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# Vulnerabilities and resilience of coastal communities: disaster risk management for flooding in Bayelsa State, Nigeria

Ekene Ebele Uchenna-Ogbodo [1, 2, *]

[1] *Disater Risk Management And Developmentall Studies, University of Portharcourt, Rivers State, Nigeria.*
[2] *project Management, Anderson School of Mnagement, University of New Mexico, USA.*

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## Abstract

Flooding is a recurrent and devastating natural hazard in Bayelsa State, Nigeria, significantly impacting coastal communities. This study employs Geographic Information System (GIS) and Remote Sensing (RS) techniques to assess flood vulnerability and resilience capacity across various Local Government Areas (LGAs). By analyzing key parameters such as elevation, land use, slope, and proximity to rivers, the study identifies highly vulnerable regions and examines community preparedness and resilience capacity. Findings indicate that Southern Ijaw and Ekeremor LGAs exhibit the highest flood vulnerability due to low elevation and proximity to water bodies, while Sagbama and Kolokuma/Opokuma are less vulnerable. The resilience assessment highlights challenges in adaptive capacity, with inadequate institutional support and emergency response systems. The study underscores the necessity for integrated flood management strategies, including improved infrastructure, early warning systems, and community-based resilience programs. These findings contribute to the broader discourse on disaster risk management, offering insights for policymakers and stakeholders to enhance flood mitigation efforts in coastal communities.

**Keywords:** Flood Disaster; Vulnerability; Resilience Capacity; Geographic Information System (GIS); Bayelsa State

## 1. Introduction

Geographic Information System (GIS) is an important tool for mapping spatial distribution of exposure and vulnerability. It facilitates input, storage, management, analysis, integration, and output of spatial data which can help real time decision making and strategic planning for effective risk management and hazard preparedness particularly for meteorological and flood hazards (Chau *et al.,* 2013; Ukoje & Achegbulu, 2022). GIS can be used in assessing flood impacts and as a tool that can assist flood plain managers in identifying flood prone areas, helping also in real time monitoring, early warning and quick damage assessment of flood disasters (Ukoje & Achegbulu, 2022). Vulnerability assessments have been recognized as being crucial to disaster management and are conducted to understand potential for loss, focusing on nature of the hazard and who and what are exposed (Cutter *et al.,* 2001; Ukoje & Achegbulu, 2022).

In Nigeria, flooding displaces more people than any other natural disaster with an estimated 20% of the population at risk (Etuonovbe 2011; Cirella and Iyalomhe, 2018). This perennial problem consistently results in death and displacement of communities. The number of flood-related fatalities has varied significantly from flood-to-flood with the percentage of displaced versus killed persons not conclusive in the literature. In Nigeria, flood disaster has been perilous to people, communities and institutions. Flood disaster is not a recent phenomenon in Nigeria. Its destructive tendencies are sometimes enormous. Its occurrences have been reported in Ibadan (1985, 1987, 1990 etc.), Osogbo (1992; 1996; 2002), Yobe (2000) and Akure (1996; 2000; 2002; 2004; 2006). The coastal cities of Lagos, Port Harcourt, Calabar, Uyo, and Warri among others have many times experienced incidents that have claimed many lives and properties worth millions of dollars (Folorunsho and Awosika 2001; Ologunorisa, 2004; Magami et al., 2014). According

* Corresponding author: Ekene Ebele Uchenna-Ogbodo

to Sarkar and Mondal (2020), the aftermath of a flood event can be perceived in socio-economic activities, while the extent of such aftermaths is historically increasing globally (Moreno et al., 2020). Flood events can affect various entities both in urban and rural areas, while the extent of the impacts tends to be very high in urban areas (Tamiru & Dinka, 2021).

Resilience capacities (RC) focus on the possibility for proactive measures to be carried out as a means of combating unwanted events such as flood (Vaughan, 2018). Resilience is the ability of people, households, communities and institutions to prepare for, respond to and recover from shocks and stresses. According to USAID (2013), resilience is "*the ability of people, households, communities, countries and systems to mitigate, adapt to and recover from shocks and stresses in a manner that reduces chronic vulnerability and facilitates inclusive growth*." Being resilient does not necessarily imply that an entity will maintain its formal state prior the undesired event; however, it will maintain its functionality although individuals' segment of the entity may have adjusted (adapted) to the new environment. According to Afolabi et al. (2022), being able to "bounce back and transform" needs series of adequate and efficiency in the areas of communication, emotion, spirituality, community relationships, and many more.

In managing the flood events in Nigeria, several approaches have been adopted in accessing the vulnerable people and their areas for effective disaster risk management. One of the major approaches to flood management in Nigeria is through Mapping of various areas using Geographic Information System (GIS) and its techniques in creating flood vulnerability map of an area (Njoku et al., 2018; Berezi et al., 2019; Wizor & Week, 2020; Atagbaza et al., 2020; Okorafor et al., 2021; Afolabi et al., 2022). Furthermore, studies such as Meena & Gupta (2017), Danumah, et al. (2016) and Njoku et al. (2018) confirmed the use of GIS techniques in integrating various parameters to develop an output (such as map) for flood risk management. In this regard, the present study determines the extent of flood vulnerability among the communities in Bayelsa State, Nigeria.

## 2. Material and methods

### 2.1. Study Area


**Figure 1** Overview of the Study Area

The study area adopted for this paper was the entire Bayelsa State. Bayelsa State is in the Central Niger Delta and situated between the Niger and the lower Niger floodplain of the Niger Delta Region. It falls within the geographical location of latitude 4° 20'N and 5° 20'N and longitudes 5° 20'E and 6° 40'E (Figure 1). The state shares a boundary with Delta on the North, Rivers on the East and is bounded on the West and South by the Atlantic Ocean. It has a population of about 1.7 million people based on the Nigerian 2006 census (National Population Commission, 2016). The study area has a tropical climate with two distinct seasons, wet (April-October) and dry (November-March). It also experiences two distinctive prevailing winds. These are the dry and dusty laden tropical continental air mass and the moist tropical maritime air mass. The tropical continental air mass is otherwise known as Harmattan wind (Osuiwu and Ologunorisa, 1999). It is a dry cold wind, embedded in the North-East trade wind that blows over the area from December to February (dry season). Alagoa (2013) posited that the mean annual rainfall ranges from 2,000 to 4,000mm and spreads over 8 to 10months of the year between the months of March and November, this coincides with the wet season.

