Asian Journal of Applied Science and Technology (AJAST)
Volume 6, Issue 3, Pages 76-85, July-September 2022

Spatial Analysis of Flood Prone Areas in Ilaje Local Government Arae, in Ondo State, Nigeria

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DOI: http://doi.org/10.38177/ajast.2022.6309

Article Received: 29 May 2022 Article Accepted: 27 August 2022 Article Published: 30 September 2022

ABSTRACT

Flood is one of the natural disaster known to be part of the earth biophysical processes, which its occurrence can be devastating; due to mostly anthropogenic activities and climatological factors. The aim of the research is to identify flood prone areas using geospatial techniques and the specific objectives are to carry out terrain analysis of the study area and to generate flood vulnerability map of the study area. The study analyzed rain fall data; soil map, the drainage system and Shuttle Radar Topographic Mission (SRTM 30m) of the area. A geographic positioning system (GPS) device was used to take coordinate points of flooded areas in the study area during field work. With the use of ArcGIS 10.8 version the data were modelled to generate the vulnerability map of the study area. The drainage system was generated through on-screen digitization of topographic map of scale 1:50,000 of Ondo South-West. The mean annual rainfall of Ilaje local government was generated in the ArcGIS environment from the rainfall data through spatial analysis tool. The SRTM was used in terrain analysis of the study area. The soil map of the study area was clipped to generate the different soil map of the area which are Arenosol, Gleysol and Acrisols. Weighted sum analysis of ArcGIS was adopted to generate the final vulnerability map of the area. The results generated showed the lowest mean annual rain fall of the area between 1,880mm and 1,990mm and the highest mean annual rain fall was between 2,340mm and 2,440mm. Digital elevation model (DEM), slope, aspect and flow direction were generated from the SRTM. Drainage density of the area was generated using the drainage system. 360.35km square was vulnerable, 474.79km square was least vulnerable, 235.31km square was moderately vulnerable and 218.01km square was highly vulnerable in the study area.

Keywords: *Climate change, Hazard, Geospatial techniques, DEM, Flood.*

1. Introduction

Flood is a large amount of water covering an area that is usually dry. It is an overflowing of a great body of water over land not usually submerged. Nwafor (2006), defined flood as a natural hazard like drought and desertification which occurs as an extreme hydrological (run off) event.

Flood, according to the Federal Emergency Management Agency (FEMA, 2016), is a general and temporary condition of partial or complete inundation of 2 or more acres of normally dry land area or of 2 or more properties.

On the hand, Abam (2006), defined flood as large volume of water which arrives at and occupy the stream channel and its flood plain in a time too short to prevent damage to economic activities including homes.

Flooding is the most common environmental hazard in Nigeria (Etuonovbe, 2011). Flood disaster is not a recent phenomenon in the country, and its destructive tendencies are sometimes enormous. Reports have it that serious flood disasters have occurred in Ibadan (1985, 1987 and 1990), Osogbo (1992, 1996, 2002), Yobe (2000) and Akure (1996, 2000, 2002, 2004 and 2006). The coastal cities of Lagos, Port Harcourt, Calabar, Uyo, and Warri among others have severally experienced incidences that have claimed many lives and properties worth millions of dollar.Floods occur in Nigeria in three main forms: coastal flooding, river flooding and urban flooding (Folorunsho and Awosika 2001; Ologunorisa, 2004). Coastal flooding occurs in the low lying belt of mangrove and fresh water swamps along the coast (Folorunsho and Awosika 2001; Ologunorisa, 2004). River flooding occurs in the flood plains of the larger rivers, while sudden, short-lived flash floods are associated with rivers in the inland areas where sudden heavy rains can change them into destructive torrents within a short period (Folorunsho and Awosika 2001; Ologunorisa, 2004). Urban flooding on the other hand occurs in towns, on flat or low-lying terrain especially where little or no provision has been made for surface drainage, or where existing drainage has been blocked with municipal waste, refuses and eroded soil sediments (Folorunsho and Awosika 2001; Ologunorisa, 2004).

