The International Journal Of Engineering And Science (IJES)
|| Volume || 3 || Issue || 8 || Pages || 01-08 || 2014 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

Development of a Modified Rational Model for Flood Risk Assessment of Imo State, Nigeria Using Gis and Rs

OKORO B. C.[1], IBE O.P.[2], EKELEME A. C[3].
[1,3] *Civil Engineering Department, Federal University of Technology, Owerri, Imo State, Nigeria.*
[2] *Civil Engineering Department, Federal Polytechnic Nekede, Owerri, Imo State , Nigeria.*

ABSTRACT
The Geographic Information System (GIS) technique (Overlay process) and Remote Sensing (RS) were used to assess risk factors and suggest ways to manage the occurrence of flood, particularly in Imo state, Nigeria, through the application of arcview GIS software. A map showing the areas prone to very high flood risk zones, high flood risk zones, moderate flood risk zones, low flood risk zones and risk free zones was produced from overlay analysis performed with other cartographic techniques. The study found that some areas nearest to streams are prone to very high flooding. The areas prone to *very high flooding* include North-west of Oguta Local Government Area and North-west of Ohaji/Egbema Local Government Area, which represents 7.32% of the study area. The areas prone to *high risk flooding* include south-east part of Oguta LGA, South of Ohaji/ Egbema LGA and the Otamiri area of Owerri Municipal, which represents 34.08% of the study area. *Moderate flooding* zones within the study area include Owerri North, Owerri West, Owerri Municipal, Orlu, Obowo, Oru West and Ngor-Okpala Local Government Areas, which represents 29.41% of the study area. *Low risk* and *risk free* zones include Aboh Mbaise, Ahiazu Mbaise, Ezinihitte Mbaise, Ikeduru, Nwangele, Njaba, Isu, Mbaitoli, Ideato North and South, Okigwe, Nkwerre, Ehime Mbano, Isiala Mbano, South of Orlu Local Government Areas of Imo State. Such low risk and risk free zones represent 18.97% and 10.21% of the study area respectively. Recommendations made include encouraging governments at various levels to use the flood zones mapped out to fashion out strict urban planning policies which should be pursued to prevent indiscriminate building of houses in flood hazard zones.

KEY WORDS: Floods, GIS, RS, Mapping, Flood Hazard, Flood Vulnerability.

Date of Submission: 10 Aug 2014 Date of Publication: 25 August 2014

I. INTRODUCTION

Floods are among the most destructive acts of nature. World-wide, flood damages to agriculture, houses and public utilities amounts to billions of dollars each year in addition to the loss of precious human and cattle lives. In majority of cases, 'flooding' is caused by a river over-spilling its banks (Alireza, 2011). This can be due to excessive precipitation, combined with inadequate channel capacity. Over-spilling can also occur due to obstruction in or aggradation of the river bed. Flooding can also result from inadequate water way at rail and road crossings, or when there are encroachments in the flood plain (Alireza, 2011). Flooding can also occur at confluences of streams when the main river is in high stage and backs up into the tributaries and areas there about. Documentation of flood in form of flood depth, area affected, damage to crops, damage to infrastructure, number of people affected and overall monetary damages need to be quantified (Altinakar et.al, 2011). Once the causes of the flooding problem are determined, then preventive measures can be taken to reduce future damages caused by flood. The intensity and amount of rainfall in recent times has resulted in some of the significant flooding and followed with erosion experienced within the eastern region of Nigeria, particularly in Imo State in the last few years. With the effects of climate change, heavy and damaging storms will continue to increase in frequency. GIS technology is a valuable tool in developing environmental models which include use of space and time as a common denominator that provide advanced features for data storage, management analysis and display. Geoinformatics aside from being used to integrate various models also enable us to acquire information about the environment. Remote sensing technology provide land use and land cover images which when combined with ground survey data by Global Positioning System (GPS) and Total Station instrument enable us to model soil erosion and other environmental hazards. The integration of these various Geoinformation technologies do not only enable us to estimate soil loss but they provide the spatial distribution of the flood and erosion sites. Accurate erosion risks and sensitivity index maps can be generated by the system (Ehiorobo et.al, 2010; Yuksel et. al, 2008)

Study Area : Imo State lies within latitudes 4°45'N and 7°15'N, and longitude 6°50'E and 7°25'E with an area of 5,135 sq km. It is bordered by Abia State on the East, by the River Niger and Delta State on the west, by Anambra State to the north and Rivers State to the south as shown in Figure 1.

