# Flood Vulnerability Analysis in Alimosho Local Government Area, Lagos State Cooperative Information Network, Obafemi Awolowo University, Osun State

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**Abstract**

Alimosho Local Government Area (LGA) is the most populated LGA in Lagos state. Recently, flooding has devastated lives and properties, hampering residents' daily activities when rain falls. This research adopts geospatial techniques and Multi-Criteria Decision Analysis (MCDA) to map out areas vulnerable to flood and to evaluate flood mitigation measures in the study area. Satellite images (such as topographic maps, Shuttle Radar Thematic Mission (SRTM)), Rainfall data (GCM), Landsat TM (2005), and OLI (2015) were acquired to get five criteria i.e Slope, Annual Mean Rainfall (AMR), density, Digital Elevation Model (DEM) and Land Use / Land cover (LULC) which are perceived to influence flooding, and they were subsequently ranked according to their importance using ArcGIS and Erdas Imagine, respectively. The analytical Hierarchy Process (AHP) approach was used to assign weight to the factors used for the multi-criteria analysis. The weighted sum analysis overlaid the processed maps to generate the flood vulnerability map. The result shows that most areas in Alimosho LGA are vulnerable to flooding in various degrees.

***Keywords:*** *Flood, Multi-Criteria Decision Analysis, Flood Vulnerability Map, Geo-Spatial Techniques, Analytical Hierarchy Process.*

## I. INTRODUCTION

A flood is a type of natural disaster that occurs when there is an overabundance of water. It can originate from rivers, surface water, artificial water, sewers or drains, saturated groundwater, streams, or low-lying coastal areas that flood due to sea level rise. Precipitation might collect on already-saturated ground. Heavy rainfall is the main cause of flooding when natural watercourses cannot move the surplus water.

While some floods build up and recede rapidly, others may take days or months to build up and flow. Flooding has the potential to ruin property, lives, farms, etc.

The National Weather Service (NWS), (2005) has classified flood severity into three categories: mild, moderate, and major flooding. Each category's definition is based on risks to the public and property damage; for example, minor flooding is defined as little to no property damage but maybe some nuisance or threat to the public. If roads and structures near streams become submerged, it is classified as moderate flooding, which may require relocating property to higher ground or evacuating residents. Also, major flooding is said to occur when roads and structures are flooded to such an extent that many people must be evacuated and property moved to higher elevations.

- *According to Environmental Technology (2019), there are different types of flooding, they are:*

- *Flash Floods*

Flash floods are a sudden influx of water along a stream or in a low-lying urban area. This type typically results from significant rain, dam failure, or snowmelt and happens in hours, sometimes even minutes. It can occasionally be brought on by several or slow-moving thunderstorms that produce heavy rainfall. Since they frequently catch individuals off guard, they are the deadliest and most destructive. Most of the time, there might not be any forewarning or planning, and the effects can be abrupt and catastrophic. The length and intensity of the rainfall, and the steepness of the gradients in the watershed and streams are major contributors to flash floods. Flash floods can also result from the collapse of debris dams, the release of ice jams, and dam failure. Although they often subside quickly, flash floods can be dangerous and swift-moving while they're happening. It can be avoided by preventing excessive development in floodplains and installing effective drainage systems.

- *River or Fluvial Floods*

A river flood is due to an existing watercourse's water level rising to the extent that an ordinary dry area is submerged. One of the most common types of inland floods occurs when a body of water exceeds its capacity, typically due to prolonged, intense rainfall. Rivers require strong defenses to stop floods, particularly in flat or populated locations.

River flooding is frequently brought on by heavy rain from tropical systems making landfall, prolonged thunderstorm activity over the same region, precipitation and snow melt coupled, and ice jams (flood the awesome power).

- *Coastal Flooding*

Severe storms frequently hit coastal communities hardest, especially if they have intensified over the oceans. Sea levels can rise due to extreme weather and high tides, which can lead to coastal flooding. Generally speaking, low-lying coastal areas are protected from the sea by dunes other natural barriers, or man-made defenses. Coastal flooding is predicted to become a more frequent and serious issue as global warming progresses.

- *Groundwater Flood*

Whereas flash floods happen quickly, groundwater flooding happens gradually. The ground fills up with water when it rains for a long time until it is unable to hold on to any more. This results in floods as water rises above the surface of the ground. Flooding of this kind may continue for several weeks or maybe even months.

- *Drain and Sewer Flooding*

Not all sewer floods are caused by bad weather. They may also happen due to a blockage or similar drainage system failure in addition to rainfall. Flooding from drains and sewers can occur externally or internally (within a building). Rivers and streams follow a fundamental equation:

$$Q = A \times V \quad (1)$$

Where Q is discharge (amount of water),

A is an area of the river channel, and V is velocity

When a river or stream has an excess discharge, the water first flows more quickly, increasing in velocity and maybe causing channel erosion, or an increase in area. Water must, however, flow out of the channel (the confining area, [A]) and onto the surrounding region, referred to as the floodplain, if discharge (Q) rises too quickly. The area that gets flooded first is known as the floodplain.

➢ *Statement of the Problem*

Over time, flooding has been an issue in some parts of Alimosho Local Government Area (LGA) which might be attributed to the wetlands surrounding the area, the flood impact is always severe during the rainy seasons and as a result, causes overland flow of water on roads, affecting many buildings, despite the effort of Lagos state environmental bodies and government. Hence, many types of research have been done on floods in other LGAs in Lagos (Adewara *et al.*, 2018; Hudson *et al*, 2017), etc. but so far not much has been done in Alimosho as regards flooding, therefore this study aims at studying and analyzing the flood vulnerability and mapping of flood zone areas in Alimosho LGA.

