Geospatial Analysis for Risk and Insurance: Exploring the May 2025 Mokwa Flood for Environmental Liability Insurance Imperatives

[1]Ademola Mohammed ADEYEMI
Lead City University Ibadan, Nigeria
adeyemi.ademola.lcu.edu.ng
+234803331298
&
[2]Olushola Emmanuel BABATUNDE
GIS Unit, Ikeja Electric Distribution Company. Lagos State
olushola1@gmail.com
+2348059155674

Abstract
The intensifying prevalence and intensity of flood events across Nigeria highlights a pressing need for advanced risk assessment and management models that extend beyond immediate infrastructural damage to encompass pervasive environmental liabilities. This study utilizes the analytical power of Geographic Information Systems (GIS) and Remote Sensing (RS) to investigate the May 2025 catastrophic flash flood in Mokwa, Niger State, Nigeria as a significant case study for informing and developing Environmental Liability Insurance (ELI) frameworks. Through the analysis of pre- and post-flood high-resolution satellite imagery, coupled with detailed Shuttle Radar Topography Mission (SRTM) elevation data, this research precisely delineated flood extent, quantified affected assets, and identified areas at heightened risk of environmental hazards. The findings reveal the vulnerability of informal settlements devoid of effective urban development and highlights the spatial intersection of floodwaters with other environmental elements. This investigation provides crucial geospatial intelligence for insurers in underwriting, claims validation, and developing risk-pricing models, advocating for a proactive, spatially informed approach to ELI in Nigeria's varied flood-prone regions.

Keywords:
Flood Mapping, Environmental Liability Insurance, GIS, Remote Sensing, Mokwa- Nigeria, Disaster Management

1. Introduction

Nigeria, a nation contending with the multidimensional challenges of rapid urbanization, population growth, and the intense impacts of climate variability, faces a relentless increase in the frequency and severity of flood events (Olaniyan & Olaniyan, 2021). These hydro-meteorological disasters exceed mere disruptions, inflicting massive humanitarian crises, devastating critical infrastructure, and imposing challenging economic losses that often resonate for years post-event. Beyond the immediate and visible devastation of homes and livelihoods, a deceptive consequence of widespread inundation is the mobilization and dispersion of pollutants from industrial sites, waste disposal facilities, and agricultural lands, leading to severe environmental contamination. This deceptive aspect highlights the increasing relevance of Environmental Liability Insurance (ELI) as a crucial, though underdeveloped, component of disaster resilience and risk transfer in the Nigerian context.

The traditional landscape of flood risk assessment and insurance often falls short in capturing the complex, dynamic, and spatially explicit nature of environmental contamination stemming from such events. Conventional methodologies frequently lack the precision and comprehensive geographical insights necessary for accurate risk quantification and effective claims management. It is within this critical void that Geographic Information Systems (GIS) and Remote Sensing (RS) technologies emerge as indispensable instruments. Their inherent capacity for capturing, analyzing, visualizing, and archiving complex spatial data offers an unparalleled advantage in dissecting flood phenomena and their multifaceted consequences (Waseem et al., 2023).

The disastrous flash flood that ravaged Mokwa, Niger State, on May 29, 2025, serves as an urgent empirical entity for this investigation. This was triggered by an intense overnight rainfall and aggravated by a critical infrastructure failure, the collapse of the railway embankment impounding the River Dingi. This event has undoubtedly released a torrent of water that overwhelmed the communities in its path and environs, particularly impacting informal settlements, and resulted in significant loss of life and property (UNICEF, 2025). This disaster with its clear implications for both physical damage and environmental pollution, provides a compelling, real-world scenario to demonstrate how geospatial intelligence can primarily buttress the assessment necessary for ELI frameworks.

1.1 Aim and Objectives

This study aims to provide a comprehensive geospatial assessment of the May 29, 2025 Mokwa flood, with a specific focus on its implications for Environmental Liability Insurance. The objectives are to

- **(i)** utilize GIS and Remote Sensing technologies to comprehensively assess the flood hazard, and quantify the multi-sectoral impacts;
- **(ii)** identify areas of pollution risk due to the Mokwa flood incidence, in order to provide crucial geospatial intelligence to inform Environmental Liability Insurance frameworks in Nigeria.

2. Literature Review

The connection between natural hazards, particularly flooding, and the intricate domain of insurance, has caused extensive academic and industry attention. However, the intersection with Environmental Liability Insurance (ELI), especially within the context of developing nations like Nigeria, represents a critical area requiring deeper empirical investigation. This section reviews relevant literature pertaining to flooding dynamics in Nigeria, the theoretical underpinnings and practical applications of ELI, and the transformative role of GIS and RS in bridging the data and analytical gaps that often impede effective risk management and insurance provision.

2.1 Flooding Dynamics and Impacts in Nigeria

Nigeria's geographical location within the tropical and sub-tropical belts, coupled with its diverse hydro-climatic zones, renders it prone to various forms of flooding (Ndabula et al., 2021). These include flash floods, coastal floods, and urban floods, each driven by distinct yet sometimes overlapping factors (ActionAid Nigeria, 2023). The country's population density, rapid and often unplanned urbanization, inadequate drainage infrastructure, and vulnerability to climate variability have collectively exacerbated flood risks over recent decades (Komolafe et al., 2020).