*2.1.1. Data Requirement and Sources*

The following data sets were used for the study

- Administrative map of Bayelsa State sourced from Open Street map
- Digital Elevation Model (DEM) sourced from United State Geological Survey (USGS)
- 2023 Landsat 8+ Imagery (30m resolution) source from United State Geological Survey (USGS)
- Slope/drainage map source from DEM from USGS
- Research questionnaire for resilience capacity assessment

*2.1.2. Flood Vulnerability Parameters and Reclassification*

Four (4) contributing factors were examined in determining flood vulnerable areas in Bayelsa State. These include elevation, land-use, slope and proximity from river (Table 1). The reclassification tool was used to reclassify the values in the raster. For instance, using the DEM to produce elevation maps, it was used to reclassify the raster to produce areas of a particular elevation range to actualize low plains, moderate and the high plains within the study area (Saaty, 2008).

The impact of each of the above contributing factors was examined by introducing them one after the other in the model. The result shows a very close representation of reality. The contributing percentages for the factors are elevation (35%), slope (20%), proximity from river (25%) and Land use (20%). The weight value provided the prioritize factor expressed as a percentage value between 0 and 100%. Using a linear weighted combination, the sum of weight was expressed as 100%. The information in the above table was applied to generate the distribution of areas vulnerable to flooding in the study area. The range of ranking was 1 to 5; the highest influence factor was rank 5 and the lowest influence factor was 1 (Berezi et al., 2019). Once the weight in each factor was determined, the multi-criteria analysis was performed to produce a flood-vulnerable area by using the GIS approach. The codes used in the maps are shown in Table 2.

**Table 1** Relative weight and reclassification of the parameters

| Parameters | Relative Weight (%) | Reclassified Parameter | Ranking |
|---|---|---|---|
| Land use/Land cover | 20 | Built-up | 1 |
| | | Farmland/Bare land | 2 |
| | | Sand | 3 |
| | | Vegetation/Waterbody | 4 |
| Slope (degree) | 20 | <1.25 | 1 |
| | | 1.25-2.71 | 2 |
| | | 2.71-4.79 | 3 |
| | | 4.80-8.13 >8.13 | 4 |
| Elevation (m) | 35 | <10 | 1 |
| | | 10-20 | 2 |
| | | 20-30 | 3 |

| | | | |
|---|---|---|---|
| | | >30 | 4 |
| Proximity from river (m) | 25 | <200 | 1 |
| | | 200-1000 | 2 |
| | | 1000-1500 | 3 |
| | | >1500 | 4 |

Source: Saaty, (1987)

**Table 2** Code and Classes of Vulnerability

| Code | Class | Description |
|---|---|---|
| 1 | Highly vulnerable zone | Zones that are extremely susceptible to flood occurrence |
| 2 | Moderately vulnerable zone | Zones that are fairly susceptible to flood occurrence |
| 3 | Vulnerable zone | Zones that are prone to flood occurrence |
| 4 | Marginally vulnerable | Zone with very low flood impact |
| 5 | Non-vulnerable zone | Zones that are not susceptible to flood occurrence |

MCA is a decision-making technique utilized for solving complex problems with many parameters of interrelated objectives or concerned criteria. The level of each parameter is not equal; some parameters are dominant over others. Different weights can generate a difference in the level of susceptibility (Ahmed 2015). The selected four high-influence parameters (rainfall, slope, soil and land use) were combined using the raster calculator in the map algebra under arc-toolbox to produce the flood vulnerability map of the study area.

### 2.2. Resilience Capacity Assessment

In generating perception toward the RCA of the LGAs in the state towards flood hazards through the designed questionnaire, twenty (20) heads of households were randomly selected from each LGAs were selected. Also included in the study were the community chiefs, administrative from the LGA and social workers such as teachers and healthcare providers. The total population of the study was 200 respondents.

*Data Analysis:* The retrieved questionnaire coding was done with MS Excel before being transferred to the Data entry of Statistical Package for Social Sciences (SPSS). Using the SPSS window (Version 22), the analysis tool from the tool menu-bar containing the descriptive statistics tools (frequencies, percentages, mean and standard deviation) were adopted for the analysis.

## 3. Results

### 3.1. Flood Vulnerability Assessment

Elevation Parameter: Based on elevation parameters, highly vulnerable flood areas were recorded in southern Ijaw (9.23%), followed by Ekeremor (8.42%), Nembe (6.32%) and Brass (5.9%) local government areas respectively. These LGAs have very low elevation with some areas ranging below sea level. On the other hand, non-vulnerable areas to flooding based on elevation were recorded in Sagbama (9.61%), Yenegoa (3.6) and Kolokuma/Opokuma (7.5%) LGAs. This parameter alone shows that elevation alone contributed significantly to more flooding in some parts of Bayelsa State while some parts were not vulnerable based on differences in elevation. Details provided in Table 3 and Figure 2.

