MAPPING OF FLOOD PRONE AREAS IN IMO STATE, SOUTHEASTERN NIGERIA USING GIS TECHNIQUES

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Abstract- **Flooding is a natural environmental hazard which has on a global scale caused irreparable losses on lives and property as well as deformation of the environment resulting in soil-nutrient loss, pollution of rivers/waterways, sedimentation of reservoirs and other negative issues in southeastern Nigeria. This study therefore makes use of GIS techniques to map areas in Imo State that are most prone or exposed to flooding. Satellite imagery and SRTM data were analyzed using ESRI ArcGIS 10.2 and Global Mapper v15 to generate maps for digital elevation model (DEM), digitized contour, 3D relief and flood vulnerability assessment. On analyzing the maps generated *Oguta* and *Ohajiegbema* were mapped as the most prone areas while *Okigwe, Ideato North, Ideato South* and *Nkwerre* were mapped the least prone. Nonetheless over 60% of the study area is still open to flood events if requisite environmental protective actions are not considered and implemented. On observing that the chief cause of flooding in the study area is heavy/prolonged rainfall/downpour with poor drainage channels, flood monitoring and assessment with proper design/construction of drainage networks/channels were among recommendations made to manage flood incidents in the study area.**

Keywords: flood, prone, flooding, mapping, GIS, drainage, DEM

I.INTRODUCTION

Globally, several forms of environmental problems/issues ensue of which include soil erosion, global warming/climate change, ozone layer depletion, drought, desertification and deforestation, oil spillage, water pollution, waste management e.t.c. but floods are the most devastating natural occurrences. Flooding is normally considered as the overflowing of the riverbanks of a water body thus resulting in uncontrolled spread of water beyond the water carrying capacity of the catchment area surrounding the water body (Okorafor *et al*., 2015). According to Nwafor (2006), flood is defined as a natural hazard like drought and desertification which occurs as an extreme hydrological (runoff) event. Flood is the most common and destructive environmental issue (Olajuyigbe *et al*., 2012; Etuonovbe, 2011; Bello and Jeb, 2014) and is one of the most harmful disasters in the world. Ojeh and Ugboma (2012) asserted that flooding is arguably the weather-related hazard that is most widespread around the globe which is continually ravaging the natural landscape of the environment. Floods have large social and economic consequences for communities and individuals and its impact is felt by loss of human life, damage of property, loss of livestock and deterioration of health conditions owing to water-borne diseases.

Every year over 20000 lives are lost and 74 million people are adversely affected by flood and flood related problems (Smith, 2002). Every year floods cause enormous damage all over the world. In the last decade of the 20^{th} century floods killed about 100,000 persons and affected over 1.4 billion people. The statistics show that floods have a large impact on human well-being on a global scale (Ezemonye and Emeribe, 2011). Severe flooding events have become a frequent phenomenon facing communities and authorities in Nigeria each year. According to Bello and Jeb (2014) in 2010 and 2011 respectively extreme flood events resulted in the devastation and economic damages worth millions of dollars in the affected urban cities such as Lagos, Kano and Ibadan with rural settlements in Sokoto and Kebbi State. Reports from National Emergency Agency (NEMA) in 2012 states that 30 out of 36 states in Nigeria were affected by floods of different degrees resulting in the death of 363 people and displacement of over 2.1 million people; the flood of 2012 was termed the worst in 40 years with 2.6 trillion as the estimated worth of damages. The flooding of 2012 had devastating effects and was attributed to excessive and prolonged rainfall of that year which resulted in the failure of dams particularly Lagdo dam in Cameroun (Okonkwo and Onyeizugbe, 2017).

In Nigeria, at least 20% of the population is at the risk of one form of flooding or another (Hula and Udoh, 2015). Floods in Nigeria are severely experienced in coastal/riverine areas of the country which include Lokoja, Lagos, Port-harcourt, Benue, Bayelsa e.t.c. Floods occur in Nigeria in three main forms: coastal flooding, river flooding and urban flooding (Folorunsho and Awosika, 2001) and other causes of flooding include in rising global temperatures which results in heavy downpour, melting of polar and glacier regions and thermal expansion of oceans. Within 2017 alone heavy flood incidents have been experienced Lagos, Imo, Abia, Uyo, Calabar, Benue and virtually all the important cities in Nigeria causing failure of drainage canals, destruction of residential apartments and displacement of populates. About a year ago catastrophic and life-threatening flood incident occurred in Houston, Texas (fourth largest city in America) rendering many people homeless and destroying properties worth billions of dollars. Climate change and global warming have been the repeated pointers for rise in ocean and sea levels which translates into recurrent incidents of flooding.

