ISSN: 2639-7455

Research article

Earth & Environmental Science Research & Reviews

# Flood Risk Assessment of Communities to Flood Hazards in Central Niger Delta, Nigeria

**Agwumafa O F, Weli V E, Eludoyin O S.**

*Department of Geography and Environmental Management, University of Port Harcourt, Port Harcourt, Nigeria*

***Corresponding author**

Weli V E, Department of Geography and Environmental Management, University of Port Harcourt, Port Harcourt, Nigeria.

**Submitted**: 29 July 2021; **Accepted**: 07 Aug 2021; **Published**: 13 Aug 2021

***Citation:*** *Agwumafa O F, Weli V E, Eludoyin O S (2021) Flood Risk Assessment of Communities to Flood Hazards in Central Niger Delta, Nigeria. Eart & Envi Scie Res & Rev, 4: 70-83.*

***Abstract***

*The study examined the risk assessment of communities in the Central Niger Delta, Nigeria with a view to employing analytical hierarchical ranking process technique. The study considered the landuse, elevation, soil texture and proximity to active river channels as factors determining flood vulnerability (FV) while factors such as accessibility, social infrastructure, water supply, agriculture, commercial activities and disaster preparedness of communities were used for flood exposure (FE) using purposive sampling technique. Both FV and FE were combined together using UNION Module of ArcGIS 10.5 to produce flood risk map of the Central Niger Delta. Descriptive statistics using frequency and percentages were used for the data analysis. Findings revealed that 20.25%, 51.66% and 28.09% of the entire study area were lowly vulnerable, moderately vulnerable and highly vulnerable to flood. Similarly, 0.3%, 45.7% and 54.8% were lowly exposed, moderately exposed and highly exposed to flood. However, 14.3%, 28.3% and 57.4% of the study area had low flood risk, moderate flood risk and high flood risk respectively. The study concluded that majority of the area in the Central Niger Delta is risky to flood. It is recommended among others that channelization and dredging of River Niger Creeks in the study area are important in order for the river to accommodate more volume of water whenever there is excessive rainfall.*

**Keywords:** Atmospheric Visibility, Variability, Air Pollutants, Meteorological Parameters, Suspended Particulates

## Introduction

The trend in the frequency and intensity of flood disasters locally and internationally is due to unpredictable climatic changes, severe flooding, fire, drought, terrorism, epidemics and urbanization especially in developing countries. One very important but frequently ignored aspect in disaster management efforts in Nigeria is risk assessment. Urbanization and lack of good local governance have been regarded as a major creator of urban flood risk [1, 2]. Urbanization exacerbates the damages caused by flooding by restricting where flood or storm waters can go. Large parts of the ground with roofs, roads and pavements are covered, obstructing sections of natural channels and building drains that ensure that water moves to rivers faster than it did under natural conditions. In an urbanizing environment, the infiltration capacity is reduced by the replacement of ground cover with impervious urban surfaces [3]. In the urban centres, the event of climate change impact the environment either directly or via changes in water flows. Hydrological changes within the river systems are cause for concerns due to related increase in flooding incidence or significant changes in base flows. In many cities in Nigeria there is lack/inadequate infrastructural provisions to curb flooding. Urban areas in Nigeria are particularly vulnerable to flooding due to inadequate capacity of drainage structures; changes to ecosystem through the replacement of natural and absorptive soil cover with concrete; and deforestation of hillsides, which has the effect of increasing the quantity and rate of runoff, and through soil erosion and the silting up of drainage channels. According to Action Aid International flood hazards are natural phenomena, but damage and losses from floods are the consequence of human action [4]. Flash flooding /urban flooding destroys the produce e.g. crop, rice paddy, fruit tree and vegetables thereby posing the risk of hunger to those engaged in subsistence farming and great loss to those engaged at a commercial scale [5].

With the increasing number of urban dwellers worldwide, the number of people at risk or vulnerable to flood hazards is likely to increase. Any increase in disasters, whether large or small, will

threaten development gains and hinder the implementation of the Millennium Development Goals (UN-ISDR, 2008). Disaster such as flood poses serious challenge to the economy of a nation. It must be noted that the economic environment of a nation consists of its financial systems, social welfare, power sector, transportation, investments, commerce, manufacturing, and construction, banking among others. Flood disasters when they occur usually result in pains and huge losses to the economy and in most cases; it is always difficult to quantify the actual cost of damages and recovery. In flood disaster, there's loss of lives, destruction of public utilities and disruption in the smooth functioning of the system that renders fear and uncertainties among the populace. In addition, there was the loss of livelihoods, damage to the environment, financial loss, and diversion of resources, epidemics, migration, food shortages and displacement of the people. The impact can be very high in the urban areas, because the areas affected are densely populated and contain vital infrastructure. A more disturbing issue is the lack of attention to the promotion of sustainable environmental management especially in disaster prone areas resulting in devastations which could have been averted.

## Materials and Methods

The study made use of both primary and secondary sources of data. The primary data sources consist of field data collection and questionnaire administration, which was used to collect the required information from the respondents. The primary data included Landuse map of Central Niger Delta acquired from the Landsat imagery of 30m x 30m acquired from the United States Geological Survey website, the drainage network and communities' location extracted from the topographic map of 1:500,000 scale of the study area; and soil map derived from the FAO website. Topographic map of the study area from Surveyor General's Office, Ministry of Lands and Survey of Bayelsa State, Delta State and Rivers State and flood related issues from relevant literature, journals, magazines, and newspaper. Secondary data sources consisted of books, both published and unpublished materials.

## Geo-Information and Vulnerability Map Generation

The bands of landsat satellite imageries of the study area of path 189 and row 056; path 189 and row 057; path 188 and row 056 and path 188 and row 057 were combined to have a single-band imagery for each of the scenes. Thereafter, the scenes merged together using mosaicked process for further analysis. The shapefile of Central Niger Delta was used to clip the mosaicked imagery to have a definite boundary of the study area. However, topographical map was geo-referenced to world coordinate system (WGS 84) in ArcGIS 10.5 from where the communities and river networks were obtained while the Shuttle Radar Topographic Mission (SRTM) imagery was used to determine the elevation or relief map of the study area. The soil map in was generated from the World Soil Map created by FAO/UNESCO (1973). From the imagery, landuse map of the study area was acquired while drainage network, road network and communities were derived from the topographical map.

## Vulnerability Criteria

This study made use of ranking methods of the vulnerability factors which is embedded in Analytical Hierarchy Process (AHP) proposed by Saaty (1980). AHP is a multi-criteria decision-making technique, which provides a systematic approach for assessing and integrating the impacts of various factors, involving several levels of dependent or independent, qualitative as well as quantitative information (Bapalu and Sinha, 2006). Ranking method was adopted because the criterion weights are usually determined in the consultation process with choice or decision makers which resulted in ratio value assigned to every criterion map (Lawal et al, 2011). In ranking method, every criterion under consideration is ranked in the order of the decision maker's preference. To generate criterion values for each evaluation unit, each factor was weighted according to the estimated significance for causing flood.

## Land use Map

The landuse/land cover map was generated from the satellite imageries. Supervised classification technique was adopted with the use of MAXLIKE (Maximum Likelihood Algorithm) module to classify the imagery in the area. The area in square kilometer of each landuse type was computed. The major landuse identified were waterbodies, built up area, mangrove, farmland/light forest; and swamp forest/thick forest.