Urban flood problem is a global experience but the management practices differ according to prevailing technologies and aptness in planning concerns. The experience is however worse in Third World cities where unplanned and uncoordinated development is prevalent. Odemerho (2004) and Nwafor (2006) identified 12 causes of urban flooding. These include: surcharges in water level due to natural or man – made construction on flood path, sudden dam failure, inappropriate land use, mudflow, inadequate drainage capacity to cope with urbanization, excess encroachment in flood ways, ice jam, rapid snow fall, deforestation of catchment basins, reclamation, construction sites and solid waste. Odemerho (2004) also identified three factors.

accentuating flood problems in Benin City, Nigeria namely: land and physical development problems, gaps in basic hydrological data, design and implementation problems and cultural factors.

Okereke (2007) listed the consequences of urban flooding in his studies in Dhaka, Bangladesh to include: loss of human lives, flooding of houses, streets, inflow to soak away, municipal pollution, damage to properties, health hazards, cleanup costs, disruption of services, traffic problems, adverse effects on aesthetics, disturbances on wildlife habitats, economic loses and infrastructural damage.

In Nigeria, the pattern is similar with the rest of world. Flooding in various parts of Nigeria have forced millions of people from their homes, destroyed businesses, polluted water resources and increased the risk of diseases (Etuonovbe, 2011).

2. Materials and Methodology

2.1. Study Area

Ilaje local government situates roughly between Latitude 6°00´ and 6°20´ North and Longitude 4°45´and 5°45´ East. It shares boundaries with Ese-odo local government of Ondo State in the North, the Atlantic Ocean in the South, Ogun state in the West and Delta state in the East, (Ilaje Renaissance, 2013).

The coastal area of Ondo State is largely found in the Ilaje Local Government Area. Ilaje local government area was carved out of the Ilaje/Ese-Odo local government on October 1st, 1996 by the then Military Head of State with their headquarters at Igbokoda. The defunct local government area was splitted with the intention of spreading development to places that has not been impacted on, and to enable a level of autonomy that can enhance the holistic development of the region (Osopadec, 2010).

Ilaje local government situates roughly between longitude 6°20´ and 6°00´ North and latitude 4°45´and 5°45´ East. It shares boundaries with Ese-odo local government of Ondo State in the North, the Atlantic Ocean in the South, Ogun state in the West and Delta state in the East. (Ilaje Renaissance, 2013). The local government has about 80 km long shoreline, thereby giving Ondo State one of the largest coastlines in Nigeria.

The physical geography of the area, apart from communities located in the upland that has extensive undulating plain, which is a characteristic of the South-western part of Nigeria. All other communities fall within the coastline and it is covered by troughs and undulating lowland surfaces.

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The coastline consists of rivers, creeks, estuaries and stagnant swamp covers. The extreme south of the area is covered by silt, mud and superficial sedimentary deposits. The region falls within the tropical rain forest zone. The ecosystem of the area is highly diverse and supportive of numerous species of terrestrial and aquatic flora and fauna and human life.

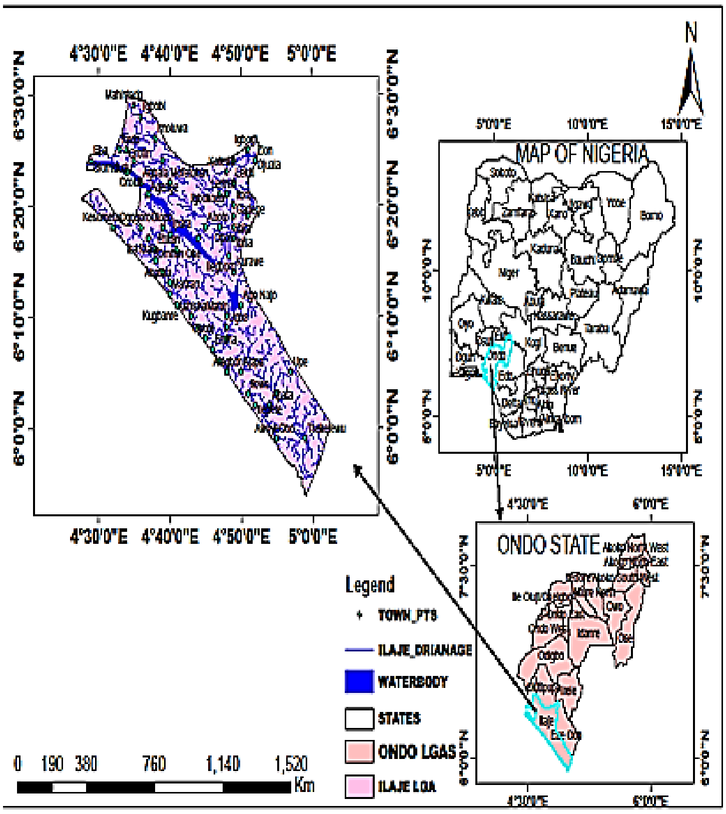

Fig.1. Study area map

The data used for this research are mostly secondary data and the only primary data was the ground control points with the aid of GPS.

