GEOSPATIAL TECHNOLOGY FOR FLOOD RISK MAPPING, VULNERABILITY ASSESSMENT, AND EVACUATION PLANNING IN KOGI STATE, NIGERIA.

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Abstract

Flooding is one of the most devastating natural disasters, affecting millions and causing significant economic damage globally. Kogi State, Nigeria, located at the confluence of the Niger and Benue Rivers, is particularly vulnerable to floods, exacerbated by the annual release of water from the Lagdo Dam in Cameroon. This paper explores the application of geospatial techniques, including GIS and remote sensing, to assess flood risks and develop evacuation maps. The study aims to provide decision-makers with tools to improve flood preparedness and response in Kogi State, enhancing disaster risk reduction.

Keywords: Flood Risk, GIS, Remote Sensing, Evacuation Mapping, Disaster Risk Reduction, Kogi State

1. Introduction

Flooding is one of the most destructive natural disasters, and Kogi State faces significant risks due to its location at the Niger-Benue confluence. Recurrent floods, worsened by water releases from upstream dams, disrupt lives, damage infrastructure, and hinder economic activities. Nigeria has faced severe floods, notably in 2012, causing massive financial losses (NEMA, 2012). Kogi has experienced floods in 1994, 2004, 2010, 2012, 2017, 2018, 2019, and 2020, with significant death tolls and displacement (NEMA (2013); Kogi Flood (2022); Adaoyichie, G. (2019)). Effective flood management is critical, and traditional methods have been insufficient. Geospatial technologies like GIS and remote sensing now play essential roles in flood risk assessment and disaster management.

This study aims to create flood evacuation and risk maps for Kogi State, demonstrating how GIS can enhance disaster preparedness and improve resilience in flood-affected communities.

2. Study Area

Kogi State, located in north-central Nigeria, covers 25,934 sq. km with a population of 4.47 million as of 2021 (Kogi State Government, 2021). Situated

at the confluence of the Niger and Benue Rivers, the state is highly flood-prone, particularly near Lokoja, the capital. Its diverse topography, including hills, valleys, and floodplains, increases flood risks, especially during the rainy season and after upstream dam releases. All 21 LGAs experience flooding to varying degrees, necessitating flood risk assessments and disaster management strategies.

3. Data

This study employs a comprehensive approach combining data collection, analysis, and application of geospatial techniques to assess flood risk and develop evacuation map for Kogi State.

3.1 Data Collection:

Data	Data Source	Data Source Type	Year
ASTER SRTM	USGS	Secondary	2022
LandCover	ESA World User	Secondary	2021
Boundary Shapefile	GRID3	Secondary	2023
Road Network	HOT OSM	Secondary	2022
Water Body Map	OSM	Secondary	2024
Kogi State Population	National Bureau of Statistics	Secondary	2006

Table 1: Data, Data Type and Data Sources.

3.1.1 Data Source and Acquisition

This study utilized secondary data. ASTER SRTM data was sourced from USGS (2022), land use from ESA (2021), Kogi State boundaries from GRID3 (2023), road networks from HOT OSM (2022), and water bodies from OSM (2024). Population data was retrieved from the National Bureau of Statistics (2006 census).

4. Objectives

This study analyzes flood risk using GIS-based hydrological models by evaluating factors such as proximity to water bodies, elevation, slope, land cover, and population density, and develops flood evacuation maps by identifying high-risk areas in relation to road networks, ensuring accessibility during flood events, while providing actionable resources like evacuation routes and safe zones for residents and emergency responders.

5. Results and Discussion

5.1 Flood Risk Assessment Map

The flood risk map for this study was developed using GIS-based hydrological models, incorporating key factors such as elevation, proximity to the Niger and Benue Rivers, and buffer distances from major water bodies. The risk of flooding decreases with increasing distance from the rivers and higher elevation.

The flood risk areas in Kogi State are categorized into three, high-risk areas, which are located in low-lying regions close to the Niger and Benue Rivers where the risk of inundation is severe, particularly affecting vulnerable regions such as Idah, Lokoja, and nearby riverine areas, with the annual release of water from the Lagdo Dam further exacerbating these risks and causing extensive damage during peak rainfall periods; medium-risk areas, which include slightly elevated regions like parts of Dekina and Ofu that have a moderate risk of flooding due to their proximity to tributaries and seasonal streams, although they are not as severely affected as riverine areas, still experiencing periodic flooding; and low-risk areas, consisting of elevated regions such as Mapo-Muro, Ijumu, and Kabba, which are further from major water bodies and at higher elevations, making them less prone to flooding and serving as potential safe zones and evacuation points for communities in more flood-prone areas, and by integrating elevation data, proximity to rivers, and buffer distances, this flood risk map provides a comprehensive overview of the regions at greatest risk and supports better flood disaster preparedness and risk reduction efforts.