➢ *Aim and Objectives*

- *Aim*

✓ To analyze the flood vulnerability in Alimosho Local Government Area, Lagos State.

- *Objectives*

✓ To determine the level of flood vulnerability in the area.
✓ To evaluate the mitigation measures chosen by residents to curb the problem in the area.

➢ *Study Area*

Alimosho, the study area, is a local government area in the Ikeja Division, Lagos State, Nigeria. At about 1,288,714 residents and a land area of 923,768 km², it is the most populous local government in Lagos state, according to the official 2006 Census. It is situated at an elevation of 13 to 60 meters above sea level and has the geographic coordinates 6° 36' 39'' N and 3° 17' 46'' E.

The study region is located in Nigeria's tropical climate's semi-hot equatorial zone. January often sees temperatures of around 26°C (76°F). With a mean temperature of 29°C, March is normally the hottest month and July the coldest.

Every year, 1,500 mm of rain falls on average. There may be as much as 140 mm of rainfall every day during the rainy season. In the project region, it rains for almost eight months out of the year.

The study area's soils are representative of its topography and geology. They have evidence of being close to sea influences and are quite deep and well-drained. Their pale loamy soils are layered on top of dark-brownish loamy surfaces.

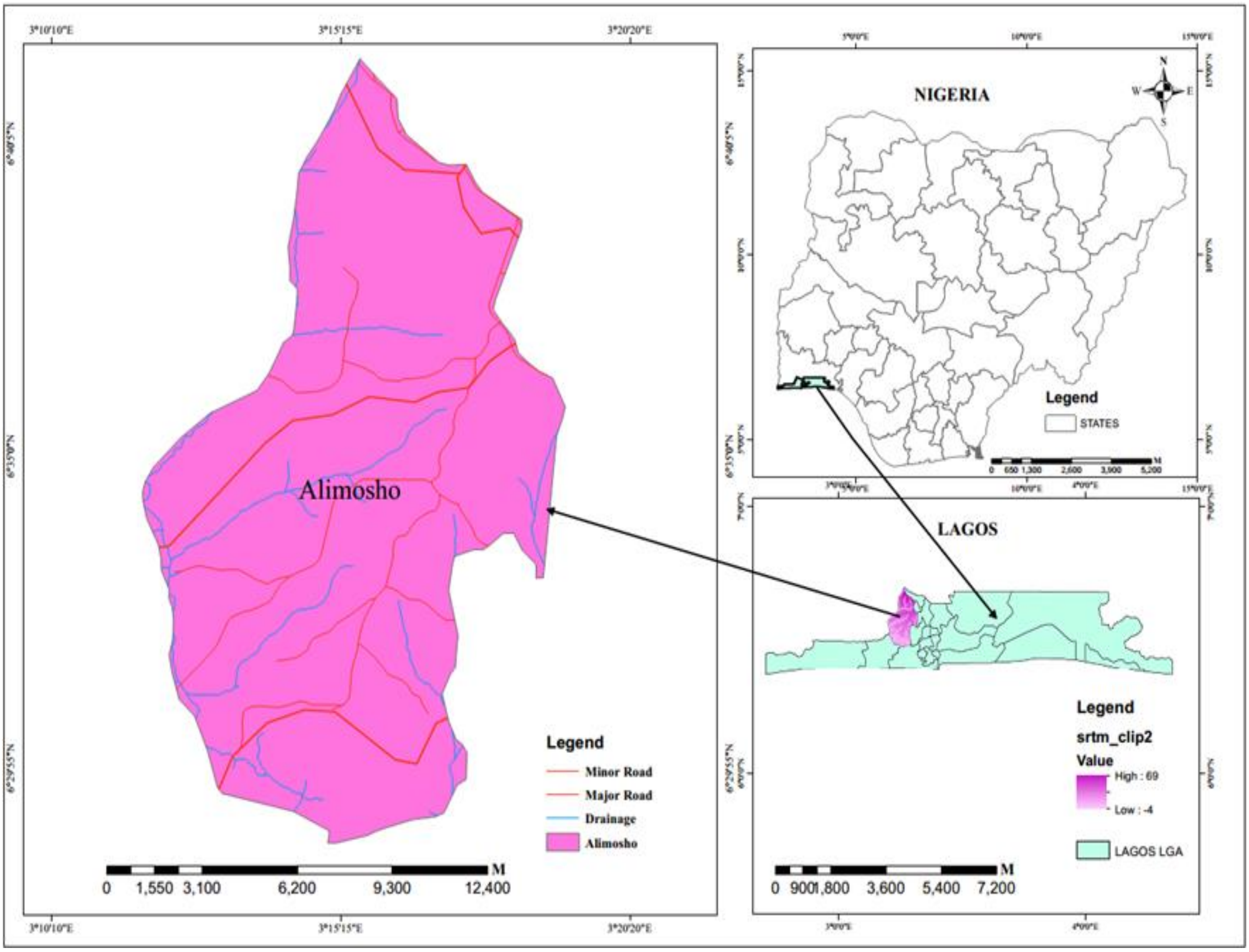

Fig 1 Study Area Map

## II. METHODOLOGY

➢ *Materials*

Both primary and secondary data were collected for the project.