## Proximity to river channels (Drainage) and Community Map

The drainage network which determines the proximity to river channels and communities were digitised from the topographical map of the study area as vector data in ArcGIS 10.5.

## Elevation or Relief Map

The elevation map was derived from the SRTM elevation data of 30km grids. The shapefile boundary of the study area was used to clip the raster data and geo-processed for further analysis.

## Soil texture Map

The soil textural map was obtained from the World Soil Map created by FAO/UNESCO and the soil textural classes were coarse, sand, silty/loam, fine which depended on the major soil types like Fluvisol, Gleysol, Ferrasol, Nitisol and Regosol.

## GIS Analysis and Generation of Vulnerability Maps

The landuse, proximity to river channels (drainage), elevation or relief and soil texture maps were reclassified into high vulnerability, moderate vulnerability and low vulnerability.

## Reclassification based on Landuse types

There are five landuse types in the study area and they are; waterbodies, built up area, mangrove, farmland/light forest, and swamp forest/thick forest. In terms of landuse map, the swamp forest/thick forest and farmland/light forest were reclassified to moderate vulnerability; while waterbodies, built up area and mangrove were reclassified to high vulnerability.

## Reclassification based on drainage network

In terms of drainage network, buffering method was used whereby zones of influence were generated as rings of 500 meters, 1000 meters and 1500 meters from the active river channels. The ring of 500m was regarded as high vulnerability, 1000m as moderate vulnerability and 1500m as low vulnerability.

## Reclassification based on elevation

The elevation map was also reclassified as follows -10.00m-89.00m as high vulnerability, 89.01m-178m as moderate vulnerability and above 178m as low vulnerability.

## Reclassification based on soil texture

Soil strength map was determined using the soil texture of soil in the Central Niger Delta. The soil textural types identified were coarse, sand, fine/clay and silty/loam. According to Duncan and Wright soil strength indices are essential in assessing the stability of slopes and soil, and can be used to construe the ability of a soil to withstand stresses and strains associated with naturally occur-ring instances of increased pore pressure, cracking, swelling, development of slicken sides, leaching, weathering, undercutting, and cyclic loading [6]. The coarse and sand were reclassified to low vulnerability, silty/loam to moderate vulnerability while fine/clay was reclassified to high vulnerability.

## Final Flood Vulnerability Map

The vulnerability level values of 3, 2, and 1 were assigned to be high vulnerability, moderate vulnerability and low vulnerability respectfully. This was done in order to rank the items or components of each major factor causing flood. Using these values, the landuse vulnerability map, drainage network vulnerability map, soil texture vulnerability and elevation vulnerability map were overlaid with the use of UNION MODULE. Thereafter, reclassification method was applied to have high vulnerability, moderate vulnerability and low vulnerability. The output of this map was regarded as the flood vulnerability map of the Central Niger Delta. Spatial query was used to determine the vulnerability levels that each community fell into and also used to determine the spatial extent (square kilometer) of each vulnerability level.

## Exposure Criteria

The study made use of six flood exposure in the study area and they included accessibility, social infrastructure, water supply, agriculture, commercial activities, and disaster preparedness. The ranking methods are highlighted thus:

Accessibility: Very accessible – 1, accessible – 2, less accessible -3, not accessible - 4

Social infrastructure: Present – 1, Absent - 2

Water supply: very available - 4, available – 3, less available – 2, not available – 1.

Agriculture (crop production, fishing and livestock farming) where high-3, medium – 2, low – 1

Commercial activities: Present – 2, Absent – 1.

Disaster preparedness: Very prepared – 1, prepared – 2, less prepared – 3, not prepared – 4.

## Results and Findings

### Landuse/Land cover Vulnerability

The landuse map vulnerability to flood was determined according to the vulnerability levels assigned to each landuse identified in the Central Niger Delta. Figure 1 and Figure 2 explain the types of landuse observed and the spatial coverage of each of them. The mangrove had the highest spatial extent (11970.00 km2), followed by swamp forest/thick forest having 8626.08. The analysis also revealed that water bodies recorded 1068.27 km2 while the built up area recorded 6301.85 km2 and farmland/light forest having 7203.39 km2. The analysis further showed that the spatial coverage of the area for moderate flood vulnerability covered 45.01% while high flood vulnerability was 54.99 %.

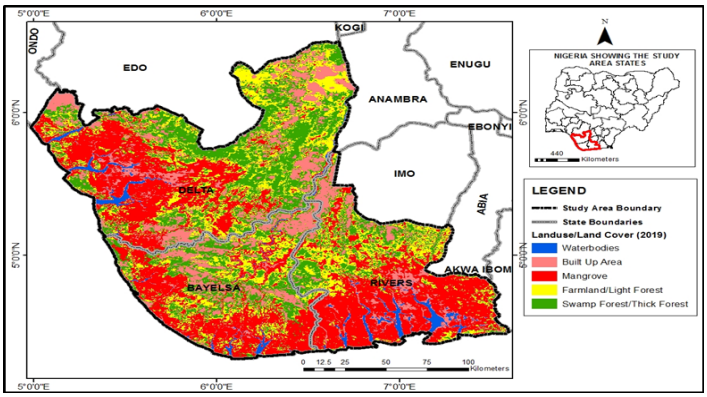


**Figure 1:** Landuse/Land cover of the Study Area

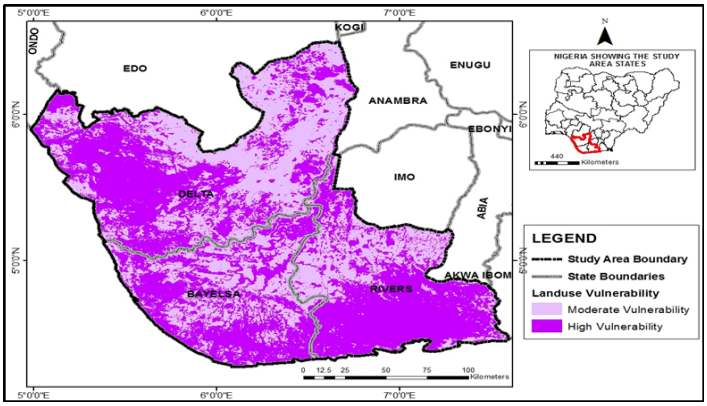


**Figure 2:** Landuse Vulnerability Level to Flood

**Table 1. Landuse/Landcover Vulnerability Levels to Flood**

| Landuse | Vulnerability Level | Vulnerability Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Waterbodies | 3 | High | 1068.27 | 3.04 |
| Built Up Area | 3 | High | 6301.85 | 17.92 |
| Mangrove | 3 | High | 11970.00 | 34.04 |
| Farmland/Light Forest | 2 | Moderate | 7203.39 | 20.48 |
| Swamp Forest/Thick Forest | 2 | Moderate | 8626.08 | 24.53 |
| Total | | | 35169.59 | |

## Nearness to Drainage Channel Vulnerability Map

Table 1 and Figures 3 and 4 describe the river network and their levels of vulnerability maps of the Central Niger Delta respectively. The results show that the buffer of 500m from the rivers (i.e. high flood vulnerability level based on the nearness to active channel) covered a spatial extent of 6250.15 km2, the buffer of 1000 m covered 5438.65 km2 while the buffer of 1500m covered a spatial extent of 4503.73 km2. Thus, the high vulnerability area covered 38.60%, moderate 33.59% and low covered 27.81%.