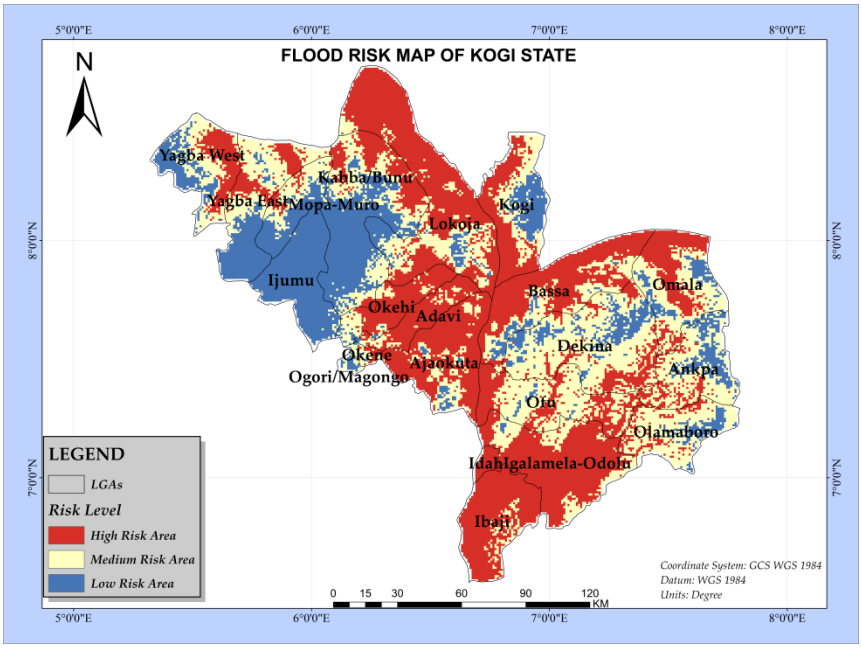

Fig 1: Flood Risk Map

S/N	Raster	Influence (%)
1	Reclassified Water	35

2	Reclassified Elevation	22
3	Reclassified Slope	18
4	Reclassified LandCover	15
5	Reclassified Population	10
Total		**100(%)**

Table 2: Weighted Overlay Table.

5.2 Evacuation Routes Map

The evacuation routes map highlights areas with varying levels of road network accessibility, indicating that flood-prone villages in Idah and Ibaji suffer from low road network accessibility with poor connectivity, often relying on only one major access route, leading to delays in evacuation during severe flood events as emergency vehicles struggle to navigate waterlogged or damaged roads, while towns like Ajaokuta and Ofu exhibit moderate road network conditions with more robust systems, although some routes still face challenges due to poor maintenance or congestion during emergencies.