This study therefore, aims at mapping areas prone to flooding in Imo State by making use of satellite imagery and Shuttle radar topography mission (SRTM) analysis through remote sensing and GIS techniques to generate maps for digital elevation model (DEM), contour, 3D relief-elevation, flow drainage model and flood vulnerability assessment.

II.DESCRIPTION OF STUDY AREA

Imo State falls within the tropical rain forest region/belt and lies within Latitude 5º15'N-5º45'N and 6º45'E-7º15'E (Okorafor *et al*., 2018) with two distinct seasons (dry and wet), and covers a spatial extent of about 5530km^2 (Duru and Chibo, 2014). The rainfall pattern experienced in the area is oscillatory ,bimodal and usually has two peaks within the year which is around June, July and September (Okorafor *et al*., 2017); the mean annual rainfall amount ranges from 2250-2500mm, with a mean monthly temperature range of 28-35ºC and relative humidity of about 80-85% (Duru, 2008). The resultant vegetation is rich with luxuriant grass and hardwood trees draped with underbrushes and creepy stems/under growths but its density has been drastically reduced due to anthropogenic activities such as urbanization, deforestation and other destructive activities. The soils are formed from two different underlying formations which are Oligocene (Benin-Ogwashi/Asaba formation) and Oligocene-Miocene (sedimentary formation) (Onweremadu and Peter, 2016; Okorafor *et al*., 2017). Hence the soil within the area is predominantly sandy with little percentages of clay, shale, silt and loam; the soil profile is remarkably uniform with varied percentages of nitrogen and carbon and heavily leached (Njoku *et al*. 2011; Okorafor *et al*. 2018).

III.METHODOLOGY

The satellite imagery of the study area was downloaded from google earth maps online using google earth pro-software with latitude-longitude extent co-ordinates of 5º12'-6º02'N and 6º52'-7º62'E respectively. The SRTM (Shuttle Radar Topography Mission) data of the study area was also downloaded from USGS (United States Geological Survey), this website explores the world's largest civilian collection of satellite images and data, aerial photography, elevation and land cover datasets, digitized maps and our image gallery collections. The SRTM data presents the digital elevation model (DEM) which contains elevation grids that give a 3D representation of the terrain surface and spot heights data of different locations in the State as well as reflect the topography of the study area.
After the download both the satellite imagery and SRTM data were imported to ESRI ArcGIS 10.2 software and Global mapper v15 for data visualization, detail analysis, mapping, geo-referencing, processing using FCC (false color composites) and combination with other spatial datasets. From the thematic analysis carried out on the satellite imagery and SRTM data of the study area maps for digitized contour, digital elevation model (DEM), 3D elevation and flood vulnerability were developed/generated accordingly. The satellite imagery downloaded for the analysis is as shown in Figure 1.0.

