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Posted Date: November 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11183917/v1

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Additional Declarations: No competing interests reported.

Understanding the Socioeconomic Effects of Flooding on Households and Coping Strategies in Jalingo Local Government Area, Nigeria

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Abstract

Flooding constitutes one of the most pervasive and disruptive environmental hazards in Sub-Saharan Africa, yet its specific socioeconomic ramifications in secondary urban centers remain inadequately documented. This study employed a mixed-methods approach, integrating GIS-based flood vulnerability mapping with household surveys (n = 400) to assess physical exposure, livelihood disruptions, health risks, and household coping strategies among flood-affected households in Jalingo, Nigeria. The findings reveal that over 60% of the study area falls within moderate to very high flood vulnerability zones, predominantly concentrated along the floodplains of the Lamurde and Mayogwoi rivers. The 2022 flood event damaged 34.8% of residential structures and precipitated extensive losses in agriculture, infrastructure, and public health. More than 68% of households reported experiencing flood-related diseases, while school-aged children faced educational disruptions due to impassable roads (45.7%) and damaged facilities (31.9%). Critically, 42% of households adopted no

coping strategies, and 68% lacked alternative income sources. Institutions' responses and relief support were perceived predominantly as inadequate. These findings elucidate the intricate relationship between environmental exposure, socioeconomic vulnerability, and constrained adaptive capacity. The study underscores the imperative for integrated disaster risk management, livelihood diversification, and robust urban planning aligned with the Sendai Framework and the Sustainable Development Goals. The integration of spatial analysis with community-level data provides a replicable framework for assessing urban flood risk in similarly vulnerable contexts across Sub-Saharan Africa.

Keywords: Household vulnerability, socioeconomic impacts, Coping strategies, Urban resilience, Disaster risk reduction, Climate adaptation

1. Introduction

Flooding represents a widespread and catastrophic natural hazard with profound global societal implications. It disproportionately affects low- and middle-income countries characterized by inadequate infrastructure and limited institutional capacity, resulting in unprecedented socioeconomic consequences, human suffering, and environmental degradation (Christian et al., 2021). Flooding constitutes a significant environmental challenge arising from multiple factors such as deforestation, urbanization, and deficient urban drainage systems (Güneralp et al., 2015; Barnieh et al., 2020; Padonou et al., 2021; Tiepolo & Galligari, 2021). As one of the world's most devastating natural disasters, flooding accounts for 44% of all disaster events from 2000 to 2019, affecting over 2 billion people and resulting in substantial economic losses (Djalante, 2019). This environmental disaster disrupts lives and livelihoods, significantly undermining national efforts to achieve the Sustainable Development Goals (SDGs). The impacts of flooding exhibit considerable spatial and temporal variability, contingent upon the location and extent of inundation, as well as the vulnerability and significance of affected ecosystems and built structures (Bhattacharjee &

Behera, 2018; Ologunorisa et al., 2022). The frequency and intensity of flooding events are escalating annually, adversely affecting the social and economic conditions of the affected countries. The Sendai Framework for Disaster Risk Reduction (2015-2030) emphasizes comprehending disaster risk in all dimensions, including exposure, vulnerability, and capacity, as a prerequisite for informed decision-making (UNDRR, 2015). It advocates integrating disaster risk reduction (DRR) into development strategies, particularly strengthening the resilience of economically disadvantaged and marginalized populations. Similarly, SDG Goal 11 underscore the necessity of transforming cities and human settlements into inclusive, safe, resilient, and sustainable entities, with a specific target to substantially reduce the number of people affected by disasters (UN, 2015).

Flooding in Nigeria has emerged as a critical environmental and socioeconomic concern, affecting both rural and urban areas (Ologunorisa et al., 2022). The country's geographical location, characterized by extensive river systems and coastal regions, compounded by climate change and rapid urbanization, exacerbates the intensity and frequency of flooding incidents. In recent years, the compounded effects of rapid population growth, inadequate urban planning, and insufficient waste management infrastructure have further heightened exposure to flood hazards, particularly in secondary cities such as Jalingo. These urban centres experience direct physical damage and cascading effects on public health, education, and local economies, disproportionately impacting vulnerable groups, including women, children, and low-income households (Adesola et al., 2024). Flooding's long-term consequences extend beyond immediate displacement and property loss, often resulting in persistent health challenges, disruption of educational activities, and erosion of social capital, thereby deepening poverty cycles and impeding sustainable urban development.

Over the past 20 years, floods have increased in Nigeria at an unprecedented rate, making it one of the most vulnerable countries to water-related disasters in Sub-Saharan Africa. The

socioeconomic consequences of flooding in Nigeria, like those in other developing countries, are multifaceted and impact various aspects of life and development. In addition to displacements and deaths, outbreaks of diarrhea and other waterborne diseases are significant effects of floods (Gong et al., 2019; NEMA, 2022; Adesola et al., 2024). According to Adesola et al. (2024), over 600,000 animals were perished, and large poultry farms, commercial pig farms, commercial cattle operations, and crop investments worth approximately $20 million were lost during the 2022 floods. Nigeria has a history of small-scale and large-scale floods events, occurring in three distinct forms: fluvial (river overflow), coastal (impacting shoreline regions), and pluvial (flash floods following intense storms in urban areas on low-lying terrain, particularly where surface water management is inadequate or drainage system are obstructed by municipal solid waste and sediments) (Otomofa et al., 2015; Zarma et al., 2020; Mfon et al., 2022). The economic burden of displacement is immense, affecting livelihoods, housing, and access to essential services and exacerbating poverty and inequality. Nigeria has experienced numerous floods, with major flood events in 1973, 1974, 1985, 1988, 2000, 2005, 2007, 2009, 2010, 2011, 2012, 2013, 2018, 2019, 2021, and 2022 (Adelekan, 2016; Angelakis et al., 2023; Nkwunonwo, 2016; Umar & Gray, 2023). The 2022 floods were the most devastating since 2012, affecting 34 out of 36 states, claiming over 600 lives, displacing more than 1.3 million people, with damages and losses estimated at $9.12 billion (Onefeli et al., 2023; Umar & Gray, 2023). The impacts extend beyond immediate physical destruction to include long-term disruptions to agricultural production, health systems, and local economies. For example, the loss of livestock and commercial farms during the 2022 floods has had cascading effects on food security and rural livelihoods, while repeated flooding events have contributed to forced migration and community fragmentation.

Zarma et al. (2020) reported that Northeast Nigeria experienced two significant floods from September to October 2012, resulting from intense rainfall, outflow from the Lagdo Dam, and River Benue flooding. The inundation submerged hundreds of kilometers of rural and urban land, displacing an estimated 1.3 million individuals and causing approximately 431 fatalities, along with extensive destruction of farmland. Similarly, Danjuma et al. (2021) documented significant impacts in the Jambutu ward of Yola North Local Government Area (LGA), with agriculture most severely affected through crops and farmlands destruction, while transportation disruptions hindered agricultural production due to the inability to transport goods. Oruonye (2012) revealed that the 2011 flood disaster ravaged three northeast states (Taraba, Borno, and Bauchi), with over 4000 farms washed away and over 5000 houses destroyed. In Taraba state alone, 2068 farms and 368 houses were swept away, 1,562 houses damaged, over 6,213 people displaced, and 1,420 households affected in Jalingo, Lau, Ardo Kola, and Yorro LGAs.

Despite these negative impacts, flooding plays a crucial ecological role by recharging groundwater systems, fills wetlands, transporting nutrients, increasing fishing activities, and triggering dispersal, migration, and breeding (Adelalu et al., 2020; Oruonye, 2016). Thus, effective flood management strategies must balance hazard mitigation with preserving essential ecosystem services. Mitigating flood disasters can be achieved through improved drainage systems, construction of flood breaks, and preventing construction on water channels (Ikyapa et al., 2022; Sun et al., 2023).

Jalingo is undergoing rapid urbanization, with over 240,000 people in 2022. Developmental activities are occurring in major metropolitan centers, especially in rapidly expanding towns like Jalingo, where urban expansion and settlement encroachment in flood-prone areas are progressing rapidly (Oruonye, 2015). Flooding events leave inhabitants of environmentally insecure and flood-prone zones vulnerable, particularly in the context of

urban expansion and development. This further intensifies the flooding rate in the central and lower sections of the Lamurde and Mayogwoi Rivers (Oruonye, 2015). The high population density, extensive violation of planning directives, outdated buildings stock, poor construction quality, and uncontrolled solid waste dumping in canals, streams, and rivers render Jalingo neighbourhood extremely vulnerable to flooding (Oruonye & Kuje, 2016). The National Emergency Management Agency reported that over 100 buildings were submerged; lives were lost, and the Nukai bridge was covered by floodwaters, in numerous structures destroyed in Jalingo as a result of prolonged rainfall (NEMA 2022). Oruonye and Kuje (2016) noted that the increased clustering of buildings around the streams and the Mayogwoi River narrows watercourse, resulting in an uneasy runoff after heavy downpour and leading to flash floods. Drainage blockage, commonly caused by solid waste deposition, further worsen Jalingo's vulnerability to flooding events.

