International Journal of Allied Sciences (IJAS)
Volume.16, Number 6; June-2025;
ISSN: 2836-3760| Impact Factor: 8.13
https://zapjournals.com/Journals/index.php/Allied-Sciences
Published By: Zendo Academic Publishing

GEOSPATIAL ANALYSIS OF FLOOD VULNERABILITY IN JALINGO METROPOLIS, TARABA STATE, NIGERIA

[1]Garba, A. Hajara., Ezekiel, B. Bwadi and Saleem I. Mohammed,
Corresponding email: hajogarba57@gmail.com

Article Info
Keywords: Exposure, Flood Vulnerability Index, Susceptibility, Resilience.
DOI
10.5281/zenodo.16032941

Abstract
This study analyzed spatial flood vulnerability in Jalingo Metropolis, Taraba State, Nigeria. The primary data were generated using a structured questionnaire. A multi-stage sampling procedure was used to administer questionnaire to three hundred and ninety-eight (398) respondents. The Flood Vulnerability Index [FVI] and Analysis of Variance [ANOVA] were used to analyze the data and presented using tables and maps. The result of the FVI computation with respect to the exposure factor showed that the Majidadi ward had the highest score of 0.665, making it the most exposed ward to flood. In terms of susceptibility, Majidadi Ward has the highest score of 0.624, making it the most susceptible to flood. The resilience factor computation revealed that the highest index score of 0.450 was recorded in the Barade ward. The resultant vulnerability map portrays that Majidadi has a very high level of vulnerability to floods, Sarkin Dawaki and Kona wards were found to be highly vulnerable to floods, Kachalla Sembe ward has a medium vulnerability to floods, while Barade ward showed a low level of flood vulnerability in the study area. The ANOVA results ($F [4, 10] = 1.850$, $p > 0.05$) showed that the flood vulnerability index factors in Jalingo metropolis did not statistically vary significantly. Based on these findings, the study recommends continuous flood inundation prediction, improved land-use planning and zoning, enhancing resilience while reducing the exposure and susceptibility levels of the metropolis based on the SDGs and SFDRR (2015), and continuous awareness campaigns on floods, climate change, and its attendant consequences.

1.1 INTRODUCTION

Globally, flooding has become a major ecological issue. According to Jeb and Aggarwal (2008), a flood is a temporary state in which typically dry areas are partially or completely submerged due to overflowing tidal or

[1] Department of Geography, Taraba State University, P.M.B 1167, Jalingo, Nigeria

inland waterways, or due to an unusually high volume of runoff. Bloschl et al. (2020) asserted that during the last 3 decades, Europe has experienced some of the greatest floods in the last 500 years. Africa is experiencing a rise in both the frequency and intensity of urban flooding. In Sub-Saharan Africa, Aliyu et al. (2023) argued that flooding is the most frequent natural disaster and a challenge to sustainable development given the current state of the continent's development. Nigeria has seen many flood events in recent years, and due to the high level of vulnerability and lack of coping capacity of the people, extreme events caused by climate change are putting many lives and properties at risk (Echendu, 2020; Komolafe et al., 2015).

Vulnerability has been defined differently in the various scientific areas in which it has been used (Füssel, 2010). Vulnerability, according to Adger (1999), refers to the exposure of a group or individual to stress due to social and environmental changes that disrupt livelihoods. The Intergovernmental Panel on Climate Change [IPCC] explored vulnerability through three core concepts: firstly, 'exposure magnitude' to which a system is physically in harm's way; secondly, 'sensitivity' of a system i.e. its likelihood to be affected by a shock; and thirdly, the 'adaptive capacity' of a system to cope or adjust with the negative impacts of a shock (Barnett & Adger, 2007; Smit & Pilifosova, 2003; McCarthy, 2001). In the assertion of Balica et al. (2012) assert that vulnerability is mostly determined by social, economic, physical, and environmental factors. People and communities are vulnerable to floods due to three main factors: exposure, susceptibility, and resilience (Balica, 2007; Balica et al., 2012). It is however, worthy to note that a comprehensive approach to a society's vulnerability and risk assessment comprises all components (social, economic, physical and environmental) that either increase or decrease the level of flood vulnerability (Balica et al., 2009; Balica et al., 2012).

In recent years, flood vulnerability has increased rapidly in many countries (Hidayah et al., 2021). Kim and Gim (2020) identified rise in the frequency and scale of floods as the reasons for this increase. Mackay (2008) defined vulnerability to flooding as the extent to which all components (physical, environmental, economic, and social) are vulnerable and incapable of overcoming the negative impact of flooding. Flood-prone locations are frequently inhabited by impoverished and marginalized groups, who lack the resources to prepare for or recover from disasters (Hallegatte, 2020). Similarly, Bibi et al. (2023) stated that urban areas are especially vulnerable because of their dense population and large areas of impermeable surface, which increase runoff and overwhelm drainage systems. These vulnerabilities are also worsened at the increased frequency and intensity of extreme weather events such as storms and heavy rainfall. Thus, assessing a society's susceptibility becomes essential for effectively reducing the risk of flooding. (Kissi et al., 2015). Jalingo metropolis is plagued by periodic floods, and the concomitant effect is the loss of life and property. In the previous ten years, an increase in the frequency and severity of floods in Jalingo has been observed, indicating an extreme risk to the city's residents (Oruonye, 2012).

Several studies have been conducted on flood vulnerability assessment, particularly in developing countries. Nasiri et al. (2019) computed the district FVI of Kuala Lumpur in Malaysia, taking cognizance of the four vulnerability components (social, physical, environmental and economic) and the exposure, susceptibility, and resilience factors. The result showed that the six districts of Wangsa Maju, Sentul, Damansara, City Center, Bukit Jalil, and Bandar Tun-Razak had FVIs of 1, 0.822, 0.768, 0.99, 0.56, and 0.50, respectively. The study by Yankson et al. (2017) on coastal communities' vulnerability to floods using an indicator-based approach in the Greater Accra Metropolitan Area, Ghana showed that exposure to floods is relatively high in all communities.

Ikusemoran et al. (2014) applied remote sensing and GIS techniques for terrain analysis of the vulnerability assessment of flood disasters in Niger State, Nigeria. The study revealed that the Niger valley and the low-lying terrain of the state were classified as highly vulnerable and vulnerable respectively to flood disasters, covering more than half (58.43%) of the total land area of the state. Jeb (2014) study on flood risk in Kaduna metropolis, Nigeria revealed that about 52.82% of the study area fell within the low-vulnerability zone, while 47.18% lie within the highly vulnerable zone.