**Table 2 Drainage Vulnerability to Flood**

| Proximity to Active Drainage through River Buffer (m) | Vulnerability Level | Vulnerability Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| 500 | 3 | High | 6250.15 | 38.60 |
| 1000 | 2 | Moderate | 5438.65 | 33.59 |
| 1500 | 1 | Low | 4503.73 | 27.81 |
| Total | | | 16192.53 | 100.0 |

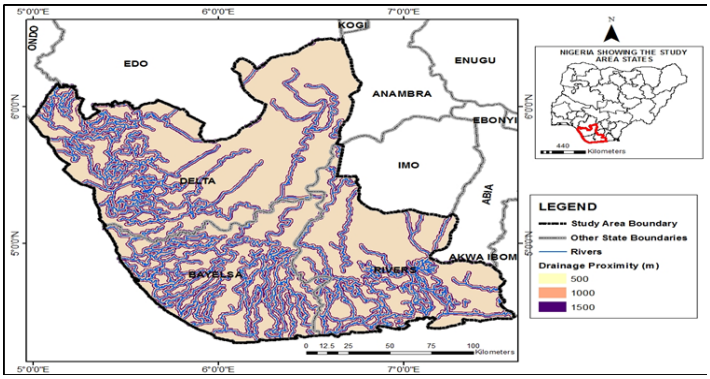


**Figure 3:** River Buffer from the Active Drainage

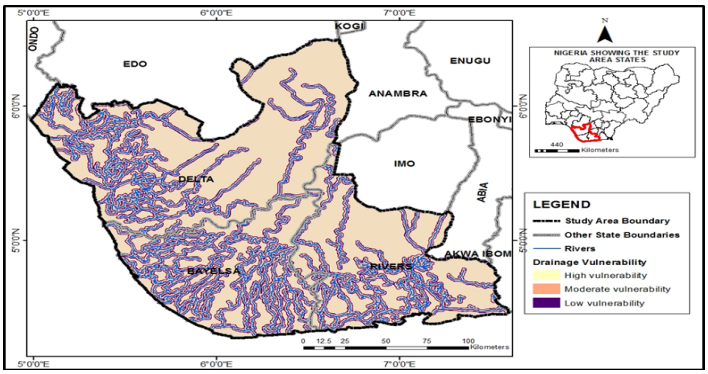


**Figure 4:** Proximity to River Channel Vulnerability

## Flood Vulnerability Map based on Relief or Topography

The flood vulnerability level based on relief or topography is shown in Table 3, Figure 5 and Figure 6. It shows that the high vulnerability zone based on relief was between 10m and 89.0m while the moderate vulnerability was between 89.01m and 178.0m. The low vulnerability zone was between 178.01m and 317.0m. The analysis also revealed that the high, moderate and low vulnerability covered 33540.74 km2 (94.52%), 1040.68 km2 (2.93%) and 905.57 km2 (2.55%) respectively.

**Table 3: Topography/Relief of the Study Area**

| Relief (m) | Vulnerability Level | Vulnerability Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| 10.00-13.00 | 3 | High | 13989.10 | 39.42 |
| 13.01-27.00 | 3 | High | 15799.64 | 44.52 |
| 27.01-52.00 | 3 | High | 3160.96 | 8.91 |
| 52.01-89.00 | 3 | High | 591.04 | 1.67 |
| 89.01-134.00 | 2 | Moderate | 347.83 | 0.98 |
| 134.01-178.00 | 2 | Moderate | 692.85 | 1.95 |
| 178.01-224.00 | 1 | Low | 534.60 | 1.51 |
| 224.01-317.00 | 1 | Low | 370.57 | 1.04 |
| Total | | | 35486.59 | 100.0 |

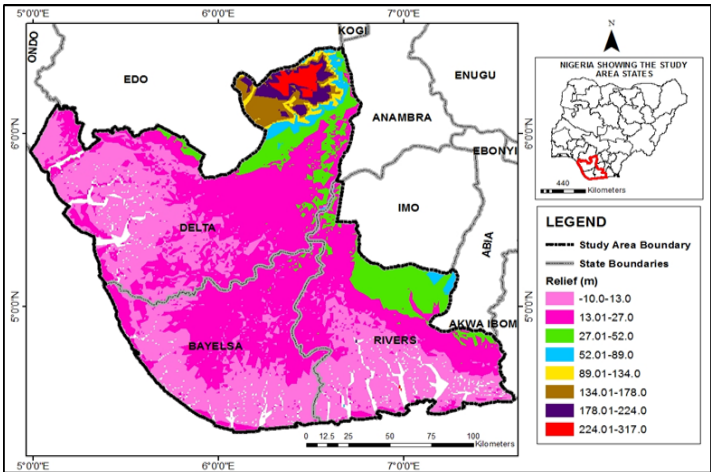


**Figure 5:** Relief Classes of the Study Area

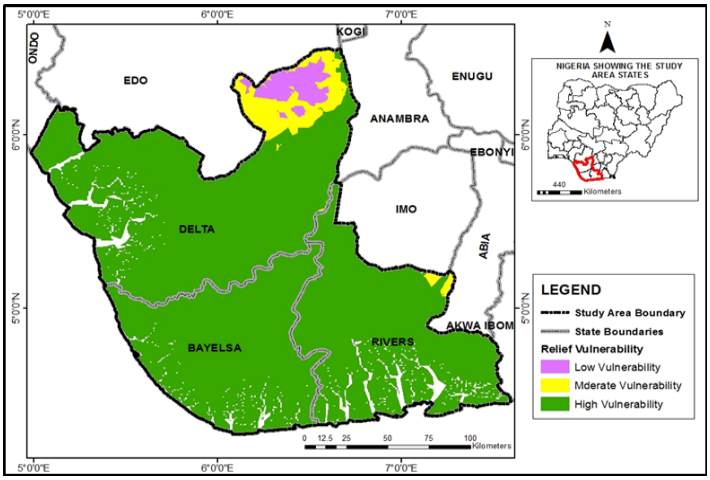


**Figure 6:** Relief Vulnerability to Flood

## Soil Texture Vulnerability Map

Table 4 and Figures 7 and Figure 8 describe the soil texture vulnerability to flood in the study area. The analysis showed that the fine texture covered 16031.17.0 km2, coarse covered 7753.93 km2, silty loam covered 9568.86 km2 and sand covered 3483.64 km2.

In the table 4.4, fine/clay had been categorized as high vulnerability level, coarse and sand have been categorized low vulnerability while silty/loam was categorized as moderate vulnerability. Thus, 43.52%, 25.98%, and 30.51 % was for high vulnerable, moderate vulnerable and low vulnerable respectively.

