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A Geographical Assessment of the Causes of Excess Flooding in Borno State, Nigeria

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Abstract- ***This study assesses the causes of excess flooding in Borno State, Nigeria, using GIS spatial analysis and a household survey of 200 residents. GIS results show that high-risk flood zones are concentrated in low-lying areas such as Ngala, Marte, Jere, and Maiduguri, where flat terrain and proximity to rivers increase susceptibility. Survey findings reveal that flooding occurs mainly during July–September, often remaining stagnant for over a week due to inadequate drainage. Major drivers identified include river overflow (92%), construction on floodplains (84%), heavy rainfall (76%), blocked drains (76%), and poor drainage infrastructure (80%). Land-use changes, especially the conversion of wetlands and farmlands into residential areas, combined with increased paved surfaces have intensified runoff. Respondents also observed heavier rainfall in recent years. The study concludes that both environmental and human factors contribute significantly to flooding and recommends improved drainage systems, strict land-use regulation, restoration of natural water pathways, and enhanced government-led flood management.***

Keywords: Flooding, GIS, Flood Risk Mapping, Land-Use Change, Climate Change

I. INTRODUCTION

Generally, a flood is an overflowing or eruption of a large body of water over land not usually submerged (Daniel and Udo, 2019). It is an extreme weather event often linked to rising global temperatures, which can result in heavy downpours, thermal expansion of the ocean, and glacier melt. These factors, in turn, can cause a rise in sea level, leading to the inundation of coastal lands. Flooding causes inundation and harm to plants and animals, including humans, buildings, and infrastructure (Ujene and Oguike, 2020). However, flooding is a global natural hazard that has affected lives, led to the loss of properties, and the extinction of species in the environment. In fact, flooding is a threat that affects the quality of the environment. Given the issues relating to flooding, it is regarded as a factor used in defining the environmental quality of residential neighborhoods. Other environmental hazards include drought, desert encroachment, soil erosion, and tsunamis.

From the foregoing, it is clear why flooding is regarded as a regular global occurrence. Due to the global nature of flooding and its relatively negative implications, there have been numerous attempts by world governing organizations to manage the situation. For instance, the World Bank Group (2016) showed that flooding has affected several countries worldwide. They specified that flooding is among the most frequent and destructive disasters, causing significant damage and further disrupting livelihoods globally. Flooding occurs more frequently in developing countries due to poor environmental management practices. The weak management practices and enforcement regarding flooding are often due to weak institutional and legislative frameworks in the development control process in developing countries. For instance, developers build haphazardly without considering floodplains and areas susceptible to flooding. There is also poor funding from relevant organizations to facilitate the creation of drainage distribution channels, among other management options that can lead to the mitigation of flooding in the environment.

In Nigeria, flooding has remained a prevalent environmental problem. Available studies have shown a frequent occurrence of flooding (Ishaya et al., 2009; Kolawole et al., 2011; Ejenma et al., 2014; Komolafe et al., 2015; Nkwunonwo, 2016; Yesufu, 2016; Sule et al., 2016; Adetuji and Oleyele, 2018; Bamidele and Badiora, 2019; and Onwuemele, 2018). These studies point to the fact that flooding has negative implications for the survival of livelihoods and social

and economic activities. Basically, in recent decades, flooding has led to the loss of thousands of lives and properties. According to available studies, flooding in Nigeria is caused by weak implementation of planning policies, obstruction of streams and channels due to indiscriminate waste disposal habits, and human activities in floodplains (Evan et al., 2017).

Problem Statement

Flooding, a recurring and often devastating natural hazard, poses a significant threat to human livelihoods and socio-economic well-being across various regions. As highlighted by Ojikpong et al. (2016), flooding leads to the destruction of lives, properties, and critical socio-economic activities. The extent of loss and destruction is influenced by a complex interplay of factors, including the timing and seasonality of floods, geographical location, infrastructure vulnerabilities (such as damaged embankments and roads), river encroachment, the condition of drainage systems, and the prior experiences and management strategies in place. Consequently, flooding disrupts the livelihood activities of residents in both rural and urban settings through the collapse of infrastructure, the submersion of vital farmlands and marketplaces, and the destruction or loss of agricultural produce.

