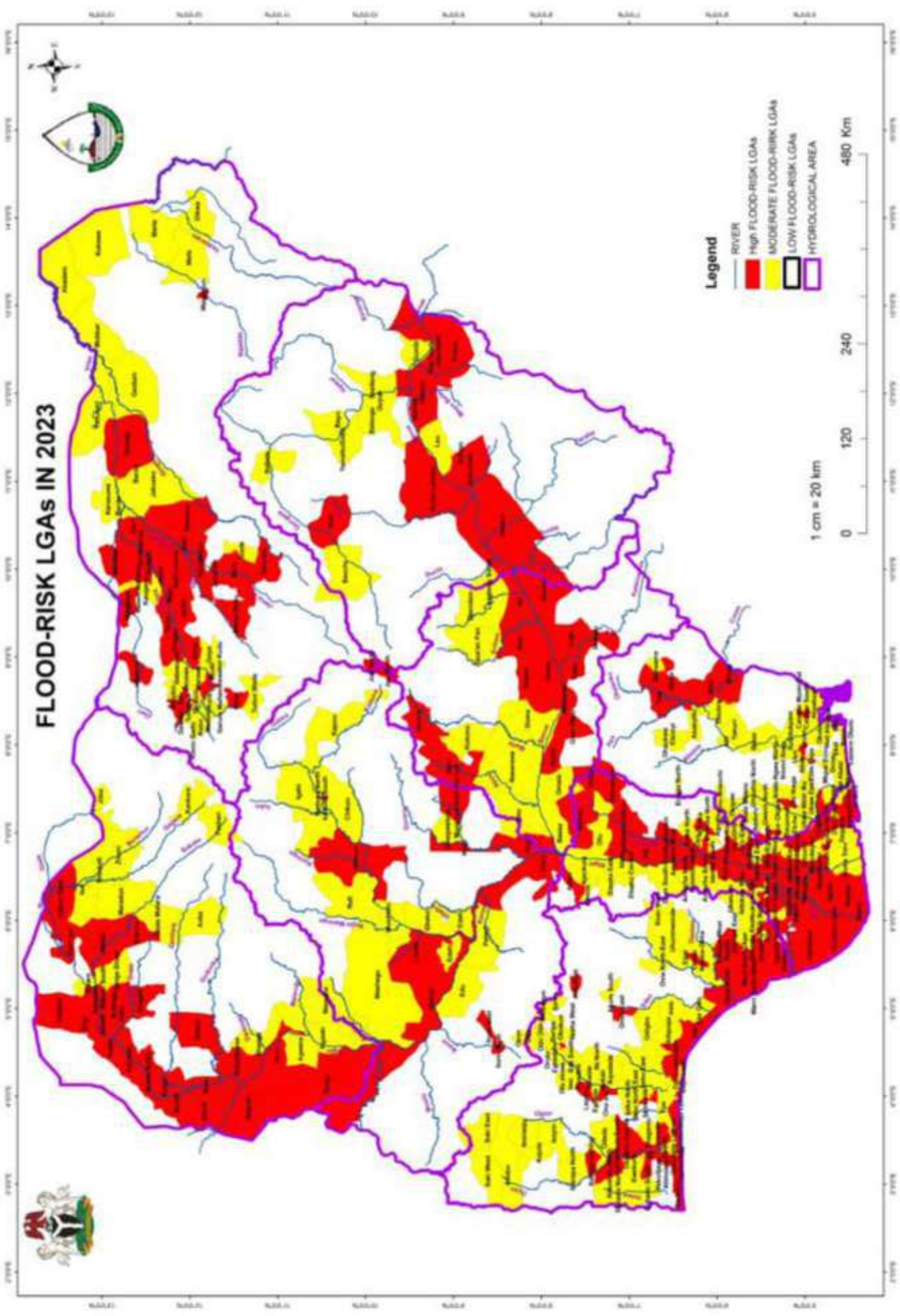


Table 3.1: High Flood-Risk Areas

S/N	STATE	Local Government Areas (LGAs)		
		April – June (AMJ)	July – September (JAS)	October – November (ON)
1.	Adamawa	Yola South, Lamurde, Demsa	Yola South, Numan, Lamurde, Fufore, Gombi, Demsa	Yola South, Numan, Lamurde, Demsa
2.	Akwa Ibom	Eastern Obolo, Ibeno	Eastern Obolo, Ikot Abasi, Ibeno	Eastern Obolo, Ibeno
3.	Anambra	Ogbaru, Anambra East, Anambra West	Ogbaru, Anambra East, Ayamelum, Anambra West	
4.	Bauchi	Toro	Toro	Itas/Gadau
5.	Bayelsa	Southern Ijaw, Ekeremor, Sagbama	Southern Ijaw, Ekeremor, Kolokuma/ Opokuma, Yenegoa, Sagbama	Southern Ijaw, Ekeremor
6.	Benue	Buruku	Buruku, Makurdi, Guma	Buruku, Makurdi, Guma
7.	Borno	Ngala, Monguno	Abadam, Kukawa, Mobbar, Ngala, Monguno	Marte, Abadam, Kukawa, Mobbar
8.	Cross River		Obubra, Biase, Odukpani	Obubra, Biase, Odukpani
9.	Delta	Oshimili South, Ndokwa East, Ughelli South, Warri South-West, Warri South, Ughelli South	Oshimili South, Warri South-West, Warri South, Ndokwa East, Ughelli South, Burutu, Isoko South	Warri South-West
10.	Ebonyi		Ikwo	Ikwo
11.	Edo	Etsako East, Etsako Central	Etsako East, Etsako Central	
12.	Imo		Ohaji/Egbema	
13.	Jigawa	Kaugama, Hadejia, Auyo, Ringim	Taura, Miga, Ringim, Jahun	Guri, Kiri Kasamma, Auyo
14.	Kaduna	Kajuru, Kachia, Kuban	Kajuru, Kachia, Kuban,	
15.	Kano	Dawakin Kudu, Sumaila, Makoda, Karaye	Garun Mallam, Ajingi, Rimin Gado, Tofa, Warawa, Bebeji, Kabo, Wudil, Kura, Madobi,	Dawakin Kudu

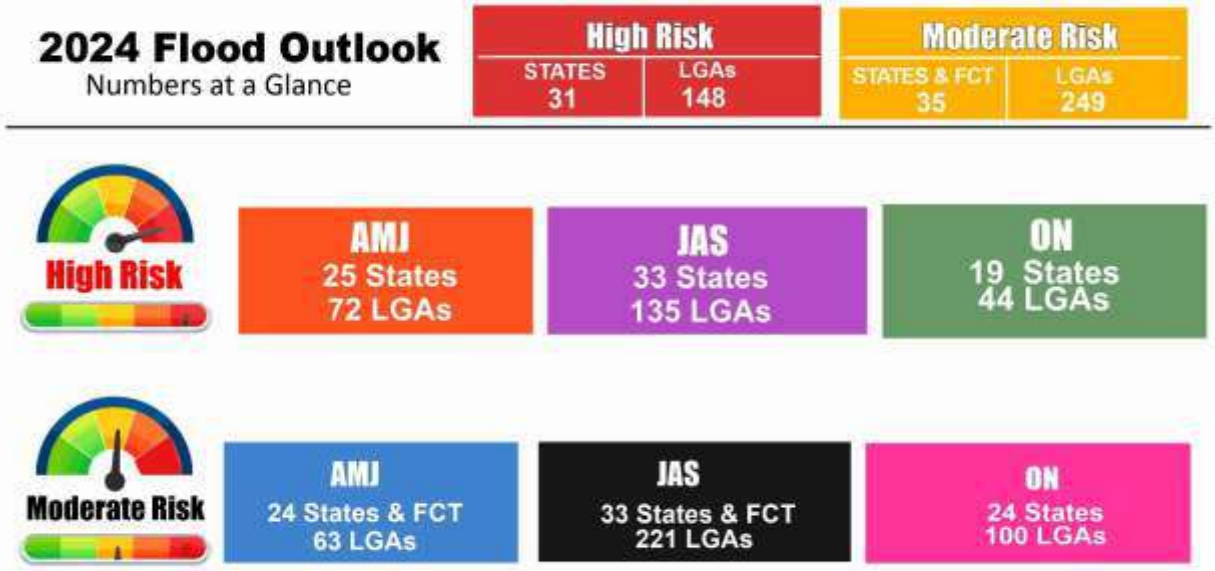
S/N	STATE	Local Government Areas (LGAs)		
		April – June (AMJ)	July – September (JAS)	October – November (ON)
			Sumaila, Makoda, Karaye	
16	Katsina	Faskari, Sandamu	Faskari, Sandamu	
17.	Kebbi	Bagudo, Ngaski, Yauri	Bagudo, Ngaski, Yauri	Bagudo, Yauri
18.	Kogi	Bassa, Kogi, Bassa, Ibaji, Ajaokuta, Lokoja, Kogi	Bassa, Kogi, Idah, Bassa, Igalamela-Odolu, Ibaji, Ajaokuta, Ofu, Okene, Adavi	Lokoja, Kogi
19.	Kwara	Pategi, Edu	Pategi, Edu	
20.	Lagos	Badagry	Amuwo Odofin, Ikeja, Ojo, Ikorodu, Epe, Badagry	Amuwo Odofin, Ojo, Badagry
21.	Nasarawa		Nasarawa, Toto, Doma	
22.	Niger	Mokwa, Edati, Borgu, Lapai	Mokwa, Katcha, Edati, Gbako, Wushishi, Lapai	
23.	Ogun	Abeokuta North, Odeda, Ado Odo/Ota, Ogun waterside	Ewekoro, Abeokuta North, Odeda, Ado, Odo/Ota, Ogun waterside, Obafemi Owode, Ijebu East, Ifo	Ado Odo/Ota, Ogun waterside
24.	Ondo	Ilaje	Odigbo, Ilaje	Ilaje
25.	Osun		Obokun, Olorunda, Ifelodun	
26.	Plateau	Bassa	Bassa	
27.	Oyo		Itesiwaju	
28.	Rivers	Ogba/Egbema/Ndoni, Degema, Ahoada West	Ahoada East, Ogba/Egbema/Ndoni, Degema, Ahoada West, Akuku Toru, Abua/Odual, Ikwerre, Emuoha, Oyigbo, Opobo/Nkoro	Degema, Abua/Odual
29.	Sokoto	Goronyo, Sokoto North, Sabon Birni, Sokoto South, Wamako		Goronyo, Sabon Birni, Sokoto South, Wamako
30.	Taraba	Lau Takum, Gashaka, Ussa, Donga, Sardauna	Gassol, Ardo-Kola, Karim Lamido, Ibi, Lau, Wukari, Takum, Gashaka, Ussa, Donga, Sardauna	Lau
31.	Yobe	Bade, Jakusko	Bade, Jakusko, Yunusari	Bade, Jakusko, Yunusari