**Table 4: Soil Texture of the Study Area**

| Proximity to Active Soil Texture | Vulnerability Level | Vulnerability Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Fine/Clay | 3 | High | 16031.17 | 43.52 |
| Coarse | 1 | Low | 7753.93 | 21.05 |
| Silty/Loam | 2 | Moderate | 9568.86 | 25.98 |
| Sand | 1 | Low | 3483.64 | 9.46 |
| Total | | | 36837.60 | 100.0 |

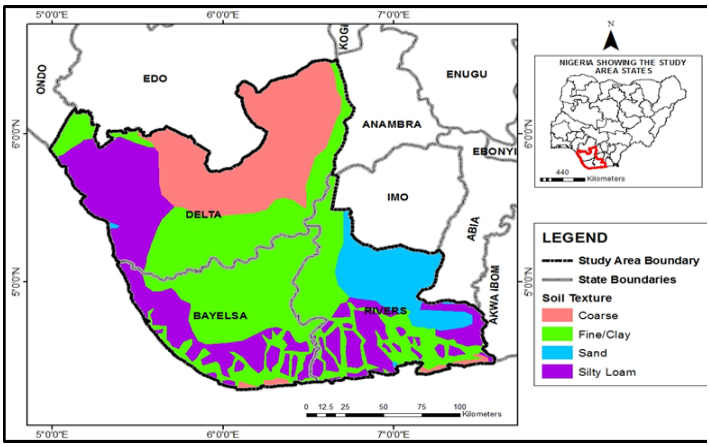


**Figure 7:** Soil Texture Characteristics of the Study Area

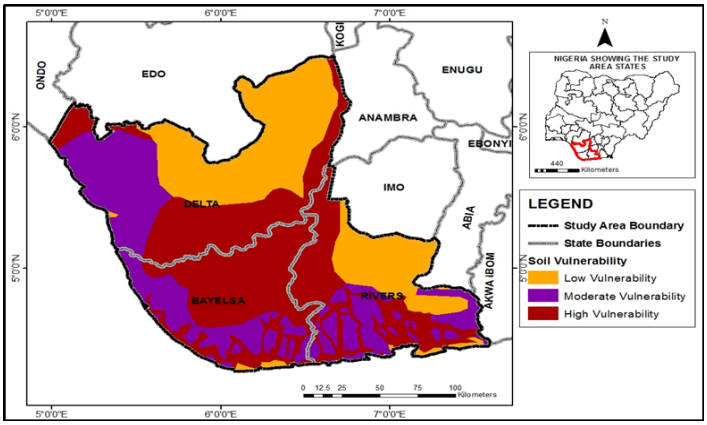


**Figure 8:** Soil Texture Vulnerability

Flood Vulnerability Map and Communities Vulnerability Levels

Table 5 and Figure 9 present the flood vulnerability levels of communities within the Central Niger Delta. The analysis showed that the areas that have low vulnerability to flood were 7540.71 km2 (20.25 %) of the entire area. The moderate vulnerability areas covered a spatial extent of 19238.88 km2 (51.66%), while high vulnerability areas covered 10458 km2 (28.09%). This imply that areas with moderate and high vulnerabilities covered 79.7.5% of the entire study area, which means majority of the part of the study area was prone to flood considering the above factors.

Table 4.11 presents the overlay of communities on the flood vulnerability levels of the Central Niger Delta. It is shown that about 295 (17.14%) communities which included Aabom, Abah, Abaji Okolo, Abara, Abayo, Abbi, Abedei, Aboh Ogwashi Ukwu, Abuluku, Adonta Afara, Asarama, Elem Kalabari had low flood vulnerability levels (Figure 4.10). The communities with moderate vulnerability feature were about 877 (50.96%) (Figure 4.11). However, 549 (31.90%) of the entire communities were highly vulnerable to flood in the study area. These communities include Abolikiri, Akaba, Alese, Amarata, Bille, Ekeki, Ebekiri, Efebiri, Ikodu, Ikuru, Imiringi, Kalabari, Katsun, Kula, and so on (Figure12).

**Table 5: Final Flood Vulnerability**

| Flood Vulnerability Level | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|
| Low Vulnerability | 7540.71 | 20.25 |
| Moderate Vulnerability | 19238.88 | 51.66 |
| High Vulnerability | 10458.50 | 28.09 |
| Total | 37238.09 | 100.0 |