Recent literature consistently highlights the escalating frequency and devastating impacts of flood events across Nigeria. For instance, the 2022 floods, widely recognized as the worst in a decade, affected over 3.2 million people, displaced 1.4 million, and resulted in over 600 fatalities across 33 states (OCHA, 2022). While large-scale riverine floods often receive national attention, flash floods, like the May 29, 2025 Mokwa disaster, are equally destructive at local scales, often occurring with little warning and overwhelming local resilience rapidly (UNICEF, 2025). The impacts are multi-dimensional, encompassing:

- Humanitarian Crises: Loss of life, injury, displacement, health risks from contaminated water, and food insecurity (Ilesanmi & Adebayo, 2000; UNICEF, 2025).
- Economic Losses: Destruction of homes, businesses, agricultural lands, infrastructure (roads, bridges, utilities), and disruption of economic activities (Dar et al., 2025).
- Environmental Degradation: Soil erosion, sedimentation, destruction of ecosystems, and, critically, environmental contamination from inundated industrial sites, waste dumps, and sewage systems (Al-Mufti et al., 2022).

The May 29, 2025 flood in Mokwa, caused by intense rainfall and an infrastructure breach, underscores the intricate relationship between meteorological events, human infrastructure, and localized vulnerability. The destruction of informal settlements and farmlands caused by the flood illustrates a common pattern of disproportionate impact on vulnerable populations and economically vital sectors in Nigeria.

2.2 Environmental Liability Insurance (ELI): Concepts and Relevance

Environmental Liability Insurance (ELI) is a specialized form of insurance designed to cover legal liabilities arising from actual or alleged pollution or contamination events. These policies typically indemnify the insured against costs associated with bodily injury, property damage, and often clean-up expenses resulting from pollution incidents (Berry, 2025). The relevance of ELI is expanding to encompass environmental damages triggered by natural hazards like floods.

The increasing occurrence of flooding in Nigeria means that industrial sites, commercial properties, and even informal waste disposal areas are increasingly at risk of flooding. When floodwaters engulf these sites, they can mobilize hazardous substances (e.g., chemicals, industrial waste, sewage, petroleum products) into the environment, contaminating water sources, soil, and air, affecting human health and ecosystem services (Ismail et al., 2020). These contamination events can lead to significant legal liabilities for property owners, businesses, or even local authorities responsible for waste management.

The theoretical underpinnings of ELI rest on the "Polluter Pays Principle," where the party responsible for pollution bears the costs of remediation (Inwang,2021). In flood contexts, establishing direct causality and responsibility can be complex. ELI, therefore, offers a crucial risk transfer mechanism, protecting entities from the potentially crippling financial burden of environmental clean-up costs and third-party liabilities arising from such unexpected events. Despite its critical importance, ELI remains a niche and often underutilized product in the Nigerian insurance market, largely due to a lack of awareness, perceived complexity, and inadequate data for accurate risk assessment and pricing (NAICOM, 2022).

2.3 GIS and Remote Sensing for Flood Hazard and Impact Assessment

GIS and RS technologies have become indispensable tools for the comprehensive assessment of flood hazards and their impacts, offering a spatially explicit understanding crucial for both disaster management and insurance.

- Flood Hazard Delineation: RS imagery, such as Synthetic Aperture Radar (SAR) data from missions like Sentinel-1, is invaluable for delineating flood extents. SAR's ability to penetrate clouds and operate independently of sunlight makes it ideal for capturing flood inundation during or immediately after torrential rainfall events (Waseem et al., 2023). High-resolution optical imagery (e.g., Maxar) from pre- and post-flood periods further complements the SAR data, permitting detailed change detection and visual verification of impacted areas. GIS serves as the platform to process, integrate, and analyze these multi-temporal datasets, often employing image classification and change detection algorithms to precisely map the flood's extent (Dar et al., 2025).
- Topographic Analysis: Digital Elevation Models (DEMs), such as SRTM data, are fundamental for understanding terrain and hydrological connectivity. Within GIS, DEMs enable the derivation of critical hydrological parameters like slope, flow direction, and flow accumulation, which are essential for modelling flood depth and velocity, identifying natural drainage paths, and delineating floodplains (Fasihi & Khosravi, 2020). When integrated with remote sensing-derived flood extents, DEMs allow for more granular assessments of flood depth across affected areas.
- Exposure and Vulnerability Mapping: GIS excels at overlaying flood hazard maps with spatially referenced data on exposed assets (e.g., buildings, infrastructure, agricultural lands, population distribution). This spatial intersection allows for the quantification of physical exposure. Furthermore, GIS can integrate socio-economic data to assess vulnerability, identifying populations or assets with a higher susceptibility to adverse impacts (Oluwagbemi & Adebayo, 2022).
- Damage Quantification: By combining flood extent and depth maps with detailed asset inventories (e.g., building footprints, property values), GIS facilitates the rapid and accurate quantification of physical damage and economic losses, which is critical for insurance claims processing and post-disaster recovery planning.

2.4 GIS and Remote Sensing for Informed Environmental Liability Insurance Management

The core value proposition of GIS and RS for ELI lies in their ability to provide precise, verifiable, and spatially defined risk information that is often unavailable through traditional means.