Table 3.2: Moderate Flood Risk Areas

S/N	STATE	Local Government Areas (LGAs)		
		April – June (AMJ)	**July – September (JAS)**	**October – November (ON)**
1.	Adamawa	Yola North, Shelleng, Guyuk	Yola North, Shelleng, Song, Jada, Guyuk, Mayo-Belwa	Yola North, Shelleng, Mayo-Belwa
2.	Abia	Ukwa West	Osisioma Ngwa, Umunneochi, Umuahia South, Aba North, Umuahia North, Ukwa East, Ugwunagbo, Ukwa West, Isiala-Ngwa North, Isiala-Ngwa South, Aba South	
3.	Akwa Ibom	Mbo, Oron, Esit Eket	Mkpat Enin, Okobo, Mbo, Udung Uko, Eket, Onna, Oron, Esit Eket, Itu, Ukanafun, Ibiono Ibom, Uruan, Urue Offong/Oruko	Mbo, Esit Eket, Ukanafun
4.	Anambra	Idemili North, Onitsha North, Nnewi North, Idemili South, Onitsha South	Ihiala, Idemili North, Onitsha North, Nnewi North, Ekwusigo, Idemili South, Onitsha South	
5.	Bauchi	Bauchi, Jama'are, Shira, Zaki, Ganjuwa	Bauchi, Ganjuwa	Bauchi, Jama'are, Shira, Warji, Katagum, Zaki
6.	Bayelsa	Nembe	Brass, Ogbia, Nembe	Nembe
7.	Benue	Agatu, Tarka	Agatu, Tarka, Gwer West, Logo, Katsina-Ala, Kwande	Agatu, Tarka, Gwer West, Logo
8.	Borno	Damboa, Gwoza	Kwaya Kusar, Maiduguri, Shani, Hawul, Askira/Uba, Damboa, Gwoza	Dikwa, Mafa
9.	Cross River	Calabar South, Calabar Municipal, Akpabuyo	Calabar South, Calabar Municipal, Akpabuyo, Abi, Yala, Ogoja, Etung	
10.	Delta	Aniocha South, Patani, Oshimili North, Warri North	Ndokwa West, Sapele, Aniocha North, Aniocha South, Patani, Ughelli North, Udu, Ethiope West, Okpe, Bomadi, Oshimili North, Warri North, Uvwie Isoko North	Sapele, Udu, Okpe, Bomadi, Warri North, Uvwie

S/N	STATE	Local Government Areas (LGAs)		
		April – June (AMJ)	**July – September (JAS)**	**October – November (ON)**
11.	Ebonyi		Izzi, Abakaliki, Afikpo North	
12.	Edo	Esan South-East	Ikpoba-Okha, Etsako West, Esan South-East, Esan North-East, Ovia North-East	Ikpoba-Okha
13.	Enugu		Aninri	Aninri
14.	Ekiti		Ado-Ekiti	
15.	FCT, Abuja	Municipal Area Council, Gwagwalada	Kwali, Municipal Area Council, Abaji, Kuje, Gwagwalada	
16.	Gombe	Dukku	Kwami, Yamaltu/Deba, Gombe, Funakaye, Dukku	Kwami, Yamaltu/Deba, Gombe, Funakaye
17.	Imo		Oguta, Owerri West, Owerri North, Ahiazu, Mbaise, Okigwe, Ngor-Okpala, Ehime -Mbano, Ihitte/Uboma, Ezinihitte, Aboh-Mbaise, Obowo	
18.	Jigawa	Malam Madori	Gumel, Gwaram Dutse, Malam Madori, Biriniwa, kiyawa, Kafin Hausa	Sule Tankakar, Babura, Gumel, Gwaram, Dutse, Malam Madori, Biriniwa, Maigatari, kiyawa, Kafin Hausa
19.	Kaduna		Igabi, Chikun	
20.	Kano			Takai, Rano, Dawakin Tofa, Dala, Bunkure
21.	Kastina			Jibia
22.	Kebbi	Argungu, Suru, Augie, Jega, Maiyama	Argungu, Suru, Koko/Besse, Sakaba, Augie, Gwandu, Jega, Dandi, Kalgo, Birnin Kebbi, Bunza, Maiyama, Aleiro	Argungu, Suru, Augie, Gwandu, Jega, Kalgo, Birnin Kebbi, Bunza, Maiyama, Aleiro

S/N	STATE	Local Government Areas (LGAs)		
		April – June (AMJ)	**July – September (JAS)**	**October – November (ON)**
23.	Kogi	Dekina, Omala, Yagba West	Dekina, Ogori/Magongo, Okehi, Omala, Yagba West	
24.	Kwara		Kaiama, Asa, Baruten	
25.	Lagos	Lagos Mainland, Lagos Island, Kosofe, Eti Osa, Apapa, Ibeju, Lekki, Surulere, Shomolu, Ajeromi/Ifelodun	Lagos Mainland, Lagos Island, Alimosho, Kosofe, Eti Osa, Apapa, Mushin, Ibeju Lekki, Oshodi/Isolo, Agege, Ifako/Ijaye, Surulere, Shomolu, Ajeromi/Ifelodun	Lagos Mainland, Lagos Island, Eti Osa, Apapa, Ibeju Lekki, Surulere, Ajeromi/Ifelodun
26.	Nasarawa	Karu	Karu, Awe	Karu
27.	Niger	Agwara	Bida, Magama, Muya, Agwara, Agaie, Shiroro, Chanchaga, Rafi, Lavun	Agwara
28.	Ogun	Abeokuta South	Abeokuta South, Egbado South, Ipokia, Ijebu North East, Ijebu North	
29.	Ondo		Ese Odo	Irele
30.	Osun		Irewole, Isokan, Irepodun, Ilesha West, Orolu, Osogbo, Ede North, Ife North, Boripe, Ede South, Aiyedire, Egbedore, Aiyedade	
31.	Oyo	Ibarapa East	Ona ara, Lagelu, Ibarapa Central, Kajola, Egbeda, Ogbomosho South, Ogbomosho North, Iseyin, Ibarapa North, Ibarapa East	
32.	Rivers	Andoni, Bonny, Port-Harcourt, Okrika, Asari-Toru	Andoni, Ogu Bolo, Omumma, Bonny, Etche, Port-Harcourt, Obio/Akpor, Gokana, Tai, Khana, Okrika, Asari-Toru	Andoni, Ogu Bolo, Bonny, Port-Harcourt, Obio/Akpor, Okrika, Asari-Toru
33.	Sokoto	Silame	Tambuwal, Gada, Rabah, Tureta, Silame, Shagari, Kebbe	Bodinga, Tambuwal, Rabah, Tureta, Isa, Silame, Shagari, Yabo, Dange/Shuni, Kware, Wurno, Kebbe
34.	Taraba	Bali	Bali, Zing, Jalingo	Jalingo
35.	Yobe	Gulani	Geidam, Potiskum, Gulani Borsari	Geidam, Gulani, Borsari, Karasuwa
36.	Zamfara		Bungudu, Gummi, Gusau	Bakura, Maradun, Bungudu, Talata Mafara, Shinkafi, Zurmi



3.5 Flood Vulnerability/Impact Analysis of 2024 Flood

Anticipating the potential 2024 floods, comprehending its repercussions, and evaluating vulnerability is crucial for informed decision-making and mitigation planning. The looming possibility of floods in 2024 serves as a stark reminder of the increasing menace posed by climate change driven extreme weather phenomena. This projected flood is anticipated to cause immediate devastation and highlight the intricate links between socio-economic and environmental variables in determining vulnerability. A thorough examination through a flood vulnerability and impact analysis becomes imperative, enabling the identification of at-risk populations, critical infrastructure, and vulnerable ecosystems. Through such an analysis, proactive measures can be devised to bolster resilience and mitigate future losses effectively. The summary of vulnerability and potential impacts on communities are shown below:

Table 3.3: Cities with Potential Urban & Flash Floods in 2024

S/N	City	State	Hydrological Area (HA)
1	Sokoto	Sokoto	I
2	Birni Kebbi	Kebbi	I
3	Kaduna	Kaduna	II
4	Abuja	FCT	II
5	Yola	Adamawa	III
6	Makurdi	Benue	IV
7	Asaba	Delta	V
8	Warri	Delta	V
9	Onitsha	Anambra	V
10	Port-Harcourt	Rivers	V
11	Lagos	Lagos	VI
12	Abeokuta	Ogun	VI
13	Osogbo	Osun	VI
14	Ibadan	Oyo	VI
15	Benin-City	Edo	VI
16	Akure	Ondo	VI
17	Calabar	Cross River	VII
18	Abakaliki	Ebonyi	VII
19	Nguru	Yobe	VIII
20	Kano	Kano	VIII

Table 3.4: Potential High-Risk Flood Impact Analysis for the year 2024

S/N	State	No. of LGAs at Risk	Vulnerable Communities	Population at Risk	Infrastructure at Risk	Exposed Farmland (Hecters)
1.	Adamawa	6	987	1,441,300.00	14,136	3,476.43
2.	Akwa Ibom	3	59	341,200.00	1,120	
3.	Anambra	4	109	998,800.00	5,902	434.16
4.	Bauchi	2	31	1,025,900.00	1,760	4,450.50
5.	Bayelsa	5	794	1,800,900.00	10,506	
6.	Benue	3	383	1,011,700.00	9,013	2,815.11
7.	Borno	6	244	1,312,400.00	57,191	6,704.01
8.	Cross River	3	399	812,600.00	3,105	1,952.55
9.	Delta	7	870	2,101,000.00	12,675	579.42
10.	Ebonyi	1	51	320,200.00	3,908	1,785.42
11.	Edo	2	65	356,900.00	4,018	
12.	Imo	1	93	254,200.00	3,950	2,172.42
13.	Jigawa	9	254	2,327,400.00	12,890	4,080.33
14.	Kaduna	3	328	535,300.00	4,181	1,890.81
15.	Kano	14	362	3,749,200.00	23,352	2,212.29
16.	Katsina	2	175	592,100.00	3,535	3,350.43
17.	Kebbi	3	582	793,900.00	22,011	2,658.15
18.	Kogi	10	184	2,240,800.00	16,339	3,091.14
19.	Kwara	2	104	469,100.00	21,113	
20.	Lagos	7	447	3,261,400.00	246,231	2,446.65
21.	Nasarawa	3	255	1,379,300.00	30,999	6,620.40
22.	Niger	7	893	1,753,100.00	35,446	1,531.26
23.	Ogun	8	1,386	1,847,200.00	45,820	3,118.68
24.	Ondo	2	25	802,000.00	1,148	2,437.29
25.	Osun	3	47	630,300.00	6,057	2,535.30
26.	Oyo	1	20	182,100.00	2,436	2,437.29
27.	Plateau	1	N/A	188,300.00	N/A	
28.	Rivers	11	746	2,202,800.00	30,140	-
29.	Sokoto	5	362	1,415,800.00	14,681	2,985.21
30.	Taraba	11	571	2,539,900.00	8,932	5,417.55
31	Yobe	3	118	783,300.00	22,356	4,158.72

NB: Infrastructure considered are buildings and roads.

3.6 High Flood-Risk Basins

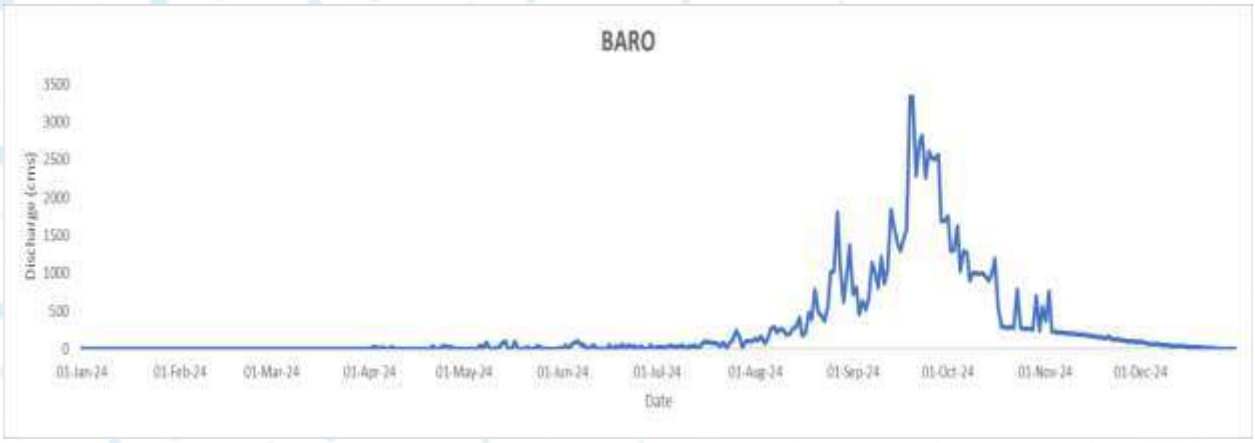
The high flood risk basins are: Upper and Lower Niger, Upper and Lower Benue, Anambra–Imo, Niger–Delta, lower fringes of Ogun–Osun part of Cross River, Sokoto–Rima and Komadougu–Yobe. A total of One Hundred and Forty-Eight (148) LGAs are predicted as High Flood-Risk for 2024/2025 Hydrological Year.

3.7 Moderate Flood-risk Areas

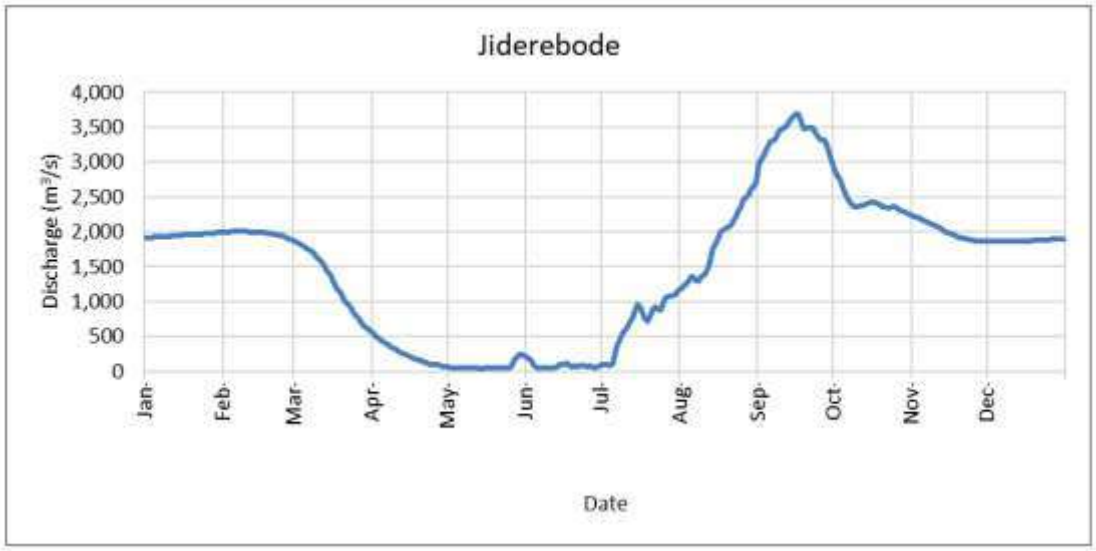
Floods in this category are expected to be moderate in terms of occurrence. Two Hundred and Forty-Nine (249) LGAs are predicted to fall within this category.

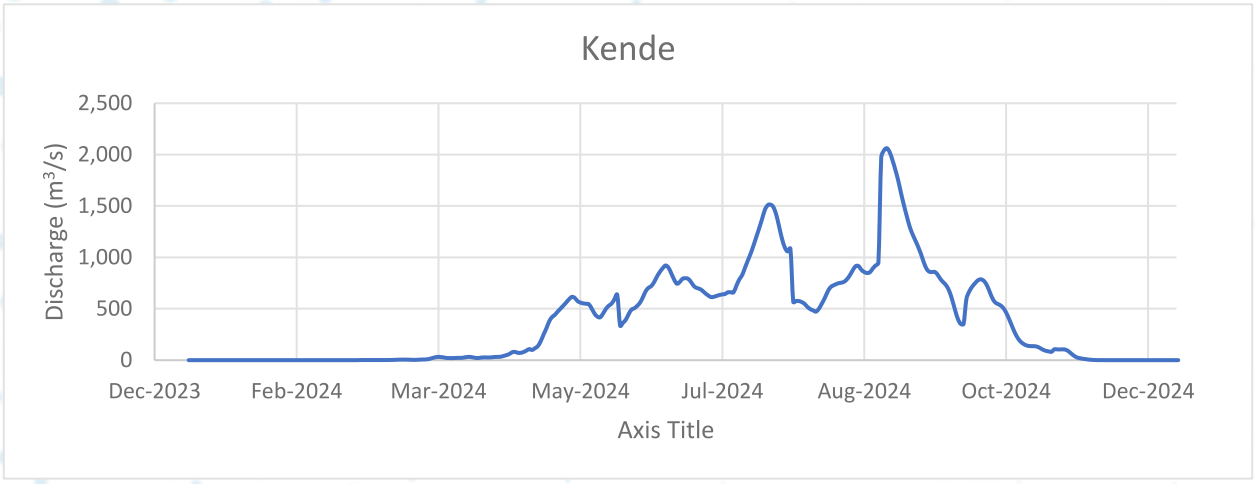
3.8 Simulated Hydrographs at selected stations