The detrimental effects of flooding extend across multiple dimensions of human and environmental well-being. Agbonkhase et al. (2014) categorized these impacts based on human, natural, and physical resources, as well as monthly income and monetary assets, demonstrating the negative returns on investment and widespread destruction associated with flood events. Studies in Nigeria, such as that by Oruonye et al. (2017) in Taraba State, further underscore the negative consequences of flooding on the socio-economic status and livelihoods of rural communities, including the devastation of farmlands, destruction of agricultural products, and the exacerbation of environmental degradation like gully erosion. The situation is particularly concerning in Borno State, Nigeria, which has witnessed increasing occurrences of severe flooding in recent years. This has resulted in tragic loss of life, widespread displacement of communities, significant damage to agricultural lands, and substantial disruption to essential socioeconomic activities. Despite the escalating impacts, there remains a critical gap in geographically focused research that comprehensively examines the spatial causes of flooding in Borno State. A thorough geographical assessment is urgently needed to understand the complex interplay of natural factors, such as rainfall patterns and topography, and human-induced factors, including land use change and urbanization, that contribute to the escalating flood risk in the region.

Therefore, this lack of spatially-informed data represents a significant impediment to effective flood mitigation, accurate risk mapping, and the development of robust community resilience plans in Borno State. Addressing this knowledge gap through a comprehensive geographical investigation is crucial to provide the necessary evidence base for informed decision-making and the implementation of targeted strategies to protect livelihoods and build resilience against the growing threat of flooding in the state.

Objectives of the study:

1. To identify and map the major flood-prone areas in Borno State using GIS.
2. To analyze the environmental and human-induced causes of excess flooding in the region.
3. To assess the role of land use changes and urban development in increasing flood risk.
4. To provide spatial and policy recommendations for effective flood risk management.

II. LITERATURE REVIEW

Flooding in Nigeria has been linked to both climatic and non-climatic drivers (Nkwunonwo et al., 2020). Climate change has led to increased rainfall intensity and variability (IPCC, 2023), while poor urban planning, blocked drainage systems, and deforestation exacerbate flood risks (Adelekan, 2019). In the northeastern part of Nigeria, particularly Borno State, the combination of Sahelian climatic conditions and anthropogenic land degradation has created a fragile ecosystem vulnerable to hydrological extremes (Yahaya et al., 2021).

Tabiri (2015) identified four primary causes of flooding in Accra, Ghana: negligence or ignorance (possibly stemming from overconfidence), inadequate city planning, construction on waterways, and the

indiscriminate disposal of waste. Tabiri noted Accra's vulnerability to flooding and stressed the urgent need for preventative measures, including the development of efficient drainage systems for surface runoff and proper waste management by relevant authorities.

Reviewing flood risk in Nigeria, Komolafe et al. (2015) highlighted the diverse flood events experienced in the country. Their research, based on existing scholarly work and secondary data, attributed Nigerian flooding to a combination of high community vulnerability, a lack of adequate coping mechanisms, and the increasing frequency of extreme weather events due to climate change. Their study also pointed to the sporadic increase in flooding due to poor urban planning and management, warning of the significant risk to lives and property. They concluded by emphasizing the need for advanced flood modeling techniques and the integration of hydrological processes for more accurate flood prediction and risk mapping in Nigeria. Furthermore, they recommended additional research into the environmental and health consequences of flooding.

Nkwunonwo et al. (2015) assessed flooding and flood risk reduction strategies in Nigeria to pinpoint critical shortcomings. Their study observed the increasing frequency of flooding in the country, attributing it to factors like rapid population growth, urbanization, poor urban planning, and climate change, particularly the increased frequency and intensity of rainfall. Specifically, their data indicated that between 1985 and 2014, flooding in Nigeria affected 11 million people, caused 1,100 deaths, and resulted in over US$17 billion in property damage (Mfon, Oguike, Eteng, & Etim, 2015, p. 1780). They noted that while Lagos State experienced the highest percentage of flooding, Niger, Adamawa, Oyo, Kano, and Jigawa states also faced significant flooding. Despite the growing threat of flooding, they argued that insufficient action has been taken to mitigate its occurrence in Nigeria. They recommended the adoption of more robust and scientific approaches to flood risk reduction, such as flood modeling and vulnerability assessments, in Nigeria's flood management strategies. Geographical approaches to flood studies emphasize spatial analysis, environmental mapping, and the integration of physical and human data to understand flood risks (Gencer, 2022). The use of Geographic Information Systems (GIS) enhances the ability to map flood-prone areas and analyze their relationship with land use patterns, elevation, and hydrology.