**Table 3** LGAs Vulnerability Status Based on ELevation

| LGAs | Highly vulnerable | Moderately vulnerable | Vulnerable | Not vulnerable |
|---|---|---|---|---|
| Ekeremor | 8.42 | 5.11 | 2.73 | 4.25 |
| Southern Ijaw | 9.23 | 4.93 | 3.18 | 7.34 |
| Nembe | 6.32 | 1.43 | 1.75 | 1.59 |

| | | | | |
|---|---|---|---|---|
| Brass | 5.9 | 0.65 | 0.21 | 1.01 |
| Ogbia | 1.21 | 0.32 | 1.02 | 3.81 |
| Yenegoa | 1.06 | 0.44 | 1.62 | 3.6 |
| Kolokuma/Opokuma | 0.72 | 0.53 | 1.34 | 7.5 |
| Sagbama | 0.54 | 0.68 | 1.95 | 9.61 |
| Total | 33.4 | 14.09 | 13.8 | 38.71 |

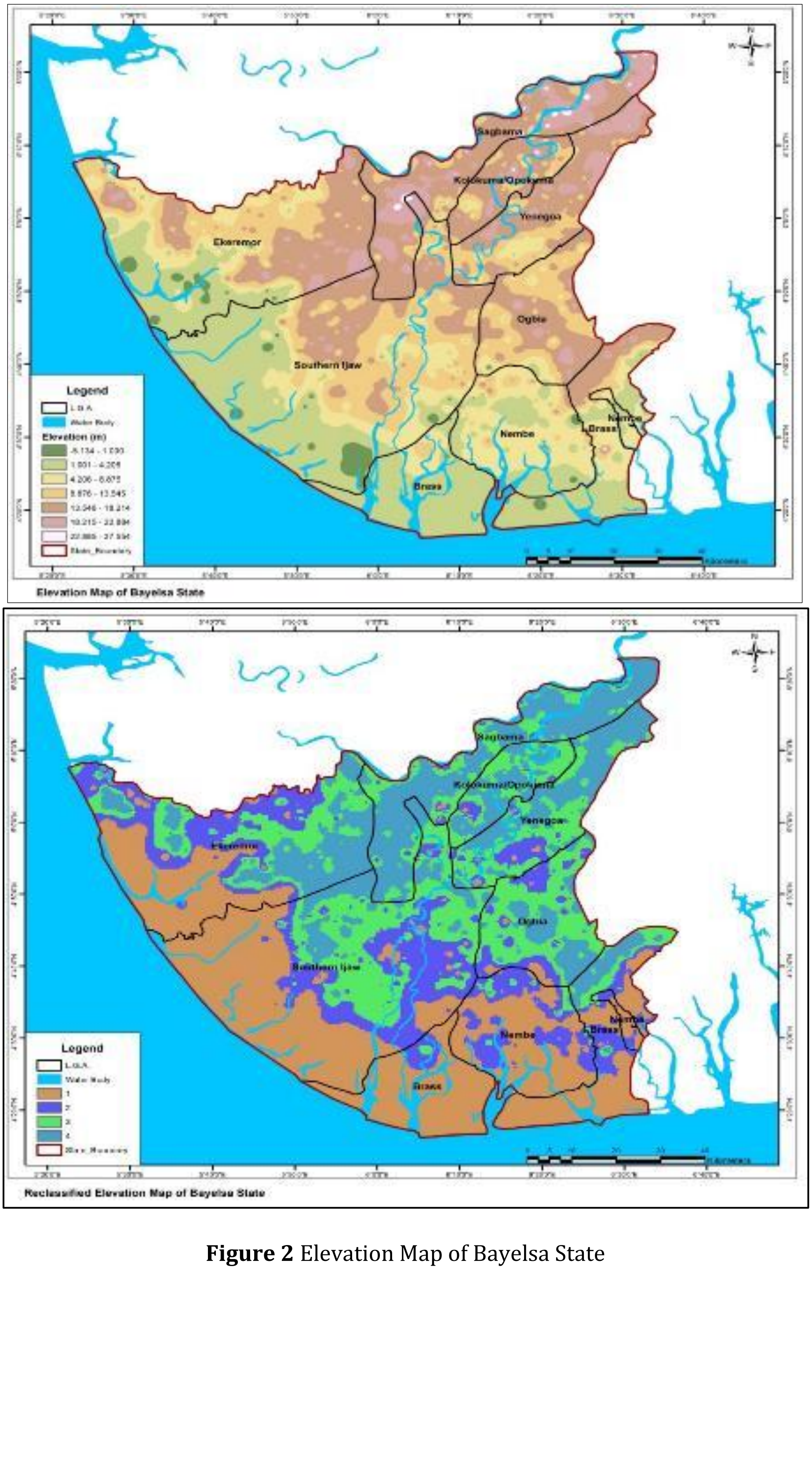
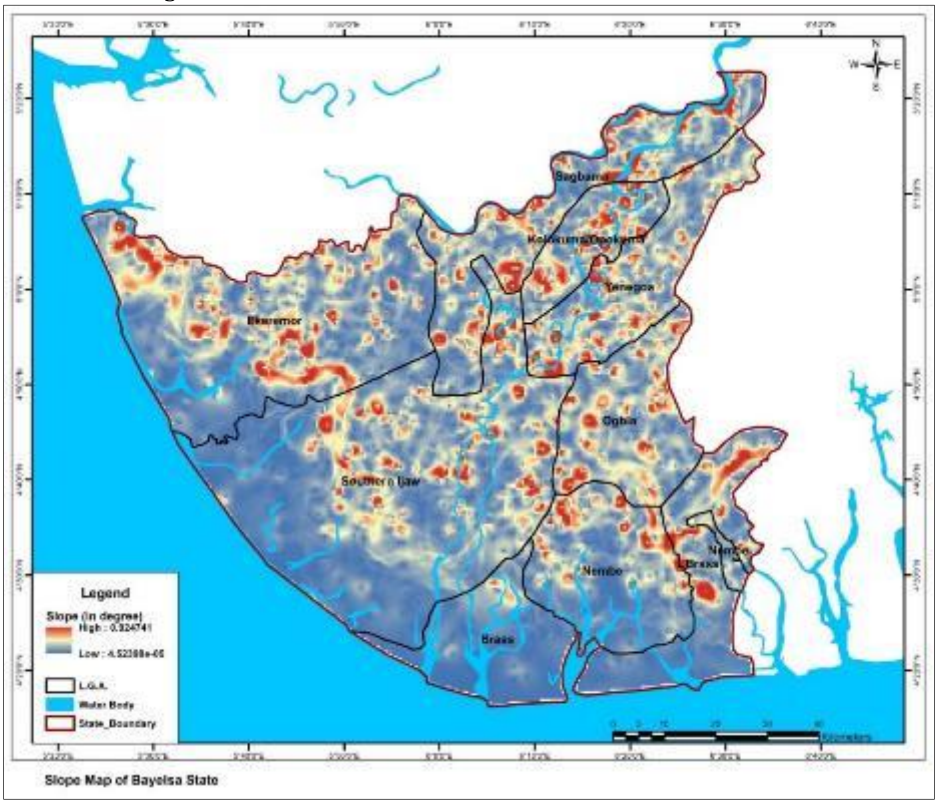