The 2022 flood in Jalingo exemplifies these challenges, resulting in significant displacement, economic losses, and disruption of essential services. The impacts extend beyond immediate destruction, as affected households face persistent threats to health, livelihoods, and education, with vulnerable populations bearing the greatest burden. The increasing frequency and severity of flood events, projected to intensify under future climate and urbanization scenarios (IPCC, 2022; Angelakis et al., 2023). Addressing these issues requires an integrated approach that combining robust data collection, spatial analysis, and participatory engagement with affected households to inform adaptive policy interventions and sustainable urban planning. This study aims to describe the socioeconomic effects of the flooding on affected households, contributing to localized disaster risk knowledge and informing adaptive policy interventions. By employing a multidimensional assessment framework and considering both the negative and positive impacts of flooding, this research seeks to advance the scientific understanding of urban flood risk and resilience, providing actionable insights

for policymakers, urban planners, and disaster risk practitioners in Jalingo and similar rapidly growing urban centers.

2 Materials and methods

2.1 Study area

Jalingo is located in Taraba State, Northeastern Nigeria, between Latitudes 8° 55′ and 9° 0 ′ N, north of the Equator, and Longitudes 11° 15′ and 11° 25 ′ E, covering approximately 195 square kilometers (Fig. 1). Jalingo LGA had a population of 140,318 persons in 2006 (Yusuf et al., 2022) projected to be 220,700 persons in 2022, using an annual population growth rate of 3%. It is bounded east by Yorro LGA and west, north, and south by Ardo-Kola LGA. Jalingo comprises ten wards: Barade, Kachalla-Sembe, Kona, Majidadi, Mayogwoi, Sarkin Dawaki, Sintali, Turaki A, Turaki B, and Abbare-Yelwa (Oruonye, 2016). Average yearly precipitation is 1,200 mm, and typical annual temperatures of approximately 29°C (Yusuf et al., 2022). Two distinct seasons characterize the area: the dry season (November to March), and the wet season (April to October). Climate change has led to notable alteration in rainfall patterns, resulting in more intense precipitation. Humidity levels are moderate, ranging from 60-70% during the dry season and dropping to 35-45% in the rainy season (Yusuf et al., 2022). The area comprises a mix of urban and peri-urban settlements and experiences seasonal flooding due to its topography, rainfall patterns, and poor drainage infrastructure. The 2022 flood severely impacted the area, displacing thousands of residents and damaging property and farmlands (NEMA, 2022).

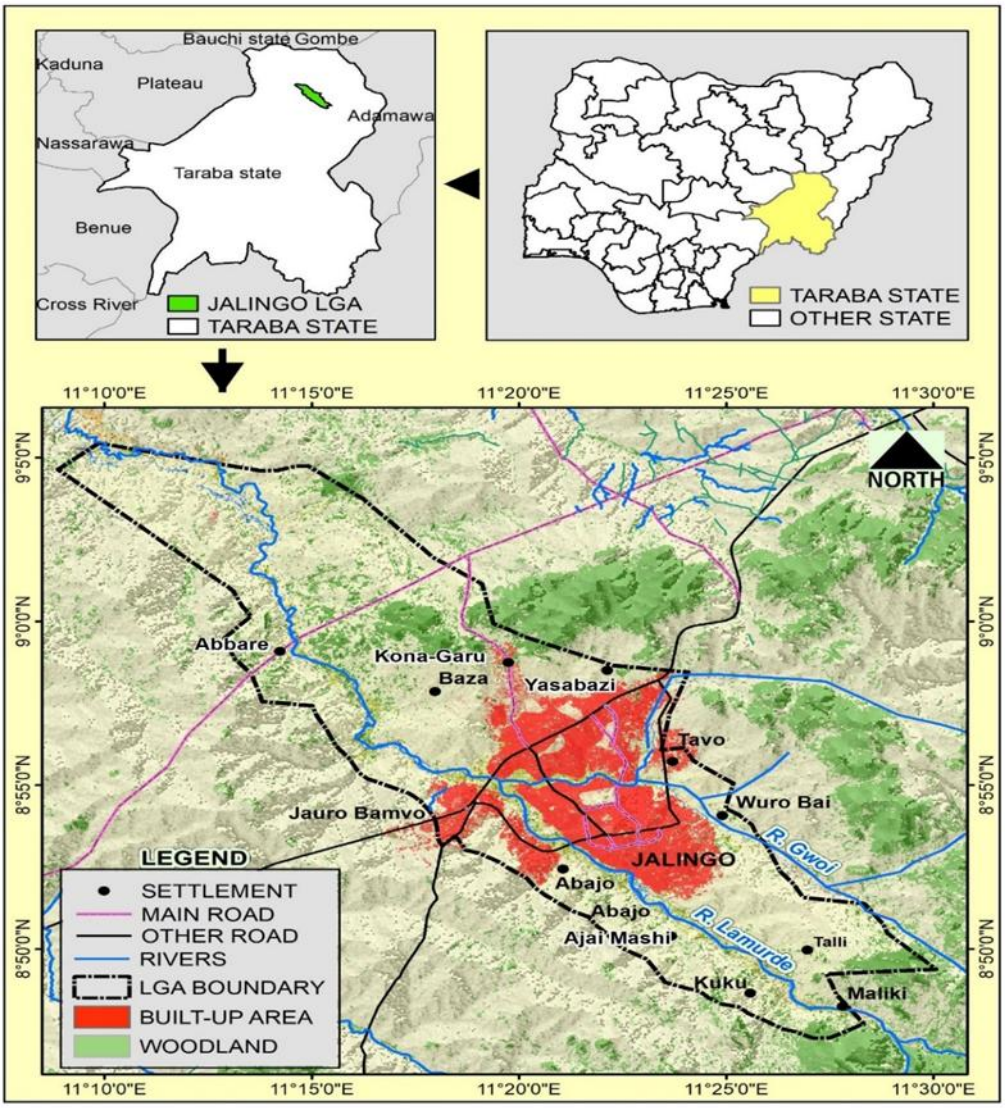


Figure 1: Location of the study area (Map showing Jalingo LGA with Taraba State, Nigeria, with administrative ward boundaries)

2.2 Research design data collection

A descriptive cross-sectional design was adopted using a mixed-methods approach, enabling quantitative measurement of household-level impacts and qualitative exploration of experiences and coping mechanisms. The field survey was designed in three phases: (1) coverage of urban built-up areas and floodplains across Jalingo; (2) coverage of the ten political wards; and (3) administration of structured questionnaires to prevent redundant

surveying of the same feature. The sampled wards had a total population of 308,181 (NPC, 1991, projected to 2023). Yamane's (1967) sample size determination method was employed, yielding a sample size of 400 respondents, calculated using Equation 1:

$$n = \frac{N}{1+N(e)2} \quad (1)$$

Where:

n = sample size

N = total population

$(e)^2$= level of precision (0.05)

The sample size for each ward was then calculated based on the proportion of the ward using probability proportional to size sampling, expressed in Equation 2:

$$ni = \frac{Ni}{N} \times n \quad (2)$$

Where:

n = the total sample size (400 questionnaires)

N = total population of Jalingo (sum of all the wards)

N_i = population of ward i

n_i = number of questionnaires administered in ward i (number of respondents selected)

$\frac{Ni}{N}$ = proportion of the total population that resides in the ward i

This study was conducted in accordance with the Declaration of Helsinki and relevant national and institutional guidelines for research involving human participants. All experimental protocols were reviewed and approved by the Ethics Committee of the College of Management and Social Sciences, Kwararafa University Wukari, Taraba State, Nigeria (Approval Number: KUW/MSS/EC/2025/064). Before data collection, the purpose and scope of the study were explained to all participants in English and the local language (Hausa). Written informed consent was obtained from all individual participants and/or their legal guardians before their inclusion in the study. Participants were assured of the confidentiality and anonymity of their responses, and they retained the right to withdraw from

the study at any time without consequence. All data were collected and handled in accordance with institutional data protection guidelines.