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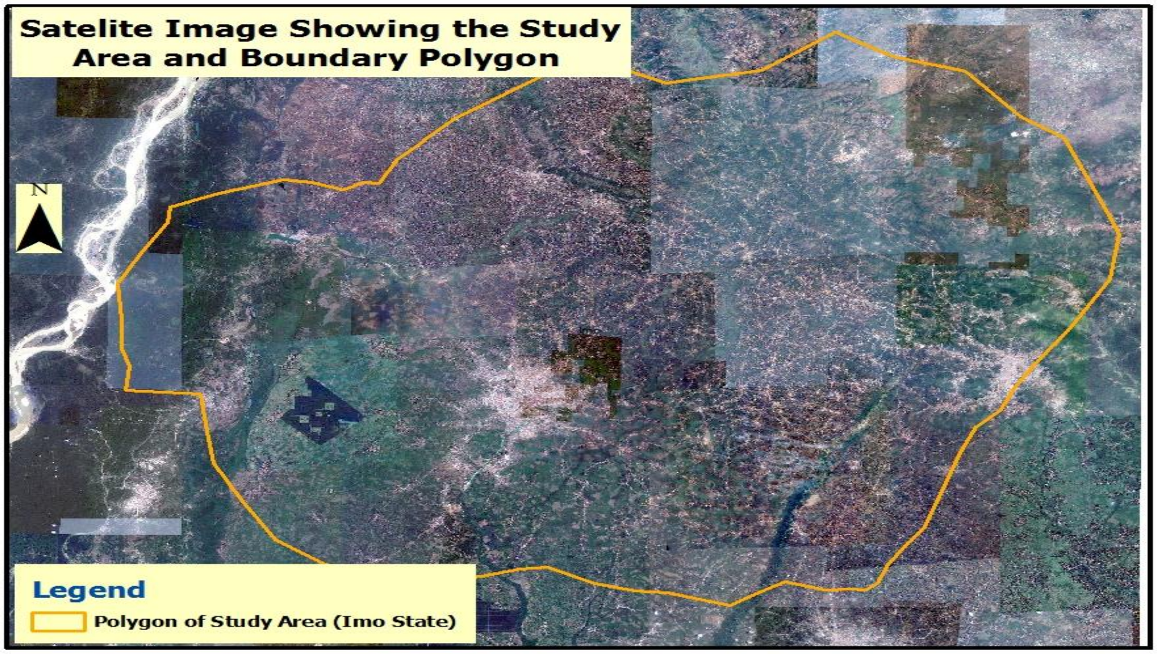

Fig. 1: Satellite Imagery of Imo State

IV. RESULTS AND DISCUSSION

The maps generated from the analysis carried out on the satellite imagery and SRTM data are shown in Figures 2, 3, 4, 5 and 6 respectively.