- *The Primary Data*

Global Positioning System (GPS) was used for the acquisition of the primary data, this includes the coordinate points and pictures of the flood-affected areas.

- *The Secondary Data*

The secondary data sources include satellite data and topographic maps.

✓ *Satellite Data*

Landsat TM (2005) and OLI (2015) images (30m) were acquired via the USGS website. Shuttle Radar Thematic Mission (SRTM) was used for the Digital Elevation Model (DEM), density and slope extractions, and Global Climate Model (GCM) for Annual Mean rainfall (AMR).

✓ *Topographic and GIS*

Topographic map of Lagos state on a scale of 1:250,000 for contour and drainage digitization of the study area.

- *Software*

✓ ERDAS Imagine 2014: for image classification.
✓ ArcGIS 10.4: for analysis.
✓ Microsoft Visio: for the flowchart.
✓ Microsoft Excel: The free web-based Analytical Hierarchy Process (AHP) software created by K.D Goepel, (2015) was used for pairwise comparison of the five criteria on a five by five matrix and the result is shown under normalized principal Eigen value as shown on table 1, with consistency ratio of 11.6%.

The flow chart of the procedure to obtain the flood vulnerability map is explained schematically in Figure 2.

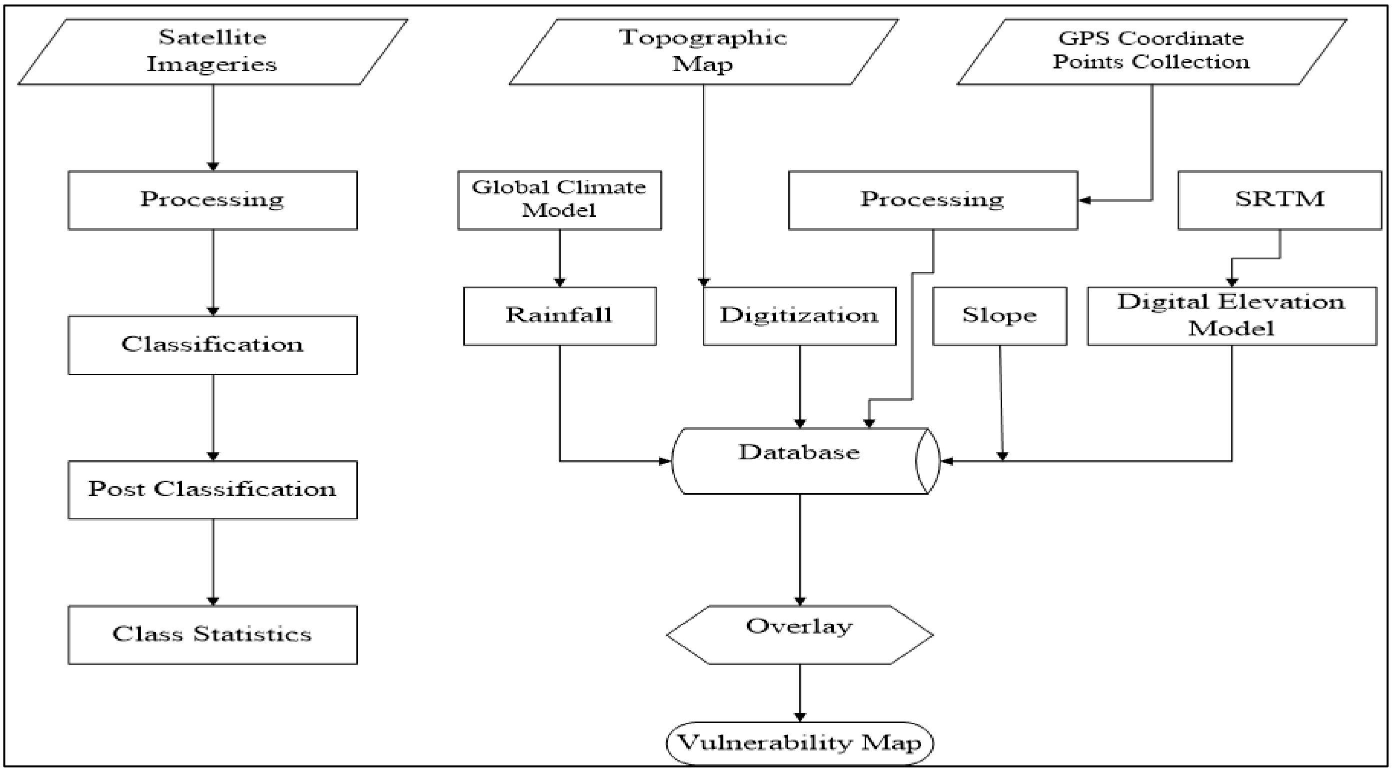


Fig 2 Schematic Overview of the Flood Risk Assessment

## III. RESULTS

➢ *Mitigation Measures*

The residents of flood-vulnerable areas adopted measures for managing the flood challenges during the rainy season. During the fieldwork, it was observed that the residents in floodable areas construct local bridges made with wood “colonial bridges” in some locations (see Plates 1 a and b) while others sand fill the floodable roads during the dry season to minimize the effect of flood during the rainy season.