Fig.1: Map of Nigeria Highlighting the Study Area.

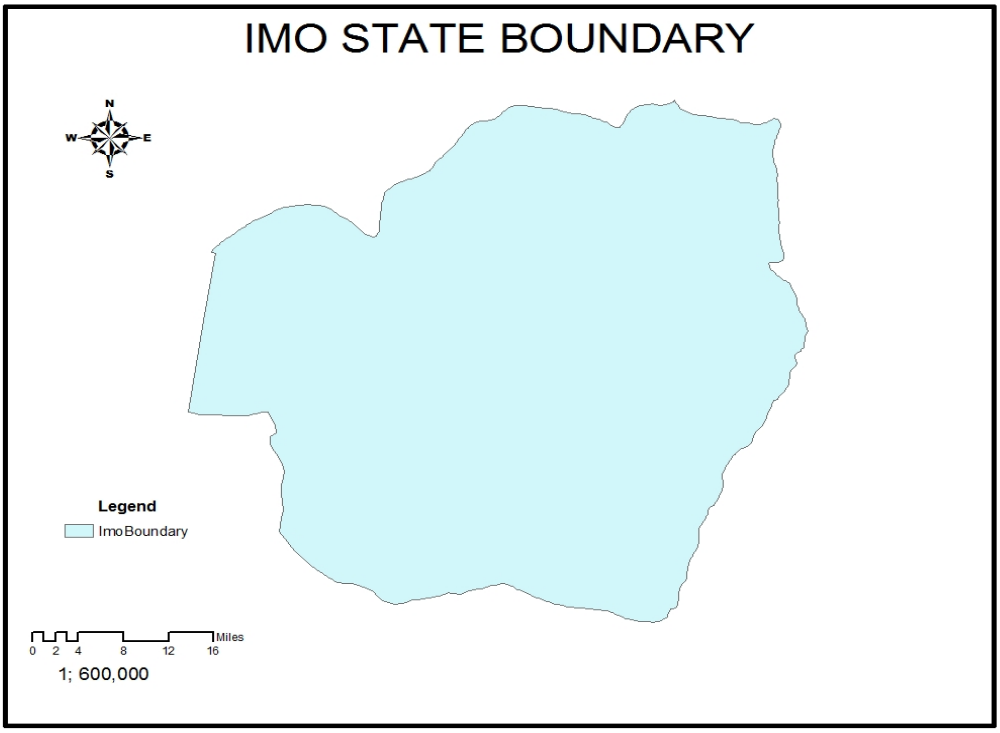

Fig. 2: Map of Imo State showing the Study Area.