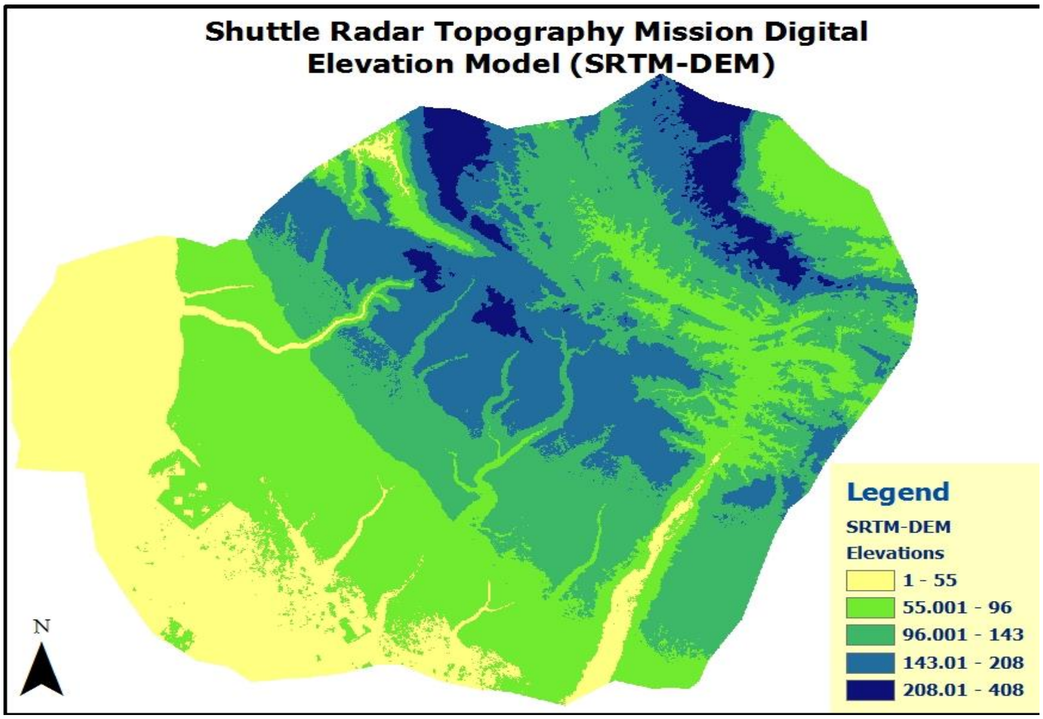

Fig. 2: Digital Elevation Model (DEM) of Imo State

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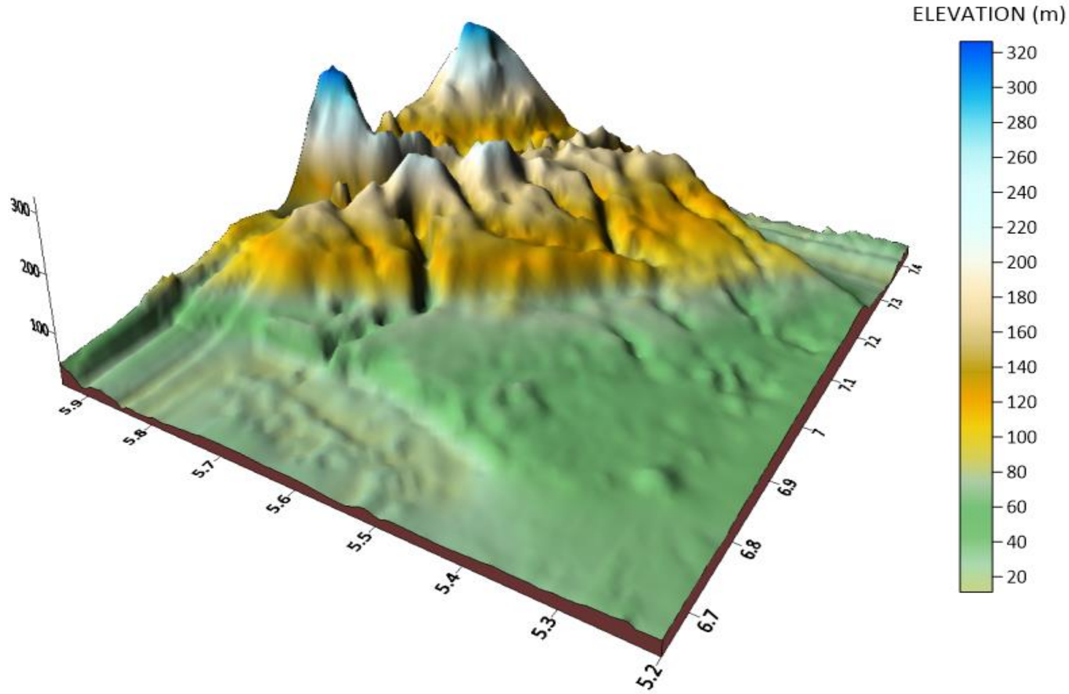

Fig. 3: 3D Relief-Elevation Map of Imo State

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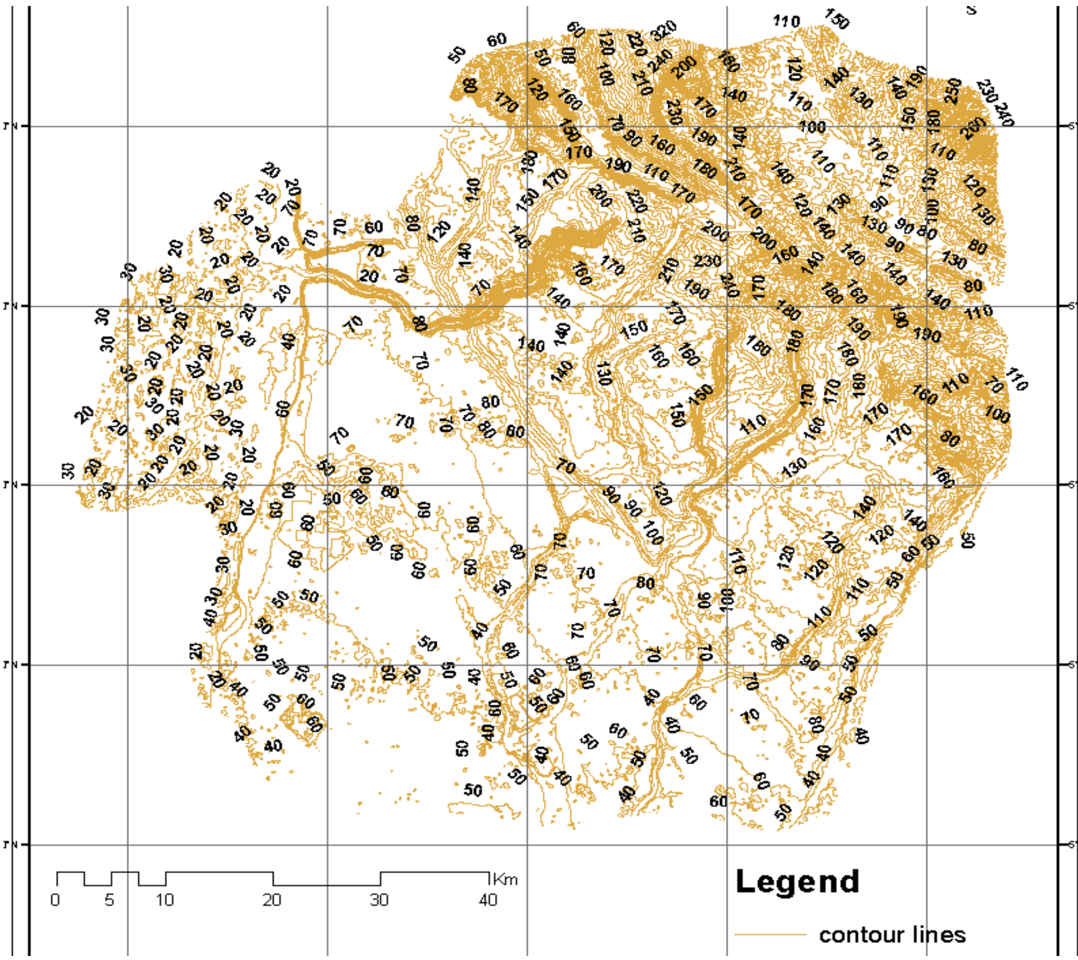