- *Flood Vulnerability Analysis*

Multi-criteria Decision Analysis (MCDA) is a tool used for analyzing criteria for a particular project, it achieves that by ranking them from the most preferable to the least preferable using a structured approach. The result of MCDA is often a set of weights linked to the various alternatives. This study used the Pairwise Comparison Method to determine the weights for the criteria. The method involves the comparison of the criteria and allows the comparison of two criteria simultaneously. It converts subjective assessments of relative importance into a linear set of weights. It was developed by Saaty, (1980) in the context of a decision-making process known as the Analytical Hierarchy Process (AHP). The criterion pairwise comparison matrix takes the pairwise comparisons as input and produces the relative weights as output. Five factors were compared; they are annual mean rainfall, slope, density, land use/land cover, and Digital Elevation Model of the study area. After the comparison of the criteria, they were overlaid using a weighted sum in the ArcGIS software to produce a flood vulnerability map. The map produced shows that most areas in Alimosho LGA are prone to flooding in various degrees.

✓ *Slope*

Alimosho LGA is more of a plain than sloppy land, just like any other area in Lagos state but slope is one of the criteria considered for flooding as the sloping nature of an area determines if a flood will be retained for a long time or not. A sloppy land does not retain flood for a long time and Alimosho LGA as shown in Fig 3 being more of a floodplain retains water in many places during the rainy season.

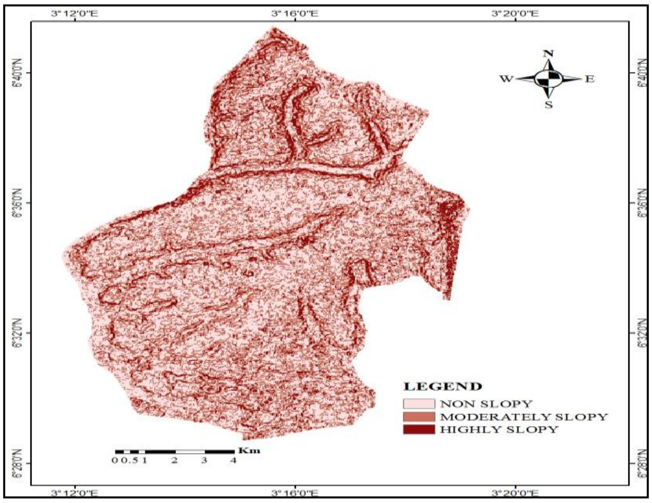


Fig 3 Slope Map of Alimosho

✓ *Mean Annual Rainfall*

The study area is one of the areas that experience heavy rainfall all through the year, the annual mean rainfall’s ranking does not show much difference (see Fig 4) but was considered as one of the determining factors and was also ranked highest (67%) in AHP analysis because flooding depends mainly on it. In Nigeria, Lagos state is one of the states with the heaviest rainfall and has all-year rain which can be attributed to the climate change effect, surrounding water bodies, etc.