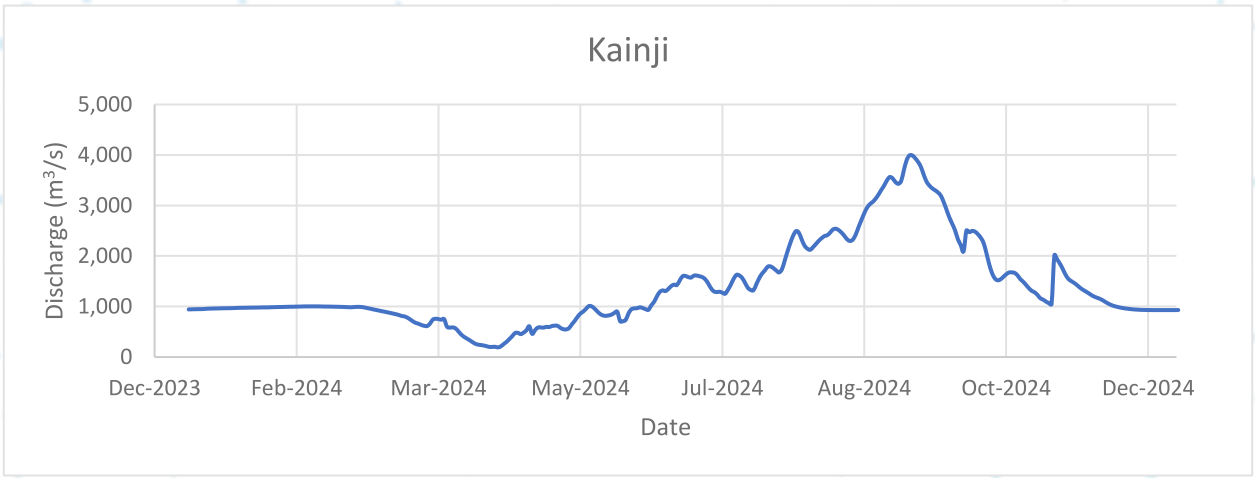
The Simulated hydrographs of gauging stations at Baro, Ibi, Jiderebode, Kende, Kainji, Shiroro, Lau, Lokoja, Makurdi, Onitsha, Sokoto, Umaisha, Wuroboki and Zungeru are presented below:


BARO
Discharge (cms)
3500
3000
2500
2000
1500
1000
500
0
01-Jan-24
01-Feb-24
01-Mar-24
01-Apr-24
01-May-24
01-Jun-24
01-Jul-24
01-Aug-24
01-Sep-24
01-Oct-24
01-Nov-24
01-Dec-24
Date

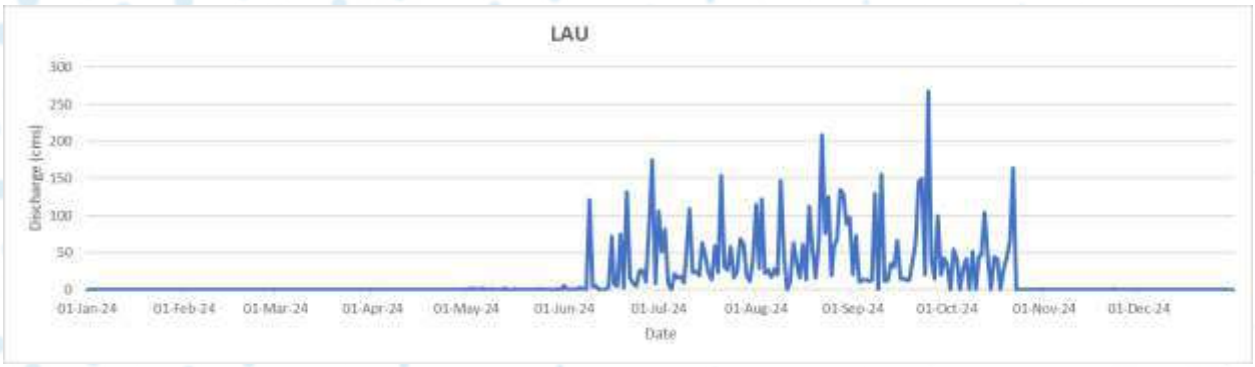

Ibi
Discharge (cms)
3000
2500
2000
1500
1000
500
0
01-Jan-24
01-Feb-24
01-Mar-24
01-Apr-24
01-May-24
01-Jun-24
01-Jul-24
01-Aug-24
01-Sep-24
01-Oct-24
01-Nov-24
01-Dec-24
Date

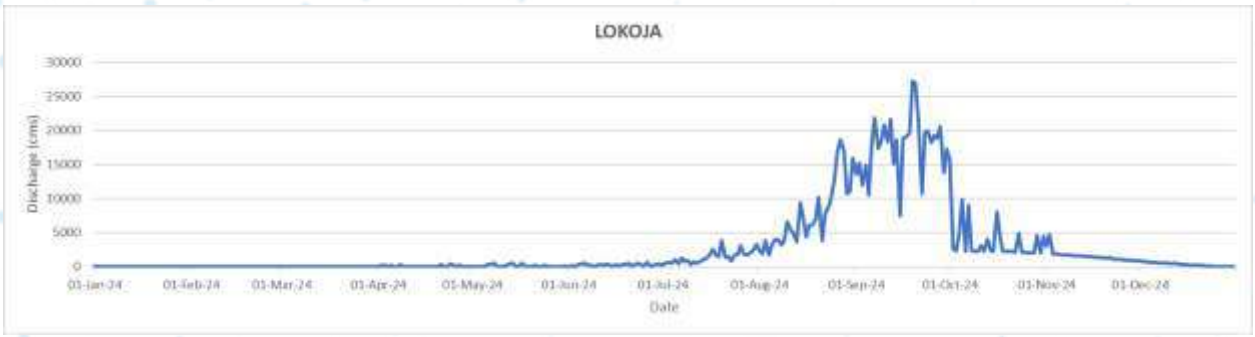

Jiderebode
Discharge (m³/s)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date


Kende
2,500
2,000
1,500
1,000
500
0
Discharge (m³/s)
Dec-2023
Feb-2024
Mar-2024
May-2024
Jul-2024
Aug-2024
Oct-2024
Dec-2024
Axis Title

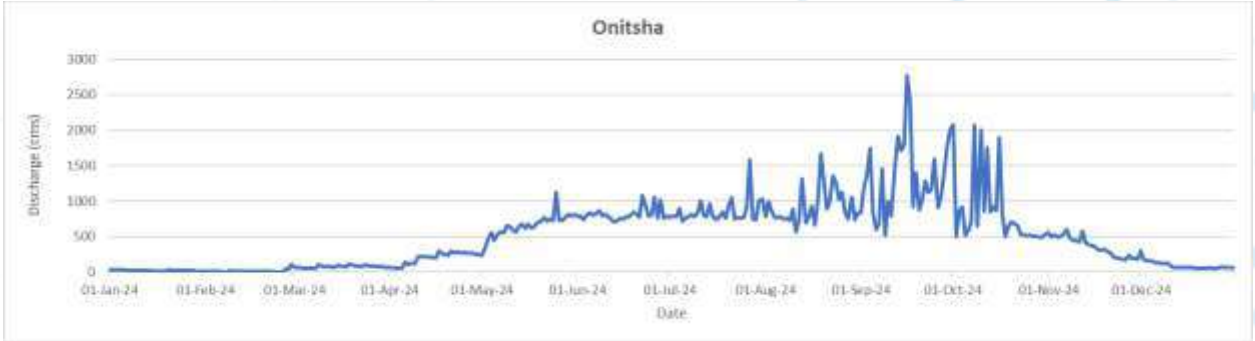

Kainji
5,000
4,000
3,000
2,000
1,000
0
Discharge (m³/s)
Dec-2023
Feb-2024
Mar-2024
May-2024
Jul-2024
Aug-2024
Oct-2024
Dec-2024
Date

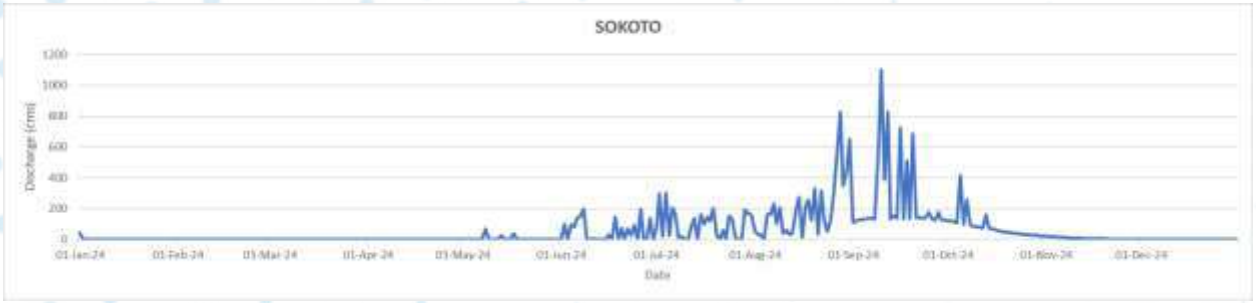

Shiroro
3,000
2,500
2,000
1,500
1,000
500
0
Discharge (m³/s)
Dec-2023
Feb-2024
Mar-2024
May-2024
Jul-2024
Aug-2024
Oct-2024
Dec-2024
Date