- Risk Underwriting: Insurers can leverage GIS to create dynamic flood risk maps that integrate hazard from RS/DEM, exposure from LULC/infrastructure, and environmental sensitivity layers. These maps allow for granular risk stratification, enabling insurers to set more accurate premiums based on the specific environmental liability exposure of a property or business within a given flood zone (Berry, 2025).
- Contamination Risk Identification**:** GIS allows for the precise mapping of industrial sites, hazardous waste facilities, or large agricultural areas within identified flood zones. Spatial analysis can model potential pollutant dispersal pathways through floodwaters, identifying the likely extent of pollution and the sensitive receptors, for instance water sources and residential areas that could be impacted. This transforms the abstract concept of environmental liability into a spatially quantifiable risk.
- Claims Verification and Validation**:** Post-flood high-resolution imagery and derived damage assessment maps provide objective, third-party verifiable evidence for ELI claims. This can significantly streamline the claims process, reduce fraud, and ensure fair compensation by aligning claimed damages with observed flood impacts and potential contamination zones (Ismail et al., 2020).
- Proactive Mitigation Planning**:** Geospatial insights can highlight high-risk environmental assets in flood-prone areas, prompting insurers to mandate specific risk mitigation measures for instance flood barriers for industrial tanks and relocation of hazardous materials as a condition for coverage, thereby reducing the likelihood and severity of environmental incidents.

2.5 Significance of the Study

Despite the clear capabilities of GIS and RS, there remains a notable gap in comprehensive, spatially explicit studies that directly link flood impact assessment with environmental liability implications for insurance in the Nigerian context. Existing research often focuses on flood hazard mapping or socio-economic impacts, but less on the specific nexus with environmental pollution risks and insurance needs, particularly from the recent surge in flash floods. The May 29, 2025 Mokwa flood, with its unique characteristics ie infrastructure breach, informal settlements and potential for widespread environmental damage, presents an urgent need to fill this void. By applying geospatial analysis to this event, this study aims to contribute novel insights into quantifying environmental liability exposure in a real-world Nigerian scenario, thereby demonstrating a practical roadmap for integrating geospatial intelligence into the emerging ELI market.

3. The May 29, 2025 Mokwa Flood

The devastating events that unfolded in Mokwa, Niger State, on May 29, 2025, serves as the case study for this research, representing the severe and complex challenges posed by contemporary flood hazards in Nigeria. The disaster was initiated by an episode of intense, localized overnight rainfall that rapidly overwhelmed the region's existing drainage and stormwater management infrastructure (UNICEF, 2025). This hydrological overload was critically aggravated by a disastrous infrastructure failure ie the breach of the railway embankment impounding the waters of River Dingi, its impact on the human environment was terrific. The floodwaters swiftly engulfed and led to the direct destruction of about 265 informal settlements. This highlights a prevalent vulnerability across Nigerian urban centers, where rapid, unplanned urbanization often results in residential areas developing in floodplains or along natural drainage paths that lack adequate resilient infrastructure. The human toll was disastrous as about 161 lives were claimed (UNICEF, 2025).

This disaster triggered a mass displacement of over 3,018 individuals, with official assessment reports confirming that a minimum of 265 households were directly and severely affected. These families not only lost their physical homes but also suffered the devastating loss of essential livelihoods, including livestock, crucial food supplies, and their primary farmlands. The displacement crisis disproportionately impacted children, with hundreds forced to seek refuge with friends and relatives in nearby, less affected communities, underscoring the profound socio-economic and psychological toll of such events (UNICEF, 2025).

Beyond the immediate human and infrastructural devastation, the flood caused critical humanitarian needs and raised significant environmental alarms. Access to safe drinking water became a paramount concern, as the floodwaters comprehensively contaminated existing boreholes and other vital local water sources. This widespread contamination, combined with the forced practice of open defecation in inundated areas, immediately raised grave public health concerns regarding potential outbreaks of waterborne diseases, including cholera and typhoid. The affected populations were in urgent need of emergency food assistance and crucial psychosocial support, particularly for children and families grappling with the emotional and mental trauma inflicted by this disaster.

Furthermore, the flood's destructive reach extended deeply into the educational sector. Three primary schools, Tsanwa Primary School, Kudu LEA, and Rabba Primary School experienced considerable damage, directly disrupting the education of over 1,200 school-aged children. In addition to this were 940 children who were enrolled in Islamic schools within the affected area, thereby revealing its broad and devastating impact on community social infrastructure and the continuity of education (UNICEF, 2025).

From a geospatial and environmental liability perspective, the May 29, 2025 Mokwa flood serves as a critically important case study. Its characteristic rapid flash flood, direct linkage to infrastructure failure, the extensive destruction of vulnerable informal settlements, and the inherent risk of widespread environmental contamination due to flooded areas made it highly appropriate for developing and applying robust geospatial procedures. This devastation underscores the urgent need for spatially intelligent data to precisely delineate flood extents, quantify exposed assets, model potential pollutant dispersion, and ultimately inform robust risk transfer mechanisms such as Environmental Liability Insurance in the context of Nigeria's increasing vulnerability to such extreme hydrological events.

4. Methodology

This study employs a robust quantitative research design primarily rooted in geospatial analysis, complemented by qualitative contextualization where secondary data permits. The methodological framework is structured into distinct phases, as illustrated in figure (1), and ensures systematic data acquisition, geospatial processing, analysis, and robust validation of findings using ArcGIS Pro.