**Figure 2** Elevation Map of Bayelsa State

- Slope Parameter: Taking slope into consideration, the analysis shows that Ekeremor, Southern Ijaw LGAs are highly vulnerable to flooding while in total, 53.54% of Bayelsa is highly vulnerable to flooding based on slope. Considering moderately vulnerable areas with a total of 19.33%, southern Ijaw and Ekeremor LGA recorded highest. Similarly, when considering areas that are not vulnerable to flooding based on slope, Kolokuma/Opokuma recorded highest, followed by Ogbia and Brass respectively with a total of 13.05% as shown in Table 4 and Figure 3.



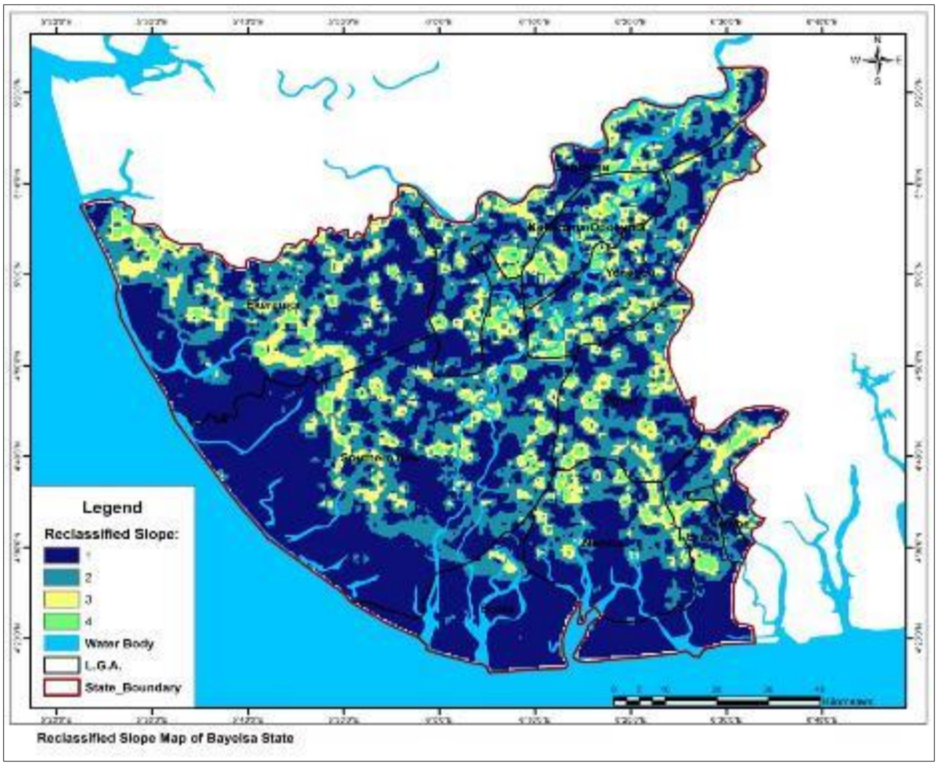




**Figure 3** Slope Parameter of the Study Area

**Table 4** LGAs Slope Status Based on Elevation

| LGAs | Highly vulnerable | Moderately vulnerable | Vulnerable | Not vulnerable |
|---|---|---|---|---|
| Ekeremor | 10.19 | 4.11 | 2.11 | 1.18 |
| Southern Ijaw | 17.26 | 5.12 | 3.54 | 0.89 |
| Nembe | 7.52 | 2.11 | 2.43 | 1.03 |
| Brass | 8.67 | 2.57 | 1.18 | 2.15 |
| Ogbia | 3.56 | 1.87 | 0.96 | 2.19 |
| Yenegoa | 2.34 | 1.43 | 1.87 | 1.04 |
| Kolokuma/Opokuma | 1.89 | 1.18 | 0.94 | 3.13 |
| Sagbama | 2.11 | 0.94 | 1.05 | 1.44 |
| Total | 53.54 | 19.33 | 14.08 | 13.05 |

Proximity from Stream Parameter: Using proximity from stream as a case study, more than 38% of Bayelsa are not vulnerable to flooding while only 22% are highly vulnerable. Specifically, the highly vulnerable LGAs are Southern Ijaw and Obia while the non-vulnerable LGAs include Kolokuma/Opokuma, Yenegoa and Sagbama LGAs. The details are presented in Table 5 and Figure 4.

**Table 5** Proximity from Stream of the LGAs

| LGAs | Highly vulnerable | Moderately vulnerable | Vulnerable | Not vulnerable |
|---|---|---|---|---|
| Ekeremor | 2.13 | 3.12 | 2.25 | 1.82 |
| Southern Ijaw | 4.04 | 4.23 | 4 | 3.45 |
| Nembe | 2.71 | 2.28 | 3.65 | 2.89 |
| Brass | 3.67 | 2.54 | 2.26 | 3.44 |
| Ogbia | 4.16 | 2.01 | 2.47 | 4.13 |
| Yenegoa | 2.34 | 1.67 | 2.1 | 6.72 |
| Kolokuma/Opokuma | 1.13 | 1.99 | 1.45 | 7.55 |
| Sagbama | 1.85 | 1.04 | 2.07 | 8.84 |
| Total | 22.03 | 18.88 | 20.25 | 38.84 |