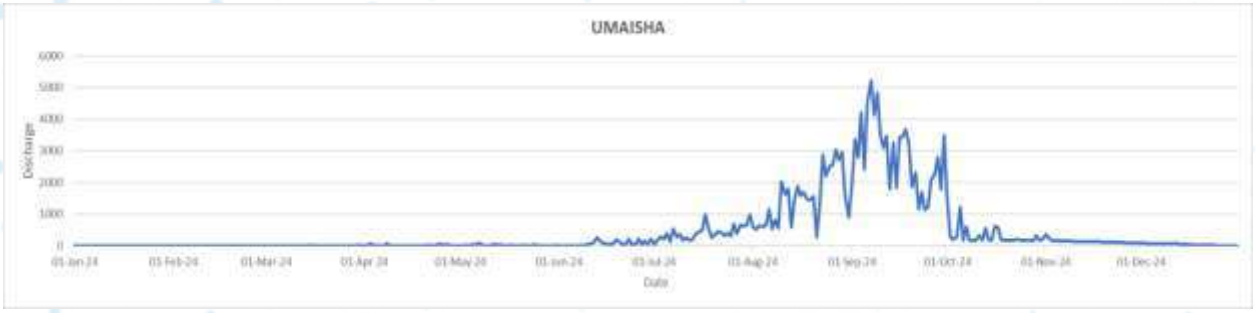

LAU
Discharge (cms)
300
250
200
150
100
50
0
01-Jan-24
01-Feb-24
01-Mar-24
01-Apr-24
01-May-24
01-Jun-24
01-Jul-24
01-Aug-24
01-Sep-24
01-Oct-24
01-Nov-24
01-Dec-24
Date


LOKOJA
Discharge (cms)
30000
25000
20000
15000
10000
5000
0
01-Jan-24
01-Feb-24
01-Mar-24
01-Apr-24
01-May-24
01-Jun-24
01-Jul-24
01-Aug-24
01-Sep-24
01-Oct-24
01-Nov-24
01-Dec-24
Date


Markurdi
Discharge (cms)
2500
2000
1500
1000
500
0
01-Jan-24
01-Feb-24
01-Mar-24
01-Apr-24
01-May-24
01-Jun-24
01-Jul-24
01-Aug-24
01-Sep-24
01-Oct-24
01-Nov-24
01-Dec-24
Date


Onitsha
Discharge (cms)
3000
2500
2000
1500
1000
500
0
01-Jan-24
01-Feb-24
01-Mar-24
01-Apr-24
01-May-24
01-Jun-24
01-Jul-24
01-Aug-24
01-Sep-24
01-Oct-24
01-Nov-24
01-Dec-24
Date


SOKOTO
Discharge (cms)
Date


UMAISHA
Discharge
Date

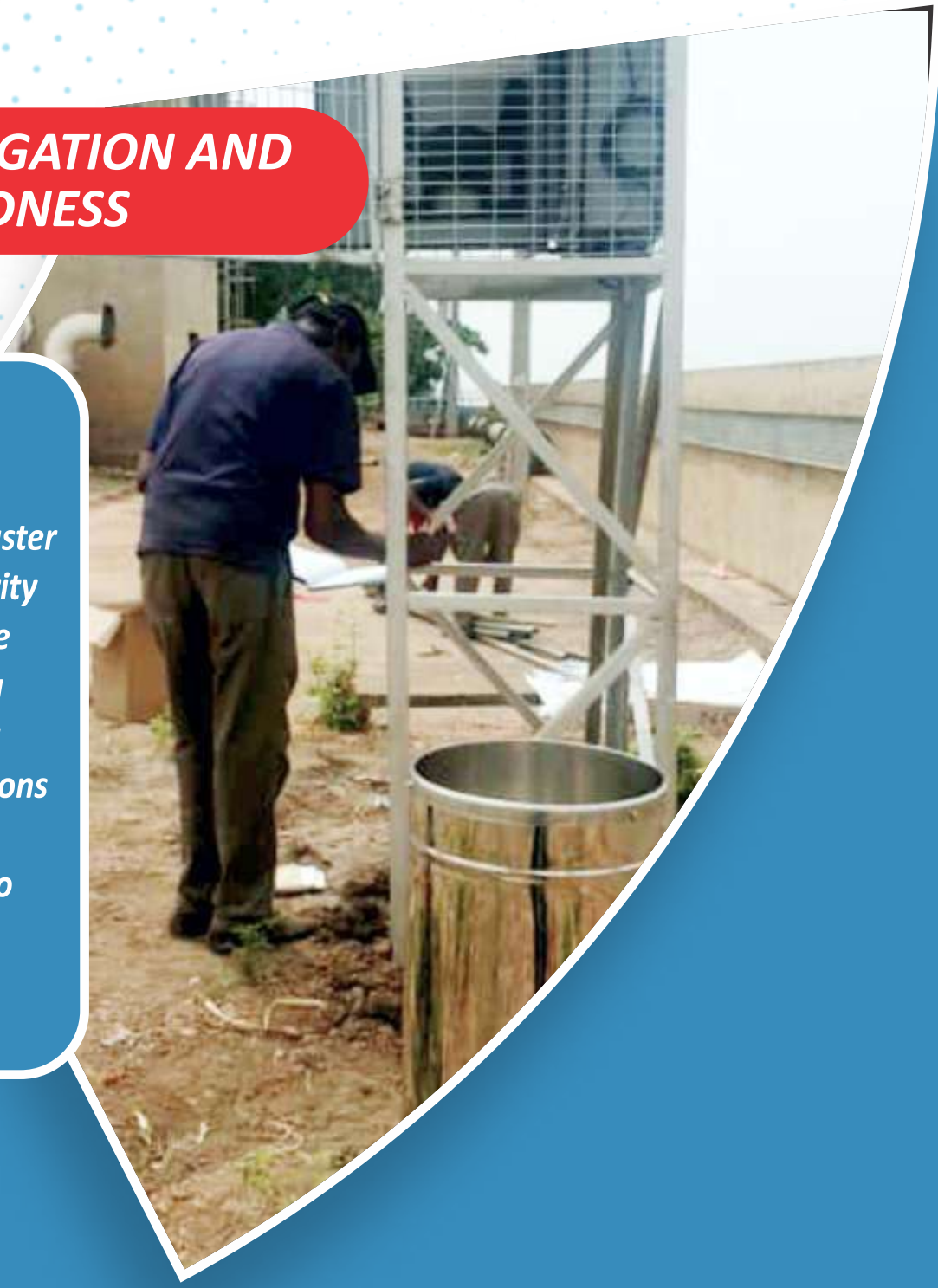

Wuroboki
Discharge (cub. metres per sec)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Jan
Mar
May
Jul
Sep
Nov
average
max


ZUNGERU
Discharge (cms)
Date

CHAPTER FOUR

4.0 Preamble

RISK MITIGATION AND PREPAREDNESS



> *Flooding is the most common natural disaster in Nigeria. The majority of Nigeria's states are increasingly suffering from annual flooding during the rainy seasons caused by increased precipitation linked to climate change.*

This chapter presents a comprehensive overview of the implication of the 2024 AFO on some key economic sectors with a focus on required proactive measures, risk mitigation and preparedness strategies that are designed to guide government, relevant stakeholders and disaster risk reduction management agencies.

4.1 Implication of the 2024 Annual Flood Outlook (AFO) on Some Key Sectors of the Economy

Flooding is the most common natural disaster in Nigeria. The majority of Nigeria states are increasingly suffering from annual flooding during the rainy seasons caused by increased precipitation linked to climate change. The Nigeria Bureau of Statistics (NBS) in 2024 reported the devastating impact of the 2022 flood to be in the range of US$3.79 billion to $9.12 billion, with the best (median) estimate at $6.68 billion. The economic value of the agriculture-related losses due to the 2022 floods was about N700 billion. Agricultural lands, crops, infrastructures and rural livelihood continue to be destroyed annually. Unlike some natural disasters, rainfall induced flooding can be controlled with proper planning and the provision of necessary infrastructures.

Flooding in Nigeria is mainly human induced with the current poor urban/rural planning practices and inadequate to non-existent environmental infrastructure contributing to and exacerbating the issue. The absence of a national Flood Risk Management (FRM) strategy is an indication of lack of attention paid to Nigeria's flooding problem. This suggests designing and implementing adequate FRM strategies comprising proper spatial planning and infrastructures would help in controlling the floods which adversely impact Nigeria's sustainable development.
Urban infrastructure, underpinned by relevant legal and policy framework, forms the backbone of human settlements. Elements such as FRM are measures aimed at reducing the likelihood and/or impact of floods while spatial planning also known as urban planning, land use planning and physical planning are methods employed by the public sector to shape the location, distribution and inter-linkages of land use activities (Acheampong 2019; Ouikotan et al. 2017). Nigerian cities are characterized by poor infrastructures which impact livability and sustainability; thus, the impact of impending flooding could further worsen the situation.

The impact of 2024 flooding on socio-economy is stated below:

4.1.1 Flooding and Poverty

Environmental challenges, particularly floods further worsen the living conditions of the already impoverished population in Nigeria, jeopardising the country's progress towards achieving the Sustainable Development Goals (SDGs). The International Organisation for Migration (IOM) in Nigeria reported that a combination of unprecedented heavy rainfall and the release of excess water from the Lagdo dam in Northern Cameroon led to the displacement of over 39,500 people in 2023.

In the year 2024, floods not only have the potential to devastate the social fabric and physical landscapes but also to deplete the meager savings of impoverished households. The recurring nature of floods compounds their detrimental effects which establishes flooding as a significant contributing factor to the perpetuation of existing poverty levels.