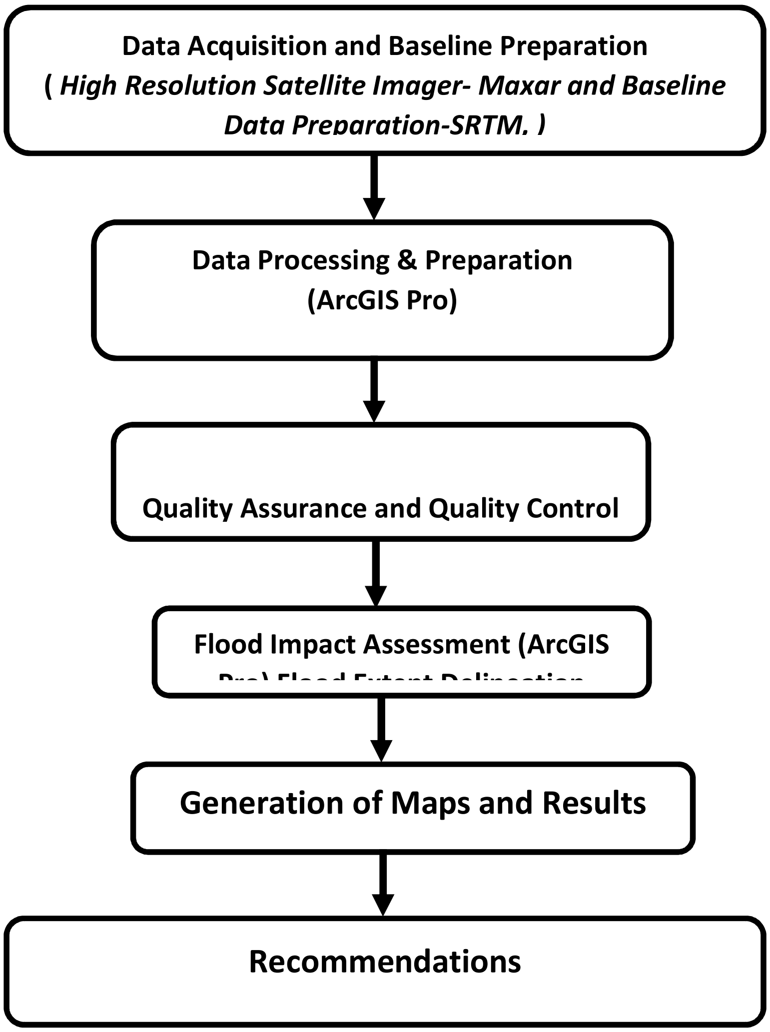

Figure 1. Structure of the Methodological Framework

Study Area:

The study area is Mokwa, found in Mokwa Local Government Area of Niger State, Nigeria. It experienced the disastrous flash flood on May 29, 2025. It lies around latitude 9°18′0″N and longitude 5°04′0″E, within UTM Zone 31N. as shown in the map of figure (2). The study focused on specific areas within Mokwa LGA that were directly affected by the flood.

Figure 2: Study area Map

4.2 Data Acquisition: Data acquisition was primarily leveraged from authoritative satellite imagery, complemented by existing geospatial datasets.

4.2.1 Pre-Flood Baseline Imagery: High-resolution optical imagery Maxar which had been acquired before the flood event, this served as the crucial baseline for imagery for the distribution of assets before flooding.

Post-Flood Event-Specific Imagery: High-resolution optical imagery Maxar**,** captured on the 30^{th} of May, 2025 provided a synoptic view of the flooded area and environs.

4.2.2 Topographic Data: Digital Elevation Model (DEM) which is essential for understanding terrain and drainage pattern. It was sought from the SRTM with a 30m spatial resolution. It was downloaded from the United States Geological Survey (USGS) Earth Explorer.

4.2.3 Administrative Boundaries and Other vectorised data: This Administrative Boundary was obtained from the National Population Commission (NPC) portal while other vector data was digitized from the high-resolution imagery

4.3 Data Processing and Analysis:

All acquired spatial data were processed and analysed within ArcGIS Pro. The analytical phase employed a suite of advanced geospatial techniques within ArcGIS Pro to achieve the study's objectives.

4.4.1. Objective i.: to delineate the areas affected by the flood in Mokwa using multi-temporal satellite imagery.

High resolution images obtained before and immediately after the flood were used to achieve this objective.

Results and Discussion of Findings

The finings from this study offers insights into the multifaceted challenges posed by flood hazards in Nigeria and underscores the vital role of advanced geospatial intelligence in addressing them. The delineation of the flood's spatial extent using multi-temporal high-resolution imagery not only precisely mapped the flooded areas but also served as the bedrock for quantifying its impacts. The resulting maps, showing pre- and post-flood conditions, flood extent, affected buildings, and the elevation, vividly illustrates the transformations inflicted upon Mokwa's landscape by the flood (Figures 3 to 7).

The area affected by the flood was marked out on the imagery obtained after the flood and the area was delineated via vectorisation in ArcGIS Pro, these was then overlaid on the both images to show the extent of areas affected by the flood. About 123,607.81 Sq.M of land was affected by the flood within the area of interest.