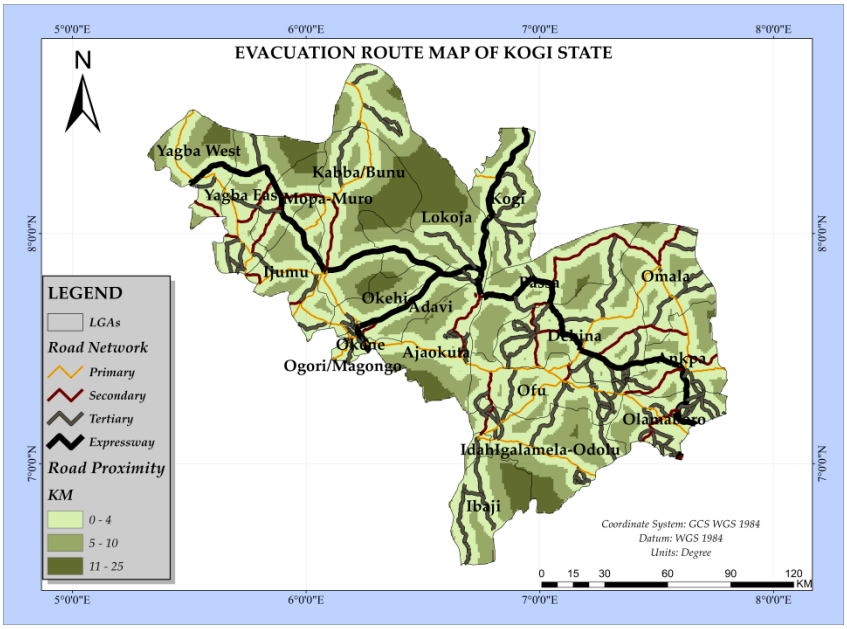

Fig 2: Evacuation Routes Map

5.3 Factors Considered

Water Body Proximity: Proximity to major rivers influences flood vulnerability, with Lokoja, Idah, and Ibaji within 2 km of the Niger and Benue rivers classified as high-risk due to frequent inundation, especially after dam releases; Ajaokuta and Dekina face moderate risk from tributary overflow, while Kabba and Ogori Magongo are low-risk.

Elevation: Elevation affects flood exposure; low-lying areas like Idah, Ibaji, and Koton-Karfe (below 50 m) are high-risk due to floodplains, Ajaokuta (50-100 m) is at moderate risk, and higher-elevation regions like Kabba and Ogori Magongo (above 100 m) are less prone to flooding.

Slope: Slope influences flood risk by affecting water runoff; low-slope areas like Lokoja, Ibaji, and Bassa are highly susceptible to flooding, moderate-slope regions like Ajaokuta and Ofu have reduced risk, while steeper areas like Ogori Magongo benefit from rapid runoff and face lower risks.

Population: High population density in flood-prone areas such as Lokoja, Idah, and Ibaji increases evacuation pressures, whereas Ajaokuta and Dekina have moderate densities, and Kabba, being less populated, encounters fewer challenges.

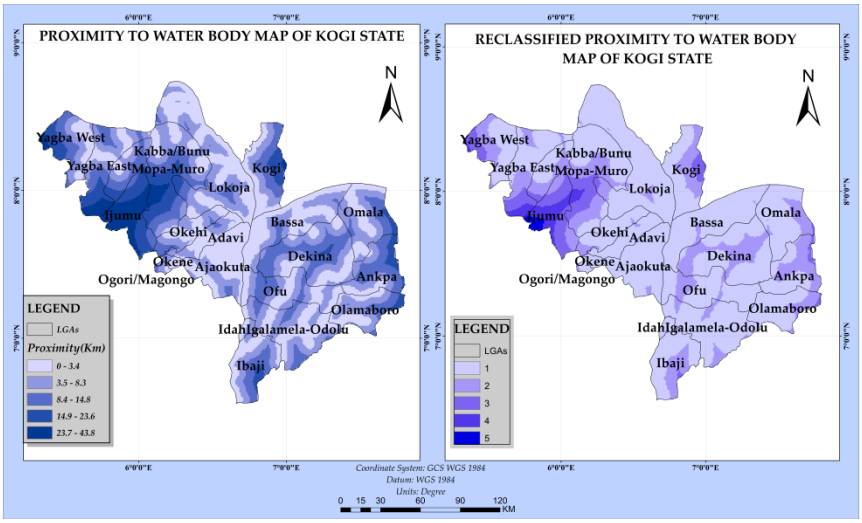

Fig 3: Proximity to Water Body Map.

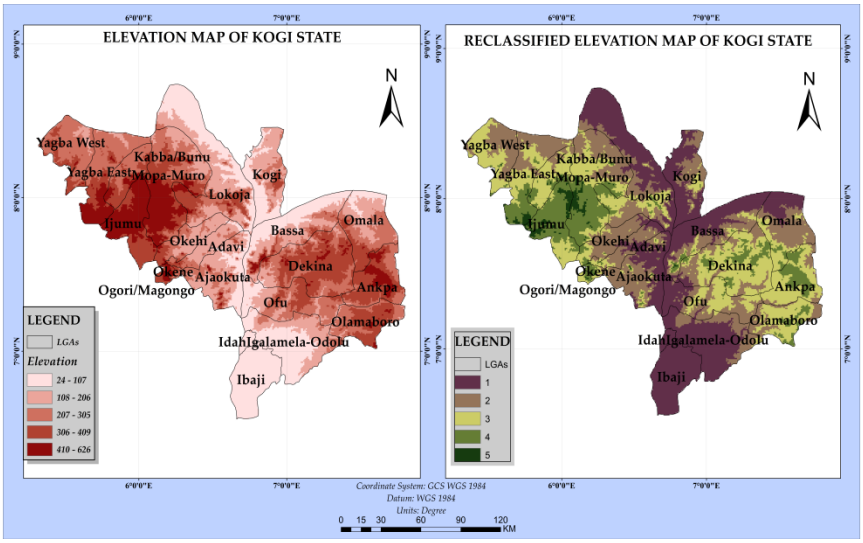

Fig 4: Elevation Map.