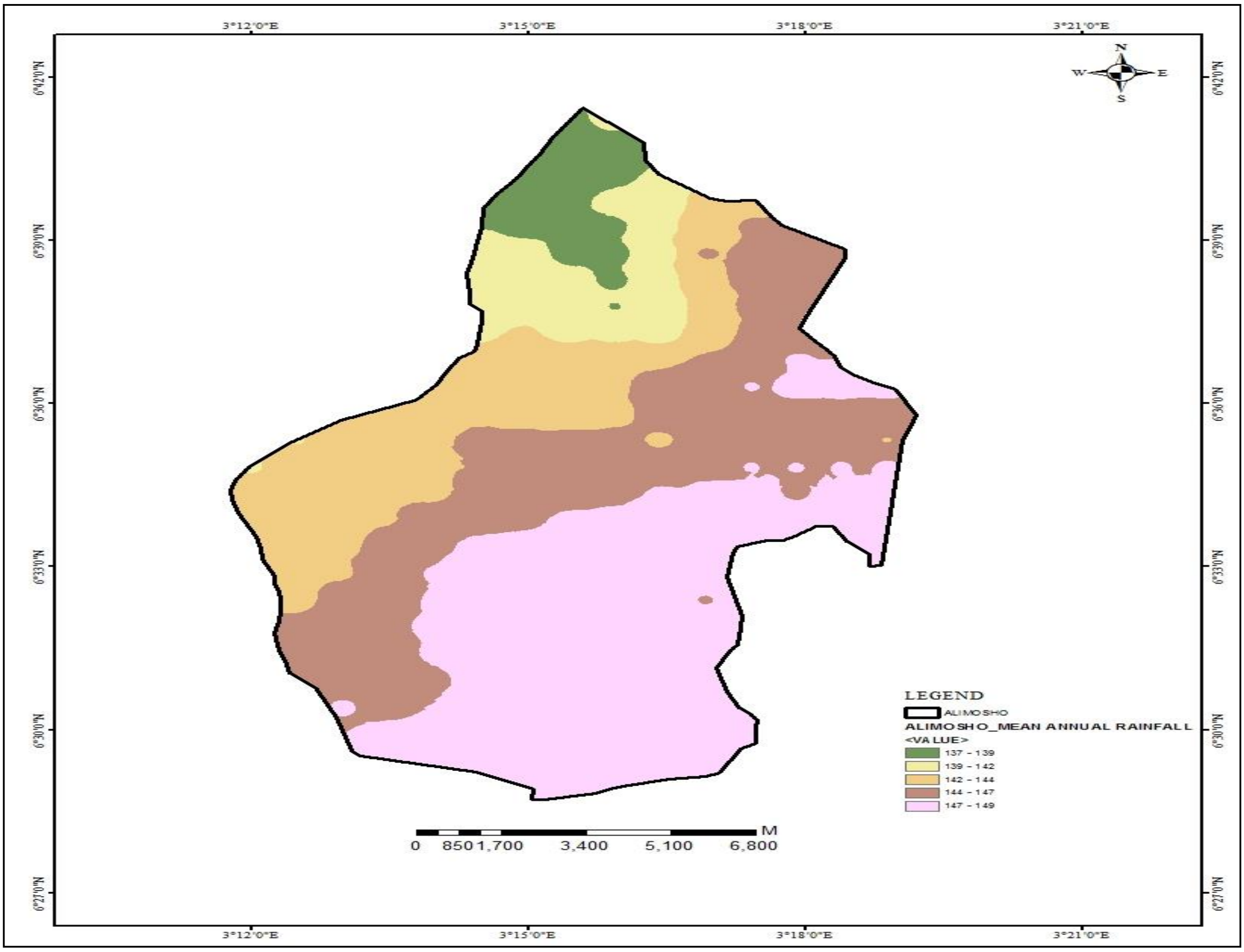


Fig 4 Mean Annual Rainfall Map of Alimosho

✓ *Land Use / Land Cover*

The two maps of land use/land cover displayed the changes observed within ten years, between 2005 and 2015 (see Fig 5). The water body of the study area reduced over time while the built-up area increased, and this will be attributed to human encroachment to the riverine areas which drive the water body backward and during the rainy season the water is forced to overflow its bank.