2.3 Sampling procedure

This study employed a multi-stage sampling approach to assess socioeconomic flood vulnerability in Jalingo. In the first stage, purposive sampling was used to select households within political wards that had experienced flooding. This non-probability sampling technique is commonly used in disaster research to intentionally select information-rich cases directly relevant to the research objective (Stratton, 2019; Shah et al., 2022). Purposive sampling ensured that only households with firsthand flood experience were included. In the second stage, systematic sampling was employed to select household heads (regardless of gender) from selected households every 10 counts, with each ward weighted in proportion to its population size. As adopted in this research, Shah et al. (2022) noted that subject must be household heads or their representatives in systematic sampling to ensure information reliability and reduces researcher discretion. Although the survey questionnaire was written in English, it was administered to some respondents in the local language (Hausa). To confirm the validity and reliability, a pre-test was conducted on 20 households outside the sample. Six research assistants (students from Taraba State University, Jalingo) facilitated data collection.

2.4 Data analysis

The first objective was achieved by creating vulnerability and baseline maps using ArcGIS platform, ArcMap 10.8 software, and Esri to acquire the digital elevation model. SPSS was used to determine vulnerability percentages. The second objective - assessing the socio-economic effects involves coding quantitative data in MS Excel and analyzing using SPSS 26 for descriptive statistics. The third objective was to examine the coping strategies was conducted based on livelihood indicators provided by the UNDP (2007). Results were presented in tables, charts, graphs, maps, and photographs.

3 Results and Discussion

3.1 Assessment of the vulnerability and baseline maps using GIS

3.1.1 Land use/land cover change in the study area

LULC changes in Jalingo between 2013 and 2023 (Fig. 2 and Table 1) reveal significant transformations likely influencing flood vulnerability. Over the decade, built-up areas increased significantly from 7.09% to 13.81% of the total land area, nearly doubling in size. This rapid urbanization typically leads to increase impervious surfaces (roads, buildings, and pavements), reducing the natural rainwater infiltration. Consequently, increased surface runoff generated during rainfall events heightens flooding in Jalingo. Simultaneously, woodland coverage decreased from 26.55% to 11.08%. Woodlands are crucial for rainfall interception, soil infiltration, and land stability; their reduction could increase flood risks. Additionally, declining bare surfaces indicates land-use conversion, much becoming impermeable due to increased built-up areas.

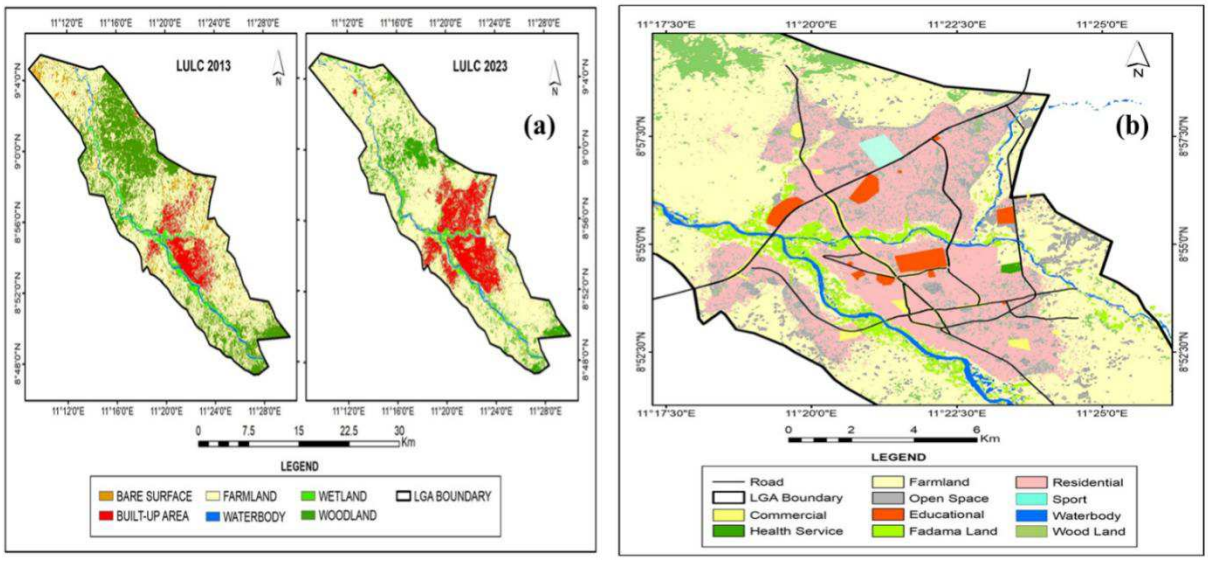


Figure 2: LULC analysis of Jalingo, (a) Land cover change map depicting changes between 2013 and 2023, (b) Land use map of the study area

Table 1: LULC changes in Jalingo between 2013 and 2023

LULC CLASS	LULC 2013	LULC 2023	LULC Change

	Area (Km²)	%	Area (Km²)	%	Area (Km²)	Annual Rate (%)
Bare Surface	13.47	3.36	6.71	1.67	-6.77	-5.02
Built-up Area	28.46	7.09	55.44	13.81	26.98	9.48
Farmland	232.43	57.89	271.58	67.63	39.14	1.68
Waterbody	6.59	1.64	7.89	1.96	1.29	1.96
Wetland	13.95	3.47	15.42	3.84	1.47	1.06
Woodland	106.62	26.55	44.50	11.08	-62.13	-5.83
Total	401.53	100.00	401.53	100.00		

Farmland increased from 57.89% to 67.63%, potentially affecting hydrological responses based on farming methods. While intensive agriculture can cause soil compaction and reduced infiltration, sustainable practices may help mitigate runoff. However, the overall increase in farmland combined with urban growth and woodland loss suggests a landscape less capable of managing heavy rainfall naturally. Slight increase in waterbodies and wetlands could temporarily store surplus water and provide flood protection. However, these increases are small compared to significant reduction and urban expansion. Figure 2 shows that land uses are concentrated around the Rivers Lamurde and Mayogwoi. This result aligns with Ojeh et al. (2022) and Gabriel & Ezekiel (2023), who revealed that most households live close to these rivers and are highly vulnerable to flooding. Without adequate flood management strategies and sustainable land use planning, these changes could lead to more frequent, intense, and damaging floods, posing risks to infrastructure, livelihoods, and the environment.

3.1.2 Analysis of flood vulnerability

The flood hazard map of Jalingo was generated using weighted sum overlay analysis in ArcGIS 10.8, where each contributory criterion was multiplied by its corresponding weight and combined to create a flood vulnerability index map ranging from 1.26 to 4.78. The index map was reclassified into five classes (very low, low, moderate, high, and very high) to

describe spatial variability of flood vulnerability (Fig. 3a). Table 2 presents the statistical extent of each flood vulnerability zone. The flood vulnerability assessment was conducted using a systematic weighted sum overlay analysis in ArcGIS 10.8. Figure S1 presents the methodological flowchart illustrating the step-by-step procedure from data acquisition to final vulnerability map generation. This framework integrates multiple biophysical and anthropogenic factors, each assigned appropriate weights based on their relative contribution to flood risk. The resulting vulnerability index was subsequently reclassified into five distinct classes to facilitate spatial interpretation.

Table 2: Flood vulnerability classes

Vulnerability Rank	Flood Vulnerability Class	Area (Km^2)	%
1	Very Low	46.23	11.52
2	Low	107.95	26.88
3	Moderate	94.96	23.65
4	High	76.05	18.94
5	Very High	76.32	19.01
Total		401.52	100.00

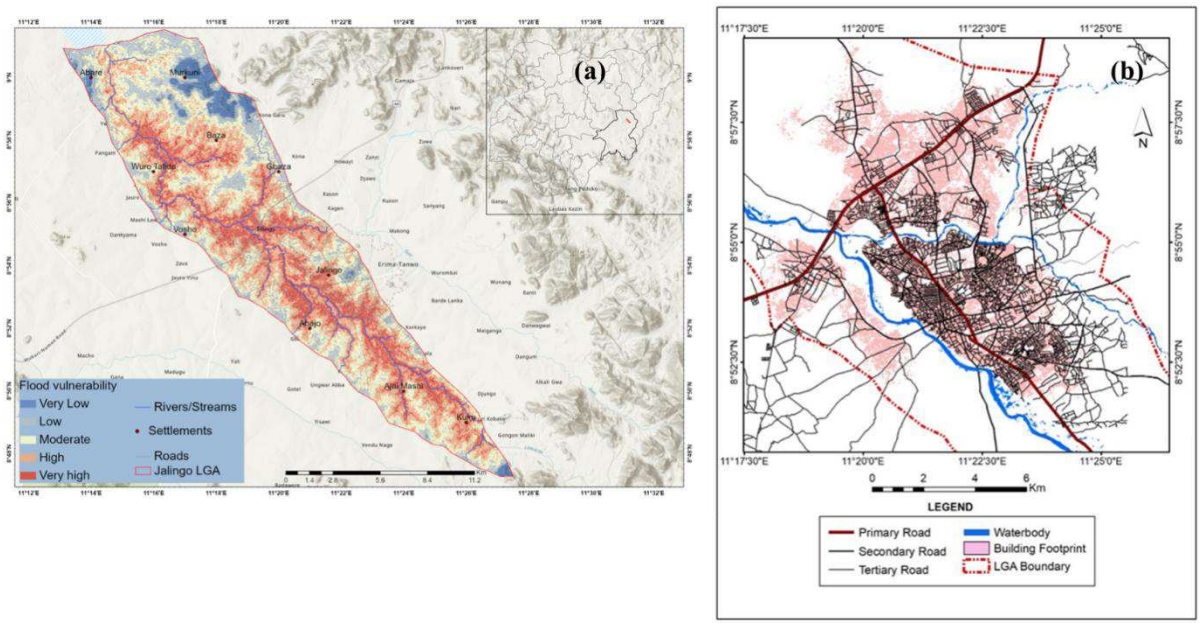


Figure 3: Map of the study area showing (a) Flood vulnerability, (b) Building structure