Fig. 4: Contour Map of Imo State

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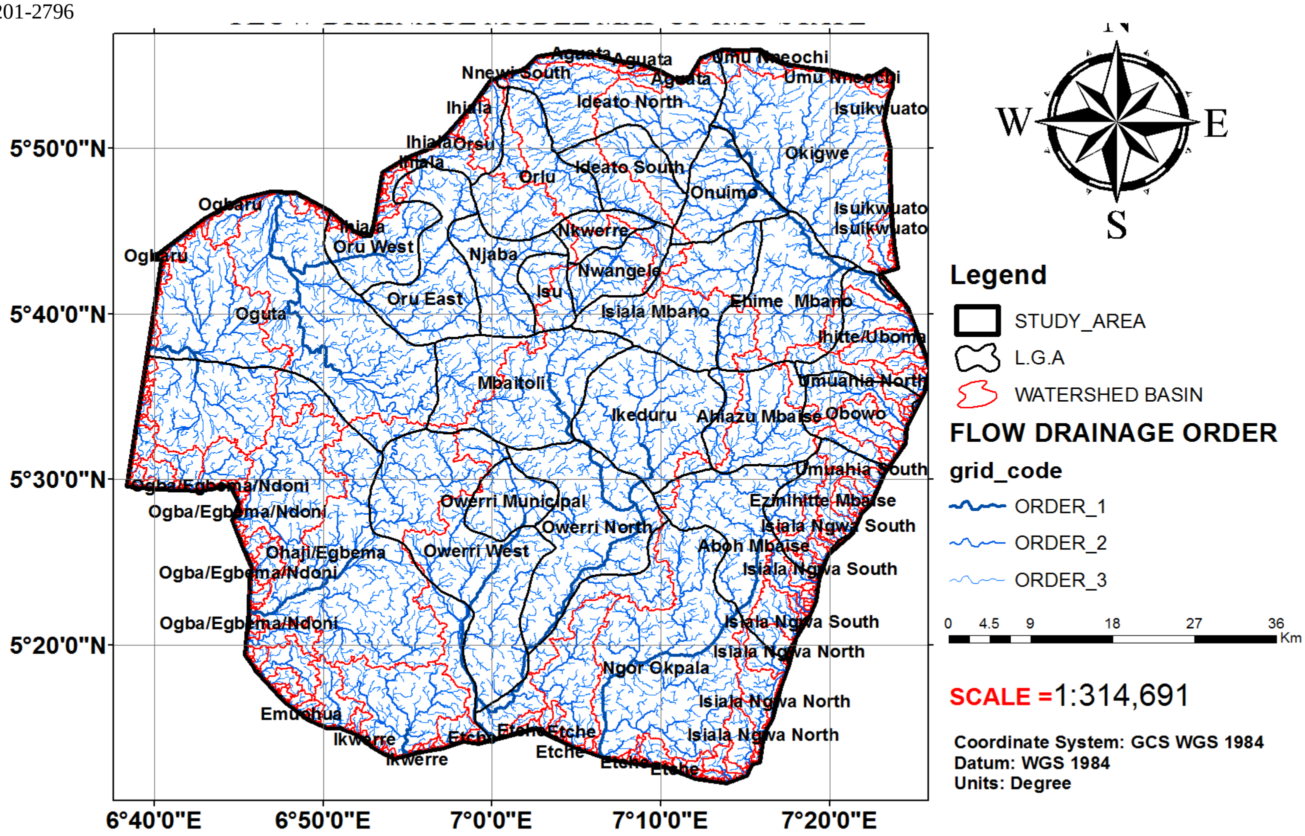