Berezi et al. (2019) employed AHP techniques to examine the flood vulnerability levels of communities in Bayelsa State, Nigeria. The study considered land use, elevation, soil texture, and proximity to active river channels as factors determining flood vulnerability. Findings of the study revealed that 15% of the communities had low flood vulnerability levels, 74% had moderate vulnerability, and 11% were highly vulnerable to floods. Flood risk within the River Adelalu and Bwadi (2023) analyzed the Benue basin, with a specific focus on the Taraba State. The datasets used included annual rainfall records, DEMs, soil types, basin slopes, drainage density, land use, and catchment areas. The study revealed that areas that are highly vulnerable to flood covered 410.6 km2. The towns of Karim Lamido, Gassol, Lau, Donga, Wukari, Ardo kola, Kurmi, Bali, parts of Takum, and Jalingo are within this highly vulnerable area.

Despite numerous studies on flood vulnerability, there remains a significant gap in determining flood vulnerability at a local scaled area particularly Jalingo metropolis. Determining the level of vulnerability at the local scale according to Yankson et al. (2017); Munji et al. (2013); IPCC (2007) is crucial for understanding flood vulnerability characteristics, which are necessary for developing site-specific and appropriate adaptation measures to match the level of exposure and sensitivity of the particular area under study. Similarly, Babanawo et al. (2022) stated that understanding the various factors of vulnerability with respect to exposure, sensitivity, and adaptive capacity of population groups at the local level also drives the prioritization and efficient allocation of scarce resources to mitigate, prepare, respond, and recover from disasters. In this regard, this study conducted a geospatial analysis of flood vulnerability in Jalingo metropolis, Taraba State.

1.2 MATERIALS AND METHODS

1.2.1 The Study Area

Jalingo is the administrative capital of Taraba State. It is located between Latitudes 8°47′ to 9°01′ North of the Equator and Longitudes 11°09′ to 11′30′ East of the Greenwich meridian. It is bounded to the north by the Lau Local Government Area, to the east by the Yorro Local Government Area, and to the south and west by the Ardo Kola Local Government Area (Figure 1). Jalingo covers a total land area of about 195km^2 (Shawulu et al., 2008). The climate of Jalingo is of the tropical continental type, characterized by marked wet and dry seasons (Oruonye & Bashir, 2011). The wet season, which lasts for a period of seven (7) months, usually begins around April and ends in October, with a break in July. However, the break was not fixed, as it sometimes extended into August (Adagba, 2000). Rains are usually peaking between August and September. The dry season is characterized by the prevalence of northeast trade winds characterized by cool, dry, and dusty winds, commonly known as harmattan winds, which begins in November and ends in March. Jalingo has a mean rainfall of about 1,200mm and a mean annual temperature of 29°C with the highest temperature experienced in March.

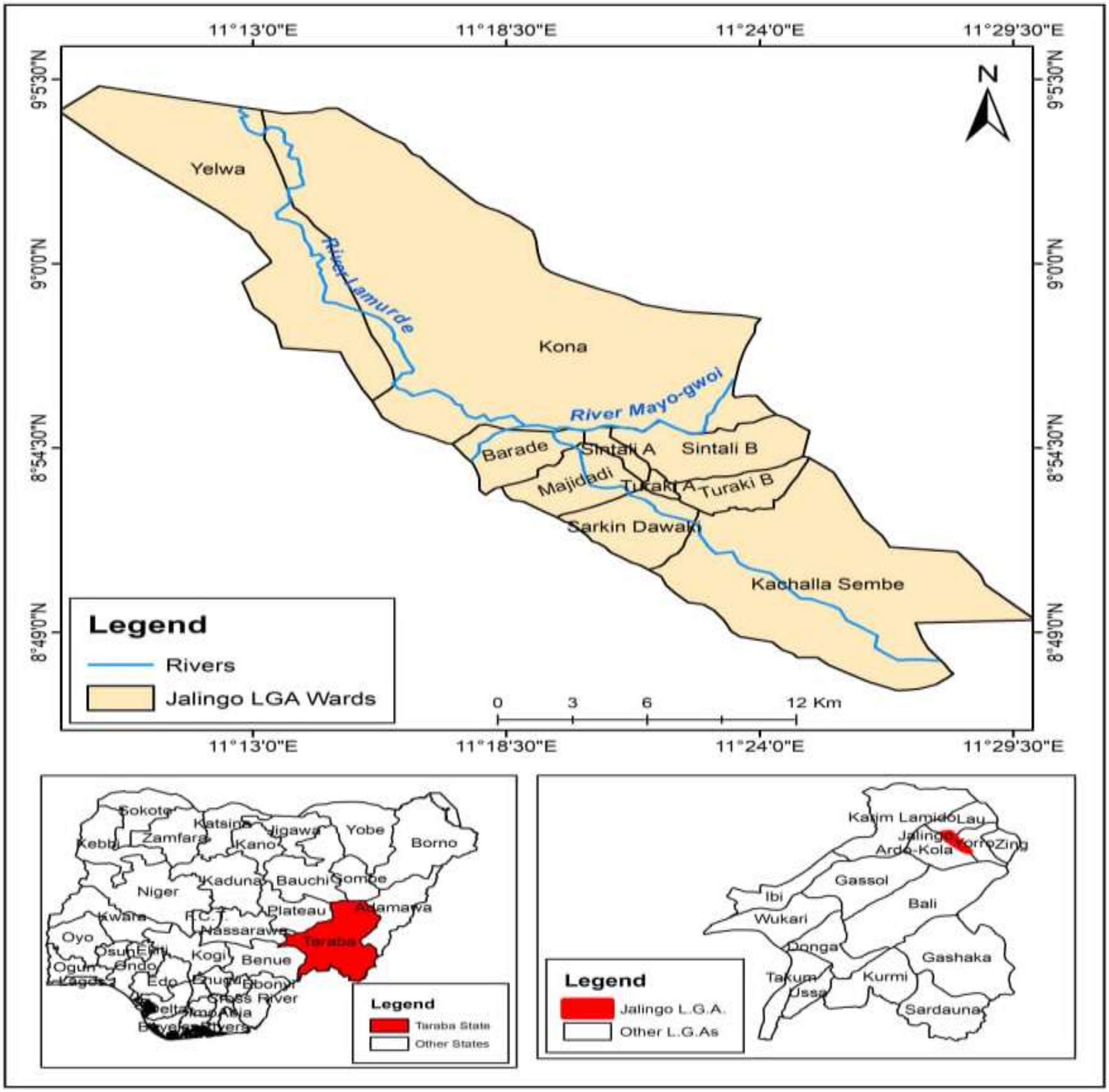

Figure 1: Map of the study area.