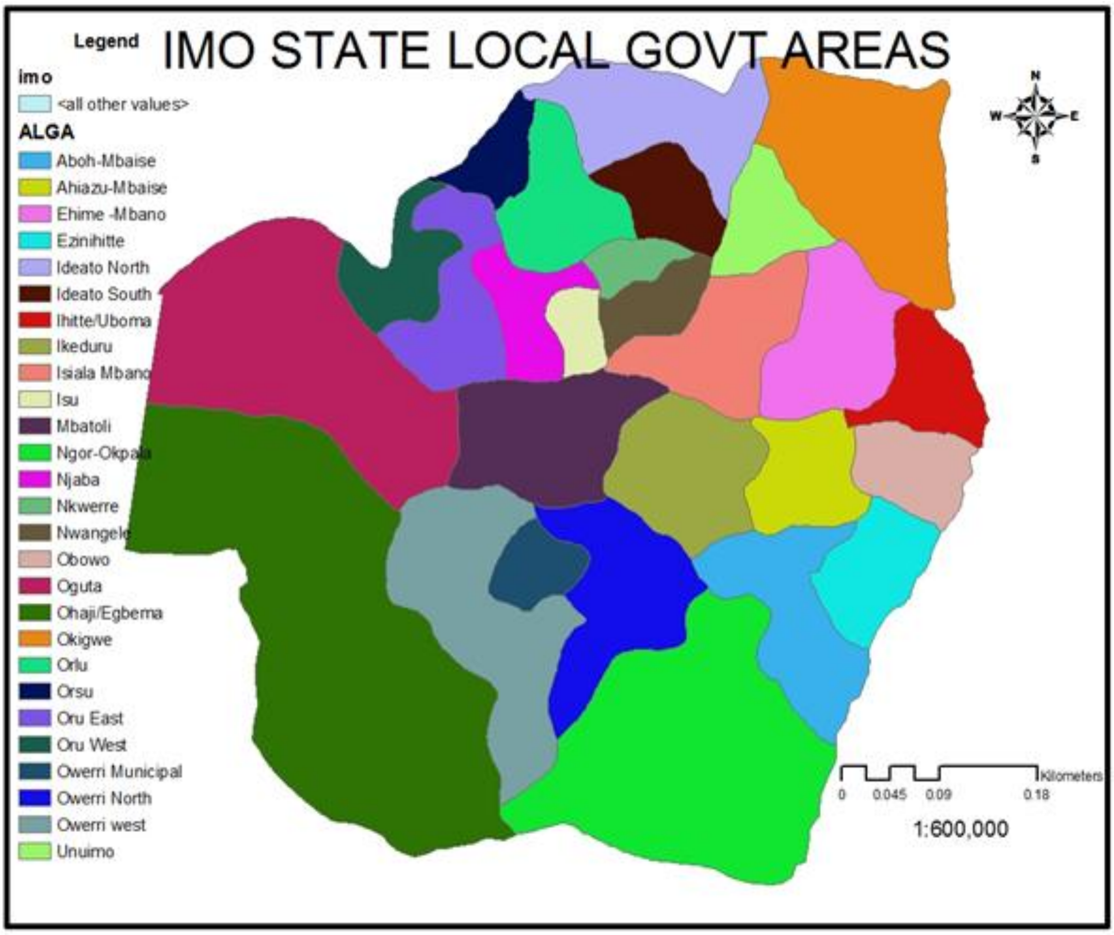

Fig. 3: Local Government Area Boundaries of Imo state.

Imo State is made up of twenty-seven local government areas as shown in Figure 3.
Besides Owerri, The major towns are Isu, Okigwe, Oguta, Orlu, Mbaise, Emekuku (Emekē Ukwu), Mbieri, Orodo, Orsu, Amaigbo, Mbano.The state is rich in natural resources including crude oil, natural gas, lead and zinc. Economically, exploitable flora like the iroko, mahogany, obeche, bamboo, rubber tree and oil palm predominate. However, with a high population density and the over farming approach of farmlands, the soil has been degraded and much of the native vegetation has disappeared. This deforestation has triggered soil erosion which is compounded by heavy seasonal rainfall that has led to the destruction of houses and roads.The soil in the area is well drained. The notable rivers and streams that are found in the state include; Imo, Nwaorie, Otamiri, Njaba, Oguta Lake.The study area lies within the tropical region. Early rainfalls usually start in January/February with full commencement of rainy season in March and ends in November of each year. The dry season lasts between four to five months of the year. The highest rainfall is recorded from July to October with little break in August. The average highest annual rainfall is about 1952 mm (Igbokwe et.al, 2008). The temperature pattern has mean daily and annual temperatures as 28^{o}C and 27^{o}C respectively.

II. MATERIAL AND METHODS

The first phase of field surveys was completed in February, 2012. This included detailed topographical surveys, location and assessment of spatial coverage of flood basins of the study area from Google imagery. The imageries for the study area are presented in Figures 4a and 4b. XYZ coordinates generated from the total station measurement were stored in Microsoft excel file format. They were thereafter imported into the ArcGIS environment using the Add XY menu. The project coordinates system were then specified in (Nigeria East Belt) and then exported into personal Geo data base as shape files for each of the flood zones. The shape files containing the elevation data were then added and a Triangulated Irregular Network (TIN) was created using the Z coordinates. The DEM (Digital Elevation Models) were generated by converting the TIN into Raster. Contour lines were generated using the created TIN to interpolate the contour with the aid of 3D analyst extension. ArcScene was then used for the visualization of the 3D model generated from the TIN.