The flood vulnerability assessment reveals varying levels influenced by topography, land use, and settlement patterns. Very high vulnerability areas cover 76.32 km² (19%) while high vulnerability zones comprise 18.94% of total land. These zones concentrate along the River Lamurde and Mayogwoi floodplains, where urban expansion has increased surface runoff. Moderate vulnerability areas span 94.96 km² (23.65%), influenced by elevation and land cover. Low and very low vulnerability zones constitute 38.4% of the area (107.95 km² and 46.23 km², respectively), typically located in higher-elevation northern areas. The settlement pattern in Jalingo, with dense building concentrations near these rivers, places many residents in moderate to very high flood vulnerability zones. This is consistent with Oruonye (2015) and Adelalu & Bwadi (2023), who observed that urbanization and building constructions have encroached on the River Lamurde and Mayogwoi floodplains.

3.1.3 Vulnerability of households to flood

As farming is the primary source of income, increased flood exposure will heighten vulnerabilities by affecting income and purchasing power. As illustrated in Fig. 3, approximately 54% of households are situated in flood-prone areas along both riverbanks,

and about 62% of the area is susceptible to flooding. Using the fundamental indicator "population dwelling in hazard-prone areas" (UN, 2007), the situation is concerning because the Lamurde River significantly contributes to the area's vulnerability. Based on the questionnaire survey, most residents live in these places due to financial capability (35%), business opportunities (29%), low costs, availability of land (16%), and family ties (15%).

3.2 Socioeconomic effects of flooding on households in the study area

3.2.1 Socio-demographic characteristics of the respondents

(a) Household demographics

The sampled households indicate that 88% were male-headed and 12% female-headed. The majority of household heads were between 26 and 35 years old (Figure 4a). Results showed that most households (37%) had only primary education, 27% had secondary education, 20% had attained tertiary education, and 6% had vocational qualifications (Figure 4b). A significant percentage (10%) were illiterate. This distribution is strongly linked to flood impacts, as educational status shares socioeconomic effect. Lower education implies increased vulnerability, reduced adaptive capacity, and heightened long-term hardship, supporting existing literature suggesting that lower education and dependence on climate-sensitive sectors significantly affect a household's adaptive capacity (Omolo & Mafongoya, 2019; Opiyo et al., 2014).

(b) Livelihood pattern

Figure 4c illustrates the livelihood patterns, showing that in Jalingo, the highest livelihood source is farming (37.6%), trading/business (24.5%), civil service (17.8%), fishing (14.3%), and unemployment (1.8%). Since farming is the primary source, increased flood exposure further heighten vulnerability by threatening household food security and potentially pushing families into poverty. Household heads involved in business or trade face

similar risks, as flooding can damage goods, disrupt market access, and cause financial instability, especially for small-scale traders lacking recovery resources.

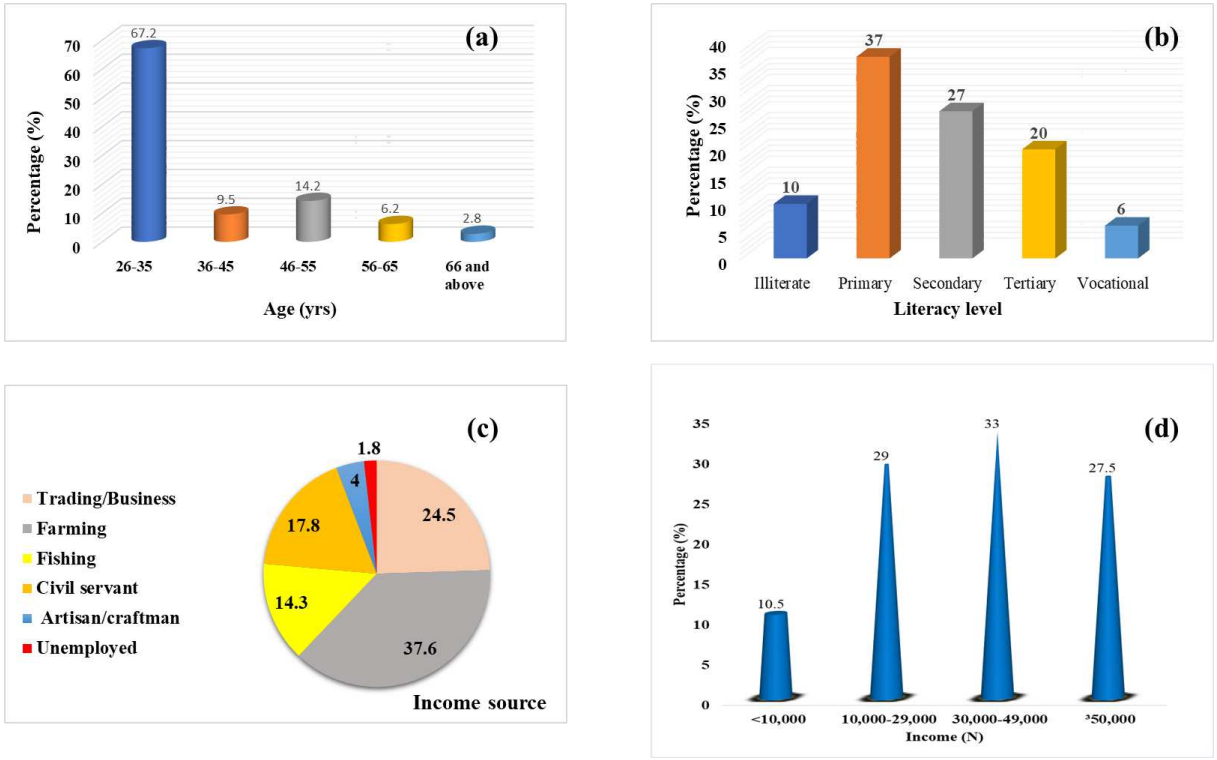


Figure 4: Socio-demographic characteristics of household heads (a) Analysis of household heads by age group (b) Analysis of educational status of households (c) Comparative analysis of livelihood pattern (d) Analysis of income of households

3.2.2 Flood impacts on physical assets

Examining flood effects on physical household assets in Jalingo uncovered significant socioeconomic disruptions threatening immediate well-being and future development paths. Figure 5 shows that residential structures bear the brunt of flood events, with 34.8% of the reported damages affecting houses and buildings. This high destruction rate indicates not only immediate loss of physical shelter but also deterioration of household stability, security, and privacy. Residential damage forces displacement, exposes households to adverse weather and health risks, and heightens reliance on limited public or communal shelters. Disrupting spatial and social connections triggers cascading impacts on household productivity, educational continuity, and social cohesion (Dinh et al., 2021). The socioeconomic impact is further

exacerbated by the significant loss of farmland (18.2%) and livestock (14.2%), essential components of rural livelihoods. Loss of fertile land and the death or displacement of livestock significantly decrease agricultural production, lower household income, and threaten local food security. Since agriculture remains the primary source of employment and sustenance in Jalingo, such losses threaten individual households and pose a systemic risk to the area's economic stability.