Source: Adopted and modified from the administrative map of Taraba State (2023)

The relative humidity ranges between 60-70% during the wet season to about 35-45% in the dry season (Oruonye & Bashir, 2011). According to Oruonye and Bashir (2011), the rivers Lamurde and Mayo-gwoi drain the city of Jalingo. The soil of the study area was classified by Osujieke et al. (2018) as Grossarenic Kandiustalfs (Arenic Lixisols) in pedons 1 and 2 and Arenic Kandiustalfs (Loamic Lixisols) in pedon. Jalingo is a heterogeneous settlement made up of the three (3) indigenous ethnic groups namely; Fulani, Kona, and Mumuye. Other tribes, such as Jenjo, Wurkum, Yardang, Kuteb, Jukun, Igbo and Yoruba are presently inhabitants of Jalingo. According to the National Population Census of 2006, Jalingo had a population of 140,318 persons, with a growth rate of 3% annually (Federal Republic of Nigeria Official Gazette, 2009).

1.2.2 Methods

The study employed multistage sampling, with the first stage involving the purposive selection of five (5) political wards that were mostly affected by the 2005–2011 flood incidence in Jalingo metropolis. The selected political wards were; Barade, Kachalla Sembe, Kona, Majidadi, and Sarki Dawaki. The next stage was the use of a convenience sampling technique to administer questionnaires to 398 household heads within the five (5) political wards that made up the Jalingo metropolis. The questionnaire contained 21 indicators further divided into three (3) main factors namely; exposure, susceptibility, and resilience. The indicators used were adapted from Kissi et al. (2015) and Ntajal et al. (2016) and are presented in Table 1.

Table 1: Selected Indicators

No.	Indicators	Factors	Relationship
1.	Flood duration	Exposure	(+)
2.	Flood height (m)	Exposure	(+)
3.	Closeness to the river	Exposure	(+)
4.	Materials used in building	Exposure	(+)
5.	Height above sea level	Exposure	(+)
6.	Literacy level	Susceptibility	(+)
7.	Household size	Susceptibility	(+)
8.	Physically challenged Persons	susceptibility	(+)
9.	No. of elderly persons (>65yrs-%)	Susceptibility	(+)
10.	No of children (<5yrs-%)	Susceptibility	(+)
11.	Awareness of floods disaster	Susceptibility	(+)
12.	Income level	Susceptibility	(+)
13.	People engaged in farming solely(%)	Susceptibility	(+)
14.	Household with affected land(%)	Susceptibility	(+)
15.	Forest area	Susceptibility	(-)
16.	Protected area	Susceptibility	(-)
17.	Warning System	Resilience	(-)
18.	Financial aid	Resilience	(-)
19.	Health care services	Resilience	(-)
20.	Com. Disaster Mgmt. Committee	Resilience	(-)
21.	Diversification of Livelihood	Resilience	(-)

Source: Kissi et al. (2015) and Ntajal et al. (2016)

In the determination of vulnerability indices, this study used variables from the survey data as indicators (Table 1). The variables were summarized using percentages and averages. To standardize each indicator value, the standardization method (min-max) used to develop vulnerability indices at political ward levels was adopted. The proposed method transforms each indicator into scores ranging between 0 and 1. The procedure was followed to standardize each indicator as follows:

$$V_{ij} = \frac{X_{ij} - Min(X_{ij})}{Max(X_{ij}) - Min(X_{ij})}$$

where:
Max = Maximum value of indicator
Min = Minimum value of indicators
X_{ij} = values of indicator j (j = 1, 2……..21) in i ward (I = 1, 2….5)
V_{ij} = matrix corresponding to normalized score.
The mean index for each factor; exposure, susceptibility, or resilience) was determined using the following formula:
f $ISW_{,mean}$ = 1 n ISW.
where f refers to either exposure (E), susceptibility (S), or resilience (R) index, and n is the total number of indicators for the factor.
Next, the composite flood vulnerability index (FVI) is calculated with the help of the following formula adopted by Quang et al. (2012)

$$\text{Vulnerability} = \frac{\text{Exposure} + \text{Susceptibility}}{\text{Resilience}}$$ -- (1).

FVI is directly related to a system's exposure and susceptibility and inversely related to its resilience. The average effects of these specific dimensions (exposure, susceptibility, and resilience) contribute in the same way to the overall vulnerability index for political wards. There are six vulnerability zones: very low, low, medium, high, and very high. The division of the vulnerability zones into six classes based on the following value ranges of the FVI: very low [0.00–0.01], low [0.01–0.25], medium [0.25–0.50], high [0.50–0.75], and very high [0.75–1.00] (Balica et al. 2013).

1.3 RESULTS AND DISCUSSION

1.3.1 Flood exposure factors

Table 2 shows that the wards showed varied levels of exposure to flooding, with high exposure accounting for 60.0%. Among the wards with high exposure levels, the Majidadi ward had the highest composite index of 0.665. This could be explained by the fact that most of the houses in Majidadi were located less than 500m from the river channel as such during flood, the water takes longer time to recede as discovered during the field measurements. It was also observed that many houses in Majidadi were erected without observing the government-approved setback of 30 meters from the river channel. This finding is corroborated by Garba (2015) in a flood study conducted in the same metropolis. Lands around Majidadi, which were about 400 meters from the river channel, were submerged in the 2005 and 2011 flood events. This result also agrees with Yankson et al. (2017) in an assessment of coastal communities' vulnerability to floods using an indicator-based approach in the Greater Accra metropolitan area, Ghana, where findings show that exposure to floods is relatively high in all communities understudied due to their closeness to the river channel.