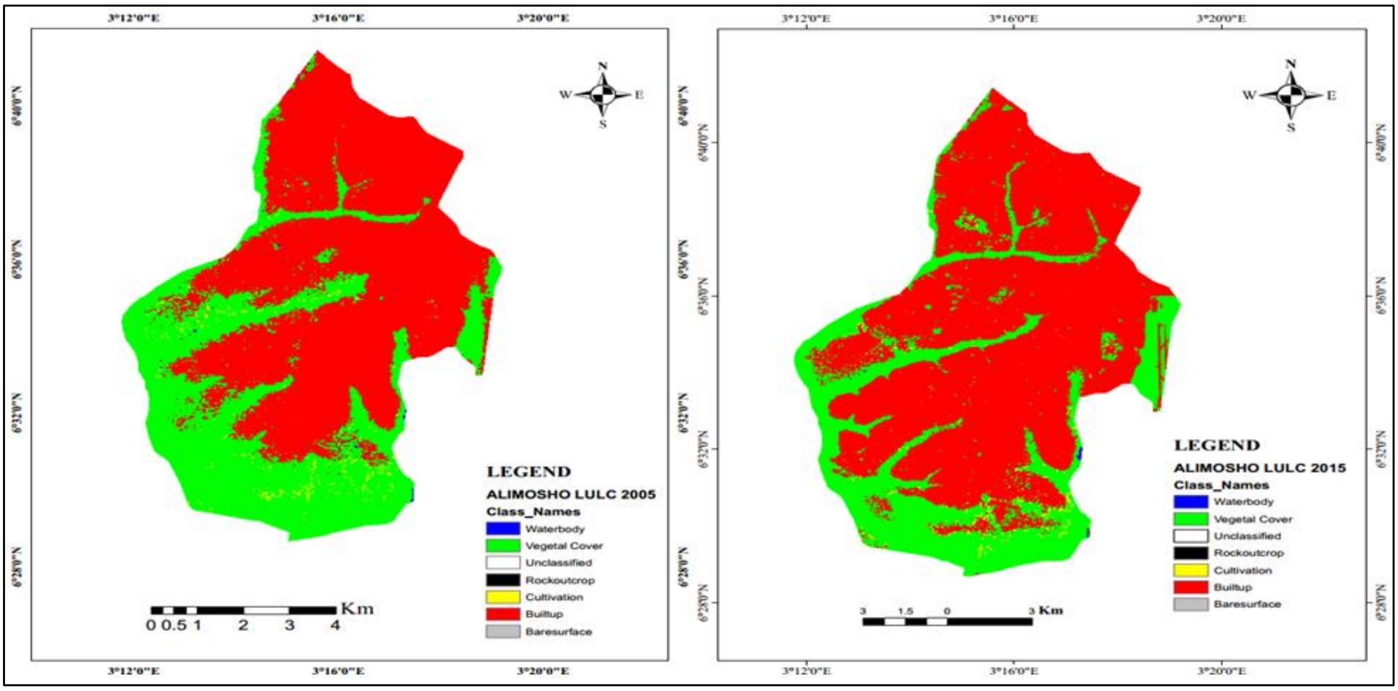


Fig 5 (a) (2005) and (b). (2015) Land Use / Land Cover Maps of the Study Area

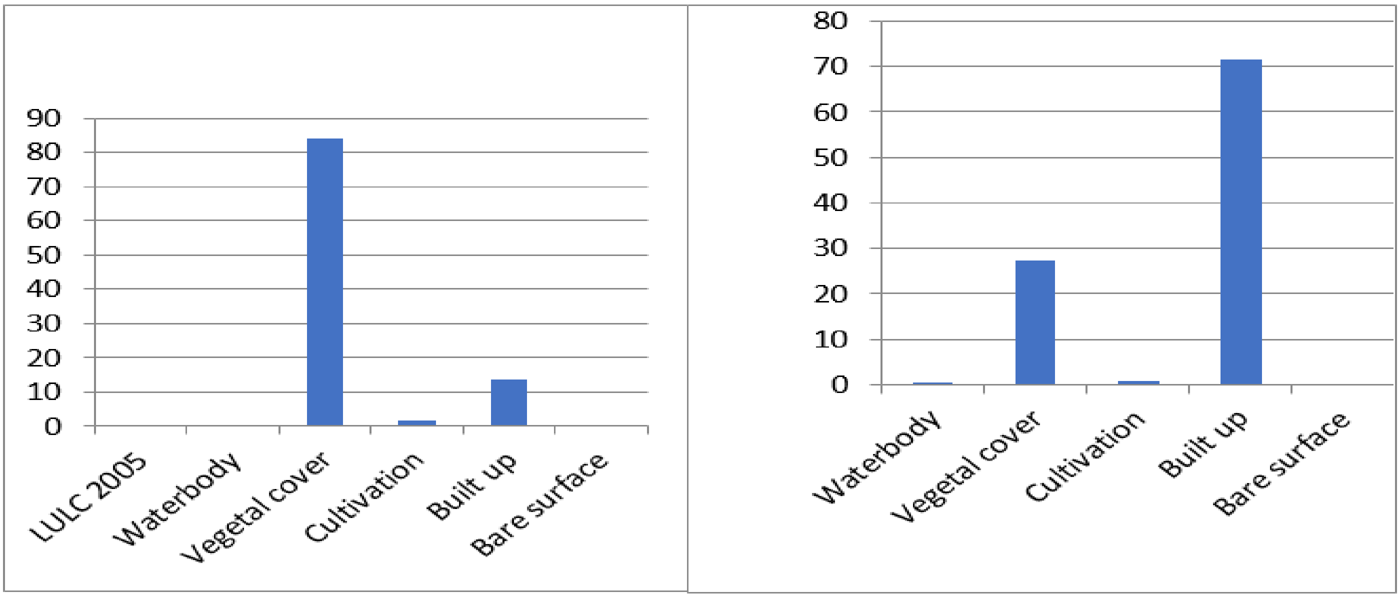


Fig 6 (a) (2005) and (b). (2015) Land Use / Land Cover Bar Charts of the Study Area

- *Digital Elevation Model (DEM)*

The Digital Elevation Model is considered an important factor in a multi-criteria decision analysis because of its ability to show an area in its three-dimensional state It tells about the nature of the terrain and indicates areas that are more elevated in terms of carrying out a flooding analysis. The image in Fig 7 shows the DEM of the study area. From the legend, the flood plains are represented in black, and they are mainly marshland, therefore, in the case of rainfall, the water in the marshland usually overflows its boundaries and covers its surroundings, especially the least and least elevated areas depending on the magnitude of the rainfall. The area represented in light blue is highly elevated, the areas represented in the other colors are elevated, less, and least elevated and can accommodate flood in various degrees.

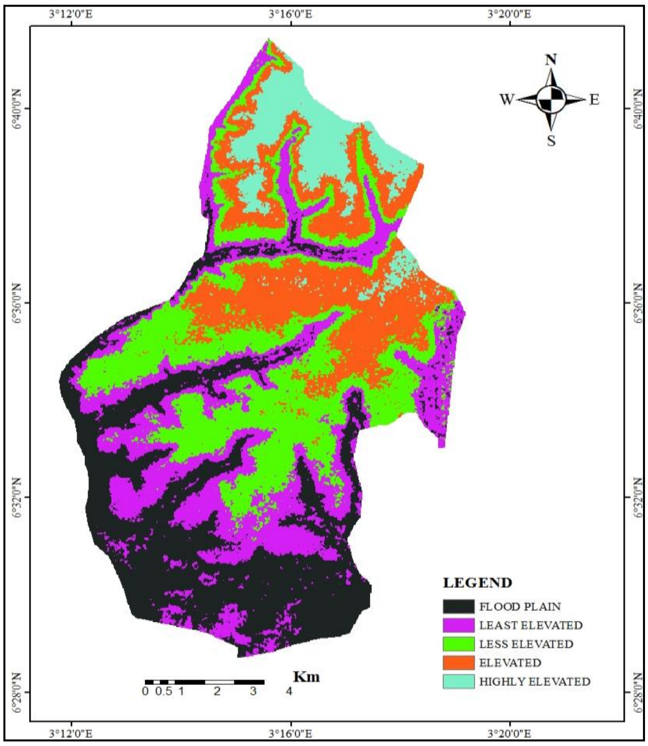


Fig 7 Digital Elevation Model (DEM) Map of Alimosho

- ✓ *Flood Density*

The higher the flood density the higher the flood risk in an area. It is also an important factor to consider when carrying out a flood vulnerability analysis. Fig 8 map, shows the flood density of the study area. The areas in brown represent the length of the streams.