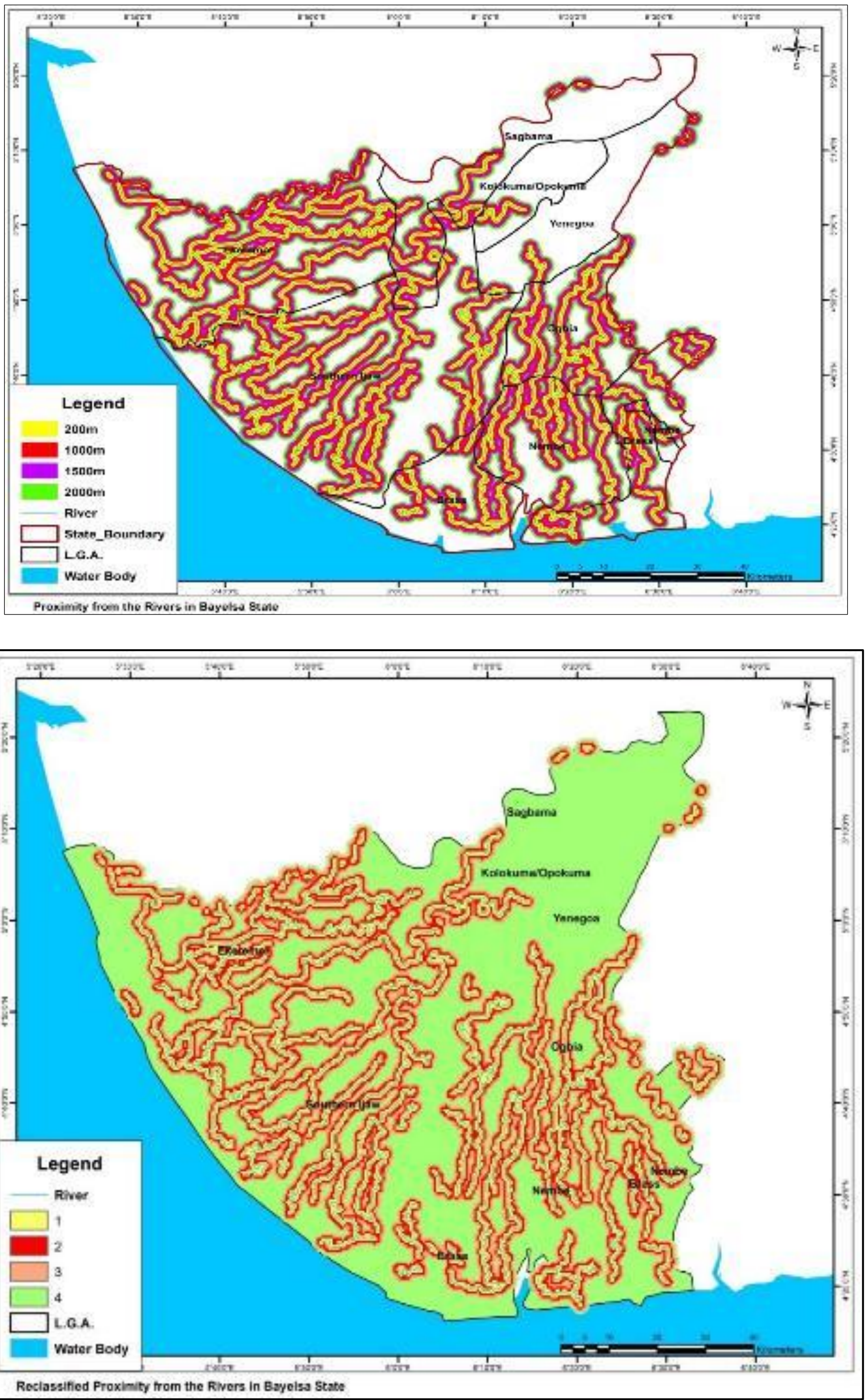
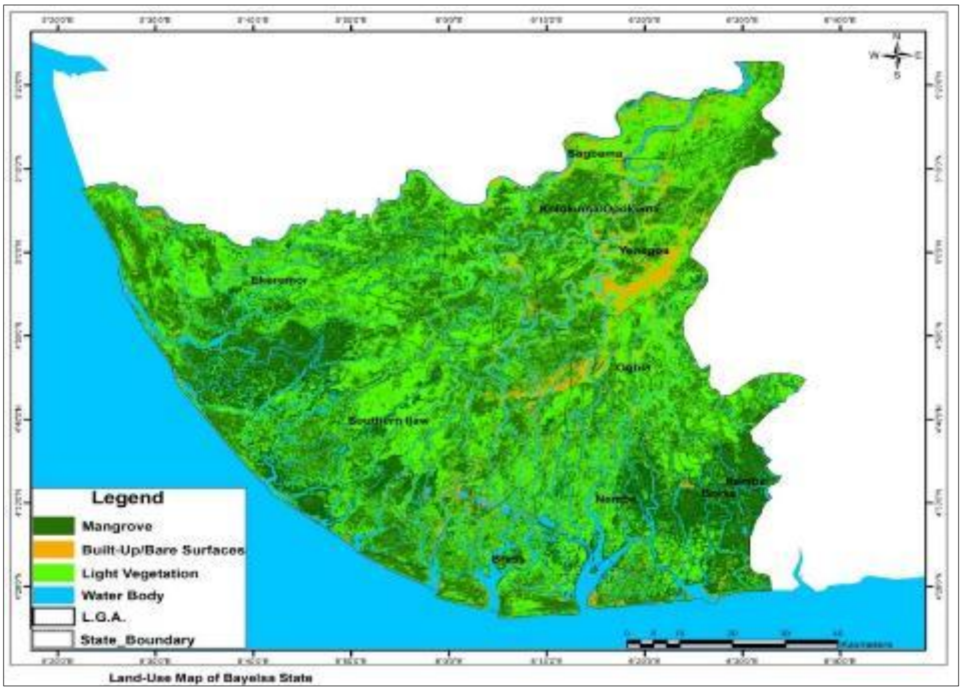



**Figure 4** Proximity from the rivers in the Study Area

Land-use and Land-cover parameters: Based on land-use characteristics, 46% of the area is not vulnerable to flood disaster while only 15% and 12% are highly and moderately vulnerable respectively. The details are presented in Table 6 and Figure 5.