Table 2: Flood Exposure Factor

Indicator	Barade	Kachalla Sembe	Kona	Majidadi	Sarkin Dawaki
Flood duration	0.270	0.651	0.000	1.000	0.422
Flood height	0.267	0.589	0.000	1.000	0.719
Closeness to the river	0.325	0.625	0.000	1.000	0.612
Materials used in building	0.000	0.008	0.138	0.326	1.000
Location height above sea level	0.985	1.000	0.683	0.000	0.255
Composite Index Score	0.369	0.575	0.164	0.665	0.602
	Medium	High	Low	High	High

Source: Author, 2025

As indicated in Table 1, Barade ward had medium-level exposure while Kona ward was least exposed to flooding in the study area. This accounted for 20% each for medium and low levels of flood exposure index. A higher frequency of responses related to low flood duration, low flood height, and farther house distance to the river were the contributing factors to the low score for exposure in Kona ward with a low exposure factor index. Figure 2 shows the mapping of the flood vulnerability exposure factor of the study area.

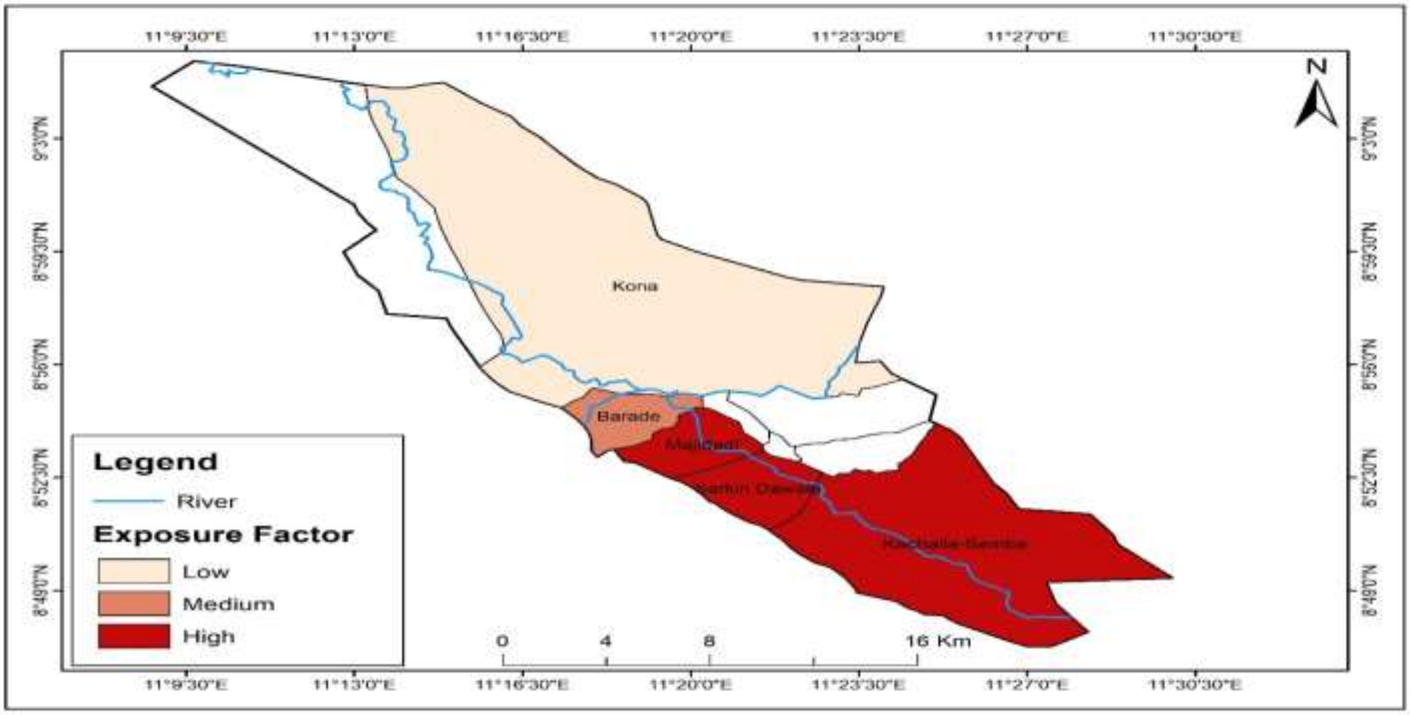

Figure 4.16: Flood Exposure Factor

Source: Field survey, 2023

1.3.2 Flood susceptibility factors

As illustrated in Table 3, the Majidadi ward rated high levels of susceptibility to flooding with a composite index score of 0.624, which accounted for 20% of the total. The high percentage of the number of physically challenged persons, older adults' persons, and children below 5 years old within households, as observed in Majidadi, explains the high level of susceptibility to flooding. Furthermore, the relatively low literacy and income levels have simultaneously contributed to this high susceptibility to flood events. This finding contradicts Kissi et al. (2015), who conducted a quantitative assessment of flood hazards across 8 communities in Togo and discovered that the two most susceptible villages out of the 8 understudied were those with a high population, a high number of women, children and the elderly.

Table 3: Flood susceptibility factors

Indicator	Barade	Kachalla Sembe	Kona	Majidadi	Sarkin Dawaki
Literacy level	0.000	0.189	0.233	1.000	0.834
Household size	0.449	0.047	1.000	0.765	0.000
No. of physically challenged persons	0.087	0.112	0.000	1.000	0.105
No. of older adults in the households	0.355	0.069	0.110	1.000	0.000
No. of children under 5 years old	0.814	0.745	0.000	1.000	0.242
Awareness of flood disasters	0.627	0.571	1.000	0.000	0.545
Income level	0.000	0.226	0.896	1.000	0.622
People engaged in farming solely	0.011	0.126	0.000	0.043	1.000
Households in the affected farmlands	0.000	0.113	0.000	0.165	1.000
Forest area	0.192	0.000	1.000	0.865	0.563

Protected area	0.245	0.223	1.000	0.021	0.000
Composite Index Score	0.253	0.220	0.476	0.624	0.446
	Medium	Low	Medium	High	Medium

Source: Field survey, 2023

Most (60%) of the wards rated a medium level of susceptibility to flooding in the study area. This trend was observed in the Kona, Sarkin Dawaki, and Barade wards (Table 3). This implies that these wards tend to have higher populations and elements that will suffer more negative impacts from flood events than wards with low levels of susceptibility. However, Kachalla Sembe was the only ward that rated a low level of susceptibility to flooding, with a composite index score of 0.220. The presence of forested land and a relatively low household size in Kachalla Sembe were significant indicators that contributed to the low level of susceptible to flooding. The levels of ward susceptibility to flooding are diagrammatically presented in Figure 3.