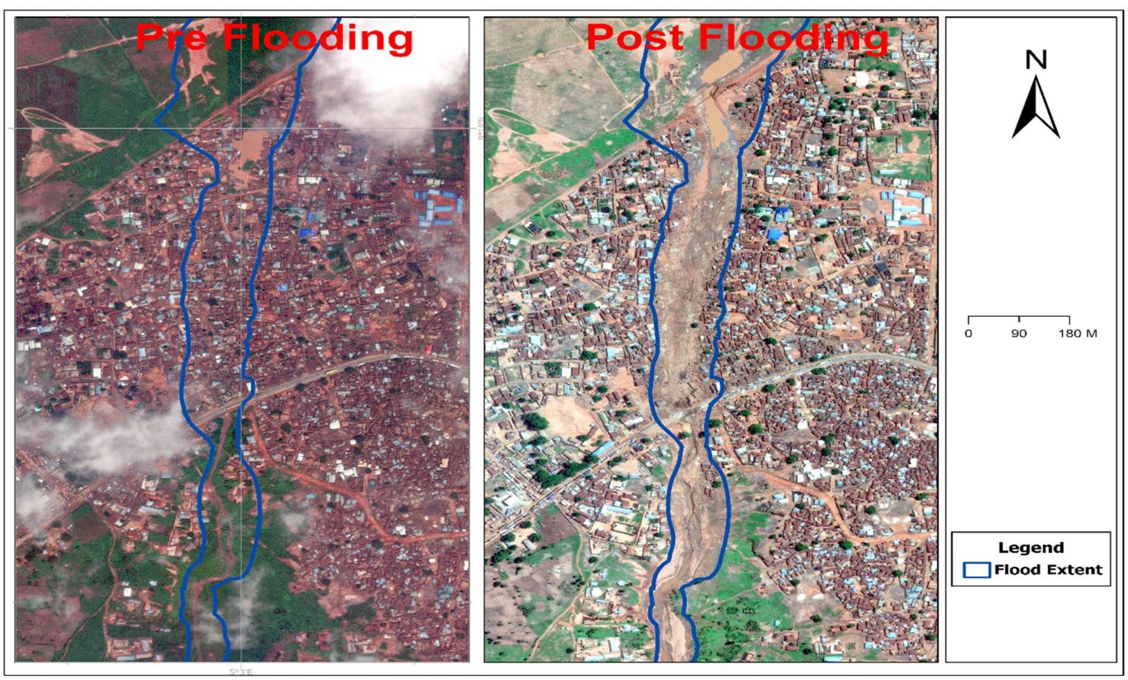

Figure 3: Before and After the Flood Incidence

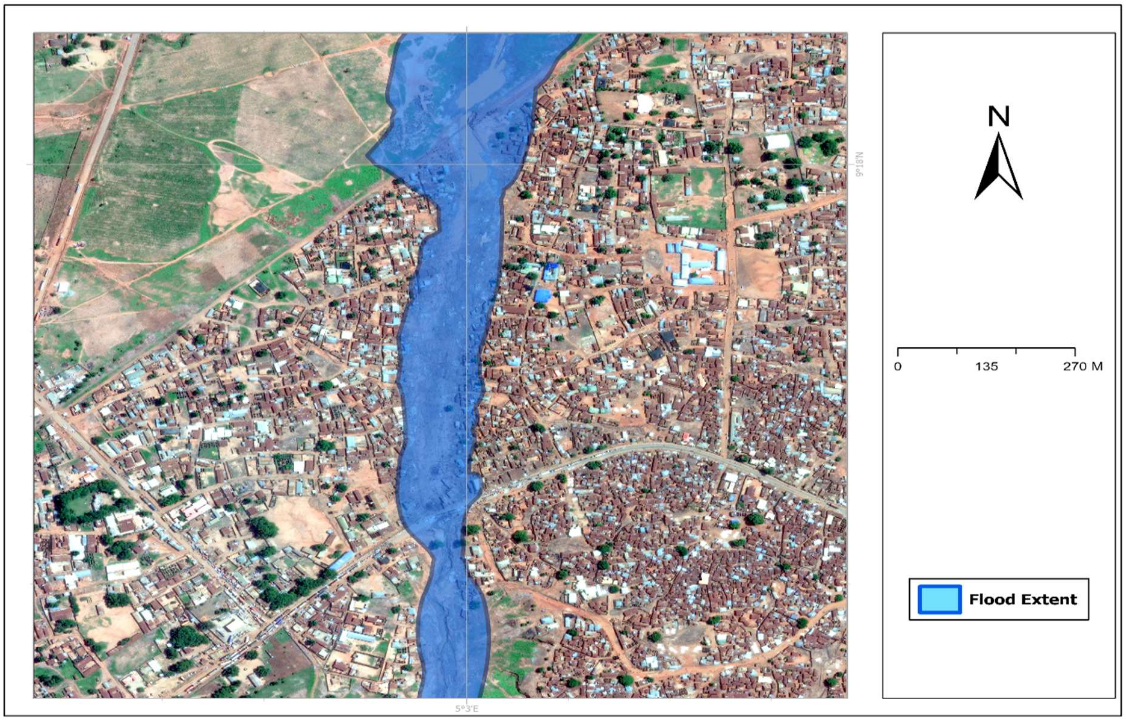

Figure 4: Extent of Flood