Picture showing the devastation caused by 2023 Flooding in Adamawa State Photo Credit: IOM, 2023

Understanding these environmental challenges is crucial for comprehending their broader implications, particularly in the context of the SDGs. By addressing the root causes and impacts of floods in Nigeria, an appropriate measure needs to be taken to avert the increase in poverty level as a result of the impending adverse effects of 2024 floodings.

4.1.2 Health Sector

Flooding has far-reaching impacts on health, encompassing both direct and indirect consequences. For instance, about 90% of these direct effects (deaths & injuries) results from flood, creating a significant burden on medical resources and services.

Medical staff attending to Internally Displaced persons in Anambra State
Photo Credit: Thisday Newspaper

The annual flooding disasters in Nigeria present a particular concern for the country's health sector. Waterborne epidemics such as Typhoid, Cholera and Dysentery become prevalent during floods, posing a threat to the already developing healthcare infrastructure. Furthermore, floods provide an ideal breeding ground for parasites like mosquitoes, contributing to the rise of malaria fever. This poses a greater risk to vulnerable populations, particularly women and children, who are more susceptible to the mortality associated with these diseases. Flooded environments also give rise to respiratory illnesses caused by the growth of mildews and molds, impacting individuals with allergies and asthma with a disproportionate effect on the elderly and children.

Additionally, post-flood power outages in developing countries lead to reliance on fossil fuel powered generators, potentially resulting in carbon monoxide poisoning if used without proper ventilation. Even as floodwaters recede, lingering health threats persist, such as the risk of electric shock from submerged wires, physical injuries from debris, snake bites, humans falling prey to lurking reptiles that came with flooding into homes etc.

Notably, in Nigeria, floods contribute to the pollution of water sources, as waterlogged grounds and overwhelmed wastewater treatment plants lead to backflow into homes and surrounding areas, further elevating health risks for the population. In 2024, the adverse effects of flooding could be forestalled, if appropriate measures are taken to curtail the overwhelming of medical facilities.

4.1.3 Education Sector

Displacements resulting from flooding have severe consequences on the education of children in flooded areas. This situation creates a lasting economic impact, hindering future opportunities for these children. Adamawa State Emergency Management Agency (ADSEMA) reports that floods have caused a large scale displacement of more than 8,504 households (51,043 individuals), the majority of whom are women, children, and the elderly, currently living in 11 temporary settlements across Yola South, Yola North, Lamurde, Madagali, and Demsa LGAs (Reliefweb, 2023). The use of educational facilities as makeshift shelters for displaced people during flooding could further exacerbate the challenges faced by these children.

Floods have led many schools to be closed leading to student drop out, the destruction of properties and infrastructure (UNICEF, 2023). The scale of damage in 2023 prevented about 1.5 million children from attending school. This impact is particularly damaging in states where access to education is already limited.

Furthermore, reconstruction efforts for damaged schools in severely affected communities often experience delays. The disruption caused by flooding affects schooling and the delivery of quality education in various ways regardless of the flood severity. Even in less severe flood areas, parents hesitate to send their wards to school due to concerns about the hazardous floodwaters en route.

Displaced people taking refuge at St. luke's Model School UBE JSS,, Adankolo . [PHOTO CREDIT: Kunle Sanni]

The adverse effects of flooding on the educational sector have become more pronounced in areas with inadequate access to education which has worsen the existing disparities. In flood prone areas such as Koton-karfe, Lokoja, Makurdi, Anambra and coastal areas of Akwa Ibom, Bayelsa, Lagos, Calabar, and Ogun States where young school children lose significant portions of the school year annually. This recurring disruption amplifies overall poorer educational performances and outcomes leading to reduced educational levels as well as long-term disadvantages that persist into adulthood. Understanding the specific challenges faced by these communities is crucial for developing targeted strategies to mitigate the impact of flooding on education and breaking the cycle of disadvantage for the affected children in 2024.

4.1.4 Transportation Sector

The flood disaster of 2023 has brought substantial repercussions on transportation infrastructures notably impacting road and rail systems. This has resulted in a significant impediment to the free movement of travelers and goods to their respective destinations. Recent instances of flooding have not only affected roads but have also taken a toll on bridges, power lines and communication facilities, thereby isolating certain communities from these vital infrastructures.

Looking ahead to 2024, the anticipated flooding poses a threat to transportation sector in places such as Koton-karfe in Kogi, Pategi in Kwara, Makurdi in Benue, Ogun State coastal areas and some communities in Adamawa state, making it difficult for travelers to move freely spending days on transit. Such occurrences have become a recurring annual challenge, emphasizing the need for proactive measures to mitigate the potential impacts on transportation networks.

Aerial View of Lokoja-Abuja (2022) road totally submerged by flooding with commuters stranded. Photo Credits: Thisday Newspaper Online

In addition to the disruption of roads, the looming flooding also introduces the risk of rail track washouts and displacements. This in turn, has the potential to severely disrupt rail services in the affected areas.

Addressing the recurrent threat of flooding requires a comprehensive approach, encompassing not only the repair and fortification of damaged infrastructure but also strategic planning to enhance resilience against future flood events. By investing in sustainable infrastructure solutions and implementing proactive measures, authorities can mitigate the adverse effects on transportation by ensuring the continued connectivity and mobility of communities in the face of natural disasters.

4.1.5 Agriculture Sector

As we contemplate the potential implications of the 2024 flooding on agriculture, it is crucial to consider the broader context of how flooding significantly disrupts access to food. The multifaceted impact includes scarcities, increased difficulty in acquisition, and a surge in prices across various channels. African Exchange (AFEX) foresees annual reductions in maize and rice production by 12% and 21% respectively due to flooding and related factors in 2024.

Photo showing Hectares of farmland destroyed by floodwater.
Photo Credit: Nigeria Health Watch, 2023

The repercussions of such floods, extend beyond the immediate agricultural losses. The World Food Programme (WFP) and the Food and Agriculture Organisation (FAO) in their report (2023) have identified Nigeria among 6 countries facing a high-risk of reaching catastrophic hunger levels. Current estimates reveal that 19 million people in Nigeria are grappling with food insecurity with a staggering 14.7 million Nigerian children at risk of malnutrition.

The impending devastating impact of the 2024 flooding on agriculture and food security may result in substantial loss of crops, livestock and other agricultural assets which underscores the vulnerability of the sector. Recognising the recurring nature of these events, it becomes imperative for communities residing in flood prone areas particularly those heavily dependent on farming to proactively prepare for the impending flood disaster in the 2024 season.

This proactive approach is crucial not only for safeguarding agricultural livelihoods but also for addressing the complex interplay of factors contributing to food insecurity in the country. Urgent measures and support systems are essential to mitigate the immediate impacts on affected communities to build a more resilient agricultural sector in the face of ongoing environmental challenges.

4.2 Flood Early Warning Systems in Nigeria

NIHSA has installed several flood early warning systems with the intent of enhancing preparedness and mitigation efforts by providing timely and accurate information about potential flooding events. These equipment are installed along the major river channels and provide real-time information on impending floods to riparian communities and relevant disaster risk management authorities. This allows for early preparation and evacuation.

With the early onset of rainy season in some areas particularly in the Southern parts of the country, there is a significant risk of flash floods, river flooding, and coastal inundation. Floods can wreak havoc on communities, causing loss of life, displacement of people, destruction of homes, infrastructures and economic disruption. Government authorities and communities alike must prioritise flood preparedness by investing in early warning systems, building resilient infrastructures, implementing land use planning measures and conducting regular drills and exercises.

Another important aspect is to also systematically document lessons learned and thereafter highlight the importance of implementing effective disaster management strategies to mitigate the impact of natural disasters in Nigeria. These will help to showcase the effectiveness of the combination of real-time data collection, monitoring and analysis in providing timely and accurate warnings to at-risk populations.

4.3 Emergency Response Planning

Emergency Response Planning involves developing and implementing strategies and protocols to effectively respond to flood events. This includes establishing clear communication channels, training emergency responders, conducting regular drills and simulations, and ensuring the availability of necessary resources and equipment.

There is need for review of our emergency response planning to include improved urban planning, investment in resilient infrastructure, increased public awareness on flood risks, and better collaboration between stakeholders at the national and local levels which are instrumental in creating resilient communities that are better prepared to mitigate the impacts of future floods.

4.4 Infrastructure Upgrades

Infrastructure upgrades have social benefits towards improving the quality of life for residents in flood prone areas. Some of the key benefits is the ability to reduce the likelihood of flooding occurring in the first place, by increasing the capacity of rivers and waterways to handle excess water, communities can minimise the risk of flooding. This not only helps protect infrastructures such as buildings, roads, and bridges from damage but also reduces the costs associated with repairing and rebuilding after a flood event. Investing in infrastructure upgrades, such as improving drainage systems, building flood barriers, and implementing early warning systems, communities can reduce their vulnerability to flooding and increase their resilience to future disasters.

Additionally, building green infrastructure such as rain gardens and permeable pavement can help reduce the risk of urban flooding and improve water quality. This not only helps protect the environment but also creates more pleasant and liveable communities for residents. This can also create job opportunities and stimulate economic growth, further benefiting the local community. This way, we can reduce the social disparities that often exacerbate the impacts of flooding on vulnerable populations.

4.5 Flood Barriers

Flood barriers are physical structures designed to prevent or reduce the flow of water during floods. They can take various forms, including levees, embankments, and sea walls. In Nigeria, the construction of flood barriers has become increasingly important as a means of protecting coastal communities, riverine areas, and urban centres from the devastating effects of flooding. By creating a barrier between the water and the surrounding land, flood barriers can help to channel floodwaters away from populated areas, reducing the risk of damage to civil structures and loss of lives.