**Source:** Reseracher's Analysis, 2020

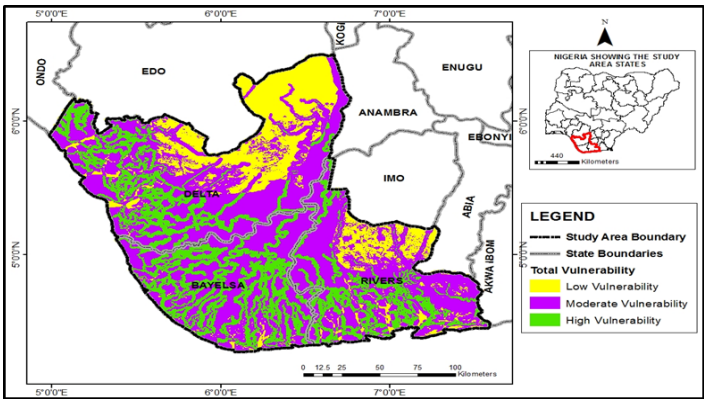


**Figure 9:** Flood Vulnerability Map of Central Niger Delta

## Flood Exposure Metrics

**Table 6. Flood Exposure Metrics of Communities to Flooding**

| S/N | COMMUNITIES | FV | ACCESSIBILITY | SOCIAL INFRASTRUCTURE | WATER SUPPLY | AGRICULTURE | COMMERCIAL ACTIVITIES | DISASTER PREPAREDNESS |
|---|---|---|---|---|---|---|---|---|
| 1 | ABALA | 2 | 3 | 2 | 2 | 7 | 2 | 4 |
| 2 | ABARA | 1 | 3 | 1 | 4 | 6 | 1 | 4 |
| 3 | ABOH | 2 | 1 | 1 | 4 | 5 | 2 | 4 |
| 4 | ADAGBABIRI | 2 | 4 | 1 | 4 | 6 | 2 | 4 |
| 5 | ADOBOR | 2 | 1 | 1 | 4 | 7 | 2 | 4 |
| 6 | AGBERE | 2 | 1 | 1 | 4 | 7 | 1 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 7 | AGBIA | 2 | 1 | 1 | 4 | 7 | 2 | 4 |
| 8 | AGORO | 2 | 1 | 1 | 4 | 7 | 1 | 4 |
| 9 | AGUDAMA-EPIE | 3 | 1 | 1 | 4 | 7 | 2 | 4 |
| 10 | AKABUKA | 2 | 1 | 1 | 4 | 5 | 2 | 4 |
| 11 | AKEMU-ASA-RUEHA | 2 | 1 | 1 | 2 | 8 | 1 | 4 |
| 12 | AKINIMA | 2 | 1 | 1 | 3 | 7 | 2 | 4 |
| 85 | Amai | 3 | 4 | 1 | 4 | | 2 | |
| 13 | AMARATA | 3 | 1 | 1 | 4 | 6 | 2 | 4 |
| 14 | AMATEBE | 3 | 1 | 2 | 1 | 7 | 2 | 4 |
| 16 | ANIBEZE | 2 | 4 | 1 | 1 | 7 | 1 | 4 |
| 17 | ARAYA | 2 | 3 | 1 | 4 | 6 | 1 | 4 |
| 86 | Aronwon | 2 | 2 | 1 | 4 | 6 | 1 | |
| 18 | ASAMABIRI | 3 | 4 | 1 | 4 | 7 | 1 | 4 |
| 19 | ASE-AZAGA | 2 | 4 | 2 | 3 | 7 | 1 | 4 |
| 20 | ASHAKA | 2 | 1 | 2 | 4 | 8 | 2 | 4 |
| 21 | AVEN | 2 | 3 | 1 | 4 | 7 | 1 | 4 |
| 22 | AYAMA | 2 | 4 | 2 | 3 | 6 | 1 | 4 |
| 104 | Aziama | 3 | 4 | 2 | 4 | 7 | 2 | 4 |
| 23 | AZIKORO | 2 | 1 | 1 | 4 | 7 | 2 | 4 |
| 105 | Bilabiri | 2 | 2 | 2 | 4 | 8 | 1 | 4 |
| 24 | BIOGBOLO | 3 | 4 | 1 | 4 | 7 | 2 | 4 |
| 89 | Bresibi | 2 | 1 | 2 | 4 | 6 | 2 | 4 |
| 99 | Deyor | 2 | 1 | 2 | 3 | 7 | 1 | 4 |
| 25 | EBOCHA | 3 | 1 | 1 | 4 | 9 | 2 | 4 |
| 26 | EBRESEGHA | 2 | 1 | 1 | 4 | 9 | 2 | 4 |
| 27 | EBRIBA | 2 | 4 | 2 | 2 | 8 | 2 | 4 |
| 102 | Egwema | 1 | 1 | 2 | 1 | 8 | 2 | 4 |
| 28 | EKPERIWARE | 3 | 4 | 1 | 1 | 8 | 1 | 4 |
| 29 | ELEMEBIRI | 2 | 4 | 2 | 1 | 7 | 1 | 4 |
| 30 | EMADIKE | 3 | 3 | 1 | 4 | 7 | 1 | 4 |
| 31 | EMEDE | 2 | 1 | 2 | 1 | 7 | 2 | 4 |
| 32 | EPEBU | 3 | 3 | 1 | 4 | 7 | 2 | 4 |
| 33 | EREMA | 2 | 1 | 1 | 4 | 5 | 2 | 4 |
| 97 | Finima | 2 | 1 | 1 | 2 | 6 | 1 | 4 |
| 83 | Guogbene | 1 | 1 | 1 | 2 | 7 | 2 | 4 |
| 34 | IBREDE | 3 | 1 | 1 | 4 | 9 | 2 | 4 |
| 54 | IDIKU | 2 | 3 | 2 | 3 | 6 | 2 | 4 |
| 35 | IGBOGENE | 1 | 1 | 1 | 4 | 7 | 2 | 4 |
| 36 | IGONI | 3 | 4 | 1 | 1 | 7 | 1 | 4 |
| 37 | IGOVIA | 3 | 3 | 2 | 2 | 8 | 2 | 4 |
| 38 | IKODU | 3 | 2 | 1 | 3 | 7 | 1 | 3 |
| 39 | IKPIDE-IRRI | 1 | 1 | 1 | 2 | 8 | 1 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 40 | IMIRINGI | 3 | 1 | 1 | 4 | 7 | 2 | 4 |
| 41 | ISELEGU | 2 | 1 | 1 | 4 | 9 | 2 | 4 |
| 42 | ISUKWA | 2 | 1 | 2 | 3 | 7 | 2 | 4 |
| 43 | ISUSU | 2 | 3 | 2 | 3 | 6 | 2 | 4 |
| 44 | IVROGBOR-IRRI | 1 | 1 | 2 | 2 | 8 | 2 | 4 |
| 45 | IYEDE-AME | 2 | 1 | 2 | 2 | 8 | 2 | 4 |
| 95 | Iyiba | 2 | 1 | 1 | 2 | 8 | 1 | 3 |
| 87 | Koko | 2 | 2 | 2 | 1 | 6 | 2 | 4 |
| 46 | KOLOWARE | 2 | 3 | 1 | 4 | 6 | 1 | 4 |
| 47 | KPANSIA | 3 | 1 | 1 | 4 | 7 | 2 | 4 |
| 15 | Kwale | 2 | 1 | 1 | 2 | 7 | 1 | 4 |
| 48 | MBIAMA | 3 | 1 | 1 | 3 | 7 | 2 | 4 |
| 107 | Ndemili | 2 | 1 | 2 | 2 | 8 | 2 | 4 |
| 49 | NDONI | 3 | 1 | 1 | 4 | 6 | 2 | 4 |
| 50 | OBAGI | 3 | 1 | 1 | 4 | 9 | 3 | 4 |
| 98 | Obete | 2 | 1 | 1 | 3 | 6 | 3 | 4 |
| 90 | Obodie | 2 | 2 | 1 | 4 | 7 | 2 | 4 |
| 51 | OBRIKOM | 2 | 1 | 1 | 4 | 9 | 2 | 4 |
| 52 | ODABOR | 2 | 2 | 1 | 3 | 7 | 1 | 3 |
| 53 | ODIEREKE-UBIE | 3 | 2 | 1 | 3 | 5 | 2 | 4 |
| 108 | Odoni | 3 | 2 | 1 | 3 | 8 | 2 | 4 |
| 55 | ODORUBU | 2 | 1 | 2 | 1 | 7 | 1 | 4 |
| 56 | OFONI | 2 | 4 | 1 | 4 | 7 | 1 | 4 |
| 101 | Ogbakiri | 3 | 4 | 2 | 4 | 6 | 2 | 4 |
| 57 | OGOR | 2 | 3 | 1 | 4 | 7 | 2 | 4 |
| 96 | Okala | 1 | 1 | 1 | 4 | 7 | 1 | 4 |
| 58 | OKARKI TOWN | 3 | 3 | 2 | 3 | 8 | 2 | 4 |
| 60 | OLOGOGHE | 3 | 3 | 1 | 4 | 6 | 1 | 4 |
| 59 | OLOIBIRI | 3 | 3 | 2 | 3 | 7 | 1 | 4 |
| 61 | OLOKUMA | 3 | 3 | 2 | 2 | 8 | 2 | 4 |
| 62 | ONOGBOKOR | 2 | 4 | 2 | 2 | 7 | 1 | 4 |
| 63 | OPOLO | 3 | 1 | 1 | 4 | 6 | 2 | 4 |
| 64 | OPUME | 3 | 3 | 2 | 3 | 6 | 1 | 4 |
| 106 | Orumegege | 1 | 1 | 2 | 4 | 8 | 2 | 4 |
| 65 | OSHI | 3 | 1 | 1 | 4 | 7 | 1 | 4 |
| 66 | OSHIEBELE | 2 | 1 | 1 | 4 | 7 | 2 | 4 |
| 67 | OSSISA | 2 | 1 | 2 | 4 | 6 | 2 | 4 |
| 94 | Ote Ogbeji | 1 | 1 | 1 | 3 | 6 | 2 | 4 |
| 68 | OTUOBHI | 3 | 1 | 1 | 4 | 7 | 2 | 4 |
| 84 | Ovenama | 1 | 1 | 1 | 4 | 7 | 1 | 4 |
| 69 | OWUBO | 2 | 3 | 2 | 4 | 9 | 2 | 4 |
| 93 | Ozara | 1 | 1 | 2 | 3 | 8 | 3 | 4 |
| 70 | OZORO | 2 | 1 | 1 | 4 | 9 | 2 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 71 | SAGATAMA | 3 | 3 | 2 | 3 | 7 | 1 | 4 |
| 103 | Sangana | 1 | 1 | 1 | 4 | 6 | 1 | 4 |
| 91 | Sapele | 2 | 1 | 1 | 4 | 7 | 2 | 4 |
| 72 | TOMBIA | 3 | 1 | 1 | 4 | 7 | 2 | 4 |
| 73 | TORU-ANGIAMA | 2 | 2 | 1 | 3 | 7 | 1 | 3 |
| 74 | UBETA | 2 | 2 | 2 | 3 | 7 | 2 | 4 |
| 75 | UBIE | 3 | 3 | 1 | 4 | 6 | 1 | 4 |
| 76 | UBTAMA | 2 | 2 | 1 | 4 | 7 | 2 | 4 |
| 77 | UDODA | 3 | 3 | 2 | 2 | 9 | 2 | 4 |
| 78 | UGBAJA | 2 | 4 | 2 | 3 | 7 | 1 | 4 |
| 88 | Ugbenu | 2 | 2 | 2 | 3 | 8 | 1 | 4 |
| 79 | ULA-UBIE | 2 | 3 | 1 | 2 | 7 | 2 | 4 |
| 80 | UMEH | 3 | 1 | 2 | 1 | 7 | 1 | 4 |
| 100 | Umu Oru | 1 | 1 | 2 | 2 | 6 | 2 | 4 |
| 92 | Upekeli | 1 | 1 | 1 | 2 | 7 | 2 | 4 |
| 81 | UTCHI | 3 | 4 | 2 | 2 | 7 | 2 | 4 |
| 82 | UZERE | 2 | 1 | 1 | 4 | 7 | 2 | 4 |