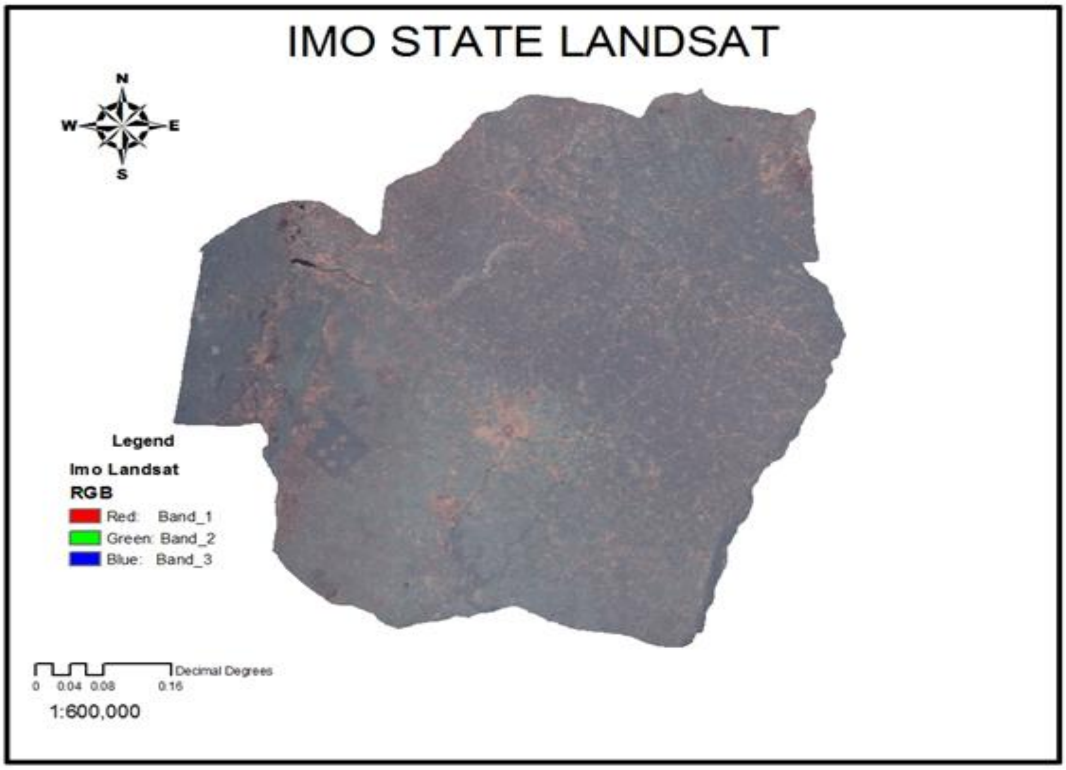

Fig. 4a: Map Showing Land Cover/ Use of the Study Area (LANDSAT 7, 2012).

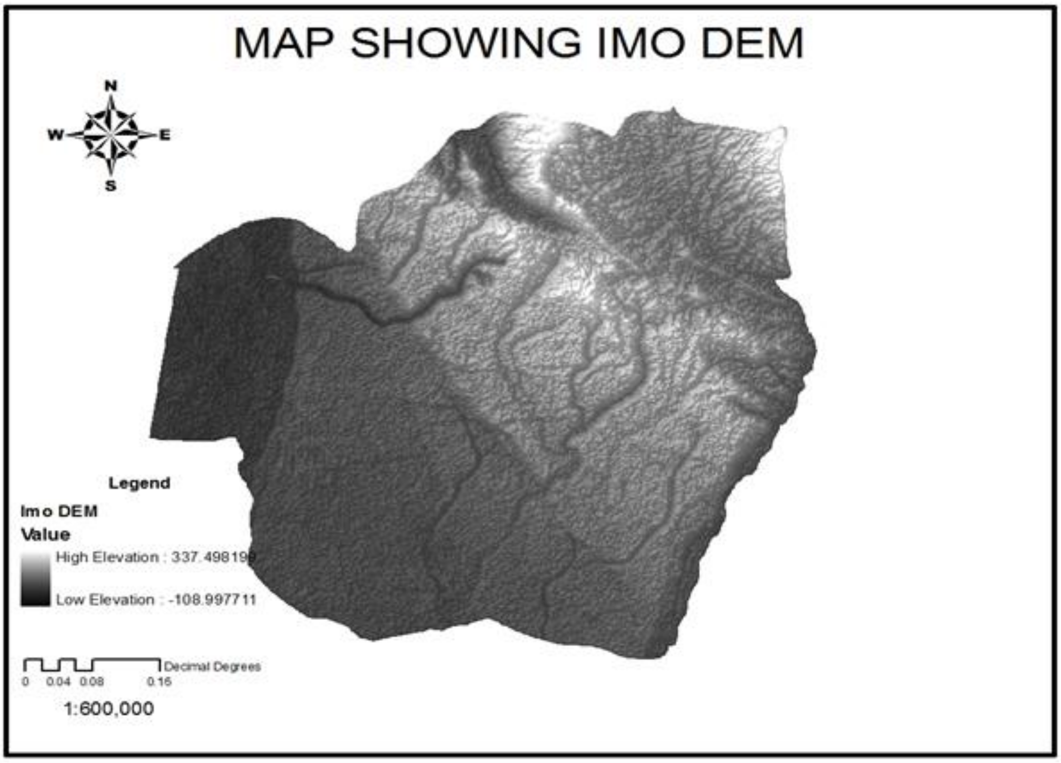

Fig. 4b: Map Showing the Digital Elevation Model of the Study Area.