The soft wares used in this research are:

(1) ArcGIS 10.8 version, (2) Microsoft office visio 2007, (3) Microsoft office word.

Table 1. Summary of Data used

Data	Data extracted	Attributes	Source
Topographic maps	Drainage	Scale: 1:50,000	OSGOF
Soil map	Prevalence soil type	1:1,300,000	Center for world food study
Rainfall	Mean annual rain fall	30years predicted value	Global climate model.
SRTM	Slope, DEM, Aspect and flow accumulation	30m	USGS
GPS	Ground control points		

Source: Researcher 2022

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The topographic and soil map of the study area was imported into the ArcGIS environment, projected to WGS 1984, zone 31 and in degrees, minutes and seconds. The map was georeferenced and updated, on-screen digitization was done on the topographic map to extract the drainage. Spatial hydrological processes was performed to generate the flow accumulation of the study area. The soil map was imported into ArcGIS and the shape file of the study area was clipped to have the predominant soil type of the area. Shuttle Radar Topographic Mission was cleaned and filled using focal statistic in the spatial analyst tools before further analysis was done. The shape file of the study area was overlaid on the SRTM and clipped to generate the slope, digital elevation model and aspect of the study area. The rain fall data was imported to the Arc map environment and converted to point data and interpolated. The point data was projected to the working environment, spatial analysis of inverse distance weighted (IDW) was done to produce the mean annual rainfall of the study area. All the participating factors were reclassified to raster and saved in the database. Weighted sum analysis was performed to generate the vulnerability map of the area and the vulnerability was grouped into four in order of severity.