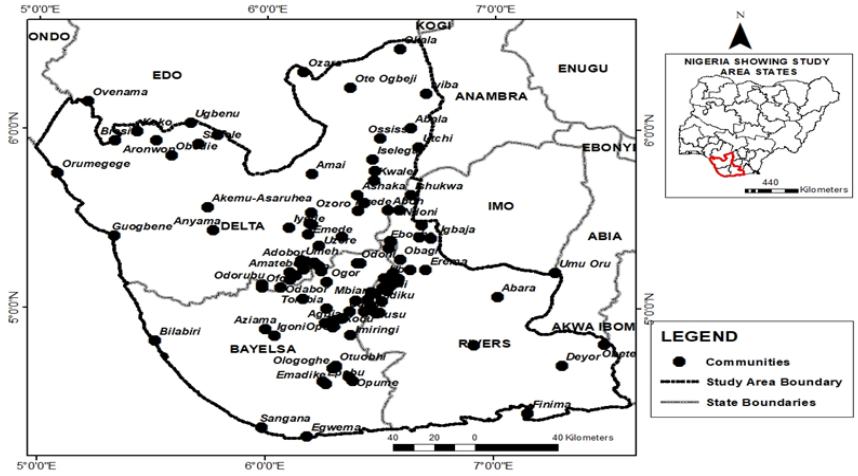


**Figure 10:** Communities Selected for Flood Exposure Assessment

Table 7 presents the level of accessibility of the community during flood. Results show that 38.0% of the entire study area was very accessible, 27.0% were accessible, 29.1% were less accessible while 6.0% were not accessible. This shows that 38% of the entire study area were exposed lowly to flood, 56.1% were moderately exposed to flood while 6% were highly exposed during flood.

**Table 7. Level of Accessibility during Flood**

| Level | Exposure Level | Exposure Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Very Accessible | 1 | Low | 13982.97 | 38.0 |
| Accessible | 2 | Moderate | 9931.01 | 27.0 |
| Less Accessible | 3 | Moderate | 10702.78 | 29.1 |
| Not Accessible | 4 | High | 2220.84 | 6.0 |
| Total | | | 36837.60 | 100.0 |

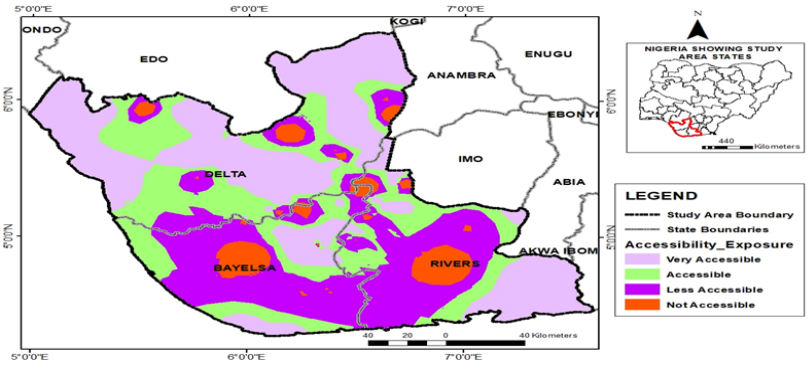


**Figure 11:** Flood Accessibility/Exposure

Table 8 presents the level of agricultural exposure of the community during flood. Results show that 1.0% of the entire study area were very low agricultural exposure, 22.9% were low, 51.9% were moderately exposure, 17.2% had high exposure level while 6.9% were very high agricultural exposure. This shows that 23.9% of the entire study area were exposed lowly to flood, 51.9% were moderately exposed to flood while 24.1% were highly exposed during flood.

**Table 8 Level of Agricultural Exposure**

| Level | Exposure Level | Exposure Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Very Low | 1 | Low | 385.05 | 1.0 |
| Low | 2 | Low | 8443.44 | 22.9 |
| Moderate | 3 | Moderate | 19133.21 | 51.9 |
| High | 4 | High | 6336.67 | 17.2 |
| Very High | 5 | High | 2539.24 | 6.9 |
| Total | | | 36837.60 | 100.0 |

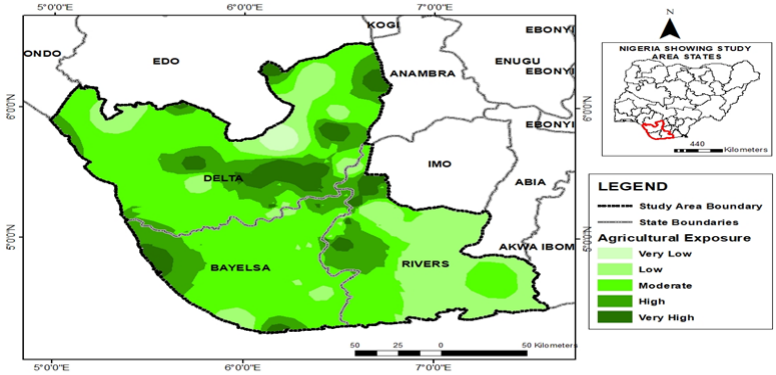


**Figure 12:** Flood Agricultural Exposure

Table 9 presents the level of commercial exposure of the community during flood. Results show that 49.6% of the entire study area experienced absence of commercial exposure while 50.4% experienced commercial exposure. This shows that 49.6% of the entire study area were exposed lowly to flood, 50.4% were highly exposed during flood.