III. METHODOLOGY

Study Area

Borno State has a 2022 projected population of 6,111,462 people on a mean annual projection of 2.75% (National Population Commission, 2020). It is bordered to Republic of Chad to the North, Niger Republic to the North East, Yobe State to the East, Adamawa to the South West and Gombe to the South (Idoko et al., 2023; Nwafor and Abiodun, 2022). It has a land mass of 70,898km2. It has a climate which is hot and dry for a greater part of the year. The maximum temperature is 42°C from March – April while the minimum is 12°C from December – January. The average temperature is 28 – 29°C per annum. The maximum rainfall for the state is 700mm in August while minimum is 300mm in February. The average rainfall for Borno State is 500mm to 700mm per annum. The maximum humidity is 65% in July – August while minimum is 15% from March to April. Average humidity is 35 to 45%. The nature of vegetation of Borno State is Saleh scrubland. It is semi-arid region with sparse vegetation dominated by thorny shrubs and stunted trees like Acaccia mellifera and Commiphora spp. Patches of grasslands found along rivers and depressions (NIMET, 2022).

Data Collection

Data for this study was basically obtained from primary source. The primary data was collected with the aid of a structured questionnaire using Open Data Kit (ODK) application which was used in collecting data from the respondents and recorded for upward data processing and analysis.

Sampling Procedure and Sample size

Multistage sampling procedure was used to arrive at the sample size. In the first stage, purposive sampling technique was used to select 1 local government area each from three zones due to proximity and security situations. In the second stage, purposive sampling technique was used in selecting 1 community each from the selected local governments due to security situation. And finally, simple random sampling was

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used to arrive at the 200 sample size.

Data analysis

Data for this study was analysed usingdescriptive statistics and GIS. Descriptive statistics such as frequency, means and percentages was used to the data garnered from the survey. While GIS was also used to map the major flood-prone areas in Borno State.

Results and discussion

This section presents the results of the household survey and interprets them in relation to the study objectives. The findings highlight the demographic characteristics of respondents, the spatial distribution of flood-prone areas, the causes of flooding, and community perceptions of environmental and urban change in Borno State.

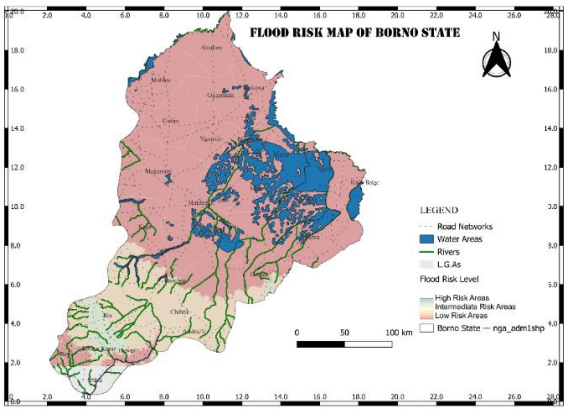

Figure. Map of Borno State showing Flood Risk.

Figure 1 presents the Flood Risk Map of Borno State, produced using GIS-based multi-criteria analysis. The map delineates three major flood-risk zones, high, intermediate, and low-risk areas. The classification was derived from spatial layers representing topography, river networks, land use, drainage density, and proximity to water bodies. These layers were weighted and overlaid to determine flood susceptibility across the state.

The results indicate that the high-risk areas (depicted in deep blue) are predominantly located along the floodplains of the Ngadda River, Yedseram River, and the Lake Chad Basin, especially in the eastern and central parts of the state, covering Local Government Areas (LGAs) such as Ngala, Kala-Balge, Marte, and parts of Jere and Maiduguri. These zones experience recurrent flooding due to flat terrain, poor drainage systems, and seasonal overflow of rivers and wetlands. Recent studies confirm that Maiduguri and its environs are particularly prone to severe flood incidents, leading to significant damage to property, infrastructure, and farmland (Obroh & Sambo, 2022; Umar et al., 2025).

The intermediate-risk areas (shown in light brown) extend across southern and central LGAs, including Konduga, Mafa, Magumeri, and Bama, where moderate elevation and partial vegetation reduce but do not eliminate flood hazards. Poor urban planning, blocked drainage channels, and unregulated settlements exacerbate exposure in these transitional zones (Okonofua & Kayode-Ojo, 2023).