**Table 6** Land use and Landcover of the LGAs

| LGAs | Highly vulnerable | Moderately vulnerable | Vulnerable | Not vulnerable |
|---|---|---|---|---|
| Ekeremor | 1.93 | 2.05 | 4.67 | 2.97 |
| Southern Ijaw | 2.83 | 2.16 | 3.38 | 3.14 |
| Nembe | 1.5 | 1.21 | 3.03 | 4.04 |
| Brass | 2.46 | 2.27 | 5.64 | 4.19 |
| Ogbia | 2.95 | 0.94 | 2.85 | 5.28 |
| Yenegoa | 1.13 | 1.06 | 2.48 | 7.87 |
| Kolokuma/Opokuma | 1.06 | 1.44 | 1.83 | 10.02 |
| Sagbama | 1.44 | 1.03 | 2.45 | 8.7 |
| Total | 15.3 | 12.16 | 26.33 | 46.21 |



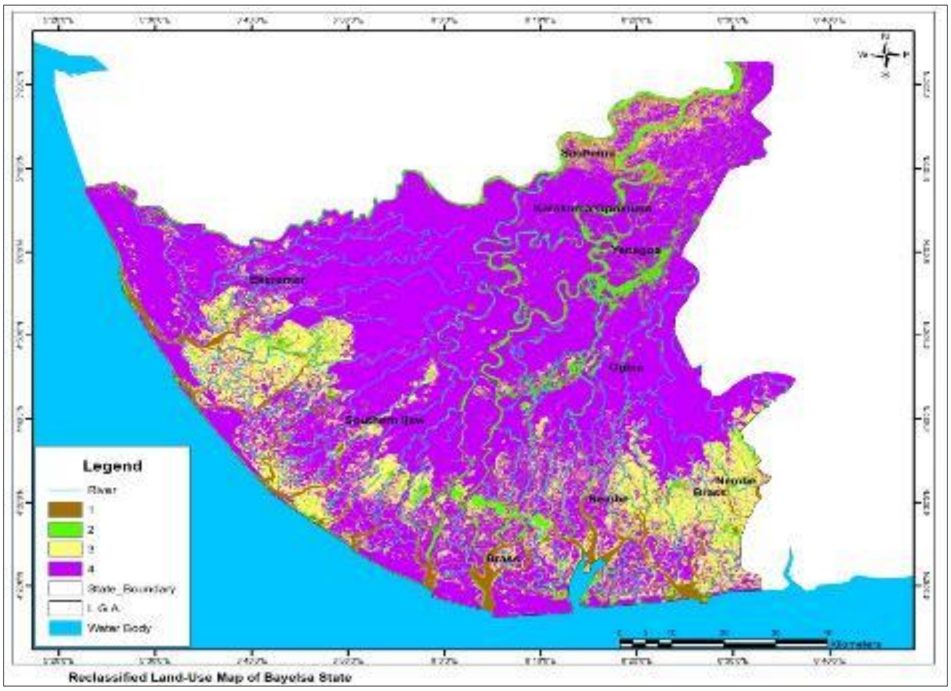



**Figure 5** Land use and Cover of the Study area

### 3.2. Flood Vulnerability Assessment of Bayelsa State

The flood vulnerability map indicates areas in the study area that are highly vulnerable to flood and zones that are non-vulnerable to flood. The detail of the result is presented in Table 7 and Figure 6 and 7. The result indicates that 33.4% of the entire Bayelsa is very highly vulnerable to flooding, about as this section lies within the highly vulnerable, which makes the study area at a high percentage to be flooded. The very highly floodable zone lies in the low land around the Atlantic coast. Low flood vulnerability and non-vulnerable areas were found in the northern parts of Bayelsa State. While across the state 33.4% of the area was highly vulnerable for flood, Southern Ijaw recorded the highest vulnerability percentage (9.23%) followed by Ekeremor (8.43%), Nembe (6.32%), Brass (5.9%) and Ogbia (1.21%) while the least is Sagbama (0.54%). Considering the moderately vulnerable flood zone, Ekeremor recorded highest spatial extent of flooded area (5.11%), southern Ijaw (4.93%) and Nembe (1.43%). In vulnerable area, Southern Ijaw recorded the highest percentage (3.18%), followed by Ekeremor (2.73%) while others include: Sagbama (1.95%), Yenegoa (1.62%) while the lowest was Brass (0.21%). In considering the not vulnerable zone, Sagbama recorded highest (9.61%), followed by Kolokuma/Opokuma (7.5%), Southern Ijaw (7.34%), Ekeremor (4.25%), Ogbia (3.81%) respectively, among others

**Table 7** Extent of Vulnerability across all the LGAs in Bayelsa State

| LGAs | Highly vulnerable | Moderately vulnerable | Vulnerable | Not vulnerable |
|---|---|---|---|---|
| Ekeremor | 8.42 | 5.11 | 2.73 | 4.25 |
| Southern Ijaw | 9.23 | 4.93 | 3.18 | 7.34 |
| Nembe | 6.32 | 1.43 | 1.75 | 1.59 |
| Brass | 5.9 | 0.65 | 0.21 | 1.01 |
| Ogbia | 1.21 | 0.32 | 1.02 | 3.81 |
| Yenegoa | 1.06 | 0.44 | 1.62 | 3.6 |
| Kolokuma/Opokuma | 0.72 | 0.53 | 1.34 | 7.5 |
| Sagbama | 0.54 | 0.68 | 1.95 | 9.61 |
| Total | 33.4 | 14.09 | 13.8 | 38.71 |

