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Mapping and Analysis of Flood Risk Zones in Uyo Urban Nigeria Using Satellite Imagery

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Abstract
Sequel to the uncountable and catastrophic effects of flood in different places all over the world, several mitigation measures have been developed by different people in different places to manage it. Unfortunately, as seen in literature, most of the mitigation measures lack proper mapping of the physical environment. It is to this effect that this study used GIS and remote sensing to identify flood risk areas within Uyo Urban so as to produce an easily understood GIS based flood risks map of the area. The ASTER DEM and Landsat ETM+ images of 2015 of the area were used in this research to characterize the topography and assess the impact of flooding. Three flood risk maps were produced identifying three category risk zones, high, medium and low risk zones. Factors that affect flooding in the study area were outlined and they include population explosion, urbanization and climate change. The area within each of the risk zones was calculated. The total area covered by the high risk zone was 8,878,080Sq km (52.50%) while the area of the medium and low risk zones were 7,873,810Sq km (47.15%) and 5,782,00Sq km (0.34%) respectively being the land use within Uyo Urban. Finally, strategies for mitigating against flood risks were discussed which include development of flood early warning system, structural and non-structural measures. And some recommendations were made to help researchers to improve on flood management in the country which include, there should monitor or discourage built-up areas that are located within the flood plains in Uyo Urban and Provision of adequate drainage and channelization system.
Keywords: Flood, Flooding, Natural hazard, Management, Runoff, Mitigation

1. Introduction

"Flooding is a general temporary condition of partial or complete inundation of normally dry areas from overflow of inland or tidal waters or from unusual and rapid accumulation or runoff" (Jeb and Aggarwal, 2008). According to EC (2007), a flood can be defined as a natural phenomenon that results in the temporary submerging with water of a land that does not occur under normal conditions. Floods can be caused by anthropogenic activities and human interventions in the natural processes such as increase in settlement areas, population growth and economic assets over low lying plains prone to flooding leading to alterations in the natural drainage and river basin patterns, deforestation and climate change (EC, 2007). They are naturally occurring, they cannot be prevented and have the potential to lead to fatal causes such as displacement of people and damage to the environment (Adeoye *et al*. 2009). In tropical regions, flooding of high magnitude that resulted in serious damages were caused by heavy rain/thunderstorms, hurricanes, snow melt and dam failures

The effects of natural hazards such as floods can be felt at local levels, affecting communities and neighbourhood, or at regional or national levels, affecting entire drainage basins and large sparse of land between states (Adeoye *et al*. 2009). Flooding incidents have claimed many lives, rendered many others homeless and disrupted a wide range of environmental factors and socio-economic activities related to agriculture, vegetation and sustenance of human and wild life (EC, 2007).

Adeoye *et al*. (2009) reported that floods have caused over 10,000 deaths in the United States since 1900. Nigeria has recorded some of the highest death toll in the West African region, the northern parts of the country, villages and huge sparse of agricultural land have been destroyed by flooding (ARB, 2010). In recent times, floods have destroyed property worth millions of naira in the different areas of Nigeria. Flooding in urban areas is seriously becoming an ecological menace in Nigeria as several coastal areas along the Atlantic Ocean, surrounding cities and river valleys are affected by flooding on a yearly basis (Jeb and Aggarwal, 2008) Floods have led to land degradation in some other parts of the country. The obvious reason for flooding especially in municipalities and coastal areas in Nigeria lies in the wide distribution of low-lying coastal areas and river floodplains, and because these areas have fast become a long-standing attraction for human settlement (Ologunorisa and Abawua, 2005).

The most recent flood was in June, 2011 and it occurred after torrential rainfall that lasted for days causing displacement of about 400 people (Uwem *et al,* 2011). Furthermore, they indicated that past floods in Uyo have claimed thousands of lives and rendered hundreds homeless and destroyed infrastructures within Uyo Metropolis and its surrounding farmlands. Over the years, the response of government and relief agencies to floods in Urban cities and other parts of the country has been in the area of rescue and supply of relief materials to victims of flood. Nothing has been done to ensure that the hazard is prevented and its associated risk is reduced to the barest minimum (Jeb and Aggarwal, 2008). Reduction of risk of flooding will depend largely on the amount of information on floods that is available and knowledge of the areas that are likely to be affected during a flooding event. Therefore, it is necessary to use modern day techniques in developing measures that will help government and relief agencies in identification of flood prone areas and in planning against flooding events in the future.