**Table 9: Level of Commercial Exposure**

| Level | Exposure Level | Exposure Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Absent | 1 | Low | 18273.25 | 49.6 |
| Present | 2 | High | 18564.35 | 50.4 |
| Total | | | 36837.60 | 100.0 |

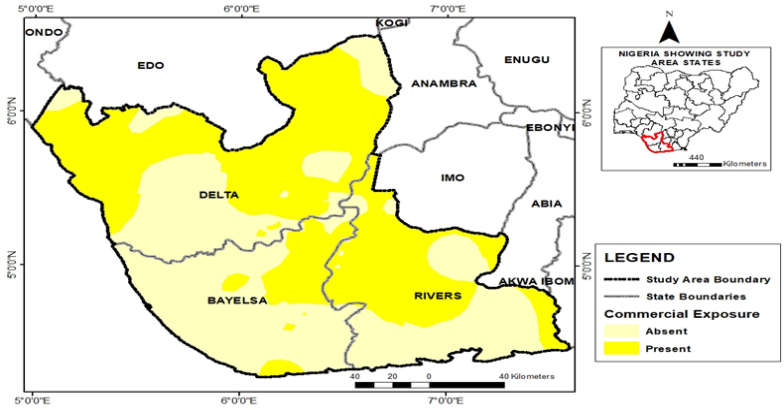


**Figure 13:** Commercial Exposure to flooding

Table 10 presents the level of flood disaster preparedness of the community during flood. Results show that 0.9% of the entire study area were very prepared, 2.2% were prepared, 10.4% were less prepared while 86.5% were not prepared. This shows that 0.9% of the entire study area were exposed lowly to flood, 12.6% were moderately exposed to flood while 86.5% were highly exposed during flood owing to unpreparedness.

**Table 10: Level of Flood Disaster Preparedness**

| Level | Exposure Level | Exposure Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Very Prepared | 1 | Low | 346.41 | 0.9 |
| Prepared | 2 | Moderate | 802.96 | 2.2 |
| Less Prepared | 3 | Moderate | 3820.585 | 10.4 |
| Not Prepared | 4 | High | 31867.64 | 86.5 |
| Total | | | 36837.60 | 100.0 |

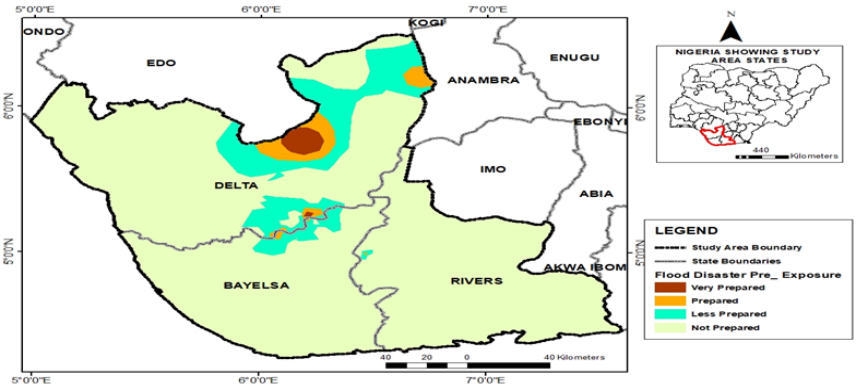


**Figure 14:** Flood Disaster Pre-Exposure

Table 11 presents the level of social infrastructure exposure of the community during flood. Results show that 51.6% of the entire study area had present of social infrastructure exposure while 48.4% were not present. This shows that 51.6% of the entire study area were exposed lowly to flood, 48.4% were highly exposed during flood.

**Table 11: Level of Social Infrastructure Exposure**

| Level | Exposure Level | Exposure Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Present | 1 | Low | 19025.19 | 51.6 |
| Absent | 2 | High | 17812.41 | 48.4 |
| Total | | | 36837.60 | 100.0 |

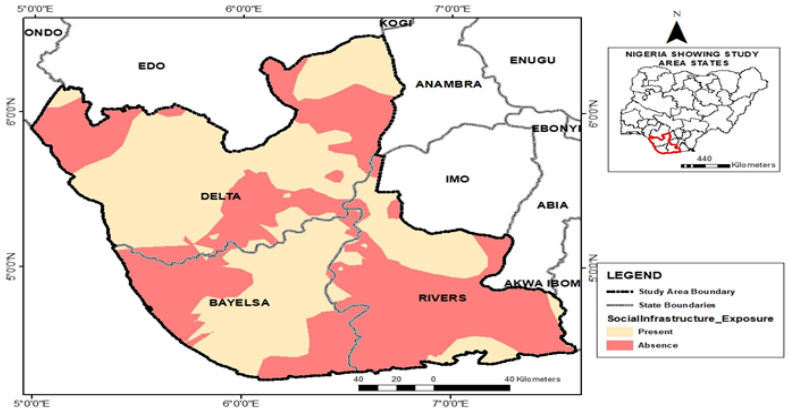


**Figure 15:** Social Infrastructure Exposure to Flooding

Table 12 presents the level of water supply exposure of the community during flood. Results show that 10.4% of the entire study area was not available, 34.7% were less available, 36.9% were available while 18.0% were very available. This shows that 10.4% of the entire study area were exposed lowly to flood, 71.6% were moderately exposed to flood while 18.0% were highly exposed during flood.

**Table 12: Level of Water Supply Exposure**

| Level | Exposure Level | Exposure Interpretation | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|---|---|
| Not Available | 1 | Low | 3841.64 | 10.4 |
| Less Available | 2 | Moderate | 12775.29 | 34.7 |
| Available | 3 | Moderate | 13576.7 | 36.9 |
| Very Available | 4 | High | 6643.97 | 18.0 |
| Total | | | 36837.60 | 100.0 |

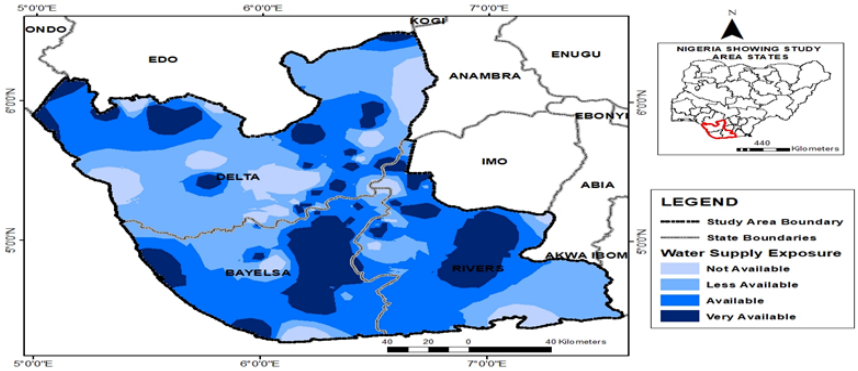


**Figure 16:** Water Supply Exposure to Flooding

Table 13 presents the final flood exposure of the communities during flood. Results show that 0.3% of the entire study area had low flood exposure, 45.7% were moderate, while 54.0% were high to flood exposure. This shows that 0.3% of the entire study area were exposed lowly to flood, 45.7% were moderately exposed to flood while 54.0% were highly exposed during flood.