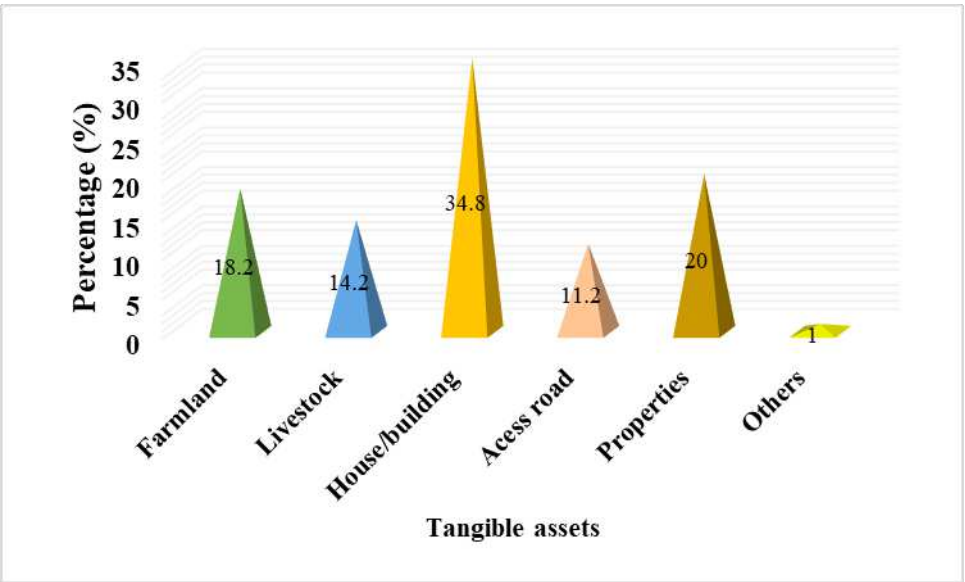


Figure 5: Analysis of flood impacts on physical assets in the study area

Additionally, damage to physical properties (20%) and access roads (11.2%) reduces functionality of both private and public sectors. Roads restricts movement, hampers emergency responses, and limits access to markets, schools, and healthcare centers. These disruptions deepen community seclusion and delay recovery efforts, further solidifying poverty and marginalization. The combined effect of these assets-specific damages reflects infrastructure, livelihoods, and welfare interdependence in disaster-affected communities, aligning with Islam & Walkerden (2022) and Ahmad et al. (2021). In Jalingo, where economic and infrastructural challenges already limit household resilience, floods worsen vulnerability by depriving households of productive assets and weakening adaptive capacity.

3.2.3 Flood impacts on health, water, and sanitation

Results revealed that most of the sampled households (68.8%) suffered from one disease or another due to the floods. Although 65.2% indicated health facilities were affected by the flood, 72.5% reported having access to health facilities, compared to 58.3% who had easy access and 41.7% who did not. Results in Fig. 6 indicates that socioeconomic impacts are complex and reflect global trends seen in flood-susceptible area. The significant occurrence of malaria/fever (38.5%), typhoid (18.5%), and diarrhoea (11.2%) highlights the established connection between flooding and increased vector-borne and waterborne diseases (Fig. 6a). These findings align with global and regional studies showing that floods create perfect conditions for mosquitoes breeding and spread pathogens through contaminated water sources, leading to malaria, dengue, cholera, and leptospirosis (Escobar et al., 2022; James et al., 2018; Onyeke, 2024). Sanitation infrastructure (Fig. 6) reveals that only 41% of households have access to toilets or water closets, while 27% practice open defecation, heightening disease spread risk, a pattern observed globally in post-flood conditions (Rina Khushi et al., 2024; Sharma et al., 2022).

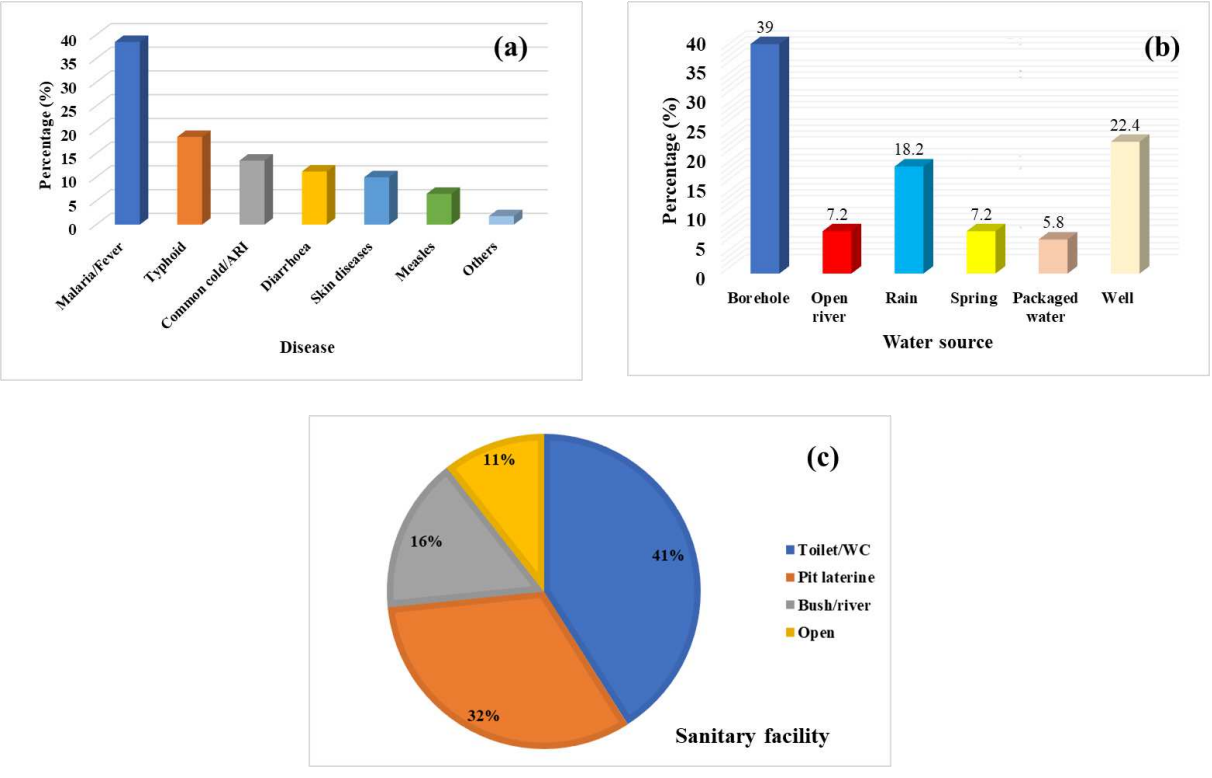


Figure 6: Analysis of flood impacts on health, water, and sanitation (a) Distribution of diseases experienced, (b) Water sources in the area, (c) Types of sanitary facilities

Socioeconomic impacts extend beyond health. Floods often lead to property damage, livelihoods loss, and forced displacement, increasing household vulnerability. Research from Thailand and the Philippines indicates household incomes can be reduced by 10-23% after major flooding events, while health and food spreading rises sharply as families struggle with increased disease burden and productive assets loss (Ashikbayeva et al., 2020; Walsh, & Hallegatte, 2020). In Jalingo, most households (39%) depend on boreholes and wells (22.4%) for water needs (Fig. 6b). In addition, a considerable reliance on rainwater, open rivers, and springs indicates a vulnerable water supply system highly susceptible to contamination during floods, further exacerbating poverty and food insecurity. Furthermore, inadequate sanitation and water infrastructure reflects findings from Latin America and Southeast Asia, where low-income communities with poor infrastructure and limited access to healthcare suffer the most from disease outbreaks and economic disruptions following floods (Acosta-España et al., 2024; Ashikbayeva et al., 2020). The combined effect of these vulnerabilities is evident in increased prevalence of skin diseases (10%) and respiratory infections (Fig. 6c), along with mental stress linked to displacement and overcrowding in temporary shelters (Kassegn & Endris, 2021; Sharma et al., 2022). These conditions affect immediate health outcomes and have long-lasting implications for educational attainment, workforce participation, and social cohesion.

3.2.4 Flood impacts on education

Figure 7 shows flood effects on education in Jalingo. Results show that impassable roads (45.7%) and damaged schools (31.9%) are the most significant effects, followed by schools surrounded by water (18.1%), submerged schools (2%), and other disruptions (2.3%). The combined effect of physical inaccessibility and structural damage presents a significant

barrier to continuing education. Frequent roads impassability implies that even when schools remain structurally intact, students often cannot attend due to infrastructural failures. In Jalingo, where transportation infrastructure is already inadequate, such disruptions exacerbate existing educational inequalities and erode the resilience. School closures impact household livelihoods and socioeconomic mobility. In Jalingo, where many households depend on farming and informal labour markets, children's school absence due to floods can increase their involvement in household survival strategies, further eroding educational opportunities. These interruptions in education disproportionately affect vulnerable groups, especially girls and children with disabilities, exacerbating social inequalities (Mfon, 2024).