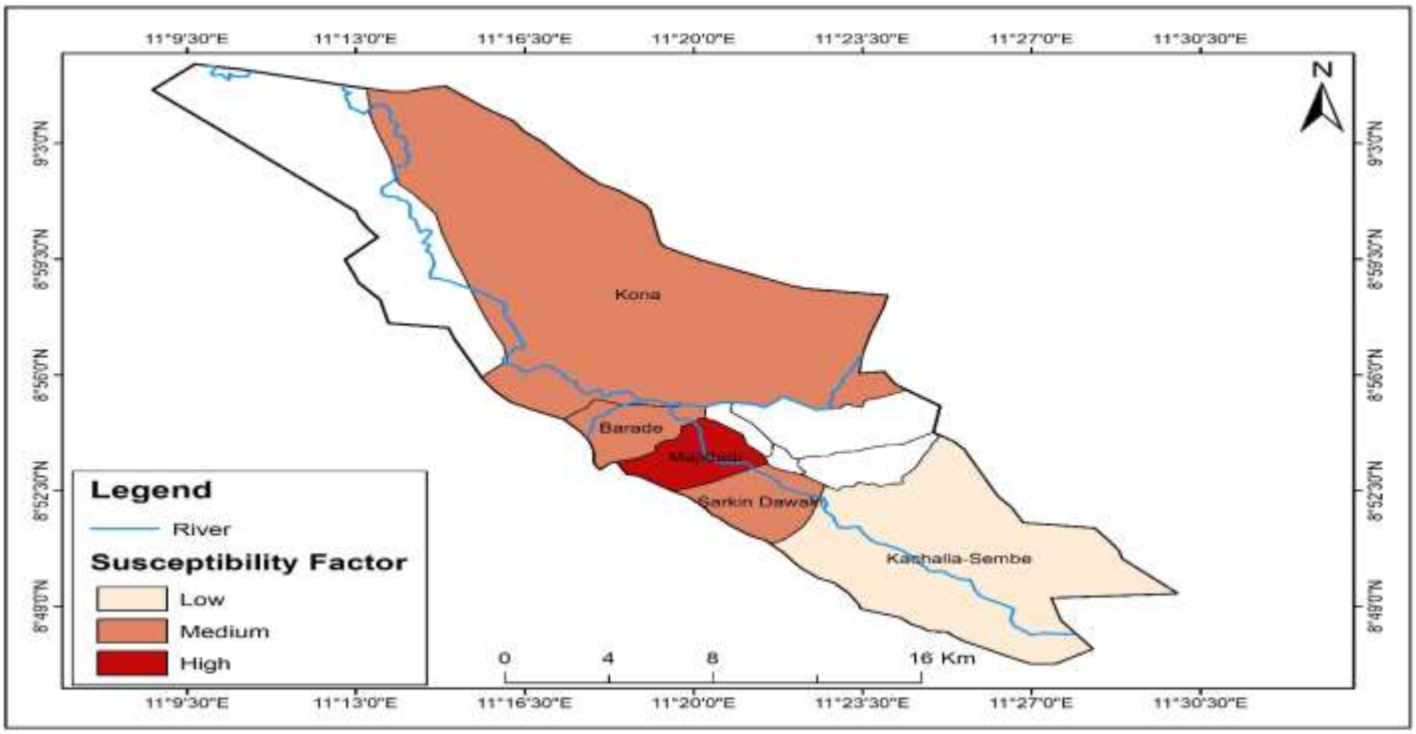

Figure 3: Flood susceptibility factors

Source: Author's, 2025

1.3.3 Flood resilience factors

The composite index of the resilience factor for each ward in Table 4 indicates that four (4) out of the five wards rated medium level which was represented by 80.0%. Barade Ward with a composite index score of 0.450 was the highest, followed by Majidadi Ward with a composite index score of 0.420. Access to health care services, particularly in the event of floods, diversification of livelihood activities widely practiced among the residents of these wards and access to financial aids, respectively, explains this level of resilience to floods.

Table 4: Flood resilience factors

Indicator	Barade	Kachalla Sembe	Kona	Majidadi	Sarkin Dawaki
Knowledge of the warning system	0.125	0.293	0.000	0.551	1.000
Financial aid	0.125	0.261	0.000	1.000	0.691
Health care services	1.000	0.775	0.388	0.508	0.000

Community disaster management committee	0.000	0.000	0.000	0.000	0.000
Diversification of livelihood	1.000	0.660	0.144	0.041	0.000
Composite Index	0.450	0.398	0.106	0.420	0.338
	Medium	Medium	Low	Medium	Medium

Source: Author's, 2025

Table 4 shows that only the Kona ward with a composite index score of 0.106 rated the low-to-flood resilience factor in the study area. The lack of knowledge about warning systems, financial aids and not having a community disaster management committee, as observed in all the wards, explains the medium and relatively low level of resilience to flooding. The deficit in the resilience factor tends to increase residents' vulnerability to flood events, as much capital is needed to implement these measures in place. The graphical representation of the composite indices of the flood resilience factor are graphically depicted in Figure 4.