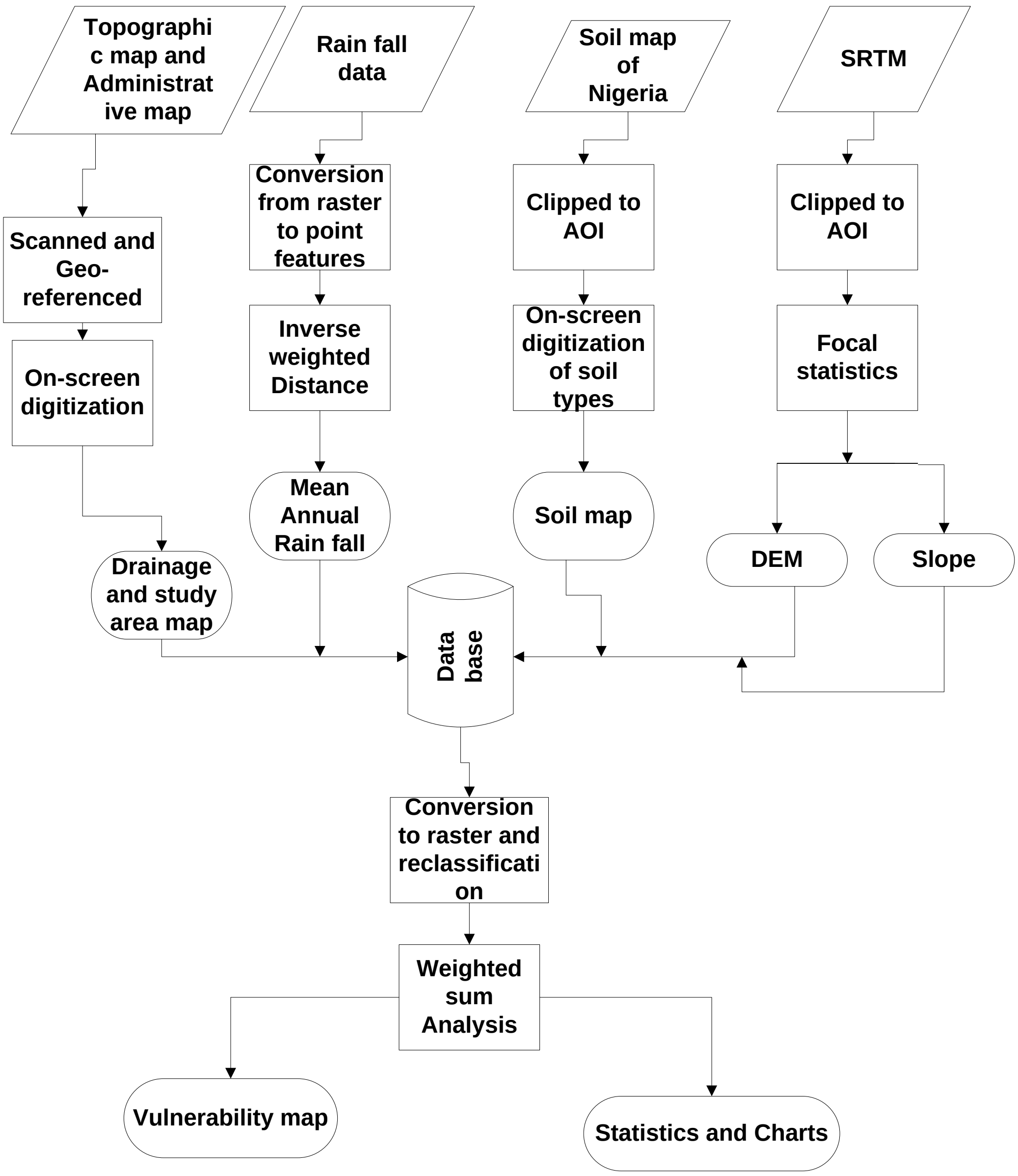

Fig.2. Work flow chart

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3. Results and Discussion

In this research, hydrological and physio-geographical factors were carefully examined and analyzed as contributing factors to flooding. The factors are discussed below.

3.1. Slope

The slope of an area determines the steepness and flatness of an area. The higher the slope value the steepest the terrain and the lower the slope value the flat the terrain. The lowest values of slope in the study area is between 0% and 6.35% and the highest values ranges between 32.4% and 77.1%. Flat terrain allowed river mouths which aid high flooding and steep terrain allowed river sources with less or without flooding. The slope is as shown in figure 3.