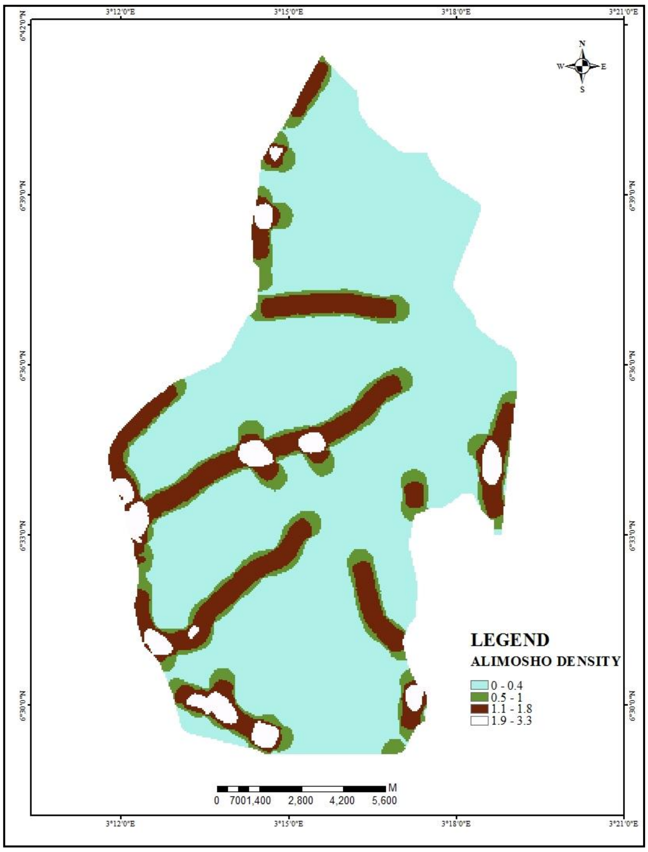


Fig 8 Flood Density Map of Alimosho

- ✓ *Flood Vulnerability Map*

Five criteria were considered, AHP multi-criteria decision analysis approach was used for the pairwise analysis (see Table 1), after which they were overlaid using weighted sum analysis on ArcGIS software, and the result obtained is shown in Figs 9 and 10.

Table 1 AHP Five by-Five Pairwise Comparison Matrix of Flood Vulnerability Criteria

| S/N | CRITERIA | | | | | | NORMALIZED PRINCIPAL |
|---|---|---|---|---|---|---|---|
| | | RAINFALL | SLOPE | DEM | DENSITY | LULC | EIGENVALUE |
| 1 | RAINFALL | 1 | 3 | 3 | 3 | 31/3 | 40.19% |
| 2 | SLOPE | 1/3 | 1 | 31/3 | 3 | 23/5 | 25.92% |
| 3 | DEM | 1/3 | 1/3 | 1 | 24/5 | 23/5 | 15.66% |
| 4 | DENSITY | 1/3 | 1/3 | 1/3 | 1 | 31/3 | 11.24% |
| 5 | LULC | 1/3 | 2/5 | 2/5 | 1/3 | 1 | 6.98% |
| Consistency Ratio | | | | | | | 11.60% |