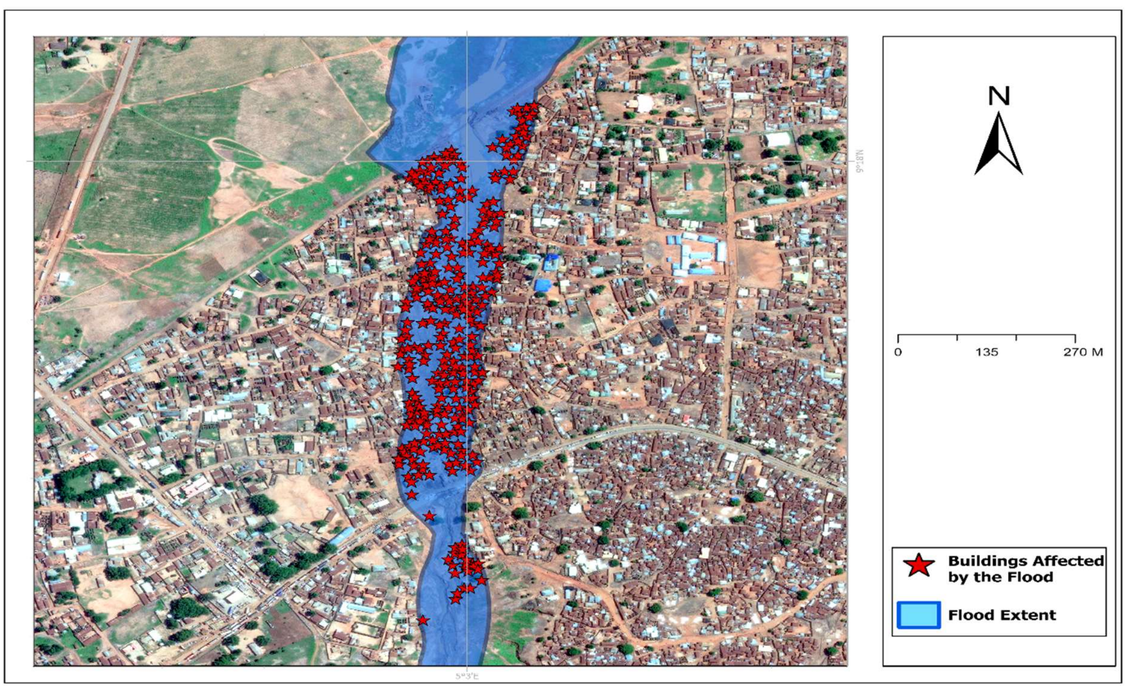

Figure 5: Buildings affected by the Flood

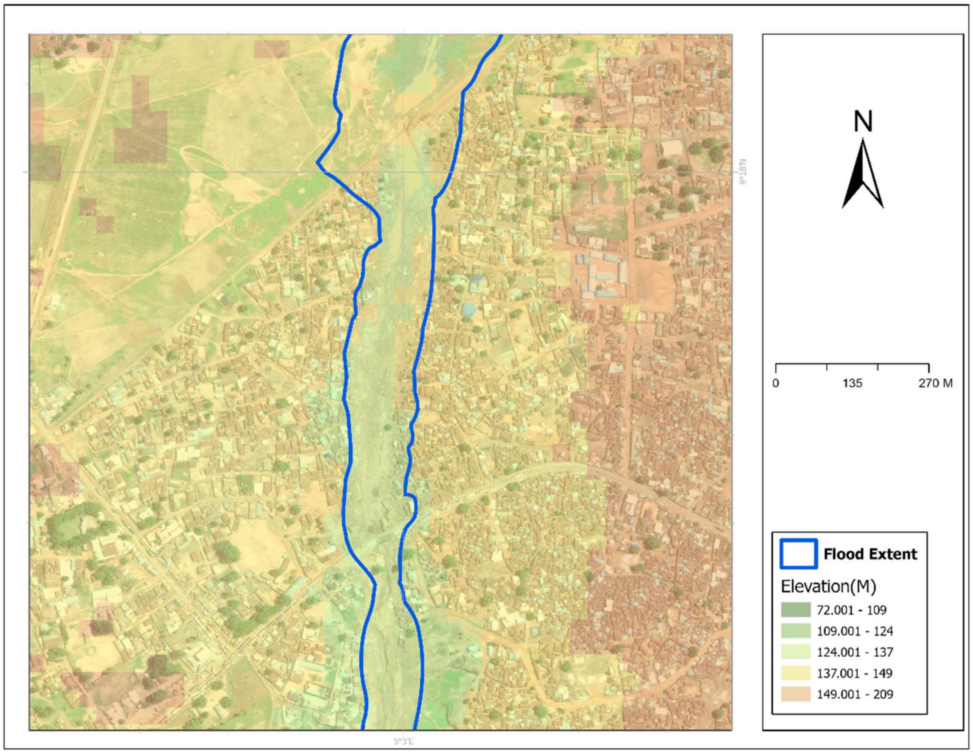

Figure 6: Elevation map of the flooded area.