2. Study Area

The study was carried out in Uyo Urban, the capital city of Akwa Ibom State, Nigeria The city lies between longitudes 37 50’ E and 37 51’ E, and between latitudes 55 40’ N and 54 59’ N. Uyo the Capital City covers an approximate area of 188.024 km² with an estimated population of 305,961. It was a district headquarters during the colonial era and was later upgraded to a local government headquarters. In 1987, it was further upgraded to the status of a State Capital. With the changes in the status of the area, developments are attracted. Fig. 1.0 shows the map of the study area.

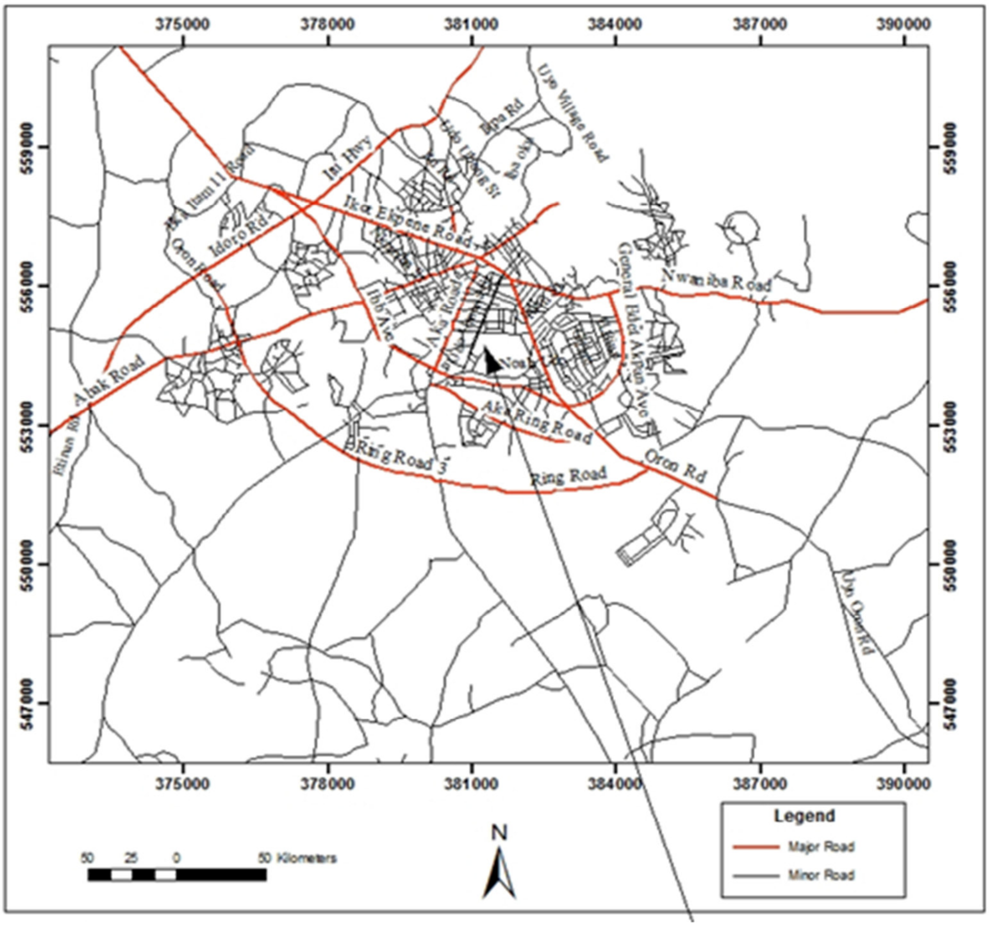


Figure:1c Map Of Uyo Urban Showing the Study Area (Source: GIS Centre Uniuyo)