Fig. 5: Flow Drainage Model Map of Imo State

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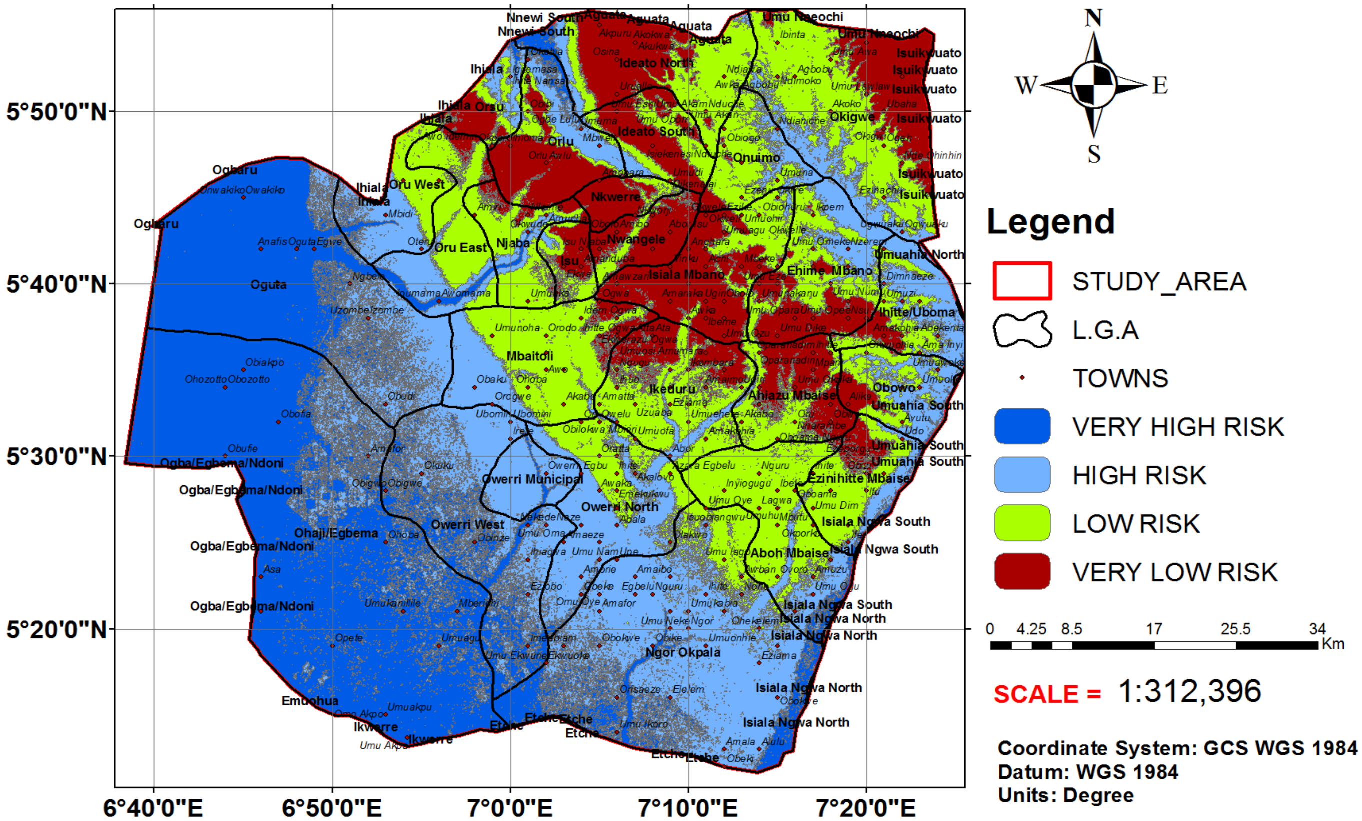

Fig. 6: Flood Vulnerability Assessment Model Map of Imo State.