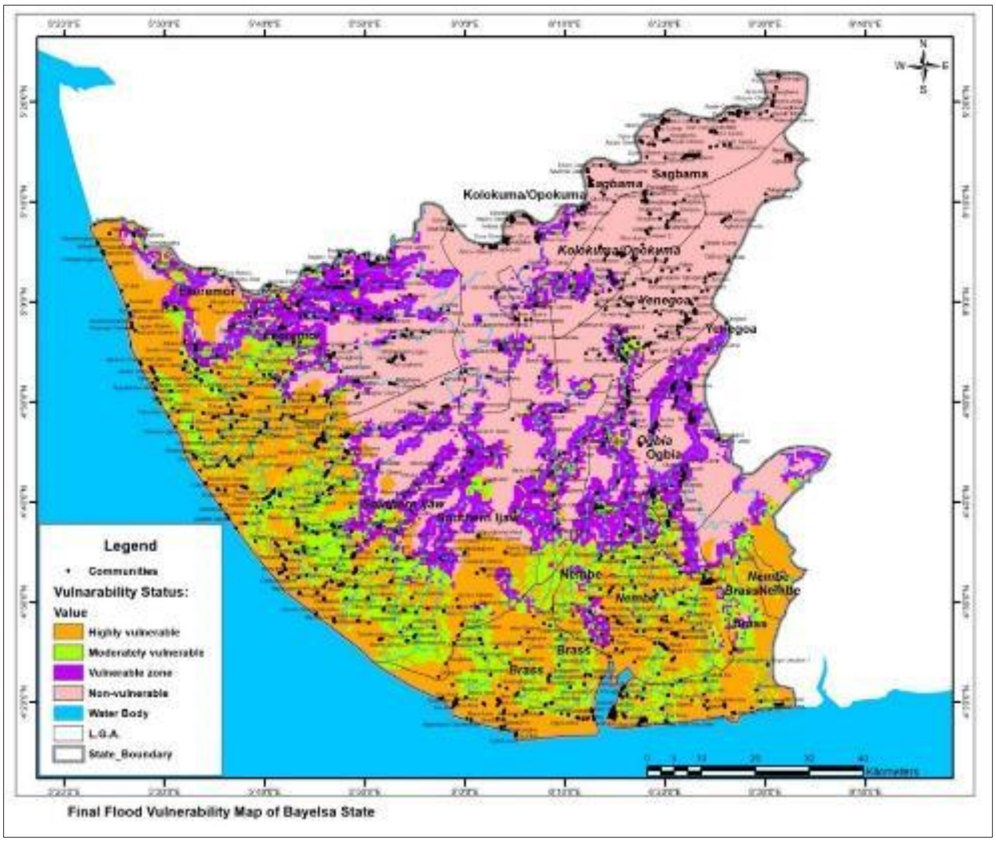



**Figure 6** Flood Vulnerability Map of Bayelsa State

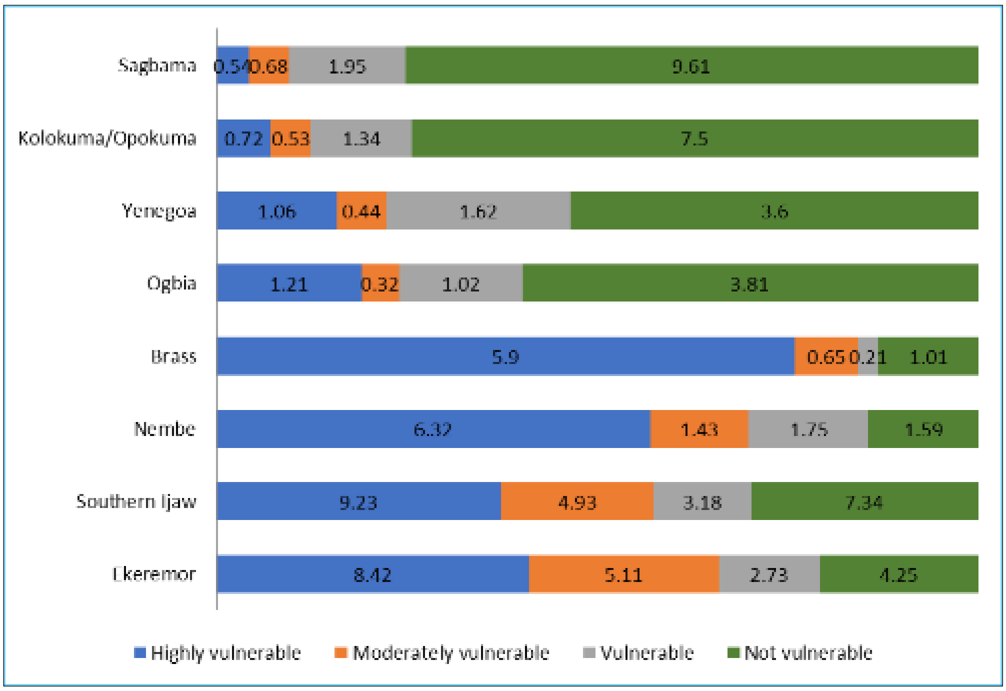



**Figure 7** Flood Vulnerability Distribution across all the LGAs in Bayelsa State

### 3.3. Resilience Capacity Assessment

The resilience capacity of the study area was assessed based on absorptive, adaptive and transformative capacity and the outcome was presented in Table 8. For the absorptive capacity, attributes such as household participating in flood diversion structure (e.g. protection of land/infrastructure from flooding) had the highest mean 3.65 while household receive emergency food or cash assistance from the government or NGO during shock events such as flooding had lowest mean at 2.14. Overall, all attributes showed 3.38 mean score indicating high agreed responses. For the adaptive capacity, attributes such as community/Household have institution that provides credit or saving support had the highest mean at 3.71 while household network with other household to achieve various services needed in the community had the lowest mean score at 2.34. Overall, all attributes showed 2.68 mean score indicating high disagreed responses. For transformative capacity, attribute such as market available for households to sell and buy agricultural had the highest mean score at 3.35 while household have access to formal safety net (e.g. food assistance, shelter and government/NGO assistant) in the community had the lowest mean score at 2.73.