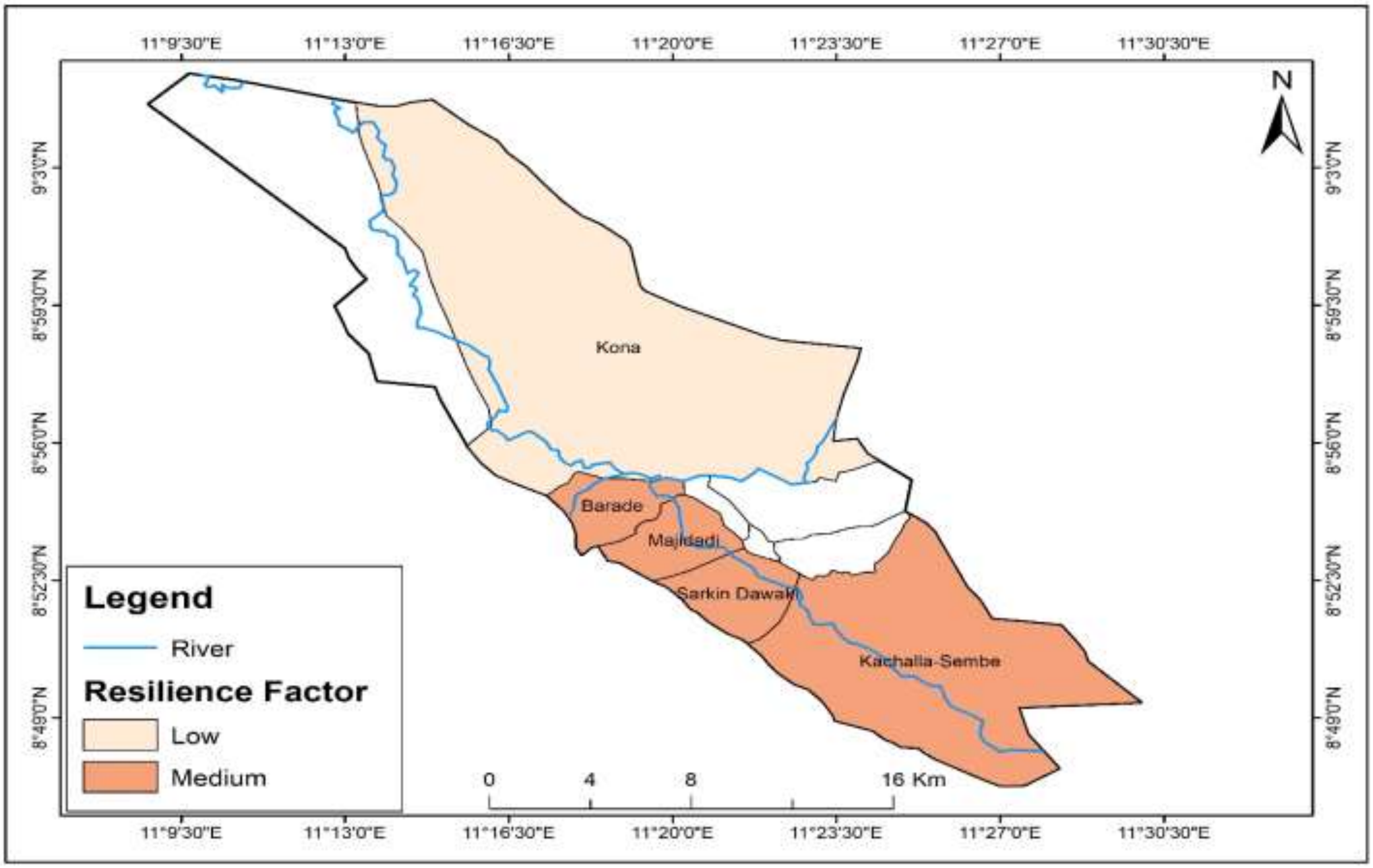

Figure 4: Flood resilience factors

Source: Field survey, 2023

1.3.4 Flood Vulnerability Index

The results in Table 5 portrays that Majidadi has a very high level of vulnerability to floods, which accounted for 20.0% of the sampled wards in the study area. The Sarkin Dawaki and Kona wards were found to be highly vulnerable to flood events, with FVI values of 0.710 and 0.534, respectively. This category of FVI ratings accounted for 40.0% of the sampled wards in Jalingo metropolis. The higher levels of exposure and susceptibility of these wards partly explain their high levels of vulnerability, as they surpass their resilience levels.

Table 5: Flood Vulnerability Index

Factor	Barade	Kachalla Sembe	Kona	Majidadi	Sarkin Dawaki

Exposure	0.369	0.575	0.164	0.665	0.602
Susceptibility	0.253	0.220	0.476	0.624	0.446
Resilience	0.450	0.398	0.106	0.420	0.338
FVI	0.173	0.397	0.534	0.869	0.710
	Low	Medium	High	Very High	High

Source: Field survey, 2023

A medium level of flood vulnerability was observed only in Kachalla Sembe ward with an FVI of 0.397, whereas Barade ward rated a low level of flood vulnerability with an FVI of 0.173 in the study area (Table 5). Each of these accounted for only 20.0% of the sampled wards in the study area. There is a varied degree of flood vulnerability in the Jalingo metropolis.

This result corresponds with Yankson et al. (2017) findings that flood-prone communities in the Greater Accra metropolitan area of Ghana showed different levels of vulnerability with respect to their exposure, sensitivity and adaptive capacity. Similarly, is the finding of Babanawo et al. (2022) in Ketu, a South Municipal Area of Ghana, which showed that vulnerability varied based on exposure, susceptibility and the community's adaptive capacities? The flood vulnerability index map of the study area is shown in Figure 5.