From the DEM map in Figure 2.0 and the 3D relief-elevation map of Imo State, the variations in heights above sea level (elevation) for the study area range from 1-408m. This implies that after a heavy and prolonged rainfall that naturally the runoff generated will flow in response to gravity which means that the flow of runoff will arise from 353m above sea level to areas of 10m above sea level, which implies that areas with low to relatively low elevation intervals are prone to incidents of sustained flooding since they become a valley for the collection and settling of runoff from higher elevations. This equally means that flow generally will move from higher elevations to lower elevation with reference to the degree of slope or gradient. According to Njoku *et al*. 2013 and Essien *et al.*, 2018, floods are pronounced in areas with low elevation above sea level, hence those areas become flood plains where all river channels and runoff settle after incidents of heavy downpour and prolonged periods of rainfall. Consequently from the digitized contour map of the study area the contours (lines on a map representing points of equal elevation) share the same relief patterns as the DEM thus reflecting the same implications for movement of runoff water. Considering the various elevation groups for the study area the vulnerability assessment classes were classified as very high risk, high risk, low risk and very low risk respectively. The locations and their classes are summarized in Table 1.0.

Table 1: Locations within the Study area and their Flood Vulnerability Risk Class

Elevation above sea level (meters)	Flood Vulnerability Risk Class	Local Government Areas within Study area
1-55	Very High	*Oguta, Ohaji-egbema*
55.01-143	High	*Ezinihitte, Ihitte Uboma, Ngor Okpala, Njaba, Obowo, Onuimo, Owerri West, Aboh Mbaise, Mbaitoli, Owerri Municipal, Owerri North, Oru West*
143.01-208	Low risk	*Ahiazu Mbaise, Ehime Mbano, Ikeduru, Isiala Mbano, Isu, Nwangelle, Orsu*

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208.01-408	Very Low	*Ideato North, Ideato South, Nkwerre, Okigwe, Nkwerre, Orlu*

From Table 1, *Oguta* and *Ohajiegbema* Local Government Areas are the areas with the highest risk of flooding due to their lowest elevation (1-55m), while the *Ideato North*, *Ideato South*, *Nkwerre*, *Orlu* and *Okigwe* Local Government Areas are the areas with the lowest flood risk owing their high elevation (208-408m) above sea level. The other Local Government Areas are in transition between high and low flood risk respectively.

V. CONCLUSION AND RECOMMENDATIONS

It is clear that the study area by virtue of its presence within the tropical rain forest belt region depicts an elevated amount of rainfall which is considered the main cause of flooding in the area and accounts for generation of runoff that causes destructive damage to life and property. Although Oguta and Ohajiegbema LGAs have been rated the highest flood prone areas over 60% of the study area is open to flooding if requisite actions are not imbibed to conserve the environment.

Apart from the effect of high rainfall amounts other general causes of flooding in the study area include; destruction of existing drainage networks/channels due to urban renewal, construction of hydraulically inadequate channels which cannot handle generated runoffs, sedimentation and siltation of existing drainage channels, construction of buildings on already planned drainage ways, poor urban and town planning activities, uncontrolled dumping of refuse/wastes on drainage ways and general human interference on existing vegetation thus exposing more areas to the destructive action of floods. In response to the recurrent flood events there is need for;

- Proper urban, town and regional planning activities to create more drainage networks/basins to conduct generated runoffs from rainfall to safe outlets without destroying the environment.
- Proper Construction and alignment of hydraulically adequate drainage channels to comfortably handle rainwater to predefined outlets.
- Proper maintenance of existing drainage channels.
- Proper disposal and management of solid waste so as to protect existing water ways and drainage networks from eventual blockage and failure.
- The use of floodplains in forest areas or regions to serve as temporary flood water reservoir before proper channeling to the requisite outlets or predefined channels.
- Increased flood monitoring by government agencies so as to tackle flood incidents prior to their occurrence.

It is believed that if the above mentioned recommendations are properly executed that the menace that is posed or caused by flooding will be minimized and managed to a bearable minimum.

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