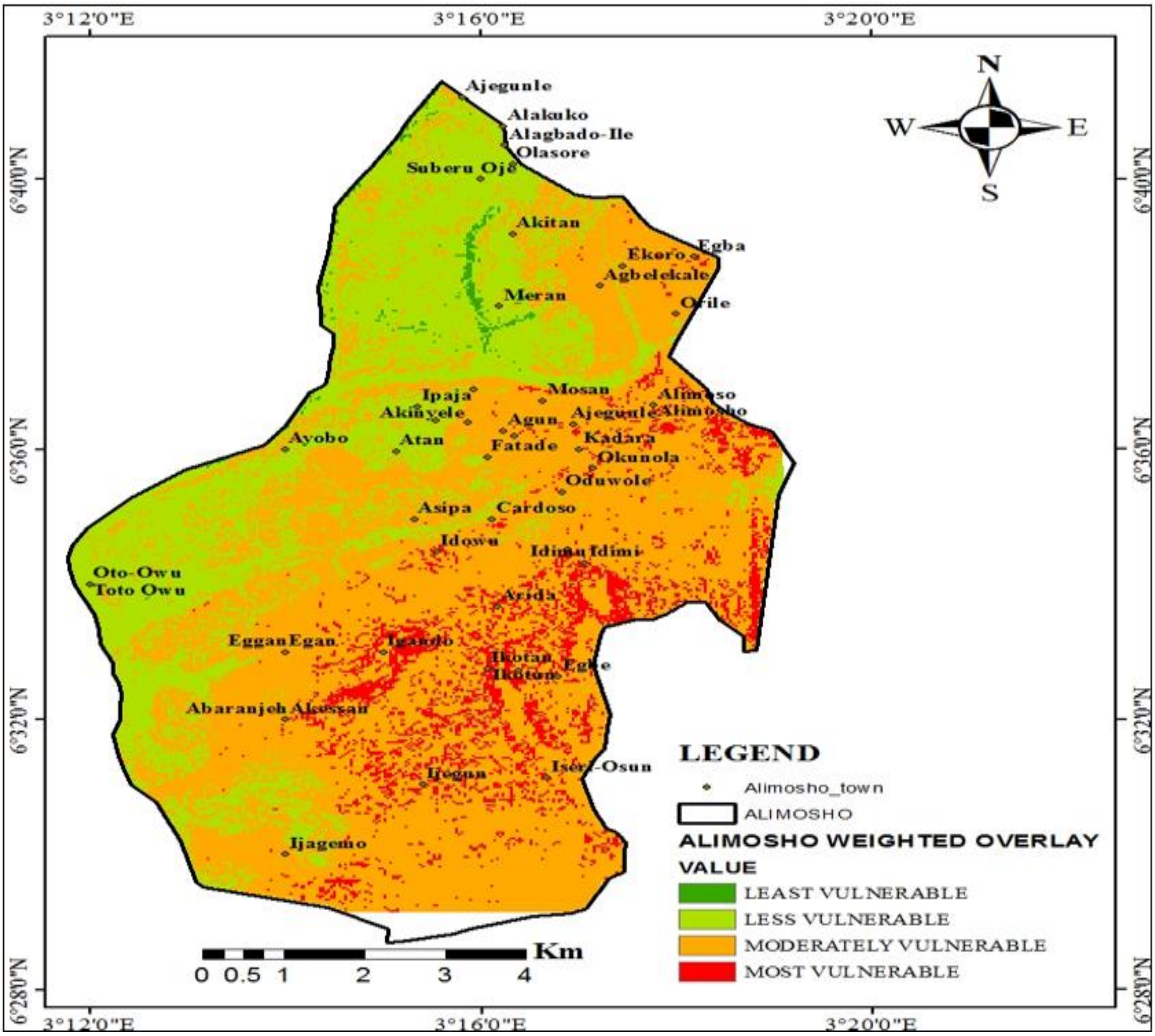


Fig 9 Vulnerability Map of the Study Area

From the flood vulnerability bar chart, the least vulnerable is within 0 Km, the less vulnerable within the range of 15000 – 20000 Km, the moderate vulnerable which ranked highest in the chart is within the range of 30000 – 35000 Km while the most vulnerable area is 5000 Km respectively.

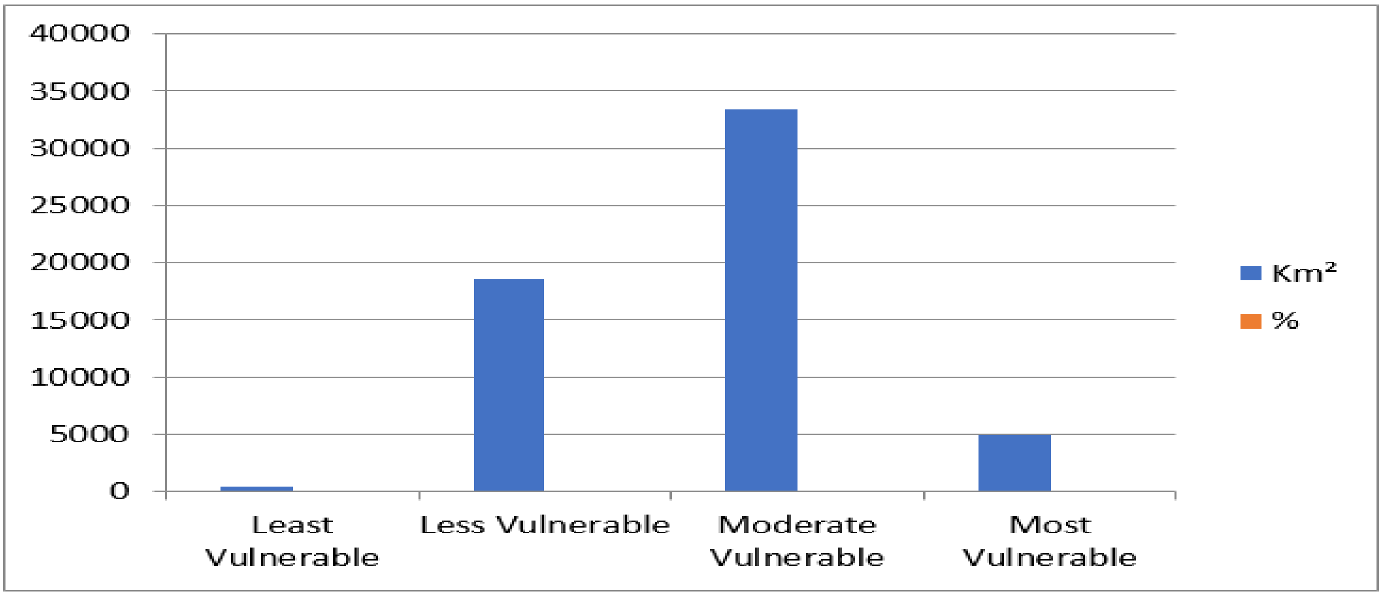


Fig 10 The Bar Chart of the Vulnerability Map of the Study Area

Plates 1 a and b: Measure Adopted by Ijagemo Residents


Plates 2 (a – f) Some Flood Damaged Areas


Plate 3 Google Image of Ijagemo, Alimosho LGA Marshland

## IV. CONCLUSION

Alimosho LGA is the most populated local government area of Lagos state. As a result of its low land, surrounding water body torrential rainfall, etc., it is always flooded during rainy seasons, especially around the swampy areas. The people living around the flooded area always adopt mitigation measures, including using locally constructed bridges and pouring and leveling sands on the affected areas. Vulnerability analysis was carried out using the AHP multi-criteria process and five factors; slope, annual mean rainfall, LU/LC of ten-year intervals, DEM, and density. Based on the findings (see Fig. 9), the study area displays varying levels of flood vulnerability, with a significant portion of the area at risk of flooding.

## RECOMMENDATIONS

- Urban development regulations should be rigorously enforced by relevant authorities, such as the Lagos State Building Control Agency within the Ministry of Physical Planning and Urban Development, to prevent the construction of properties on waterways.
- Environmental agencies should enhance their sanitation efforts within the Local Government area to ensure a cleaner and safer environment.
- The Surveyor General's office should provide flood risk maps to identify areas more prone to flooding in the study area, assisting in informed decision-making.
- Drainage systems, bridges, canals, and roads should be constructed in suitable locations, while existing blocked drainage systems must be cleared and maintained.
- The construction of levees and dams is essential to prevent water from exceeding its banks and causing flooding.

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