Land Use Map : The land use map of the area was converted into digital format such that each land use was digitized as a polygon. The digital map was again reclassified (Fig. 5) into five classes based on the perceived relationship between land use and flooding for the purpose of the analysis. The perceived relationship is that built up areas closest to water bodies in Imo State will experience high flooding since runoff is high and infiltration capacity is low; while low built-up areas as well as farmlands and light vegetation areas will experience low flooding. This is shown in Figure 5.

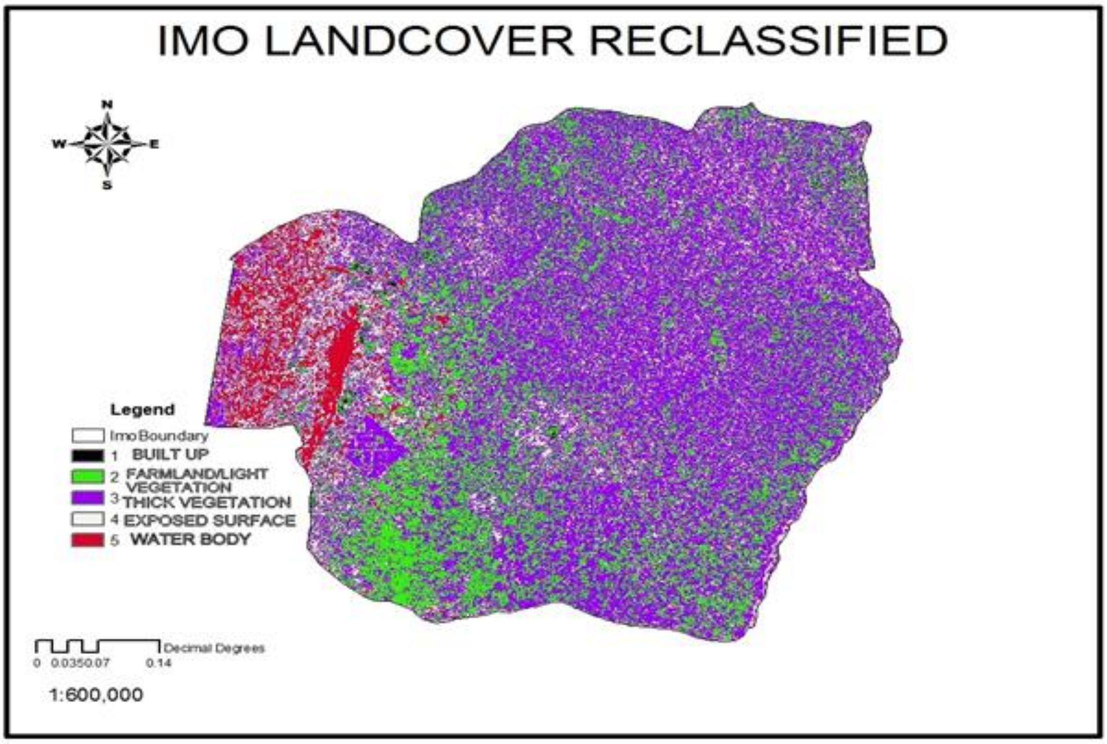

Fig. 5: Reclassified Land Cover Map of Imo State.

Reclassified Euclidean Distances from Water Bodies in Imo State : Logically, areas that are close in terms of distance to water bodies i.e. streams, rivers, lakes e.tc. are most vulnerable to flooding as a result of influences emanating from the water bodies (see Figure 6). As such, the Euclidean distance from the spatial analyst tool in ArcGIS was used in buffering areas within 1000meters of the water body, being the areas that are susceptible to vulnerability.