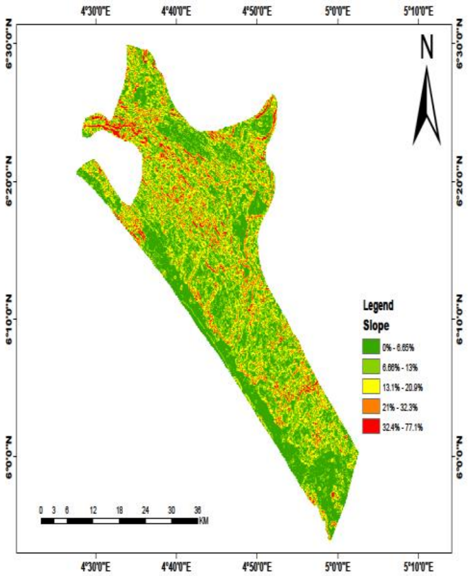

Figure 3: Slope of the study area

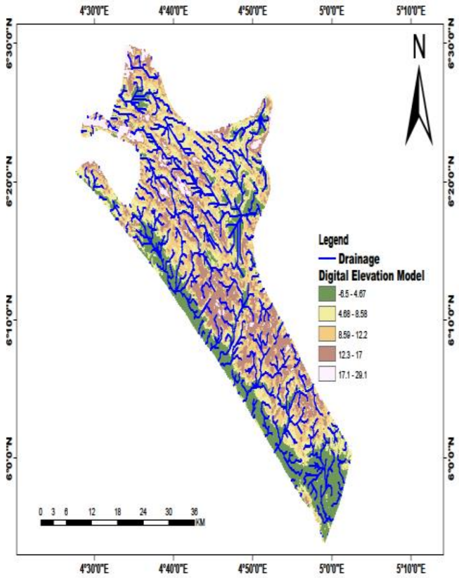

Figure 4: DEM of the study area

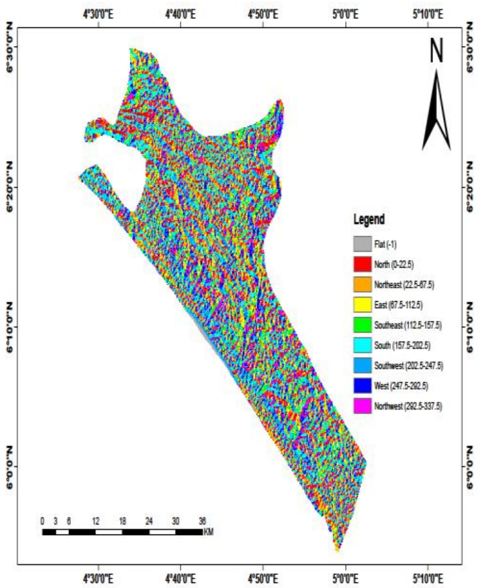

Figure 5: Aspect of the study area

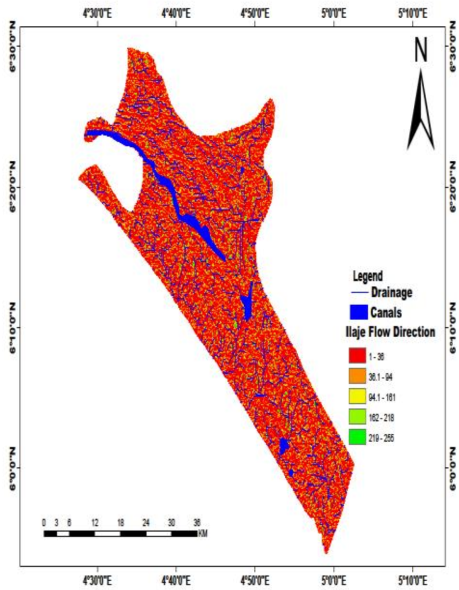

Figure 6: Flow Direction

3.2. Digital Elevation Model (DEM)

DEM is a prominent factor that determine the velocity of run-off water in an area during precipitation. Water has very high run-off in areas of high elevation thereby reducing rate of water penetration into the ground; while areas of low elevation tends to accumulates water and when saturated increase high rate of flooding. The southern and south-western part of Ilaje local government area is of low elevation with values ranges from -6.5m to 4.5m. Meanwhile, the northern and the north-eastern part of the study area is high elevation of values ranges from 12.3m to 29.1m. It is as shown in figure 4.

3.3. Aspect

Aspect is slope direction of an area that indicates the compass direction that the surface faces in a particular direction. Aspect is measured in degrees clockwise from 0 due north to 360 due north again. Flat areas having no downslope are given a value -1 (ESRI, 2015). Ilaje local government area has flat areas which were assigned -1 and the steepest slope of the area is assigned 337.5 degree north. It is shown in figure 5.

3.4. Flow Direction

Flow direction is one of the hydrological characteristic determined by the direction of steepest descent or maximum drop from each cell, as shown in figure 6.

3.5. Soil

Soil permeability of an area determines the rate of water absorption. Sandy soil is known to have the highest permeability than any other soil type, while clay soil has the lowest permeability. Soils with highest water permeability are less prone to flooding while soils with lower water permeability are more prone to flooding. Ilaje local government area is characterized with three major soil types these are; Acrisols, Arenosols and Gleysols.

Acrisols = Strongly leached, red and yellow soils of wet (sub-)tropical regions on acid parent rock, with a clay accumulation horizon, low cat ion exchange capacity and low base saturation, it allows low infiltration.

Arenosols = Sandy soils of desert areas, beach ridges, inland dunes, areas with highly weathered sandstone, etc. showing little or no profile development, it allows high infiltration.

Gleysols = Non-stratified soils in waterlogged areas that do not receive regular additions of sediment. Usually found in low terrain positions and Moderate infiltration. (Global Gridded Soil Information, 2017) as per figure 7.

3.6. Rainfall

Rainfall is one of the most prominent factor in flooding. When there is an event of high down pour, there is high likelihood of flooding if the drainage system is incapable to accommodate the run-off water in an area. In the study area, the lowest mean annual rainfall is approximately between 1,880mm to 1,990mm and the highest mean annual rainfall in the area is approximately between 2,340mm to 2,440mm, figure 8.

3.7. Drainage Density

Terrain morphology of an area plays a vital role in the determination of drainage architecture, especially Digital Elevation model of a place. Usually, run-off water tends to flow down areas of lower elevation or flat terrain from

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areas of higher elevation. Therefore, drainages or convergence of run-off waters will be denser at rivers mouth which are more prone to flooding than river sources. The study shows than higher values of densities mean higher drainage densities and lower values of drainage densities mean lower concentration of drainages. From the study, the highest drainage density values range from 114 to 176 and the lowest drainage density values range from 4.35 to 57.4, shown in figure 9.