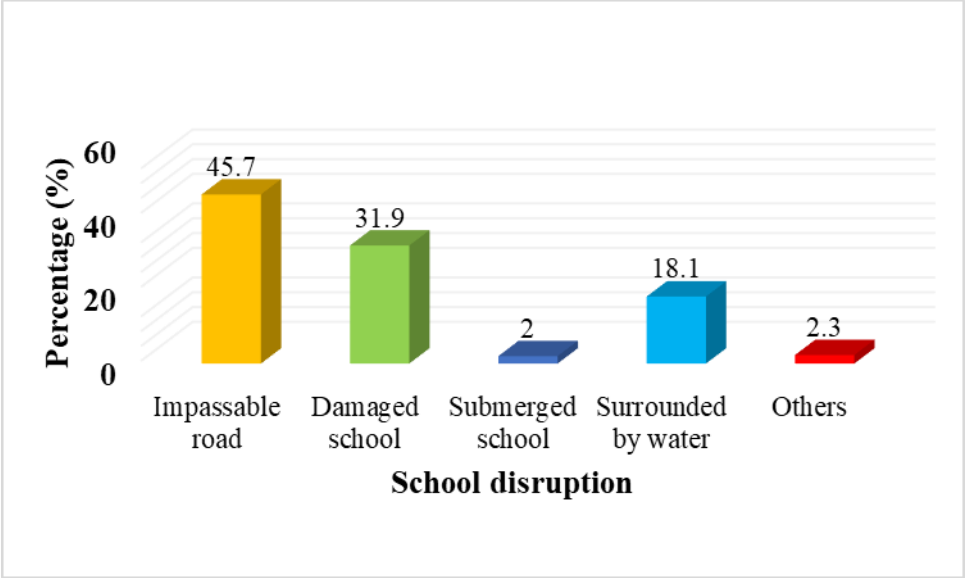


Figure 7: Analysis of flood impacts on education

Additionally, school facility destruction or damage (31.9%) indicates a shift of limited public and private resources towards reconstruction rather than educational improvements. Households may need to support temporary learning setups, transportation, or learning materials, adding financial pressure on those dealing with flood-related health and livelihood losses. Psychosocial effects on children experiencing disaster-related school displacement can reduce learning abilities and long-term academic success, resulting in less favourable employment prospects in adulthood (Gibbs et al., 2019; Pacheco et al., 2022). Education

414 effects are closely related to earlier findings on health, water access, and sanitation
415 challenges. Children in flood-affected households are more likely to suffer from illnesses
416 such as malaria and diarrhea, preventing school attending and adding to household's medical
417 expenses. Inadequate sanitation and water facilities in temporary or flood-affected schools
418 can pose additional health risks, especially for adolescent girls facing increased barriers to
419 attending school during their menstruation (D'Cunha, 2023).

420 **3.3 Underlying Causes and Coping Strategies adopted by Households**

421 **3.3.1 Underlying causes of floods**

422 Figure 8 illustrates that environmental changes and human activities cause flooding in
423 Jalingo, similar to other parts of Nigeria. It reveals that 21% reported rainfall as the primary
424 cause of flooding, followed by river overflow (19%). This may be because floods in Jalingo
425 typically occur during the rainy season, highlighting climate variability and hydrological
426 dynamics in urban flood risk. This is consistent with recent literature showing that climate
427 change has significantly impacted precipitation patterns in Sub-Saharan Africa, leading to
428 more intense rainfall and increased surface runoff that exceeding local soils and river
429 channels absorbing capacity (Banda et al., 2022; Geris et al., 2022; Oppong-Sekyere et al.,
430 2023). This implies increased occurrence of pluvial and fluvial floods, especially during peak
431 rainy season in Jalingo, which is susceptible to water accumulation due to its low-lying
432 terrain and closeness to river networks.

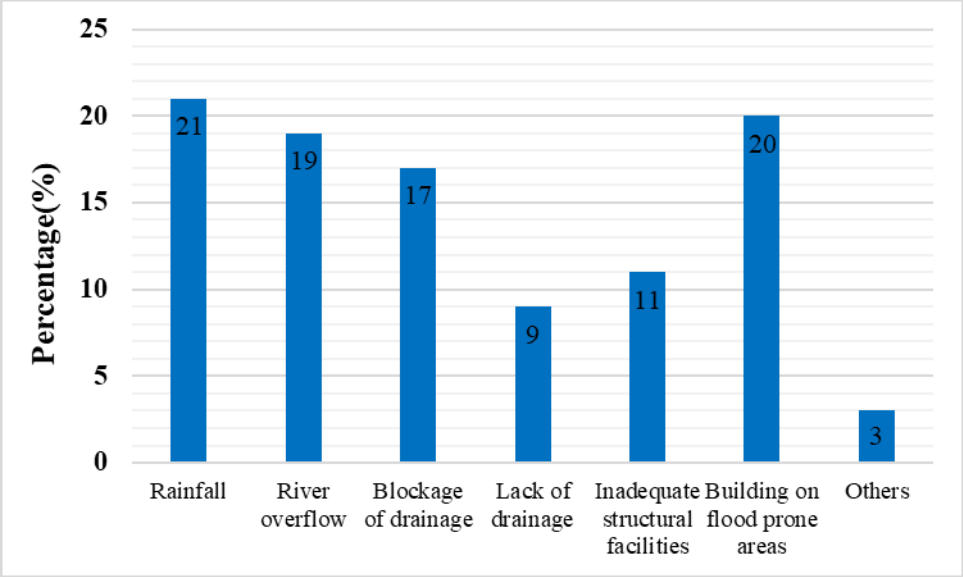


Figure 8: Analysis of the underlying causes of flooding in Jalingo

Furthermore, causes such as building in flood-prone areas (20%), blockage of drainage (17%), and inadequate drainage (9%) reveal a critical failure in urban planning and management. These suggest inadequate infrastructure and regulation lapses. Rapid urbanization without adequate drainage infrastructure leads to the encroachment on wetlands and floodplains, disrupting natural water flow and increasing runoff volumes (Echendu, 2020; Onifade et al., 2023; Veino Leslie et al., 2023). Inadequate structural facilities (11%) further highlight the poor quality of municipal systems, such as stormwater networks, embankments, and retention basins, which are essential factors in flood mitigation. These systemic challenges reflect broader institutional frailty in Nigeria's flood risk management and urban land use. As supported by the World Bank (2021), neglecting these vulnerabilities contributes to high socioeconomic costs, especially among low-income households lacking resilience and recovery resources.

3.3.2 Household Coping Strategies

Figure 9 shows coping strategies employed by households in Jalingo, revealing valuable insights into community capacity, awareness, and resources for managing flood risks. The most notable finding is that 42% of households do not adopt any coping strategy, suggesting

widespread vulnerability rooted in poverty, lack of awareness, and insufficient institutional support. Among those responding, the most commonly employed strategy is opening and clearing of drainage (24%), reflecting a basic, low-cost approach to flood mitigation. However, other households employ more resource-intensive measures, such as building or reinforcing wall fencing (14%), using sandbags (12%), and relocating to higher ground (8%). The findings imply that most households respond reactively rather than proactively, which is often inadequate during severe flooding.

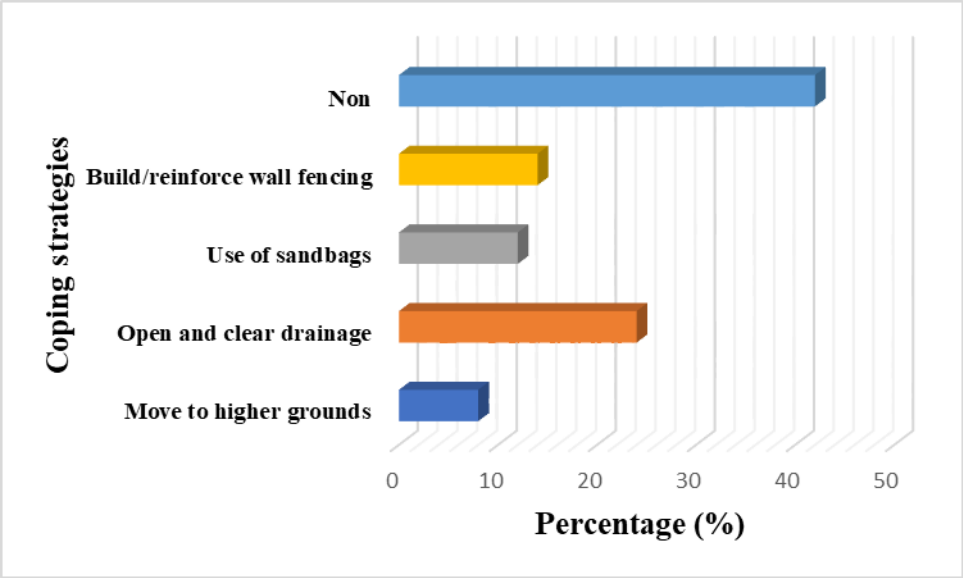


Figure 9 Analysis of coping strategies employed by households

Although these strategies are more infrastructural, they are not commonly employed due to significant costs and labour demands. For instance, building or reinforcing fencing may not be affordable for low-income households, and relocating to higher ground may require alternative housing or access to land. For many households in Jalingo, this option is impractical due to insecurity of land ownership and strong social connections to flood-prone locations. The prevalence of no action highlights larger systemic challenges in flood risk management. The Intergovernmental Panel on Climate Change (IPCC, 2022) highlights that socioeconomic constraints, institutional weaknesses, and limited access to technology and

infrastructure often impede adaptation to climate-related threats, such as flooding. This is consistent with the situation in many sub-Saharan African regions where informal settlements, poor urban planning, and inadequately funded governance structures limit community-level adaptation effectiveness (Amegavi et al., 2024).