In contrast, the low-risk areas (in light green) are concentrated in the southern uplands, particularly around Biu, Hawul, Kwaya Kusar, and Chibok LGAs, where higher elevation and better drainage reduce vulnerability. However, increasing rainfall intensity and land-use change have begun to threaten even these relatively safe zones (Aladejana & Ebijuoworih, 2024; Muhammad et al., 2024).

In all, the spatial pattern revealed by the flood risk map underscores the close relationship between topography, hydrology, and human activities in shaping flood vulnerability in Borno State. The findings align with national assessments by NEMA (2023) and UNOCHA (2023), which identify Borno among the most flood-affected states in Nigeria. The GIS-based approach adopted here provides valuable spatial evidence for targeted disaster preparedness, floodplain management, and sustainable land-use planning to reduce the impacts of future flood events.
Demographic results shown in Table 3 indicate that most respondents were aged 31–40 years and predominantly female, with a majority holding tertiary-level education and having long-term residence in their communities. This composition suggests that respondents possess sufficient experience and awareness of local flood events, strengthening the reliability of their responses (Ibrahim et al., 2025; Muhammad et al., 2024).

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Table 3. Demographics

Variable	Frequency	Percent
Age (Years)		
<20	16	8.0
21-30	64	32.0
31-40	88	44.0
41-50	8	4.0
>50	24	12.0
Male	96	48.0
Female	104	52.0
Educational Level		
No Formal Education	40	20.0
Primary		
Secondary	16	8.0
Tertiary	144	72.0
Farm Size (Ha)		
<0.5	68	26.1
0.6-1.0	124	47.5
1.1-1.5	0	0
1.6-2.0	59	22.6
>2.0	10	3.8
Experience (Years)		
<5	-	-
6-10	32	16.0
11-15	72	36.0
16-20	8	4.0
>21	88	44.0
Respondent Category		
Community Leader	16	8.0
Resident Homeowner	152	76.0
State Agency Staff	8	4.0
Farmer/Herder	16	8.0
SEMA/NEMA Staff	8	4.0

Sources: Field Survey, 2025

Identification and mapping of the major flood-prone areas in Borno State

Flood occurrence data shown in Table 4 revealed that flooding happens "occasionally" for most households, commonly reaching knee–waist-deep levels. Flooding was most frequent during July–September, and in many cases, floodwater remained stagnant for over a week, suggesting insufficient or poorly maintained drainage systems. These findings align with earlier assessments indicating persistent floodwater stagnation in Borno due to flat terrain and inadequate urban drainage (Obroh & Sambo, 2022).

Table 4. Identification of the major flood-prone area

Variable	Frequency	Percent
How often Does Flooding occur in your area?		
Every year	8	4.0
Occasionally	192	96.0
Yearly	-	-
What was the highest water level inside your compound?		
Ankle Deep (Below Knee)	64	32.0
Knee Deep to Waist Deep	72	36.0
Chest Deep	8	4.0
Overhead/Submerged single story building	56	28.0
During which month most flooding occur?		
April to June	8	4.0
July to September (Peak Rainy Season)	192	96.0
How frequently does significant flooding occur in these areas?		
Every Year	8	4.0
Every 2 to 3 years	16	8.0
Less frequently/occassionally	176	88.0
How long did the floodwater from that major event take to withdraw/empty completely?		
A few hours	8	4.0
1 to 3 days	8	4.0
4 to 7 days	48	24.0
More than a week	136	68.0

Source: Field Survey, 2025

Environmental and human-induced causes of excess flooding in the region

Table 5 revealed that respondents identified river overflow and construction on floodplains as the major drivers of excess flooding, while long rainfall duration was the least reported cause. This highlights the combined influence of natural hydrological processes and human-induced activities such as unregulated development, consistent with regional studies on flood vulnerability (Aladejana & Ebijuoworih, 2024).

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Perceptions of climatic shifts show that more than half of respondents observed heavier rainfall in recent years, and only a few noted no change as shown in Table 6. This demonstrates strong community awareness of changing rainfall patterns, supporting wider scientific evidence of increasing precipitation intensity in northern Nigeria (Umar et al., 2025).