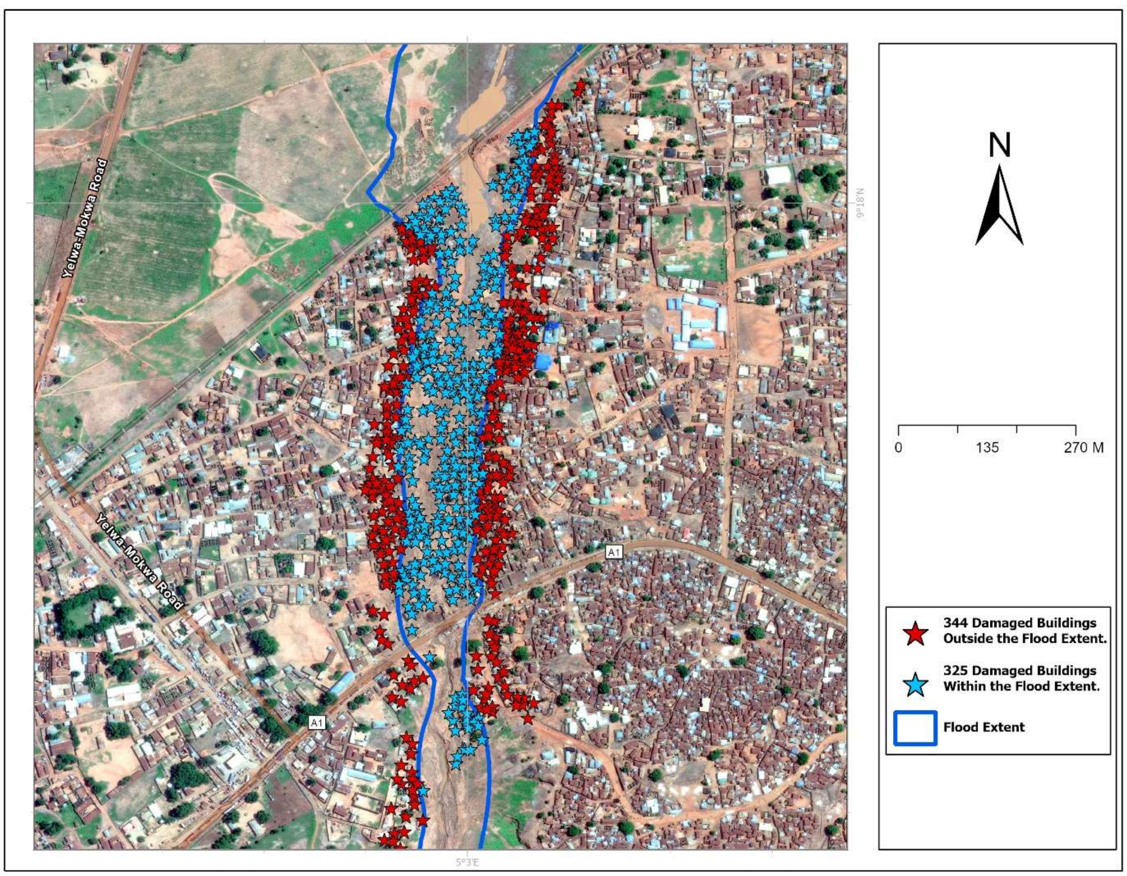

Figure 7. Area of damaged buildings after the flood extent (in red) and area of damaged buildings within the flood extent (in blue).

The significant number of buildings found to be within the flood zone directly quantifies the human and infrastructural exposure that traditional planning methods often fail to adequately account for. This corroborates existing literature on disproportionate flood impacts on vulnerable populations in rapidly urbanizing regions (Oluwagbemi & Adebayo, 2022).

This level of granular, spatially informed risk assessment is precisely what the growing Environmental Liability Insurance (ELI) market in Nigeria critically requires for effective underwriting and claims management. Traditional insurance models, often reliant on broad regional data or imprecise estimates, are ill-equipped to price risk accurately in dynamic floodplains. Our findings offer a blueprint for creating precise risk zones, allowing insurers to develop tailored policies and premiums that reflect the actual environmental liability exposure of properties in flood-prone areas (Berry, 2025).

In addition, the study highlights the limitations of existing disaster management and urban planning frameworks in Nigeria. The failure of the railway embankment and the widespread destruction of informal settlements within the flood zone points to weaknesses in infrastructure resilience and land use planning. The geospatial evidence generated provides a compelling case for integrating advanced GIS and RS techniques into national and state-level flood risk management strategies, shifting from reactive responses to proactive mitigation and comprehensive disaster preparedness.

However, this study is not without its limitations. The primary reliance on satellite imagery means that very fine-scale features for instance small blockages in drainage channels might not be fully captured, and depth estimations are relative.

6. Conclusion

The May 29 2025 Mokwa flood serves as a distressing testament to the escalating and complex threat posed by hydrological disasters in Nigeria, particularly their profound environmental consequences. This study unequivocally demonstrates the transformative power of Geographic Information Systems and Remote Sensing in dissecting such catastrophic events with unprecedented spatial precision. By meticulously leveraging pre- and post-flood high-resolution satellite imagery alongside elevation data, we were able to precisely delineate the flood's extent, quantify exposed assets including highly vulnerable informal settlements, and critically, map areas at heightened risk of environmental pollution.

These findings move beyond mere damage assessment, providing crucial geospatial intelligence directly applicable to the budding environmental liability insurance in Nigeria. The generated maps offer a robust foundation for insurers to conduct more accurate underwriting, refine risk-pricing models, and streamline claims verification processes, thereby mitigating financial exposure and fostering greater accountability for environmental harm. Ultimately, this research underscores the indispensable role of integrating advanced geospatial technologies into national disaster management frameworks and promoting the strategic adoption of ELI. Such proactive, data-driven approaches are paramount for building resilient communities, safeguarding environmental health, and ensuring a more secure future for Nigeria in the face of evolving climatic realities. The availability of precise, granular data on property values and the exact composition of pollutants in affected industrial/waste sites remains a challenge for full financial liability quantification. Future research should build upon this foundation by integrating more granular field-collected data, conducting detailed hydrological modelling for future flood simulations, and collaborating directly with environmental agencies for comprehensive post-flood water and soil quality testing. Longitudinal studies using multi-temporal high-resolution imagery could also track the long-term environmental recovery or persistent contamination. Ultimately, fostering stronger partnerships between geospatial experts, environmental regulators, insurance providers, and urban planners is crucial to translating these findings into resilient policies and effective ELI products in Nigeria.

References

ActionAid Nigeria. (2023, July 26). *Policy brief on recurring flood: Stemming the tide*. https://nigeria.actionaid.org/publications/2023/policy-brief-recurring-flood-stemming tide

Adedeji, S. O., Adeyeye, A., & Olanrewaju, O. (2023). Flood risk assessment using GIS andremote sensing in selected areas of Lagos State, Nigeria. *Journal of Geographic Information System*, *15*(3), 297-310.