3.3.3 Relief support

Figure 10 reveals relief support during or after flooding in Jalingo, highlighting inadequacies in the humanitarian aid system with severe socioeconomic implications. Results reveal that 39.2% of the respondents rated government and non-governmental organisations (NGOs) support as low, while 8% considered it non-existent, underscoring inadequate reach and effectiveness of emergency support. Only 1.8% indicated receiving substantial support. This implies that even when assistance is provided, it is unequally distributed or constrained by logistical, political, or institutional challenges. This highlights systemic inadequacy in local, national, and humanitarian authorities to address vulnerable populations' need during and after flood disasters.

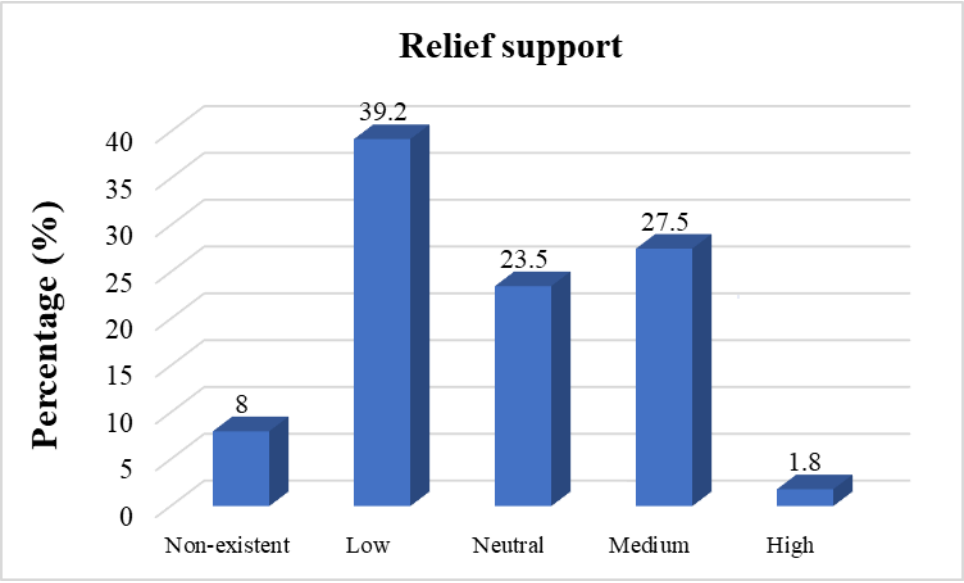


Figure 10: Analysis of household relief support and materials

The impact of inadequate relief systems is complex and closely connected to socioeconomic factors. When support is lacking or insufficient, it heightens poverty, prolongs recovery, and

increases affected households vulnerability. Households with inadequate support often resort to negative coping strategies such as reducing food consumption, withdrawing children from school, or incurring debts, exacerbating poverty cycles (Lahiri & Biswas, 2024). Additionally, 23.5% of respondents remained neutral, indicating lack of knowledge or expectations about relief materials, suggesting poor communication or public disappointment with institutional support systems. Without significant improvements in disaster preparedness, resource distribution, and inclusive response strategies, socioeconomic resilience of flood-prone communities in Jalingo will continue to decrease, heightening inequality and hindering development. This corroborates the report by Collins et al. (2025).

3.3.4 Alternative to livelihood

Figure 11 reveals alternative income sources for household in Jalingo, essential for enhancing household and community resilience, especially in coping with flooding events. Results show that only 32% of households indicate having an alternative livelihood source, while 68% do not, highlighting significant dependence on a single income source. When households lack diversification, their vulnerability increases, as they are less prepared to handle economic shocks and disruptions that flooding frequently causes. Furthermore, gender-based comparative analysis highlights inequalities in coping ability. Findings reveal that among male-headed households, only 43% have an alternative income source, compared to 57% of female-headed households.

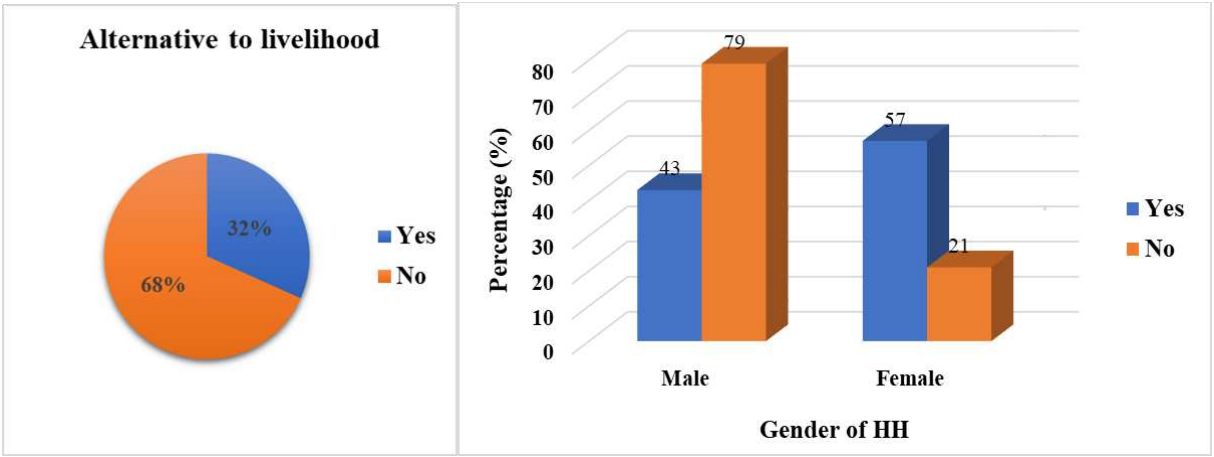


Fig. 11: Comparative analysis of household livelihood alternatives

This suggests that female-headed households in Jalingo are more likely to seek multiple income sources, possibly in response to heightened socioeconomic pressures for stable employment. The implication for the coping strategy is important. Jalingo, which is susceptible to floods and has previously seen thousands displaced, over 2,000 farms destroyed, and more than 6,000 people internally displaced (Oruonye, 2012), has a critical need to shift to alternative income-generating activities for survival and recovery. Households with diversified livelihoods, such as petty trading, livestock rearing, or off-farm work, can maintain some income and food security when floods disrupt primary activities like farming (Abdullahi et al., 2022; Mohammed et al., 2021). Conversely, household heads without alternatives often face prolonged hardship, become more dependent on external support, and experience delayed recovery, as their primary livelihood may have been destroyed by floodwaters (Arifah et al., 2022; Waldmueller et al., 2019). Similar studies in Nigeria and Ghana highlight that diversification is essential for building flood resilience. These studies indicated that women employ strategies such as cultivating fast-growing crops, engaging in petty trading, and raising livestock to mitigate flooding effect (Abdullahi et al., 2022; Mohammed et al., 2021). However, barriers such as limited capital, institutional support, and deep-rooted gender inequalities can hinder broader adoption of these coping strategies.

4. Conclusion

This study provides a comprehensive description of socioeconomic impacts and household coping strategies in Jalingo, a rapidly urbanizing area that faces increased hydro-meteorological risks. Employing an integrated approach combining spatial GIS-based flood vulnerability mapping with detailed household-level survey data, the study offers insights into systemic exposure, institutional weaknesses, and social vulnerability amid increasing flood incidents. Results reveal that more than 60% of Jalingo is located in areas with

moderate to very high flood risk. This vulnerability is primarily due to settlement expansion into floodplains, unsustainable land use changes (including 62 km² of woodland reduction), and inadequate drainage systems.

The 2022 flood led to various disruptions, affecting approximately 35% of homes, 18.2% of farmland, and over two-thirds of surveyed households reported waterborne and vector-related diseases, including malaria and typhoid. Across Jalingo wards, educational access was disrupted due to flooded roads and damaged schools. However, the most alarming indicator of systemic vulnerability is that approximately 42% of surveyed households adopted no coping strategies, and 68% lacked alternative income sources, indicating shortcomings in adaptive capacity and institutional preparedness. Relief support was inconsistent, with only 1.8% of respondents reporting adequate support, highlighting a failure in effective post-disaster response management.