**Table 8** Resilience Capacity Assessment of Isoko North LGA

| **Resilience Capacity Assessment** | **A (%)** | **D (%)** | **Mean (SD)** |
|---|---|---|---|
| Absorptive Capacity Index | | | |
| Household engage in ways of protecting their household from the impact of future shocks | 57.1 | 11.6 | 3.61(1.20) |
| 2. Household participate in flood diversion structure (e.g. protection of land/infrastructure from flooding) | 78.7 | 7.9 | 3.65(1.05) |
| Our community understand disaster preparedness practices and are involve in it | 59.3 | 10.0 | 3.61(0.98) |
| Household can get help from various categories of people living within their community program in the village | 19.5 | 53.4 | 2.51(1.37) |
| Household receive emergency food or cash assistance from the government or NGO during shock event such as flooding | 37.2 | 47.8 | 2.14(1.11) |
| | | | 3.38(0.81) |
| Adaptive Capacity Index | | | |
| Households show aspirations, confidence to adapt, and a sense of control over one's life. | 54.2 | 18.6 | 3.22(0.81) |
| Household get and give help to people OUTSIDE their community | 43.3 | 45.0 | 2.98(1.43) |
| Community/Household have institution that provides credit or saving support | 54.7 | 9.3 | 3.71(1.02) |
| Households in the community have access to necessary information and easily adopt improved practices | 40.1 | 48.2 | 2.42(1.22) |
| Household network with other household to achieve various services needed in the community | 32.0 | 56.4 | 2.34(1.32) |
| | | | 2.68(0.72) |
| Transformative Capacity Index | | | |
| Household have access to formal safety net (e.g. food assistance, shelter and government/NGO assistant) in the community. | 34.1 | 55.4 | 2.73(1.34) |
| Market available for household to sell and buy agricultural products. | 56.8 | 19.1 | 3.35(1.07) |
| Household have access to basic services (e.g. Roads, School, Healthcare, Police) in the community | 50.8 | 29.8 | 3.35(1.24) |
| Local government responded to community requests for improving community assets or services | 32.4 | 43.7 | 2.04(1.08) |
| Household participate in the decision-making process that concerns the community. | 47.7 | 23.5 | 3.32(1.18) |
| | | | 3.01(0.51) |
| Overall Resilience Capacity | | | 3.02(0.68) |

*Key: A- Agreed (Strongly Agreed + Agreed), D-Disagreed (Strongly Disagreed + Disagreed), SD= Standard Deviation

Overall, all attributes showed 30.1 mean score indicating high agreed responses. Among the capacity index, Absorptive capacity had the highest strength at mean score of 3.38 while the challenges majorly lies with the adaptive capacity at mean score of 2.68. The overall capacity resilience capacity of the study area showed some level of strength/capacity at overall mean score of 3.02.

## 4. Discussion of Findings

The procedure used in establishing the vulnerability status of the study area was similar to those adopted by the study conducted by Afolabi et al. (2022), Berezie et al. (2019) and Umar and Gray (2022). Afolabi et al. (2022) established the vulnerability categories of communities in Isoko North LGAs low, medium and high vulnerability. Chukwuma et al. (2021) through conditional factors such as slope, land use, elevation and soil texture, the vulnerability level of LGAs in Anambra state was determined. The approach adopted by this study; that is, the use of RS and GIS is a common approach to flood modelling. This was corroborated by various studies including that of Bello and Ogedegbe (2015), Orimoogunje et al., 2016 and Umar and Gray (2022). On the Land use/Landcover, the activities with high vulnerability reported for this study; that is, settlement, waterbodies, rocky land and sandy area are similar to those reported by Onuigbo et al. (2017). Wizor and Week (2020) opined that various anthropogenic activities affect the land use and landcover of an area and it can increase exposure. Among various land use/landcover categories reported for this study, settlement was rated the highest among the high vulnerability for land use/landcover. Changes in land use due to urbanization increases flood susceptibility (Kaspersen et al., 2015) as urbanization is largely associated with the removal of soil and vegetation and these are important factors for limiting surface runoff (Adeoye, 2012; Pradhan-salike & Pokharel, 2017). The outcome on elevation showed similarity with that of Happy et al. (2014), and Berezie et al. (2019) which was able to establish the vulnerability level due to elevation of their study area.

According to Afolabi et al (2022), the purpose of resilience capacity assessment is to identify the community's strength and challenges in the face of disturbance or unwanted events. This is an indication of aboriginality among the individual from the communities and this can help in community resilience building. This in line with Usher et al (2021) and Pfefferbaum et al. (2013) which both noted community connectivity as part of the basis for developing community resilience. Amangabara and Gobo (2010) suggested that the best approach to flood management in Nigeria is one that seeks a balance application of both structural and non-structural measures. According to Ologunorisa (2009), for flood risk mitigation strategies to be effective, there is need for establishment of coastal management zone authority, land-use zoning, legislation, building codes among others. Bodland and Granberg (2018) noted that mitigating community vulnerability requires public engagement towards improving adaptive capacity. According to Afolabi et al. (2022), the need for community resilience built based on community capacity, participation, social capacity, economic development and information and communication.

## 5. Conclusion

Flooding remains a major environmental challenge in Bayelsa State, exacerbated by low-lying geography, climate change, and anthropogenic factors. This study has identified critical areas of vulnerability and assessed community resilience capacity. The GIS-based flood vulnerability analysis revealed that 33.4% of the state is highly vulnerable, with Southern Ijaw and Ekeremor being the most affected. Conversely, northern regions such as Sagbama and Kolokuma/Opokuma exhibit lower susceptibility. The resilience assessment indicates that while communities demonstrate absorptive capacity in flood mitigation measures, adaptive and transformative capacities remain weak due to limited institutional support and socio-economic constraints. Authorities should develop comprehensive flood control infrastructure, including embankments, drainage systems, and retention basins to mitigate flood risks in highly vulnerable areas. Also, Local governments should implement educational programs to increase community awareness and preparedness, promoting household-level flood adaptation strategies.

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