Table 5. Causes and Drivers of Flooding in Borno State

S/N	Items	Major Cause Freq (%)	Minor Cause Freq (%)	Don't know Freq (%)	Not a Cause Freq (%)
1.	Very heavy rainfall intensity	152 (76 %)	48 (24 %)	0 (0%)	0 (0%)
2.	Long duration of rainfall	128 (64 %)	48 (24 %)	16 (8%)	8 (4%)
3.	Overflow of rivers (e.g., Ngaddabul, Alau Dam)	184 (92 %)	8 (4%)	0 (0%)	8 (4%)
4.	The flat, low-lying nature of the land	144 (72 %)	24 (12 %)	16 (8%)	16 (8%)
5.	Poor natural soil drainage	112 (56 %)	64 (32 %)	0 (0%)	24 (12 %)
6.	Blocked or narrow drainage channels	152 (76 %)	16 (8%)	8 (4%)	24 (12 %)
7.	Improper disposal of solid waste (refuse)	136 (68 %)	48 (24 %)	0 (0%)	16 (8%)
8.	Construction of buildings on water channels/flood plains	168 (84 %)	16 (8%)	0 (0%)	16 (8%)
9.	Lack of adequate drainage infrastructure	160 (80 %)	32 (16 %)	0 (0%)	8 (4%)
10.	Poor maintenance of existing drains and culverts	160 (80 %)	32 (16 %)	0 (0%)	8 (4%)
11.	Deforestation / Loss of vegetation cover	144 (72 %)	32 (16 %)	16 (8%)	8 (4%)

Source: Field Survey, 2025

Table 6. Have you noticed any changes in rainfall patterns over the years you have lived here?

Variable	Frequency	Percent
Yes, rain is heavier and more intense	104	52.0
Yes, the rainy season is shorter	80	40.0
No, It's about thesame	8	4.0
Don't Know/Not sure	8	4.0
Total	200	100.0

Source: Field Survey, 2025

Role of land use changes and urban development in increasing flood risk

Regarding historical land use, respondents reported that many flooded areas were formerly wetlands, farmlands, or forests before being converted into residential spaces as shown in Table 7. Such conversions reduce natural water absorption and increase runoff, reinforcing research linking land-use change to elevated flood risks (Muhammad et al., 2024). Additionally, most respondents acknowledged a slight increase in paved surfaces, further reducing infiltration and contributing to surface runoff consistent with established urban hydrological dynamics (Okonofua & Kayode-Ojo, 2023).

Community perceptions of urbanization in Table 9 showed that more than half believe it increases rainwater accumulation and flooding, although some remain uncertain. Nearly half also indicated that natural water pathways such as wetlands and drainage valleys have been filled or built upon, a trend that mirrors documented patterns of environmental

degradation that heighten flood vulnerability (NEMA, 2023).

Drainage assessments in Table 11 revealed that maintenance was rated mostly as "fair" or "poor," demonstrating persistent challenges in keeping drainage channels functional. This reinforces findings that weak drainage management exacerbates flooding in the region (Obroh & Sambo, 2022). Flood mitigation efforts were mainly individual actions like clearing drains, while institutional interventions such as relocation from high-risk zones were limited. The partial effectiveness of existing measures indicates that current mitigation strategies remain inadequate to address the scale of the problem (Muhammad et al., 2024).

Table 7. What was this immediate area (within 1km) mainly used for 15-20 years ago?

Variable	Frequency	Percent
Farmland	24	12.0
Bush/Forest/Unoccupied land	24	12.0
Natural Wetland/Floodplain	40	20.0
Residential (as it is now)	64	32.0
Don't know	48	24.0
Total	200	100.0

Table 8. In the last 10 years, would you say the amount of paved ground (concrete, asphalt) and buildings in your community has...?

Variable	Frequency	Percent
Increased greatly	64	32.0
Increased slightly	104	52.0
Stayed the same	32	16.0
Total	200	100.0

Source: Field Survey, 2025

Table 9. Do you think this increase in buildings and paved surfaces has affected what happens to rainwater?

Variable	Frequency	Percent
Yes, Water runs off faster and causes more flooding	104	52.0
No, It hasn't made a difference	32	16.0
Don't Know	64	32.0
Total	200	100.0

Source: Field Survey, 2025

Table 10. Are you aware of any natural wetlands, valleys, or old water channels that have been filled in for construction?

Variable	Frequency	Percent
Yes	96	48.0
No	24	12.0
Not sure	80	40.0
Total	200	100.0

Source: Field Survey, 2025

Table 11. How would you rate the maintenance of existing drainage systems?