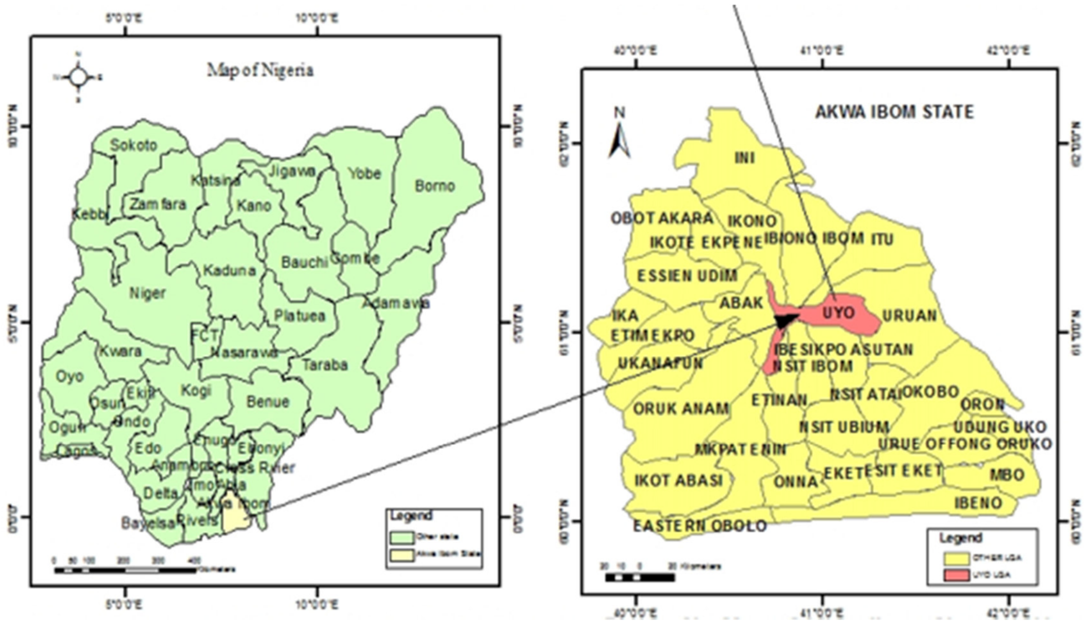
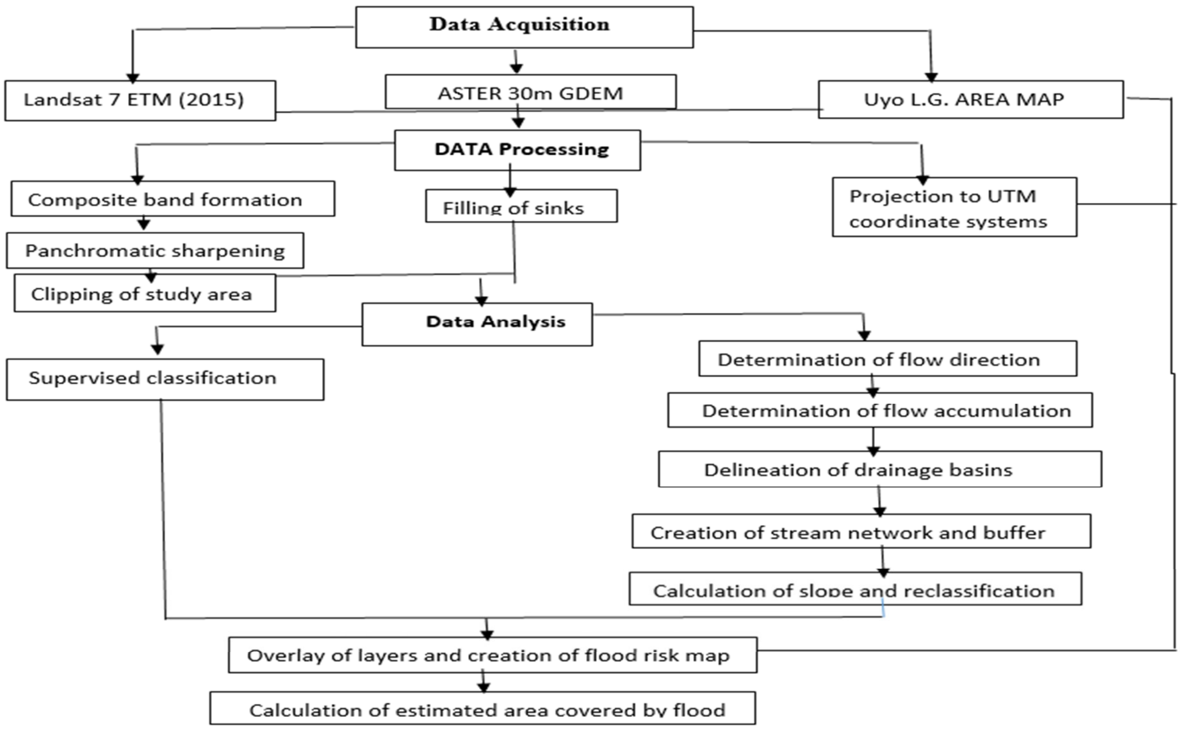