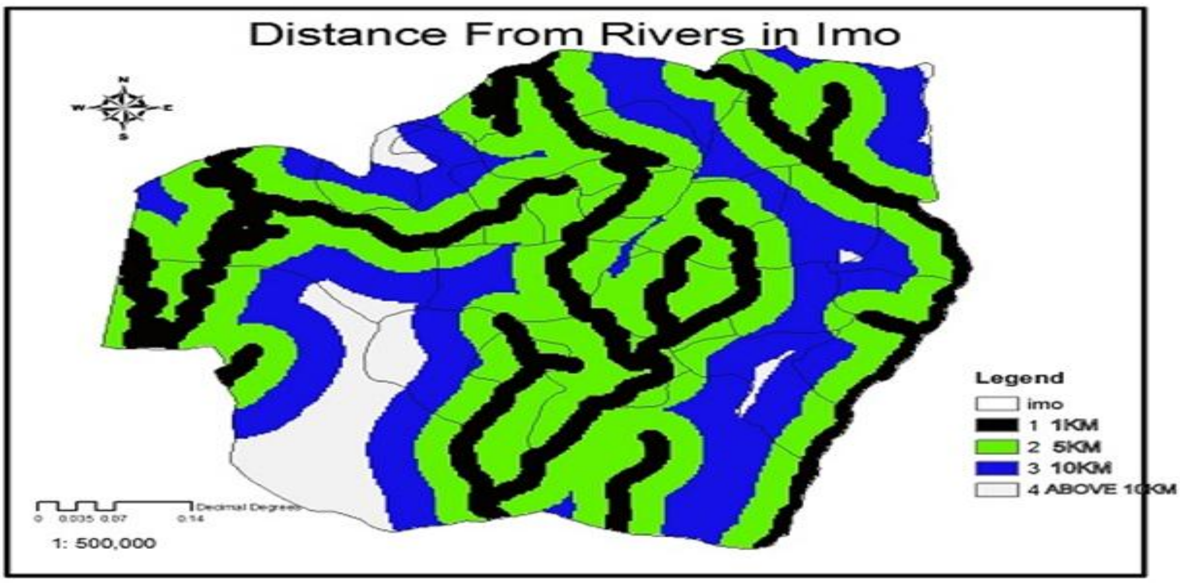

Fig. 6: Reclassified Euclidian distances from water bodies in Imo State

III. RESULTS AND DISCUSSIONS :

The result of the overlay of building density and distance from stream and digital elevation model (D.E.M) was then overlaid on the land intensity map (Hydrological Model - Modified Rational Model). Results showed that areas with high land use intensity, with low relief areas and nearest to streams are prone to high flooding. Whereas, areas with high relief, low land use intensity and farthest from water bodies are prone to low flooding; also areas with medium land use intensity and relief were shown to be prone to medium flooding. Boolean operation was then used to select areas that are prone to high flooding zones, medium flooding zones and zones prone to low flooding respectively.

S/NO	RISK VALUE RANGE (m)	RANKING OF PROCESS	RISK CLASSIFICATION	COUNT (Pixels)	PERCENTAGE OF STUDY AREA (%)
1	0-19	5	VERY HIGH RISK	397,661	7.32
2	20-50	4	HIGH RISK	1,851,491	34.08
3	51-105	3	MODERATE	1,597,832	29.41
4	106-175	2	LOW RISK	1,030,280	18.97
5	ABOVE 175	1	RISK FREE	554,771	10.21