Variable	Frequency	Percent
Good (Clearly regulated)	40	20.0
Fair (cleared sometimes)	104	52.0
Poorly (rarely or never cleaned)	40	20.0
There are no drainage systems	16	8.0
Total	200	100.0

Source: Field Survey, 2025

Spatial and policy recommendations for effective flood risk management

Respondents believe that the Federal Government should lead flood management interventions, followed by the state government as shown in Table 12. This reflects public confidence in higher-level administrative capacity to coordinate large-scale environmental solutions. Furthermore, results in Table 15 showed significant support was recorded for strengthening land-use regulations, demonstrating widespread acceptance of planning reforms such as those implemented by BOGIS in Borno State (Okonofua & Kayode-Ojo, 2023).

Generally, the results reveal a strong understanding among residents of the environmental, climatic, and human factors driving excessive flooding in Borno State. The findings highlight the need for improved drainage, stricter land-use control, enhanced institutional involvement, and climate-responsive flood management strategies.

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Table 12. What is currently being done in your community/area to manage or prevent flooding?

Variable	Frequency	Percent	Rank
Regular clearing of drains by individuals	104	52.0	1st
Government-led drainage clearance	80	40.0	2nd
Public awareness campaigns	72	36.0	3rd
Construction of new drainage channels	56	28.0	4th
Building of embankments/levees	16	8.0	5th
Relocation of people from floodplains	16	8.0	6th
Nothing is being done	8	4.0	7th

Source: Field Survey, 2025

Table 13. How effective are these current measures?

Variable	Frequency	Percent
Very effective	72	36.0
Somewhat effective	112	56.0
Not effective	16	8.0
Total	200	100.0

Table 14. Which level of government or organization should take the lead in solving the flooding problem?

Variable	Frequency	Percent
Community/Ward Level	8	4.0
Local Govenment Level	24	12.0
Borno State Government	48	24.0
Federal Government (E.g. Nema)	80	40.0
A combination of the above	40	20.0
Total	200	100.0

Source: Field Survey, 2025

Table 15. Do you think land use planning and stricter building regulations like that of BOGIS can help reduce flood risk?

Variable	Frequency	Percent
Yes, significantly	80	40.0
Yes, but only a little	96	48.0
Don't Know	24	12.0
Total	200	100.0

Source: Field Survey, 2025

CONCLUSION

This study assessed the geographical causes of excess flooding in Borno State using GIS analysis and household survey data. The findings show that flood vulnerability is highest along river floodplains and low-lying terrains such as Ngala, Mafa, Kala-Balge, Jere, and Maiduguri, confirming the influence of topography and proximity to water bodies. Flooding occurs mainly during July–September, with water stagnation lasting over a week due to poor drainage. Both natural and human factors, river overflow, heavy rainfall, blocked drains, construction on floodplains, and loss of vegetation, were identified as major drivers of flooding. Land-use change, especially the conversion of wetlands and farmlands into residential areas, has intensified runoff and reduced infiltration. Urban expansion and inadequate drainage maintenance further exacerbate flood risks. Overall, community awareness of climatic shifts and environmental degradation is high, and residents strongly support improved land-use regulation and enhanced government involvement in flood management.

RECOMMENDATIONS

The following recommendations are made:

1. Government agencies should construct additional drainage channels in high-risk LGAs and ensure regular clearance of existing drains to reduce water stagnation.
2. BOGIS and relevant authorities should strictly regulate development on wetlands, floodplains, and natural waterways, preventing further encroachment.
3. State and federal agencies should adopt GIS and remote-sensing tools for continuous mapping of flood-prone zones to guide planning, disaster preparedness, and infrastructure design.
4. Wetlands, valleys, and blocked channels should be rehabilitated to enhance natural water flow and reduce runoff.
5. Urban development projects should integrate permeable surfaces, green spaces, and sustainable drainage systems to mitigate runoff from increased paved areas.
6. Given public preference, the Federal Government (NEMA/NIHSA) and the Borno State Government

should coordinate large-scale flood mitigation policies, including embankment construction and relocation from high-risk zones.

7. Continuous sensitization campaigns should be conducted on proper waste disposal, community drainage maintenance, and the dangers of building on floodplains.
8. Policies should address rising rainfall intensity through early warning systems, rainfall monitoring, and climate-smart land management.

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