3.8. Flood vulnerability

The entire local government was classified into four different zones of vulnerability of which, 360.35km square, about 27.75% of the area is vulnerable; 474.79km square, about 36.56% of the area is least vulnerable; 245.31km square, about 18.89% is moderately vulnerable and 218.01km square, about 16.78% is highly vulnerable to flooding, shown in Figure 10.

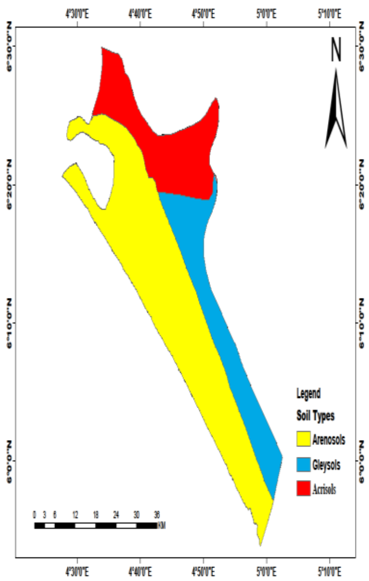

Figure 7: Soil Map of the study area

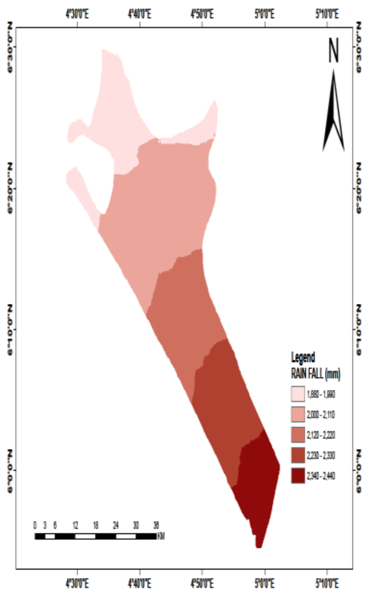

Figure 8: Rainfall Map of the study area

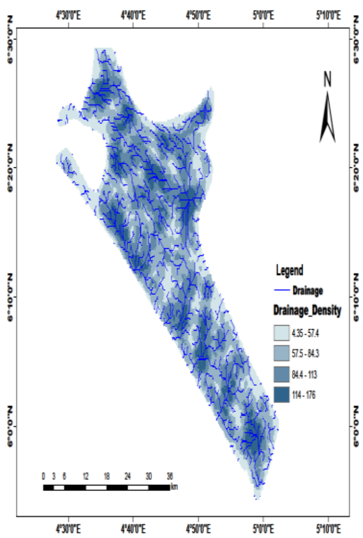

Figure 9: Drainage Density Map of the study area

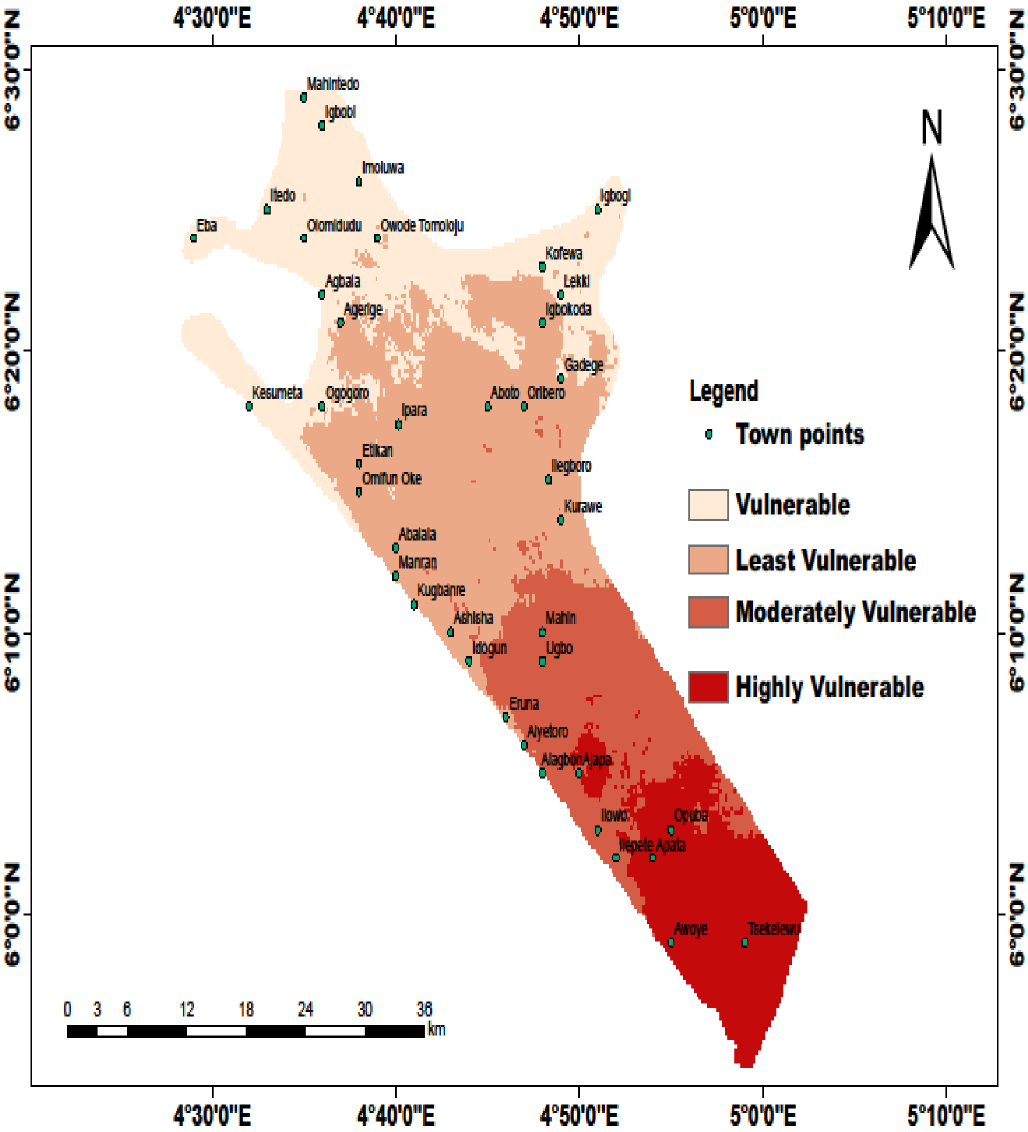

Figure 10. flood vulnerability map of the study area

Table 2. Vulnerability Level

Vulnerability	Area (km)	Area in percentage
Vulnerable	360.35	27.753
Least Vulnerable	474.798	36.568
Moderately Vulnerable	245.317	18.899
Highly Vulnerable	218.015	16.789
	1298.482	100

Source: Researcher 2021

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4. Conclusion and Recommendation

The study have been able to demonstrate the capability of GIS and remote sensing in the area of disaster management as in this case flooding. The outcome of the study shows areas in Ilaje LGA that are highly vulnerable to flooding, moderately vulnerable, least vulnerable and vulnerable.