Figure: 1 Map of Nigeria Showing Akwa Ibom. Figure: 1b Map of Akwa Ibom State Showing Uyo

2. Methodology

The methodology flowchart adopted for this study. Fig:2



2.1 Data Processing

The software used in data processing and analysis was Erdas Imaging and ESRI's ArcGIS 9.1. Uyo urban data in both vector and raster representation was acquired from the NASRDA, with the names of different street in Uyo urban The analogue base map of the study area was scanned in raster format using the Hewlett Packard A0 Scanner. The file of the scanned image was exported to ArcGIS 9.1 for georeferencing and onscreen digitization. The scanned base map was georeferenced and digitized onscreen using the ArcGIS 9.1. The features were digitized in layers, i.e, each group of features occupying each layer.

A stepwise arrangement and organisation of acquired data in a manner that was appropriate for analysis was used which started with Composite Band Formation the different bands in the Landsat image was composited in ArcGIS 9.1 to produce an image with seven bands. Panchromatic sharpening was carried out which involved the fusion of the high resolution (15m) panchromatic band/image with the lower-resolution Landsat images. The Landsat 7 ETM+ composite image was pan-sharpened with panchromatic image. The composite image was clipped to the extent of the study area. Uyo urban map was also clipped.

In order to carry out hydrology analysis on DEM, all depressions have to be filled. Such depressions are called sinks. The ASTER 30m GDEM sinks was filled using the 'Fill' tool in ArcGIS 9.1. The Uyo urban raster data was projected from Minna datum to WG 84

2.2 Data Analysis

Operations that was performed on the DEM to create risk zones. They include:

The drainage basins in the study area was delineated using the basin tool in ArcGIS 9.1 and further analysis was performed to understand the flow of water on the surface of these basins and then creation of stream channels.

The depression less DEM was used to generate a flow direction raster. The flow direction shows the possible direction of water run-off on the elevation model. This analysis was performed using the flow direction tool in ArcToolbox Spatial Analyst tools.

Determination of flow accumulation is the next step after flow direction and it shows the cells within the study area where water accumulates as it flows downwards. Thus, settlements around these cells will receive much water during an event of rainfall or any sudden release of water.

The stream network was created from the flow accumulation raster to show the path of streams on the elevation. A reclassification of the flow accumulation results was performed using the reclassification tool in Spatial Analyst tools.

The result of the stream network analysis was reclassified to create a buffer zone around areas that are within 500m of the stream because of it closeness to major road, residential area and community land.

2.3 Calculation of Slope and Reclassification

The slope angles of the DEM were then calculated using the spatial analyst tools and a reclassification was performed to create three categories:

I. Areas with slope angles above 15.3 (High slope areas)
II. Areas with slope angles between 5.55 and 14.9 (medium slope areas)
III. Areas with slope angles below 0.5.54 (low slope areas)

The total areas occupied by these three categories were also determined.