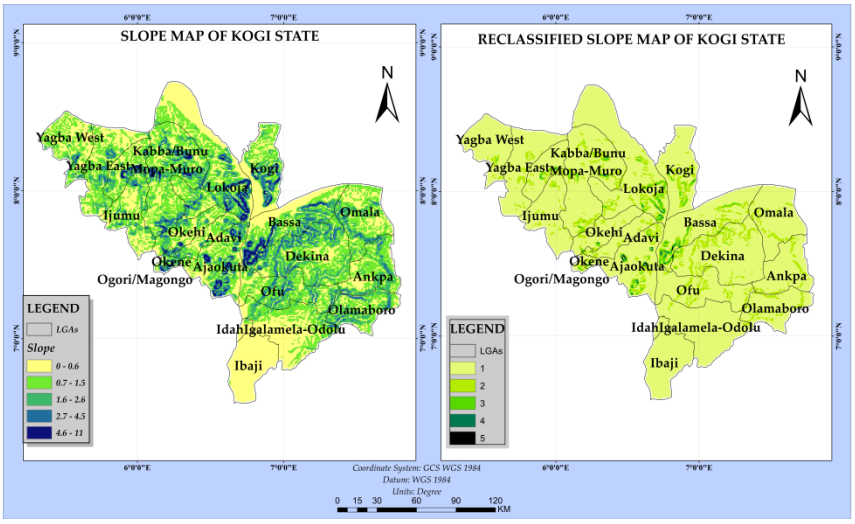

Fig 5: Slope Map.

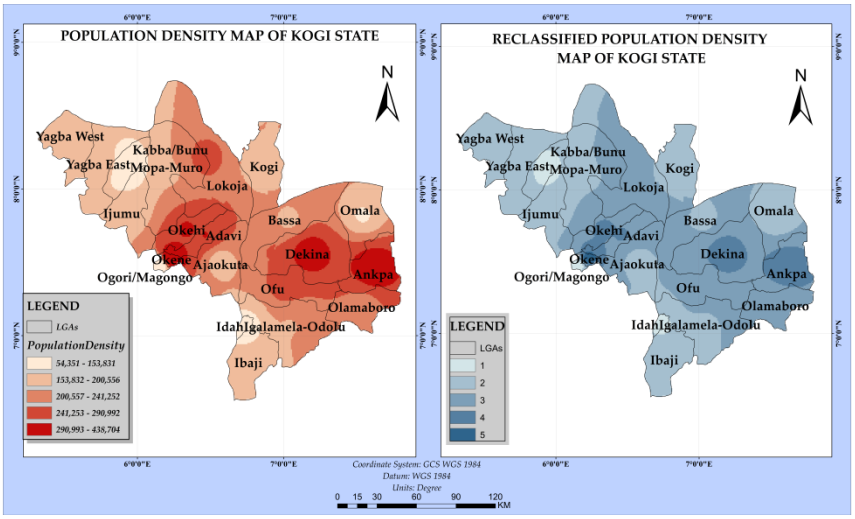

Fig 6: Population Density Map.

LandCover Analysis

The land cover classification for Kogi State reveals various landscape types vital for environmental management and planning. Wetlands and water bodies, primarily around the Niger and Benue Rivers, are key to flood risk management and supporting aquatic ecosystems. Built-up areas, notably in urban centers such as Lokoja and Kabba, reflect human settlements and infrastructure development. Agricultural land, covering a large portion of the state, especially in Dekina, Bassa, and Idah, underlines the state's reliance on farming. Dense vegetation, especially in southern regions like Idah and Igalamela-Odolu, plays a crucial role in supporting biodiversity and acting as forest reserves. Sparse vegetation and bare surfaces in some areas indicate regions susceptible to erosion or degradation, especially in arid or over-cultivated lands. These classifications are crucial for managing flood risks, protecting the environment, and supporting sustainable urban growth.