**Table 13: Final Flood Exposure**

| Level | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|
| Low | 99.874 | 0.3 |
| Moderate | 16850.49 | 45.7 |
| High | 19887.23 | 54.0 |
| Total | 36837.60 | 100.0 |

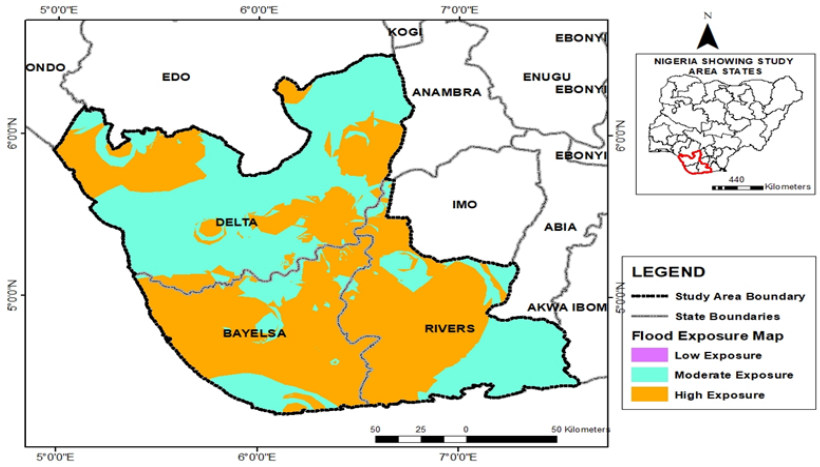


**Figure 17:** Total Flood Exposure Map

Table 14 presents the flood risk map communities during flood. Results show that 14.3% of the entire study area had flood risk, 28.3% were moderate, while 57.4% had high risk. This shows that 14.3% of the entire study area were exposed lowly to flood, 28.3% were moderately exposed to flood while 57.4% were highly exposed during flood.

**Table 14: Flood Risk Map**

| Level | Spatial Extent (sq. km.) | Percentage (%) |
|---|---|---|
| Low | 5266.66 | 14.3 |
| Moderate | 10425.11 | 28.3 |
| High | 21145.84 | 57.4 |
| Total | 36837.60 | 100.0 |

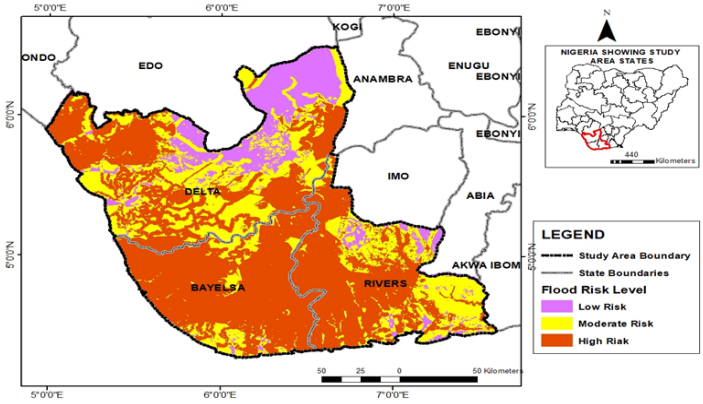


**Figure 18:** Flood Risk Map of Central Niger Delta

## Discussion of Findings

This study is aimed at examining the vulnerability and risk assessment of communities to flood hazards in Niger Delta, Nigeria. The area at high risk to flood hazard is found close to River Niger, Nun, Sagbama and minor rivers like Orashi in Rivers State, Ogbia in Bayelsa State and Ase in Delta State. These major Rivers that transverses most part of the Niger Delta communities in the study area; the hight risk is due to the presence of the river and very low elevation. This area is largely covered with vegetation, farmlands and fewer buildings. The vulnerability of this area to flood is highly disastrous because of absence of drainage system, solid waste disposal in streams and old nature of houses. Communities within this zone is predominately remote areas with poor infrastructure hence accessing this terrain its near difficult. Most communities around this zone are linked to each other by local bridges or accessed by out-board motorized engine boats, dug-out canoes, foot paths, Okada (Motor-bike) and some by local bridges during flooding making support from outside pretty problematic. It is worthy of note that its remoteness discourages better structures hence mud and wooden houses are more prevalent in this zone. Being riverine they are predominantly fisher men/women, few farmers on crops and livestock as well as petty traders. This zone constitutes traditional believers (ancestral home) who sees flood as an act of gods hence rituals can recess flood and its effects. This belief deters early warning signals, neither do they migrate to other areas for safety. Communities within this zone keep struggling with harsh impact of flood as they are also deprived of social capital towards the disaster recovery resilience. The area with medium damage/moderate risk to flooding settle along creeks like Ahoada, Obrikom, Ebocha and Erema in Rivers State, Irri and Uzere in Delta State and Ogbia, Yenagoa and Biseni in Bayelsa State, to mention but a few. Communities within this zone can be accessed by land using vehicles or motor-bike by dry season while others are by boat. These areas are characterized with blocked drainage channels, commercial areas and infrastructural facilities such as major road, transformer, health centres primary and secondary schools and few tertiary institutions making this zone better placed socially and less vulnerable. The light risk areas are the elevated part of the study area.

## Conclusion and Recommendations

Flood is a part of the lives of the people of the Niger Delta area of Nigeria. Floods of different magnitudes have a major impact on this region. The damaging impacts of floods disrupt the agriculture, infrastructure, employment, and food distribution systems, as well as other aspects of livelihood. People living here have to live their whole lives struggling against flood, and the most interesting thing is that they depend both directly and indirectly on rivers and floods for their livelihood. Hence, the majority of the people are willing to live in this place despite floods. It is also the reality that this poor community cannot leave this flood-prone area. Therefore, this rural poor community live with flood, face it with hunger and food crises, suffer a loss of income and occupation, and cope with the situation by bearing substantial debt with high interest rates and a loss of productive assets.

1. Channelization and dredging of River Niger Creeks in the study area are important in order for the river to accommodate more volume of water whenever there is excessive rainfall.
2. Massive campaign against improper dumping of refuse and public awareness of flood risks should be highlighted. Creation of awareness among people living in disaster-prone areas of the risk they face and how best to respond when it occurs can be done to enhance local people's confidence and empower them to act when faced with danger.
3. Self-help measures to reduce damage to property and stress caused by flooding should be encouraged, thereby reducing some of the negative consequences on the people.
4. Construction of drainage and bridges, dams and water catchment should be considered to trap the excess water which could be used for irrigation.

## References


1. UN-International Strategy for Disaster Reduction (UN-ISDR) (2009) "Reducing Disaster Risks through Science: Issues and Actions, the Full Report of the ISDR Scientific and Technical Committee 2009".
2. Darteh B (2010) Flooding in the City: The Blame Game. Accra Learning Alliance Blog.
3. Odemerho F O (1988) Benin City: A Case Study of Urban Flood Problems. In: Sada, P.O. and Odemerho F.O. (Eds). Environmental Issues and Management in Nigerian Development, Evans Brothers, Ibadan.
4. ActionAid (2006) Climate Change, Urban Flooding and the Rights of the Urban Poor in Africa: Key Findings from Six African Cities, A Report by ActionAid October 2006.
5. Kolawole O M, Olayemi A B, Ajayi K T (2011) Managing Flood in Nigerian Cities: Risk Analysis and Adaptation Options – Ilorin City as a Case Study. Archives of Applied Science Research 3: 17-24.
6. UN-ISDR (2005) International Strategy for Disaster Reduction: Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters, World Conference on Disaster Reduction, 18-22.
7. UN-ISDR – International Strategy for Disaster Reduction: Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters, Mid-term Review 2010– 2011, Report, 107.