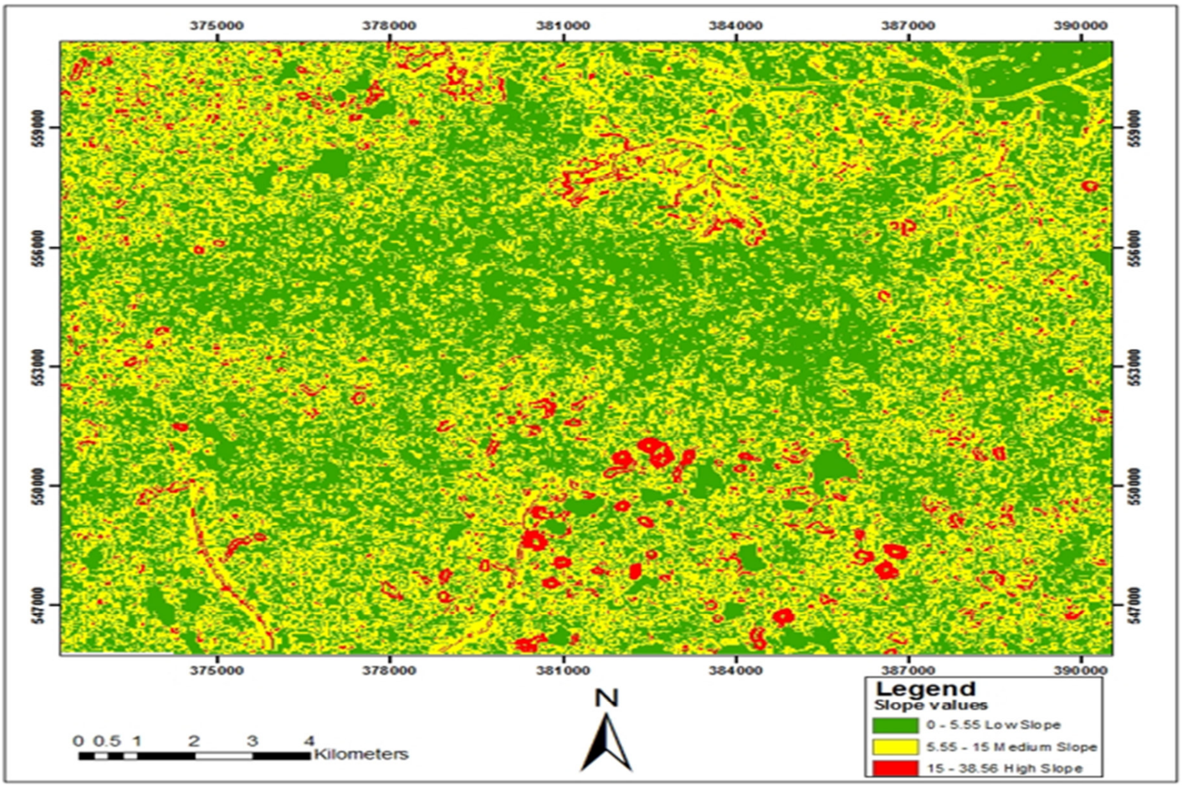


Figure 3: Diagram of reclassified Slope Angles of DEM of the Study Area.

2.4 Overlay of Layers and Production of Flood Risk Maps

After determination of slope and creation of stream buffer areas, the next major step is the addition of these two resultant layers in the raster calculator to produce a new layer showing three risk zones (Ajibade et al., 2010).