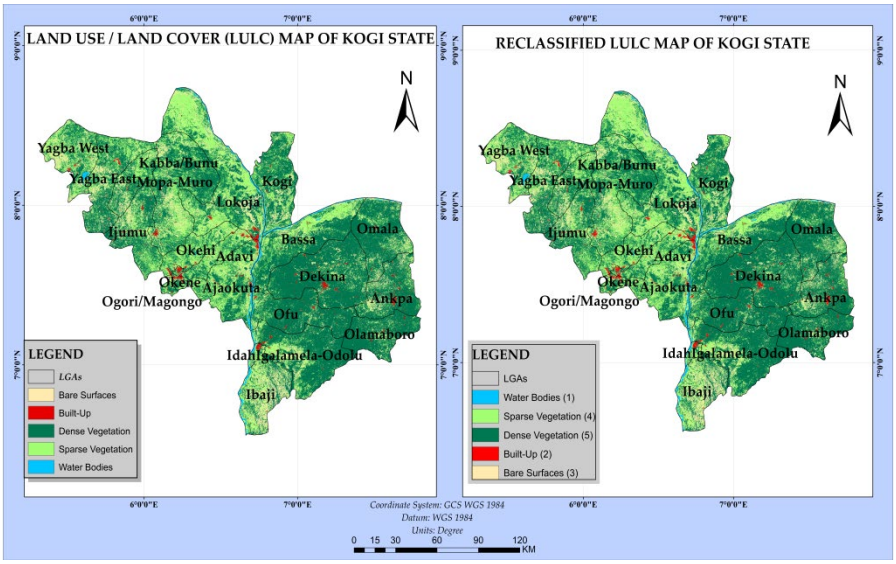

Fig 7: LandUse/LandCover Map

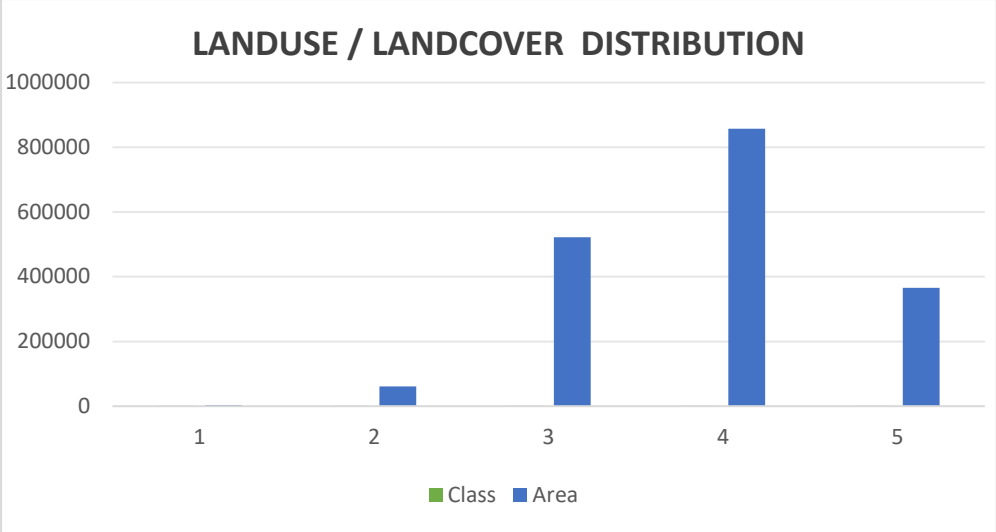

Chart 1: LandUse/LandCover Distribution

Conclusion

This study highlights the importance of geospatial techniques in flood risk assessment and evacuation planning for Kogi State. The use of GIS and remote sensing enables the identification of high-risk areas and the development of effective evacuation routes and safe zones. The results emphasize the need for decision-makers to incorporate these tools into disaster management strategies to improve flood preparedness and response, ultimately reducing the impact of future floods in Kogi State.

To enhance flood management in Kogi State, it is recommended that the government adopt GIS-based flood evacuation maps as part of its disaster management strategy to ensure timely and organized evacuations. Additionally, investing in GIS infrastructure and providing specialized training for disaster management personnel will improve flood preparedness and response. Continuous monitoring and regular updates of evacuation maps are essential to reflect changing hydrological patterns and population growth, ensuring decisions are based on accurate and current information. Collaborating with local communities and experts will help incorporate traditional knowledge and localized insights into flood risk strategies. Lastly, leveraging AI-driven models for predictive flood modeling will allow authorities to forecast floods more effectively using historical data, weather patterns, and land use changes, enabling proactive disaster response.

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