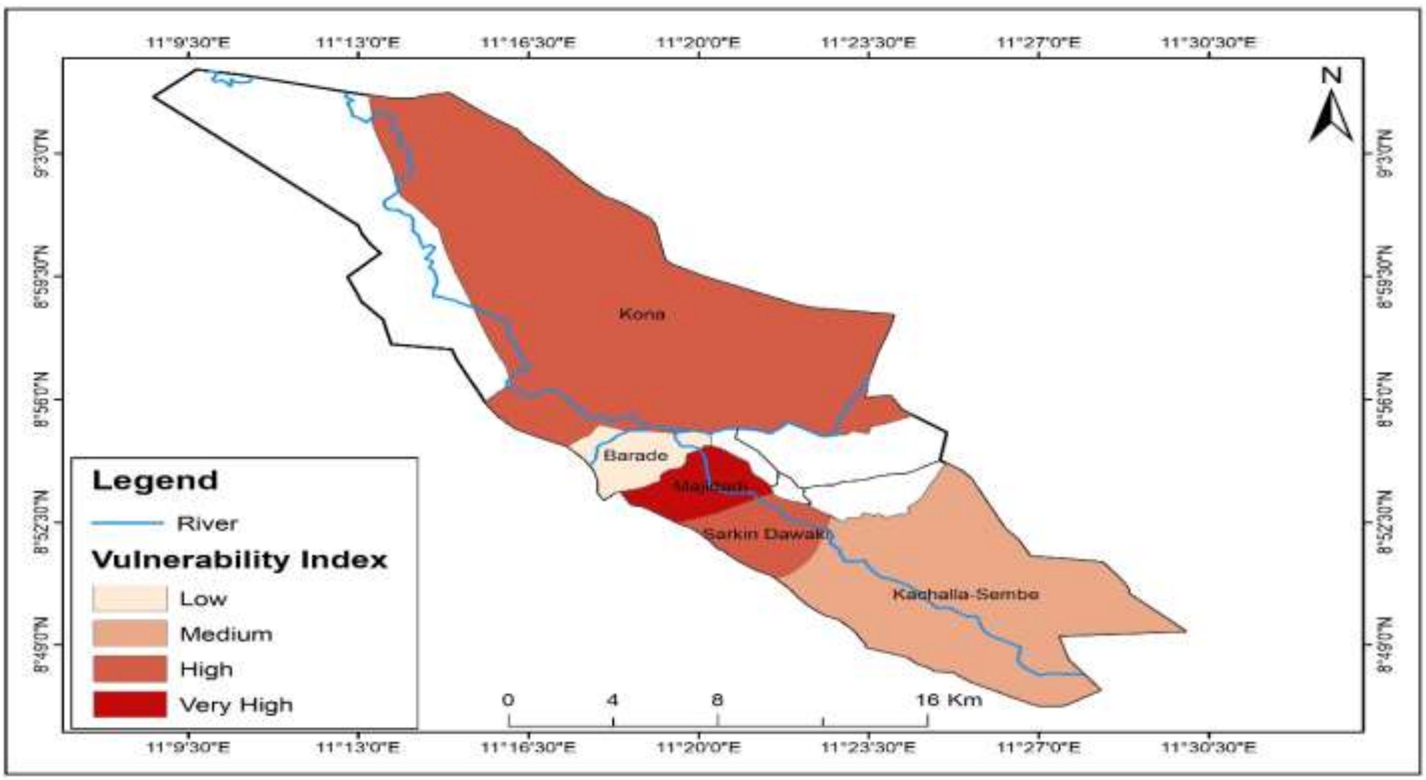

Figure 5: Flood Vulnerability Map

Source: Author's, 2025

1.3.5 Variation in the Flood Vulnerability Index Factor

A quick perusal of the results in Table 6 indicates that the highest mean value of flood vulnerability index factor was recorded in Majidadi ward, with 0.570, closely followed by 0.462 representing Sarkin Dawaki ward. However, relatively low values (less than 30%) of the coefficient of variation (CV) showed homogeneity of the flood vulnerability index factor in the different wards, except in Kona ward, which has a high CV of 79.9%. This relatively low CV implies that there is no widespread variation in the flood vulnerability index factor across the sampled political wards in the study area.

Table 6: Descriptive of the Flood Vulnerability Index Factor in the Jalingo Metropolis

Ward	Minimum	Maximum	Mean	Standard Dev.	CV
Barade	0.253	0.450	0.357	0.099	27.7
Kachalla Sembe	0.220	0.575	0.398	0.178	44.7
Kona	0.106	0.476	0.249	0.199	79.9
Majidadi	0.420	0.665	0.570	0.131	23.0
Sarkin Dawaki	0.338	0.602	0.462	0.133	28.8

Source: Field survey, 2023

1.3.6 Hypothesis Testing

H_o: There is no spatial variation in flood vulnerability index factors in Jalingo Metropolis.

The analysis of variance [ANOVA] parametric test was used to test whether there was significant variation in the flood vulnerability index factors in the study area (Table 7). The ANOVA results ($F [4,10] = 1.850$, $p > 0.05$) showed that the flood vulnerability index factors in Jalingo metropolis did not statistically vary significantly. Consequently, the null hypothesis that there is no variation in the flood vulnerability index factor in Jalingo metropolis cannot be rejected. However, the LSD post-Hoc multiple comparisons test further indicated that the flood vulnerability index factor in Kona ward only significantly varied with that of Majidadi ward at a significance level of 0.05, while other wards showed no statistically significant variation.

Table 7: Variations in the Flood Vulnerability Index Factor in the Jalingo Metropolis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.171	4	.043	1.850	.196
Within Groups	.231	10	.023		
Total	.403	14			

Source: Field survey, 2023

1.4 Conclusion and Recommendations

Based on the results of this study, it was concluded that most parts of Jalingo metropolis are under high exposure, though Majidadi ward is the most exposed, and it tends to be the worst hit in terms of a flood event. In terms of susceptibility, it is concluded from the study that most of Jalingo metropolis falls under medium susceptibility, although Majidadi ward has high susceptibility with an index of 0.624. This result also implies that residents of Majidadi ward will suffer more in the event of a flood disaster. It is further concluded from this study that no part of Jalingo metropolis has high resilience to floods, as most wards fall under low and medium resilience. This connotes that most residents lack the resources and ability to bounce back to their original state per adventure a flood disaster occurs, without receiving help from external society. The study recommends that the Taraba State Government align its Flood Management Actions Agenda with that of the SDGs and SFDRR (2015) geared toward reducing the exposure and susceptibility levels of the metropolis while enhancing resilience and intensification of awareness campaigns and sensitization visits as a way of enlightening the populace about climate change and its attendant consequences.

REFERENCES

Adagba, E. A. (2000). *An analysis of the spatial distribution of social facilities in Jalingo Local Government Area in Taraba State*. Unpublished M.Sc. Dissertation, Department of Geography and Environmental Management, Faculty of Physical Sciences, Ahmadu Bello University, Zaria.

Adelalu, T. G., & Bwadi, B. E. (2023). Multifaceted analytical flood risk assessment in major tributaries river Benue basin, Taraba State, Nigeria. *African Journal of Environmental Science Technology*, Vol. 17(1), pp. 26-36. https://doi.org/10.5897/AJEST2022.3149.

Aliyu, A., Liman-Hamza, K., & Lawal, A. (2023). Floods in Sub-Saharan Africa: Causes, Determinants and Health Consequences. *Niger Med J*. 2023 Jul 2; 64 (1):13-24. PMID: 38887440; PMCID: PMC11180243.

Babanawo, D, Mattah, P. A. D, Agblorti, S. K. M., Brenpong, L. K., Mattah, M. M., & Aheto, D.W. (2022). Local indicator based flood vulnerability indices and predictors of relocation in the Ketu south municipal area of Ghana. *Sustainability* 2022, 14, 5698.http//doi.org/10.3390/su14095698.