The result of the study revealed that villages such as Awoye and Apata falls on the highly vulnerable area with land mass of 218.015km sq. or 16.789% of the entire land. Mahin and Aiyetoro are moderately vulnerable with area coverage of 245.317km sq. or 18.899%. Igbokoda and Apara lies on the least vulnerable area with total area coverage of 474.798km sq. or 36.568%, while Mahintedo and Igbogi vulnerable with land mass of 360.352km sq. or 27.753%.

For proper management and mitigation of flood disaster in the study area, the policy makers both private and government should put in place proper emergency response measures to curb the impact of flood on the communities.

Proper town planning should be enforced to discourage residents or investors from indiscriminate usage of land such as farming, building construction etc., which could exposed Ilaje local government area to flood vulnerability.

Construction of embankments in needed area of the local government should be done, in addition; proper channelization of water ways should be done to reduce flooding in the study area.

Acknowledgement

We wish to acknowledge the contribution and the support of National Center for Remote sensing, Jos and the oceanographic team. The support of Ilaje community leaders as well as the authors of the literature cited during this study are all acknowledged.

Declarations

Source of Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Ethical Approval

Based on institutional guidelines.

Consent for publication

The authors declare that they consented to the publication of this research work.

Availability of data and material

The authors are willing to share the data and material according to relevant needs.

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