In addition to their immediate protective benefits, flood barriers also offer long-term advantages for flood risk mitigation in Nigeria. By reducing the frequency and severity of flooding events, flood barriers can help to lower the overall cost of flood damage and recovery efforts. This can have a significant impact on the economy and livelihoods of communities affected by flooding, as well as on the resources and infrastructures of the country as a whole.

However, the implementation of flood barriers in Nigeria is not without its challenges. Building flood barriers requires significant financial resources, technical expertise, and planning, which are often either inadequate or not readily available. As a result, many communities in Nigeria remain vulnerable to flooding due to a lack of adequate flood control measures.

The construction of flood barriers can alter the natural flow of rivers and disrupt ecosystems, leading to adverse effects on wildlife and biodiversity. Furthermore, poorly designed or maintained flood barriers can exacerbate flooding in some areas by channelling water to other locations, causing unintended consequences for communities downstream. Despite these challenges, the benefits of flood barriers as a flood risk mitigation measure in Nigeria far outweigh the drawbacks. By investing in flood barriers, Nigeria can protect its communities from the devastating impacts of flooding in the immediate, reduce the economic cost of flood damage, and adapt to the challenges of climate change. To ensure the successful implementation of flood barriers, government at all levels and other stakeholders must work together to develop comprehensive flood control plans, secure funding for infrastructure projects, and prioritise the protection of vulnerable communities at risk of flooding.

4.6 Dams and Reservoir Management

The Nigerian government has taken some measures to mitigate the risks of flooding in the past and one of such measures is the construction of dams and reservoirs. Dams and reservoirs play a crucial role in flood risk mitigation by regulating the flow of water, reducing the impact of floods, and providing a reliable source of water for various purposes. By retaining water in the reservoirs, dams can prevent downstream flooding and protect communities and infrastructures from damage. This storage capacity also allows dams to release water gradually, reducing the risk of sudden and catastrophic floods.

Dams and reservoirs also provide water for irrigation, which is essential for agriculture in Nigeria. By regulating the flow of water, dams can ensure a reliable supply of water for crops, even during periods of drought. This not only helps farmers maintain their livelihoods but also reduces the vulnerability of agricultural land to flooding.

Dams can have negative impacts on the environment, which may include the displacement of communities, loss of biodiversity, and alteration of river ecosystems. It is important for the government and dam operators to carefully manage these impacts and mitigate the effects on the environment. While there are challenges and drawbacks associated with dam construction, the benefits of flood risk mitigation, hydroelectric power generation, and irrigation outweigh the costs. The government should continue to invest in the maintenance and management of dams and reservoirs to ensure their effectiveness in mitigating flood risks.

Additionally, investing in research and technology to improve dam safety and efficiency will be crucial in adapting to the changing climate and increasing water demands in the future. Furthermore, educating the public on the importance of water conservation and sustainable practices is essential in ensuring long-term water security. Involving local communities in water management decisions and empowering them to take ownership of their water resources, Nigeria can create a more resilient and sustainable water future.

There is also the need for relevant stakeholders, neighbouring countries and international partners to collaborate for enhanced communication and coordination in the event of a flood emergency, especially on transboundary water issues which are key in effectively managing shared water resources and mitigating potential conflicts.

Lastly, public awareness campaigns should be strengthened to educate citizens on how to prepare for and respond during a flood. Implementing these policies will not only improve early warning systems but also mitigate the devastating effects of flooding in Nigeria.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

> "In light of the possibility of nationwide flooding in 2024, we must heed the advisory provided by NIHSA and take proactive measures to mitigate the potential impact by investing in advanced modeling capabilities and enhancing data..."

The global flooding, including Nigeria, underscores the critical importance of flood prediction and the quality of data for flood modeling. While the specific flood risks for 2024 remain probable, proactive measures can significantly mitigate potential damage. The 2024 Annual Flood Outlook has presented a range of possibilities and emphasised the importance of preparedness, infrastructure resilience, and community engagement. By implementing the extensive mitigative measures outlined in this document, including early warning systems, natural flood defenses, improved drainage systems and flood-resistant building practices, we can significantly reduce the impact of future floods.

The essence of flood prediction cannot be overemphasised, by leveraging advanced modeling techniques such as the Soil Water Assessment Tools (SWAT) and the Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS). NIHSA aims to provide accurate forecasts that inform disaster preparedness and response efforts. These models are meticulously calibrated to simulate hydrological processes, accounting for both internal rainfall and external inflows from transboundary rivers, River Niger (Jiderebode) and Benue (Wuroboki). The precise predictions generated by these models serve as invaluable tools for anticipating flood risks and implementing timely interventions.

Moreover, the quality of input provided by NIHSA is paramount through the Annual Flood Outlook. NIHSA offers detailed forecasts tailored to specific periods within the rainy season, enabling authorities to allocate resources and plan responses accordingly. This proactive approach coupled with robust data and modeling techniques are tailored to empower stakeholders at all levels of government to make informed decisions towards mitigating the impacts of flooding on communities.

In light of the possibility of nationwide flooding in 2024, we must heed the advisory provided by NIHSA and take proactive measures to mitigate the potential impact by investing in advanced modeling capabilities and enhancing data collection efforts. We can strengthen our ability to forecast floods accurately and minimize their devastating consequences through collaboration and commitment to proactive flood management strategies.

Furthermore, we can build resilience and protect the lives and livelihoods of millions across the nation. Let us, therefore, work together to ensure a safer, more resilient future for all Nigerians.

GLOSSARY

Annual rainfall amount – This is the total amount of rainfall observed and recorded in the year under reference.

Anthropogenic - It describes changes in nature made by people. If your town has rerouted water from the river for drinking water, that is an anthropogenic activity.

Basin - It is an area of land that is lower at the centre than at the edges, especially one from which water runs down into a river. It is also large, bowl shaped depression in the surface of the land or ocean floor.

Catchment - A structure, such as a basin or reservoir, used for collecting or draining water.

Climate change – It is a non-random change in climate that is measured over several decades or longer, which may be due to natural or human-induced causes.

Coastal inundation – A type of flooding which occurs when water is driven onto land from an adjacent body of water such as the sea or ocean.

Discharge - It is the volume rate of water flow per unit time, including any suspended solids (e.g. sediment), solute, and/or biological material (e.g. diatoms), which is transported by the water.

Flash flood - It is a rapid flooding of geomorphic low-lying areas: washes, rivers, dry lake sand basins. It may be caused by heavy rain associated with a severe thunderstorm, hurricane, tropical storm, or melt water from ice or snow flowing over ice sheets or snowfields.

Flood - A flood is an event where the river channel becomes inadequate to contain the flow, leading to overtopping of banks and the inundation of parts of the environment. The term has been extended to situations where, due to high permeability and relative low-lying nature of an area, overland flow stagnates in, and inundates such zones. Flooding associated with high-magnitude storm events, overtopping of river banks, high surface permeability, low elevation areas, and unrestrained/sustained inundation of communities.

Floodplains - A floodplain is the strip of very low relative relief alluvial plain that borders a river channel and is usually bounded on the channel side by levees – discontinuous, wedge-shaped ridges around active and abandoned channels, and on the landward side by bluffs and uplands. It is subject to periodic inundation particularly during seasonal floods, and comprises river channels, oxbow lakes, levees, and terraces.

Global warming – An overall increase in the world temperatures, which may be caused by additional heat being trapped by greenhouse gases mostly as a result of human activities.

Hydrology- Hydrology is the study of the occurrence, circulation and distribution of fresh water (i.e. water with total solute load less than 1000 mg L-1) on the surface of the earth. It also investigates the physical and chemical properties of the water and its interactions with man and his environment. A practitioner of hydrology is a hydrologist, working within the fields of earth or environmental science, physical geography, geology or civil and environmental engineering.

Inundation - It is the covering of the land by water as a result of flood or construction of a dam across a river.

Meteorology - It is the interdisciplinary scientific study of the atmosphere. Meteorological phenomena are observable weather events which illuminate, and are explained by the science of meteorology. Those events are bound by the variables that exist in Earth's atmosphere; temperature, air pressure, water vapor, and the gradients and interactions of each variable, and how they change in time. Different spatial scales are studied to determine how systems on local, regional, and global levels impact weather and climatology.

Morphology - It is a scientific study of form and structure, usually without regard to function.

Permeability – It is a process whereby water percolates into the ground through the interconnected pores and spaces in a rock.

Precipitation - as any product of the condensation of atmospheric water vapour that falls to the earth under gravity. The main forms of precipitation include drizzle, rain, sleet, snow and hail. Precipitation occurs when a local portion of the atmosphere becomes saturated with water vapour, so that the water condenses and precipitates.

Surface Runoff – Surface runoff (also known as overland flow) is the flow of water that occurs when excess storm water, melt water, or other sources flows over the earth's surface. This might occur because soil is saturated to full capacity. It can also occur because rain arrives more quickly than soil can absorb it.

Telemetric - It is a technology that involves the automatic measurement and transmission of data from remote sources.

Topography - This is a detailed map of the surface features of land. It includes the mountains, hills, creeks, and other physical features on the earth‟s surface.