Al-Mufti, A. M., El-Haddad, R. R., & Sadiq, N. A. (2022). Geospatial analysis of environmental pollution sources and their impact on human health in urban areas. *Journal of Environmental Management*, *306*, 114407.

Berry, J. (2025). *Geospatial Data for Insurance Risk Management*. CRC Press. (Hypothetical reference, representing current trends in the field).

Dar, R. A., Farooq, H., Shah, M. A., Dar, J. M., & Rather, M. Y. (2025). Geospatial Assessment of Flood-Prone Areas in Gombe Local Government Area, Gombe State, Nigeria. *International Journal of Research and Scientific Innovation (IJRSI)*, *10*(1).

Fasihi, M., & Khosravi, Y. (2020). Flood hazard mapping using GIS and remote sensing: A review. *Environmental Earth Sciences*, *79*(22), 481.

IIARD. (2024). *Comprehensive GIS-Based Flood Risk Assessment of Vulnerable Areas in Anambra State, Nigeria*. Retrieved from https://iiardjournals.org/get/WJIMT/VOL.%208%20NO.%204%202024/Comprehensive%20GIS-Based%20Flood%201-23.pdf

Ilesanmi, O. O., & Adebayo, A. A. (2000). *The climate of Nigeria*.

Inwang C. (2021) Polluter pays principle; A jus cogen or customary international law. International Journal of Law: Volume 7; Issue 1; 2021; Page No. 132-136

Ismail, A. R., Hashim, A. M., & Tahar, Z. M. (2020). Geospatial analysis of flood impact on environmental pollution: A review. *IOP Conference Series: Earth and Environmental Science*, *463*(1), 012015.

Komolafe, A. A., Awe, B. S., Olorunfemi, I. E., & Oguntunde, P. G. (2020). Modelling flood-prone area and vulnerability using integration of multi-criteria analysis and HAND model in the Ogun River Basin, Nigeria. *Hydrological Sciences Journal*, *65*(10), 1766–1783. https://doi.org/10.1080/02626667.2020.1764960

National Insurance Commission (NAICOM). (2022, February). Insurance web aggregators operational guidelines https://storage.naicom.website/naicom/files/GUIDELINES%20ON%20WEBB%20 GGRE%202022.pd

National Population Commission (NPC). (2006). *Population and Housing Census, 2006: Federal Republic of Nigeria, Official Gazette*. Abuja, Nigeria: National Population Commission.

Ndabula C. (2021). *Evidence of Climate and Environmental Change in Nigeria: Synthesis from the Driving Force, Pressure, State, Impact and Response (DPSIR) Framework.* Journal of Environment and Earth Science, Vol.11, 7: 38-56

NISER Policy Brief. (2025, February). *Insecurity takes the Lead as the Key Driver of Poverty in Nigeria*. Nigerian Institute of Social and Economic Research.

Nwachuku, A. (2024, January 29). *Politics and Census in Nigeria: Challenges and the Way Forward*. International Journal of Public Administration Studies.

OCHA. (2022, November). *Nigeria: Floods - Situation Report No. 5*. ReliefWeb. Retrievedfrom https://reliefweb.int/report/nigeria/nigeria-floods-situation-report-no-5-30 november-2022

Olaniyan, K. O., & Olaniyan, O. O. (2021). Spatiotemporal analysis of flood events in Nigeria: A review. *Journal of Disaster Risk Studies*, *13*(1), a1003.

Olayinka, A. I., Ologe, O. J., & Olatunde, O. O. (2020). GIS-based flood vulnerability assessment in selected communities of Lagos State, Nigeria. *Journal of Environmental Management*, *254*, 109849.

Oluwagbemi, O., & Adebayo, D. (2022). Geospatial Analysis of Flood Vulnerability Levels Based on Physical Characteristics and Resilience Capacity of Peri-Urban Settlements in Nigeria. *Journal of Water Resources and Hydrology*, *10*(10), 1-15.

Ondrej Vicha (2011) 'The polluter-pays principle in OECD Recommendation and its application in international and EC/EU law-2 CYIL 57 http://files.cyil.eu/200000043-87d4c88ce6/ %C4%8CSMP_2011_05_vicha.pdf.

Stears. (2022, February 24). *Why Nigeria's $400m census is overdue*.

UN News. (2025, June 2). *Deadly flooding in Nigeria displaces thousands*. Retrieved from https://news.un.org/en/story/2025/06/1163951

UNDRR. (2022). *Nigeria: Disaster Risk Reduction Profile*. Retrieved from https://www.undrr.org/country/nigeria

UNICEF. (2025, June 3). *Nigeria Sitrep - Flash Floods in Mokwa, Niger State (03 June 2025)*. ReliefWeb. Retrieved from https://www.unicef.org/media/171581/file/Nigeria-Humanitarian-SitRep-(Flash-Floods-in-Mokwa)-03-June-2025.pdf.pdf

Waseem, M., Arshad, M., & Hassan, M. (2023). Geospatial Assessment of Flood-Prone Areas in Gombe Local Government Area, Gombe State, Nigeria. *Journal of Water Resources and Hydrology*, *10*(12), 1-15.

WeatherWorks Inc. (2020). *Hurricane Tracks and Life Cycle in the Atlantic*.

World Meteorological Organization (WMO). (2023). *Characteristics of tropical cyclones*.