Balica, S.F. (2007). *Development and application of flood vulnerability indices for various spatial scales*. Master's Thesis, UNESCO-IHE Institute for Water Education, the Netherlands.

Balica, S. F., Douben, N., & Wright, N. G. (2009). Flood vulnerability indices at varying spatial scales. *Water Science Technology*, 60(10):2571-2580.

Balica, S. F., Popescu, I., Beevers, I., & Wright, N. G. (2013). Parametric and physically based modeling techniques for flood risk and vulnerability assessment: A comparison. *Environmental Modeling and Software*. Volume 41:84-92. https://doi.org/10.1016/j.envsoft.2012.11.002.

Balica, S. F., Wright, N.G., & Van der Meulen, F. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural Hazards*, 52, Springer Publisher, 510 ISSN 0921-030X.

Berezi, O. K., Obafemi, A.A., & Nwankwoala, H. O. (2019). Flood vulnerability assessment of communities in the flood prone areas of Bayelsa State, Nigeria. *International Journal of Geology and Earth Sciences*, 5(3):19-36.

Bibi, T. S., Reddythta, D., & Kebebew, A. S (2023). Assessment of the drainage systems performance in response to future scenarios and flood mitigation measures using storm water management model. *City and Environment Interactions*, Volume 19,100111, https://doi.org/10.1016/j.cacint.2023.100111.https://www.sciencedirect.com/science/article/pii/S2590252023000132.

Blöschl, G., Kiss, A., Viglione, A., Barriendos, M., Böhm, O., Brázdil, R., Coeur, D., Demarée, G., Llasat, M. C., Macdonald, N., Retsö, D., Roald, L., Schmocker-Fackel, P., Amorim, I., Bˇ elínová, M., Benito, G., Bertolin, C., Camuffo, D., Cornel, D., Doktor, R., Elleder, L., Enzi, S., Garcia, J. C., Glaser, R., Hall, J., Haslinger, K., Hofstätter, M., Komma, J., Limanówka, D., Lun, D., Panin, A., Parajka, J., Petri´ c, H., Rodrigo, F. S., Rohr, C., Schönbein, J., Schulte, L., Silva, L. P., Toonen, W. H. J., Valent, P., Waser, J., and Wetter, O. (2020). Current European flood-rich period exceptional compared with past 500 years. *Nature*, 583(7817):560–566.

Echendu, A. J. (2020). The impact of flooding on Nigeria's sustainable development goals (SDGs). *Ecosystem Health and Sustainability*, 6(1), 1791735. https://doi.org/10.1080/20964129.2020.1791735.

Garba, A. H. (2015). *Flood vulnerability assessment in Jalingo metropolis, Taraba State, Nigeria.* Unpublished M.Sc. Dissertation, Department of Geography and Environmental Management, Faculty of Physical Sciences, Ahmadu Bello University, Zaria.

Hallegatte, S.; Vogt-Schilb, A.; Rozenberg, J.; Bangalore, M. & Beaudet, C. (2020). From Poverty to Disaster and Back: a Review of the Literature. *EconDisCliCha* 4, 223–247 (2020). https://doi.org/10.1007/s41885-020-00060-5

Ikusemoran, M., Kolawole, M.S., & Adegoke, K. M. (2014). Terrain analysis for flood disaster vulnerability assessment: A case study of Niger State, Nigeria. *American Journal of Geographic Information System*, 3(3):122-134. doi:10.5923/j.ajgis.20140303.02.

Jeb, D. N. (2014). *Flood risk analysis in Kaduna metropolis, Kaduna State, Nigeria using Geo-Information Science*. Unpublished Ph.D thesis Department of Geography and Environmental Management, Faculty of Physical Sciences, Ahmadu Bello University, Zaria.

Jeb, D. N., & Aggarwal, S.P. (2008). Flood inundation hazard modeling of the River Kaduua using remote sensing and geographic information systems. *Journal of Applied Sciences Research*, 4(12):1822-1833.

Kissi, A. E., Abbey, G. A., Agboka, K., & Egbendewe, A. (2015). Quantitative assessment of flood vulnerability in downstream area of Mono Basin, South Eastern Togo:Yoto District. *Journal of Geographic Information System,* 7:607-619. http://dx.doi.org/10.4236/jgis.2015.76049.

Komolafe, A. A., Adegboyega, S. A. A., & Akinluyi, F.O. (2015). A review of flood risk analysis in Nigeria. *American Journal of Environmental Science*, 11(3):157-166.

Nasiri, H., Yusof, M. J. M., Ali, T. A. M., & Hussein, M. K. B. (2019). District flood vulnerability index: Urban decision-making tool. *International Journal of Environmental Science and Technology* 16, 2249–2258 https://doi.org/10.1007/s13762-018-1797-5.

Ntajal, J., Lamptey, B. L., & Sogbedji, J. M. (2016). Flood vulnerability mapping in the Lower Mono River Basin in Togo, West Africa. *International Journal of Scientific and Engineering Research*, 7(10):1553-1562.

Oruonye, E. D. (2012). Socio-economic impact of flash floods in Jalingo Metropolis, Taraba State, Nigeria. *International Journal of Environmental Sciences*, 1(3):135-140.

Oruonye, E. D. & Bashir, A. (2011). *The Geography of Taraba State*. LAP LAMPERT Academic Publishing. Germany. pp 50-56.

Osujieke, D. N., Obasi, P. E., Imadojemu., E. M., & Angyu, M. (2018). Characterization and Classification of Soils of Jalingo Metropolis, North-east, Nigeria. *Nigerian Journal of Soil Science*. Pp 72-80. DOI: 10.3626/njss.2018.280209.

Shawulu, H. M., & Adebayo, A. A. & Binbol, N. L. (2008). Appraisal of the National Poverty Eradication Programme (NAPEP) in Jalingo Local Government Area, Taraba State Nigeria," *Medwell Journals*, *the Social Sciences*, 3:291-296.

Yankson, P., Owusu, A., Owusu, G., Boakye-Danquah, J., & Tetteh, J. (2017). Assessment of coastal communities' vulnerability to floods using indicator-based approach: a case study of Greater Accra Metropolitan Area, Ghana. *Natural Hazards*. 89. 10.1007/s11069-017-2985-1.