Transboundary Aquifer Systems (TAS) - It can also be referred to as Internationally Shared Aquifer Systems. This is a situation where water bearing rock formations (aquifers) underlie two or more countries

ACRONYMS

ACMAD: African Centre for Meteorological Application for Development

ACReSAL: Agro-Climate Resilience in Semi-Arid landscapes

AFO: Annual Flood Outlook

AGRHYMET: Agriculture, Hydrology and Meteorology

AMJ: April, May, June

AMESD: African Monitoring of Environment for Sustainable Development

ArcGIS: Arc Geographic Information System

AWOS: Automatic Weather Observation Station

CHIRPS: Climate Hazards Group Infra-Red Precipitation with Stations

DAR: Deviation of Length of Rainy Season

DCP: Data Collection Platform

DEM: Digital Elevation Model

FEWSNET: Famine Early Warning System Network

FME: Federal Ministry of Environment

FMWR: Federal Ministry of Water Resources

GeoSFM: Geospatial Stream Flow Model

HA: Hydrological Area

HEC-HMS: The Hydrologic Engineering Center, Hydrologic Modeling System

HKYTF: Hadejia Komadugu Yobe Trust Fund

IPCC: Inter-governmental Panel on Climate Change

JAS: June, July, August

JICA: Japanese International Cooperation Agency

NASA: National Aeronautic and Space Agency

NASRDA: National Space Research and Development Agency

NBA: Niger Basin Authority

NEMA: National Emergency Management Agency

NIHSA: Nigeria Hydrological Services Agency

NiMet: Nigerian Meteorological Agency

NIWA: National Inland Waterways Authority

NIWRMC: Nigeria Integrated Water Resources Management Commission

NWRI: National Water Resources Institute

ON: October, November

OSGOF: Office of the Surveyor General of the Federation

PET: Potential Evapotranpiration

RBDAs: River Basin Development Authorities

SCP: Seasonal Climate Prediction

SRTM: Shuttle Radar Topography Mission

SWAT: Soil and Water Assessment tool

USGS/EROS: United States Geological Survey Centre for Earth Resources Observation and Science

USGS: United State Geological Survey

WFP: World Food Programme

APPENDIX 1

2023 FLOOD OCCURRENCE AND FORECAST MATRIX

PREDICTED & OCCURRED			
S/NO	**STATE**	**Affected Local Government Areas (LGAs)**	**Number Affected LGAs**
1.	Adamawa	Yola North, Yola South, Numan, Fufore, Gombi, Demsa	6
2.	Akwa Ibom	Eastern Obolo, Ibeno	2
3.	Anambra	Ogbaru, Anambra East, Ayamelum, Awka North, Anambra West	5
4.	Bauchi	Bauchi, Itas/Gadau	2
5.	Bayelsa	Southern Ijaw, Ekeremor, Sagbama, Brass	4
6.	Benue	Buruku, Makurdi, Guma	3
7.	Borno	Marte, Abadam, Kukawa, Mobbar	4
8.	Cross River	Obubra, Yala, Ogoja, Biase, Etung, Odukpani	6
9.	Delta	Oshimili South, Warri South-West, Warri South, Ndokwa East, Ughelli South, Isoko South	6
10.	Edo	Etsako East, Etsako Central	2
11.	Ekiti	Ado-Ekiti	1
12.	FCT Abuja	Municipal Area Council, Abaji, Gwagwalada	3
13.	Gombe	Yamaltu/Deba	1
14.	Imo	Ohaji/Egbema	1
15.	Jigawa	Guri, Kiri Kasama, Auyo	3
16.	Kaduna	Igabi, Chikun	2
17.	Kano	Dawakin Kudu	1
18.	Kebbi	Bagudo, Ngaski, Yauri	3

S/NO	**STATE**	**Affected Local Government Areas (LGAs)**	**Number Affected LGAs**
19.	Kogi	Bassa, Igalamela-Odolu, Lokoja, Ibaji, Kogi, Ajaokuta, Ofu, Okene, Adavi	9
20.	Kwara	Pategi, Edu	2
21.	Lagos	Amuwo Odofin, Ikeja, Ojo, Ikorodu, Epe, Badagry	6
22.	Nasarawa	Nasarawa, Toto, Doma, Karu	4
23.	Niger	Mokwa, Edati, Gbako, Shiroro, Wushishi, Borgu, Rafi	7
24.	Ogun	Ewekoro, Egbado South, Abeokuta North, Odeda, Ogun waterside, Obafemi Owode, Ijebu East, Ifo	8
25.	Ondo	Odigbo, Ilaje	2
26.	Osun	Obokun, Olorunda, Ifelodun	3
27.	Oyo	Itesiwaju	1
28.	Rivers	Ahoada East, Ogba/Egbema/Ndoni, Degema, Ahoada West, Abua/Odual, Ikwerre, Eleme, Emuoha, Akuku Toru	9
29.	Sokoto	Goronyo, Tangaza, Sabon Birni, Sokoto South, Wamako	5
30.	Taraba	Gassol, Ardo-Kola, Karim, Lamido, Ibi, Lau, Wukari	6
31.	Yobe	Barde, Jakusko, Yunusari	3

OCCURRED NOT PREDICTED			
S/NO	**STATE**	**Affected Local Government Areas (LGAs)**	**Number Affected LGAs**
1.	Adamawa	Larmurde	1
2.	Bauchi	Ningi	1
3.	Borno	Ngala, Monguno	2
4.	Cross River	Boki, Akamkpa	2
5.	Ebonyi	Ikwo	1
6.	Edo	Etsako West	1
7.	Ekiti	Ikere, Ekiti East, Gbonyin	3
8.	Enugu	Aninri	1
9.	FCT Abuja	Kwali, Kuje	2
10.	Gombe	Kwami, Funakaye	2
11.	Kano	Makoda, Karaye	2
12.	Katsina	Kafur	1
13.	Kogi	Ijumu, Kabba/Bunu	2
14.	Kwara	Kaiama, Asa, Baruten	3
15.	Niger	Katcha, Muya, Lapai	3
16.	Ogun	Ado Odo/Ota, Ipokia	2
17.	Ondo	Ile Oluji/Okeigbo	1
18.	Oyo	Atiba, Surulere, Ogbomosho South, Ogbomosho North	4
19.	Sokoto	Gada	1
20.	Yobe	Gulani	1

Reference:

David-Chyddy Eleke, Flood: Tales of Tragedy, suffering as Anambra Communities Remain Under Water, ThisDay Newspaper (Online) 10, October, 2023

Folakemi Ajala (2023): When Floods Threaten Nigeria's Food Security Everyone Suffers" https//articles.nigeriahealthwatch,com/when-floods-threaten-nigerias-food-security-everyone-suffers/

G Benito and D Vazquez-Tarrio (2022) "Treatise on Geomorphology" (Second Edition)

Kunle Sanni (2023), SPECIAL REPORT: In Kogi communities, flood victims share crowded classrooms with school pupils, Premium Times News (Online) 3, November, 2023

National Emergency Management Agency (NEMA)

Nigeria Meteorological Agency (NiMet)

Relief Web (2023), North-East Nigeria: Flood Incidents Report - October 2023, <https://reliefweb.int/ report/nigeria/north-east-nigeria-flood-incidents-report-october-2023>, accessed 10 January, 2024

United Nations Children's Fund, (2022) More than 1.5 million children at risk as devastating floods hit Nigeria <https://www.unicef.org/press-releases/more-15-million-children-risk-devastating-floods-hit-nigeria>, accessed 12 February, 2024.

ALIFIG INTERNATIONAL LIMITED

Alifig International Limited Is A Leading Aviation Technologies, Hydrological, Communications And Meteorological Systems Integration Company In West Africa. We Deliver Cost-effective And Comprehensive Solutions For The Full Range Of ATC, Hydrological And Meteorological Systems.

Our Range Of Products Includes The Following:

Aviation

Communication, Navigation And Surveillance Equipment

- Consoles
- ATIS/Volmet
- Marker Beacon
- Mobile ATC Towers
- Microwave Radio Systems
- VHF/UHF/HF Radio System
- Microwave Landing System (MSL)
- PABX/Intercom/Telephone Systems
- Voice Communication Control Systems (VCCS)
- En-route Navigation Aids (VOR, DVOR, DME)
- Integrated Air Traffic Control System Solutions
- Global Telecommunication System (GTS) Server
- Instrument Landing System (ILS), Localizer, Glideslope,

Global Telecommunication System (GTS) Server

Aviation Technologies

Mobile ATC Tower

Meteorology/Environment:

- Automatic Weather Observation Systems (AWOS)
- Low Level Wind Alert System (LLWAS)
- Air Quality Monitoring Systems
- Upper Air Sounding System
- Marine Meteorological Buoy
- Thunderstorm / Lightning Detection System
- Calibration Equipment
- Weather Observation Instruments: Rain Gauge, Wind instruments, Thermometers, Evaporimeter, Sunshine Recorder, Solarimeter, Autographic Instruments, Others
- Meteorological Sensors
- Weather Forecasting And Meteorological Software
- Oil Spill Detection And Alert System (OSDAS)

Air Quality Station

Low Level Wind Alert System (LLWAS)

Hydrology

- Dams
- Telemetry System
- Hydromet Stations
- Surface Water Monitoring
- Ground Water Monitoring
- Flood And Early Warning System
- Data Acquisition And Management System

Bouy

Upper Air Sounding System

Automatic Weather Observation Systems (AWOS)

Meteosat Second Generation

Our Partners

ibl GRAW GILL

KIPP & ZONEN

43b, Anthony Enahoro Street-Utako, Abuja | www.alifig.com | info@alifiginternational.com | +234-9131111178 & +234-9131111179

NIHSA
ACTIVITIES

NIGERIA HYDROLOGICAL SERVICES AGENCY

Plot 222, Shettima Ali Monguno Crescent, Utako, Abuja Nigeria

www.nihsa.gov.ng