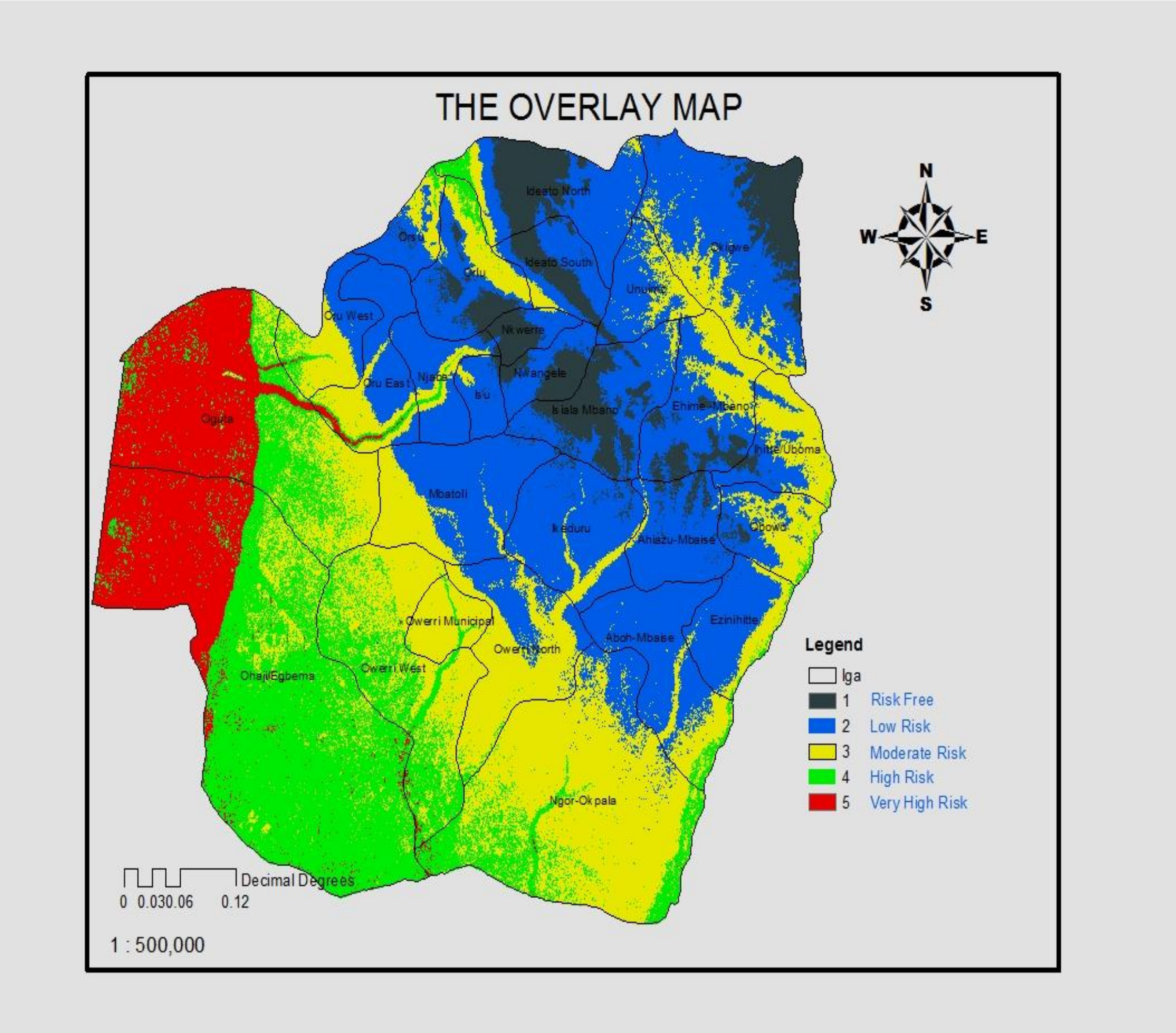

Fig. 7: Modified Rational Model of LGAs of Imo State.

S/NO	RISK VALUE RANGE (m)	RANKING OF PROCESS	RISK CLASSIFICATION	COUNT (Pixels)	PERCENTAGE OF STUDY AREA (%)
1	0-19	5	VERY HIGH RISK	397,661	7.32
2	20-50	4	HIGH RISK	1,851,491	34.08
3	51-105	3	MODERATE	1,597,832	29.41
4	106-175	2	LOW RISK	1,030,280	18.97
5	ABOVE 175	1	RISK FREE	554,771	10.21

Table 1: Reclassification of Flood Risk Assessment in Imo State.

Table 1 showed the areas that fall within the very high flood risk zone covering about 7.32 percent of the study area. However, the combination of the very high and high-risk zones constitutes a total of 41.4 percent of the entire study area. Hence, the area coverage of the flood risk zone will expand if the rainfall intensity increases above $120m^3/s$ or 30 mm/hr in a day.

From the overlay operation carried out (see Fig. 7), it was observed that Imo State can be divided into five major classes of areas that are prone to flooding as shown in Figure 7.