3. Results and Discussions

The flood risk map is shown in figure 3.0

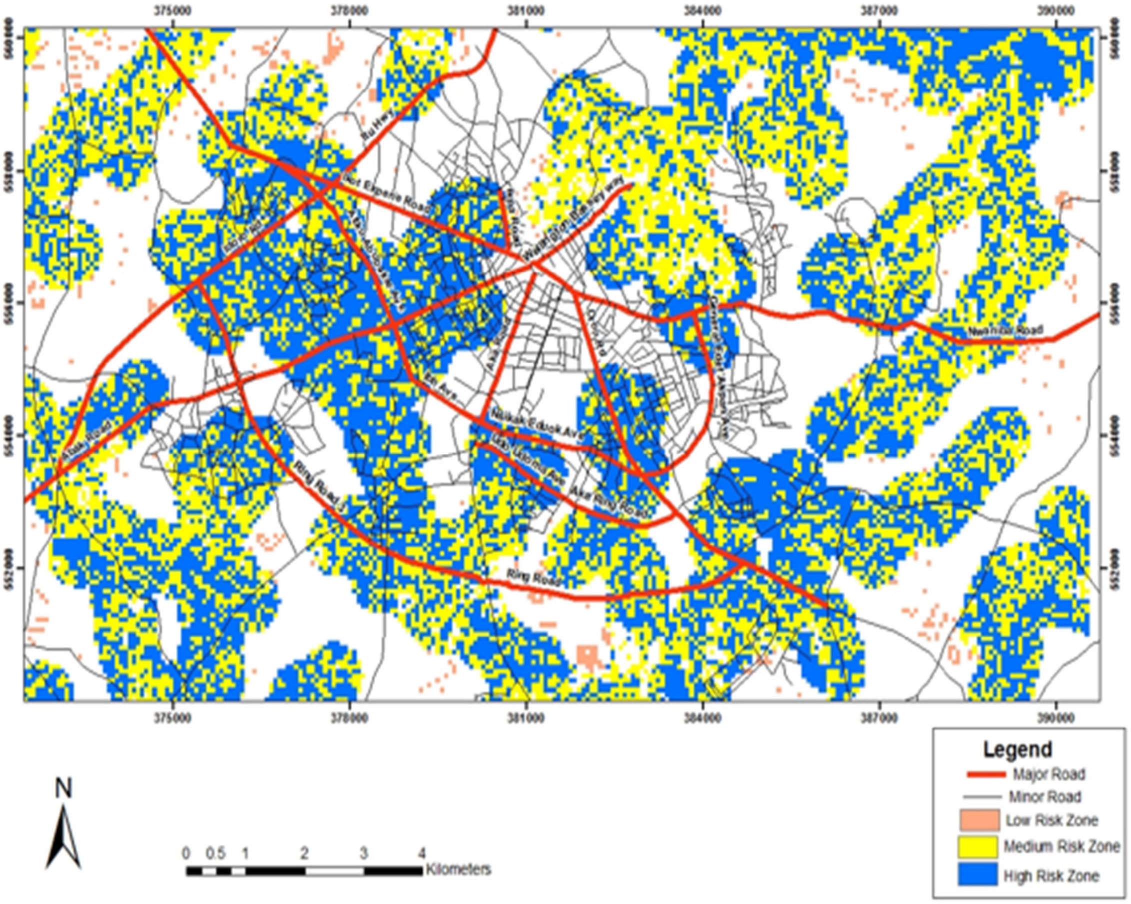


Figure 4: Flood Risk Map Showing the three different Risk Zone in The Study Area.

The flood risk maps present the areas within the study area that are most likely and unlikely to be inundated with water in a flooding event. Major water bodies in the metropolis/study area are located in far away from the built-up area. The Map shows settlements scattered within the different zones. Majority of the settlements are within the heart of the city/metropolis. They are Ikot Ekpene Road, Abak Road, Aka Road, Nwaniba Road, Atiku Abuabaka Road, IBB way,Idoro road, Nsikak Eduak Road.

3.1 Estimated area covered by flood in the study area

Past flooding in Uyo Urban have always resulted in the loss of lives and properties (Uwem et al 2011). People that would be affected live within flood prone areas. An understanding of the number of people that are likely to be affected during a flooding event will improve flood risk management. An estimate of area covered by flood within the study area was calculated based on the total area at risk within the study area. Table 2 show the results of the estimated area covered by flood within the different flood risk zones.

Table: 1 Showing the total estimated area of land use within the risk zones

RISK ZONE	LANDUSE	TOTAL AREA (SQM)	AREA(SQM)OF RISK	AREA (%)
HIGH RISK ZONE	Farm Land	76942800	26489400	34.43
	Vegetation	81567000	13218600	16.12
	Built up	57445200	26701400	46.15
MEDIUM RISK ZONE	Farm Land	76942800	28792400	37.42
	Vegetation	81567000	27778100	34.06
	Built up	57445200	23711100	41.28
LOW RISK ZONE	Farm Land	76942800	22155600	28.01
	vegetation	81567000	40734600	49.82
	Built up	57445200	7308500	12.54

FLOOD RISK ZONES	COUNT	TOTAL ESTIMATED AREA (SQM)	AREA (%)
HIGH	17891	87670800	52.50
MEDIUM	16069	78738100	47.15
LOW	1148	578200	0.34
TOTAL	35108	166987100	100

4. CONCLUSION AND RECOMMENDATION

4.0 CONCLUSION

Based on the results and the analysis done in this study it is concluded that Remote Sensing and Geographic Information System can be used as effective tools in mapping and analysis of flood risk zones in different urban cities. The study shows that both human activities and some negligence on the side of the government is responsible for vulnerability and the susceptibility in the study area.

4.1 RECOMMENDATIONS

This research presents a valuable tool that would help researchers in planning towards flood managements in the study area. However, this tool cannot be used in isolation and more information is needed for a full assessment of flood risk. Therefore, the following recommendations are made to enhance flood risk management:

i. There should monitor or discourage built-up areas that are located within the flood plains in Uyo Urban.
ii. Provision of adequate drainage and channelization system as well as adhesiveness to the regulated planning scheme in Uyo Urban should be monitor by researchers.
iii. There should be more research on Implementation of flood control policies and flood early warning systems.
iv. Furthermore, the need to monitor the various urban expansion and flood incidences within Uyo Urban.
v. That more research should be made in this area using this study as the base line data.

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