Strategic Recommendations for Policy and Practice

1. Implementation of Zoning Regulations: Planners must implement zoning laws limiting construction in flood-prone areas near the Lamurde and Mayogwoi rivers. Guidelines should require permeable materials and retention basins to enhance water absorption.
2. Investment in Drainage Infrastructure: Investment in storm-water drainage systems, culvert repairs, and sediment removal is needed. Infrastructure projects must address riverine and surface flooding, focusing on "very high-risk " areas. Public works should integrate with community maintenance plans.
3. Development of Early Warning Systems: Without adequate flood alert systems, residents face risks of sudden evacuation and property loss. Meteorological agencies should partner with mobile providers to build community-led warning networks. Risk

education in native languages should be integrated into schools, religious centers, and media.

4. Livelihood Diversification Programs: Households vulnerable to flooding, especially those dependent on farming, need access to alternative income sources. Expanding key interventions, such as vocational training, small-scale trading support, microcredit access, and agricultural insurance, is essential, with focus on female-headed households with diverse livelihoods but limited assets.
5. Strengthening Disaster Management Institutions: The study reveals significant failure in local disaster management, such as poor relief logistics, unequal aid distribution, and low institutions trust. A disaster coordination platform should be established involving government agencies, NGOs, traditional leaders, and community-based organizations. This platform should implement clear aid allocation criteria, conduct participatory needs assessments, and incorporate feedback systems.
6. Prioritizing Public Health Resilience: Given frequent post-flood disease outbreaks, prioritizing public health resilience is crucial. Investment in flood-resistant health facilities, clean water access, and elevated sanitation units in schools and markets is recommended. These efforts should be supported by hygiene education initiatives and local disease monitoring systems to track outbreak risks during flood periods.

This study offers insights into how spatial exposure combines institutional neglect and social marginalization to create ongoing disaster vulnerability. Jalingo exemplifies how secondary cities, often neglected, are becoming centers of risk accumulation due to the rapid urbanization, climate-driven hydrological changes, and infrastructure deterioration. The trends identified are typical of numerous African cities trapped in a vicious cycle of reactive measures and insufficient preventive investment. The proposed framework integrating spatial data, community input, and policy feedback mechanisms provides a model for flood risk

management replicable in similar contexts. Aligning Jalingo's flood risk management strategy with global frameworks, such as the Sendai Framework, Urban Agenda 2030, and SDG 11, is essential from ethical and developmental perspective. Therefore, adopting an anticipatory, inclusive, and systemically integrated risk governance approach is crucial for establishing sustainable resilience among the urban poor in flood-prone Jalingo and similar urban areas. While this study provides a context-specific analysis of flood vulnerability in Jalingo, offering insights for urbanizing areas in Sub-Saharan Africa, it has limitations. Self-reported household information might lead to recall bias. GIS-based analysis, though spatially thorough, lacks dynamic hydrological modeling and climate projections. Institutional response evaluations rely on household perceptions due to limited administrative records. Despite these limitations, the study presents an empirically based framework for disaster risk management relevant to policy, serving as a basis for future research on urban resilience.

Author contributions: Precious Bawa Tani: Conceptualisation, Writing - original draft, Writing - review & editing, Visualisation, Validation, Software, Methodology, Formal analysis, Data curation. **Jinxi Song**: Writing - review & editing, Supervision, Project administration. **Oluwadamilola Oluwatoyin Hazzan**: Writing - review & editing, Validation. **Nyein Myint Myint**: Writing - review &editing. **Mukhtar Iderawumi Abdulraheem**: Writing - review & editing, Formal Analysis, Methodology, Investigation. **Huck Ywih Ch'ng**: Writing - review & editing, Validation. **Abd Al Karim Jaafar**: Writing - review & editing, Validation. All authors read and approved the final manuscript.

Funding: The authors declare that no funds, grants or other support were received during the preparation of this manuscript.

Data Availability Statement: Available upon reasonable request from the corresponding author

Competing interests: The authors declare no competing interests.

Ethical Consideration: This study was conducted in accordance with the Declaration of Helsinki and relevant national and institutional guidelines for research involving human participants. All experimental protocols were reviewed and approved by the Ethics Committee of the College of Management and Social Sciences, Kwararafa University Wukari, Taraba State, Nigeria (Approval Number: KUW/MSS/EC/2025/064). Before data collection, the purpose and scope of the study were explained to all participants in English and the local language (Hausa). Written informed consent was obtained from all individual participants and/or their legal guardians before their inclusion in the study. Participants were assured of the confidentiality and anonymity of their responses, and they retained the right to withdraw from the study at any time without consequence. All data were collected and handled in accordance with institutional data protection guidelines

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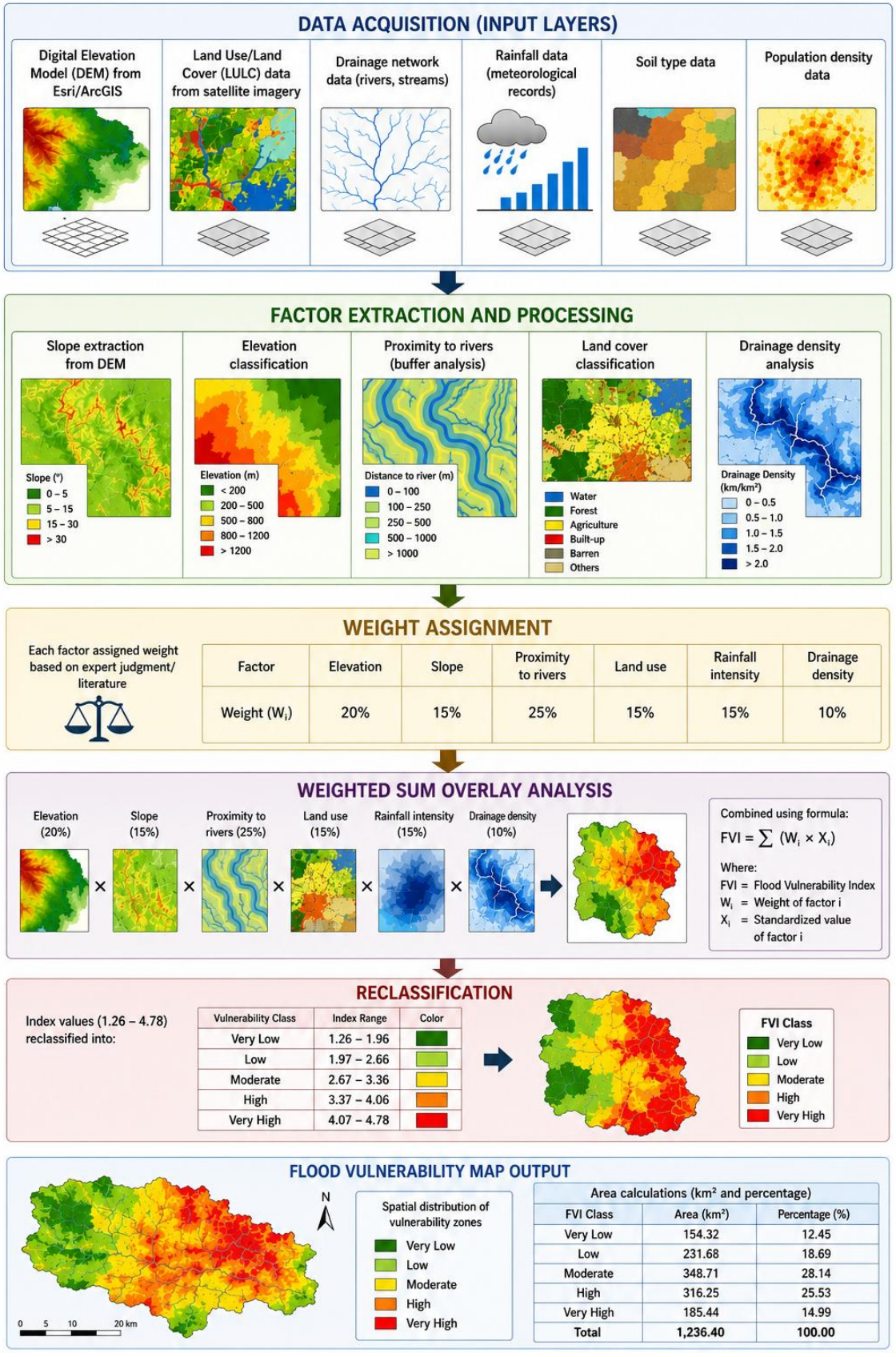


Figure S1: Flood Vulnerability Index Methodology Flowchart