The areas prone to **Very High Risk** of flooding are,

- NORTH-WEST OF OGUTA LGA
- NORTH WEST OF OHAJI/ EGBEMA LGA

While areas prone to **High Risk** of flooding are,

- SOUTH EAST OF OGUTA LGA
- SOUTH OF OHAJI/ EGBEMA LGA
- OTAMIRI AREA OF OWERRI MUNINCIPAL LGA

Areas prone to **Moderate Risk of** flooding are;

- OWERRI MUNINCIPAL LGA
- OWERRI NORTH LGA
- IHITTE/ UBOMA LGA
- NORTH OF EHIME MBANO LGA
- OBOWO LGA
- NGOR-OKPALA LGA
- ORU WEST LGA
- NORTHERN PART OF OWERRI WEST LGA
- NORTH OF ORLU LGA

Areas prone to **Low Risk** of flooding are;

- ABOH MBAISE LGA
- AHIAZU MBAISE LGA
- EZINIHITTE MBAISE LGA
- IKEDURU LGA
- OKIGWE LGA
- ORU EAST LGA
- ONUIMO LGA
- MBAITOLI LGA
- IDEATO NORTH LGA
- NJABA LGA
- ISU LGA
- SOUTH OF EHIME MBANO
- IDEATO SOUTH LGA
- NWANGELE LGA
- ORSU LGA

The areas that are **Risk Free** include;

- ISIALA MBANO LGA
- NORTH-WEST PART OF IDEATO SOUTH LGA
- SOUTHERN PART OF ORLU LGA
- NORTHERN PART OF NKWERE LGA
- EAST OF OKIGWE LGA

Identification of flood prone zones or areas is fundamental to the success of flood response operations that emergency managers need to actively prepare for flood emergencies, so that as far as possible, the flood poses no surprises. Part of a flood emergency manager's preparation is leading the planning process with the adequate information tools and the assistance of specialist flood planners. This is accomplished not only by studying past floods patterns and producing flood plans (Ehiorobo et.al, 2010a), but also by being equipped with GIS and RS based developed models which are involved in land use planning decisions. Today, there is an increasing recognition that the opportunity and need exists to automate, integrate, manage and display information about emergency events like flood-likely occurrence(s) to be in computer based systems, which is the essence of this research work. As such, the results from the research can be used in a wide range of areas which include planning for events of floods to any other related program formulation and policy development.

IV. CONCLUSION AND RECOMMENDATIONS

Flood is a natural phenomenon. Floods of varying intensity have been occurring in various parts of the world, particularly due to the effects of climatic change. However, the ever increasing occupation or encroachment of the flood-plains results in huge loss of life and damages, causing the floods to be termed as 'disasters'. The solution is equally intricate, if not elusive. The occupation of flood plains continues to increase due to rise in population, economic changes, industrial and other activities. Consequently, the effect of flood damages is also on the increase. Satellite Remote Sensing and GIS techniques have emerged as a powerful tool to deal with various aspects of flood management in prevention, preparedness and relief management of flood disaster. They have greater role to play as an improvement over the existing methodologies. GIS is ideally suited for various floodplain management activities such as, base mapping, topographic mapping, and post-disaster verification of mapped floodplain extents and depths. Remote sensing and GIS techniques can replace, supplement or complement the existing flood management system. Extensive use of these technologies have great prospect in creating long-term database on flood proneness, risk assessment and relief management.

REFERENCES

[1] Alireza, G. (2011). Using GIS/RS for Flood Management (A case study in Golestan). Journal of Geographic Information System. 3(2): 367-372.

[2] Altinakar, M. S., Marcus, Z. and McGrath, E. K. (2011). The Use of Remote Sensing and GIS for the Estimation of Flooding. Technical Paper for ICHE08, Available From http://www.serri.org/publications/documents.

[3] Di Luzio, M., Srinivasan, R., Arnold, J.G. Neitsch, S.L. (2002). ArcView Interface for SWAT2000 User's Guide. Retrieved from SWAT Web site: http://www.brc.tamus.edu/swat/

[4] Ehiorobo, J.O, Anyata B. U. and Izinyon, O. C. (2010a). Flood and Erosion Research in the Niger Delta region-Edo state. Technical Report Vol. 1, December. Submitted to NDDC Port Harcourt.

[5] Ehiorobo, J.O., Anyata, B. U. and Izinyon, O. C. (2010b). Flood and Erosion Research in the Niger Delta Region-Cross River state. Technical Report Vol. 1, December. submitted to NDDC Port Harcourt.

[6] Igbokwe, J.I., Akinyede, J.O., Dang, B., Alaga, T., Ono, M.N. and Anike, L.O. (2008). Mapping and Monitoring of the Impact of Gully Erosion in Southeastern Nigeria with Satellite Remote Sensing and Geographic Information System. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 37(8): 865-871.

[7] Yuksel, A., Akay, A.E. and Gundogan, R. (2008). Using ASTER Imagery in Land Use/Cover Classification of Eastern Mediterranean Landscapes According to CORINE Land Cover Project Sensors. 8: 1237-1257.