# COASTAL FLOOD MAPPING OF EASTERN OBOLO AND IBENO LGAS OF AKWA IBOM STATE, USING SRTM AND SATELLITE IMAGERIES

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**Abstract**
Coastal flooding is one of the devastating noticeable hazards of coastal environments. The hazard can originate from incidence such as rise in sea level, increase in precipitation, poor drainage network and anthropogenic activities. The coastal areas of Akwa Ibom state are vulnerable to these hazards as they directly border the Atlantic Ocean. The area has experienced a number of coastal flood issues in recent time necessitating the need to produce coastal flood map to show the risk zones necessary for making informed decision in case of emergency. Apart from the incessant coastal flooding, other environmental problems associated with the flooding includes waste deposits after flood, inundation of people's houses, covering of the surrounding areas with debris from water, rendering of agricultural lands unusable and alteration of the coastal ecosystem. To provide basic information that will help tackle these problems, this study mapped the coastal flooding of the area, using SRTM and satellite imageries. The primary objective was to determine the extent at which the area was at risk of coastal flooding, and to produce coastal flood map of the area. Areas within the zones that are highly vulnerable to coastal flooding were accurately mapped. SRTM and satellite imagery (Landsat8 OLI 2017) were used to classify the area into coastal flood risk zones based on factors such as elevation and slope. Landcover/Landuse classification into Built-up area, Vegetation, Mangrove and Water bodies was achieved. The classification results of Eastern Obolo and Ibeno local govt. areas in 2017 indicate that Vegetation respectively accounts for 46.49% and 50.04%, covering an areas of 4672.53 and 10615.77 hectares. Built up area had 30.09% and 31.71% with covering areas of 3024.9 and 6726.96 hectares respectively. Mangrove had 11.84% and 9.78%, covering an area of 1189.62 and 2074.5 hectares respectively. Lastly water bodies had 11.58% and 8.47%, covering an area of 1164.42 and 1797.75 hectares respectively. Also, 60% and 47.12% of the land masses are at risk of coastal flooding in Eastern Obolo and Ibeno LGAs respectively. Based on these results, there is need for further study to determine the effect of coastal flood, and the extent of rise in water level during coastal flooding.

**Keywords:** Coastal Flooding, Environment, Imageries, Mapping, Remote Sensing, Risk

## Introduction

Coastal floods occur within the coastal environment. Coastal environment refer the ecotones between land and water bodies. Thus, the area extends some distances to the landward and seaward sides at the land-sea interface. When there is a rise in sea level, as a result of natural phenomenon, such as increase in precipitation etc., which leads to much run-off from the land, the resultant effect will be overflowing of the coastal areas causing coastal flooding. Excessive rainfall adds more water to surface runoff, leading to incessant, severe flood conditions (Ekpoh, 2015).

Due to the undulating and sloppy topographic nature of most coastal areas and their low-lying elevations, coupled with a lot of anthropogenic activities such as coastal agriculture, human settlements, industrial and engineering activates, the zones experience more erosional and other hazardous effects during coastal flood menace. During coastal flooding, the low lying areas or the flood plain are mostly vulnerable to the negative effects. Coastal areas are zones rich in floral and faunal species, which are referred to as biological species or biodiversity. However, these diverse species are vulnerable to coastal flood and other coastal hazards. Ekong (2017) observed that coastal areas are highly dynamic environments .with many physical processes such as tidal flooding, sea level rise, land subsidence and erosion/sedimentation, and are faced with many human-induced environmental impacts. The study further observed that human influence on coastal change contributes to the accelerated trend in sea level rise that threatens coastal habitats.

Where there is proper management of coastal area to curb the impact of coastal flooding, there will be a stable ecosystem along the coast line, in such a way that the biodiversity within the environment have their own habitat and exhibit their ecological niche.

But when there is a coastal flood menace, there is a destabilization of such ecosystem. Having access to and generating comprehensive coastal flood information such as coastal flood map, is a stepping stone to proper management of the coastal environment. Coastal flood menace is predominant in Eastern Obolo and Ibeno LGAs of Akwa Ibom state as they directly border the Atlantic Ocean. The area is affected by the coastal hazards associated with environmental degradation where the most noticeable one is coastal flooding. Being lower in elevation, there are also many creeks and water inlets which expose the area more to the coastal erosional activities. Ibeno LGA of Akwa Ibom State had bitter experience in August 2010, when six of its indigenes lost their lives, 17 missing, 40 fishing boats vanishing and many houses submerged due to coastal flood from the Atlantic Ocean (Anita, 2018). Similar experience occurs in the adjacent LGA, the Eastern Obolo. Climate Change Indicators in the United States (2016), reported that rising sea level inundates low-lying wetlands and dry land, erodes shorelines, contributes to coastal flooding, and increases the flow of salt water into estuaries and nearby groundwater aquifers. Forkuo (2011) noted that flood is one of the most devastating natural hazards which can lead to the loss of lives, properties and resources. Thus, it becomes important to create easily read, rapidly accessible flood hazard map, to prioritize the mitigation effects. For proper coastal flood control and management, the availability of coastal flood information is essential. Unfortunately,, such information are not available in Eastern-Obolo and Ibeno. Most of the available hydrographic data in the area are focused on the deeper off-shore locations, where oil and other minerals are found. This only provides information to the oil companies, state and the federal government on the means to tap the resources. There are no coastal flood maps to show the extent of the zone at risk to coastal flood during inundation. This study aims at producing coastal flood map of Eastern Obolo and Ibeno LGAs of Akwa Ibom state using SRTM and Satellite Imageries, with the objective of determining the areas and settlements at risk of coastal flooding.

Gerl et al., (2014) applied an automatic urban structure type mapping approach on Landuse/Landeover classification generated from multispectral IKONOS data and LiDAR data in order to provide spatially detailed information about the building stock of the an area. The study shows that single-family houses suffer significantly higher damage of flood than urban structure types. Similarly, Ejikeme et al., (2015) found areas of various flood risks levels in Anambra River Basin using Satellite Remote Sensing.

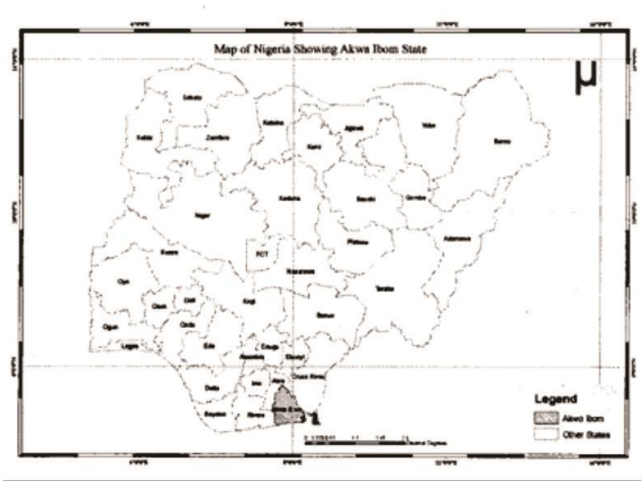



Figure 1.1: Map of Nigeria Showing Akwa Ibom State

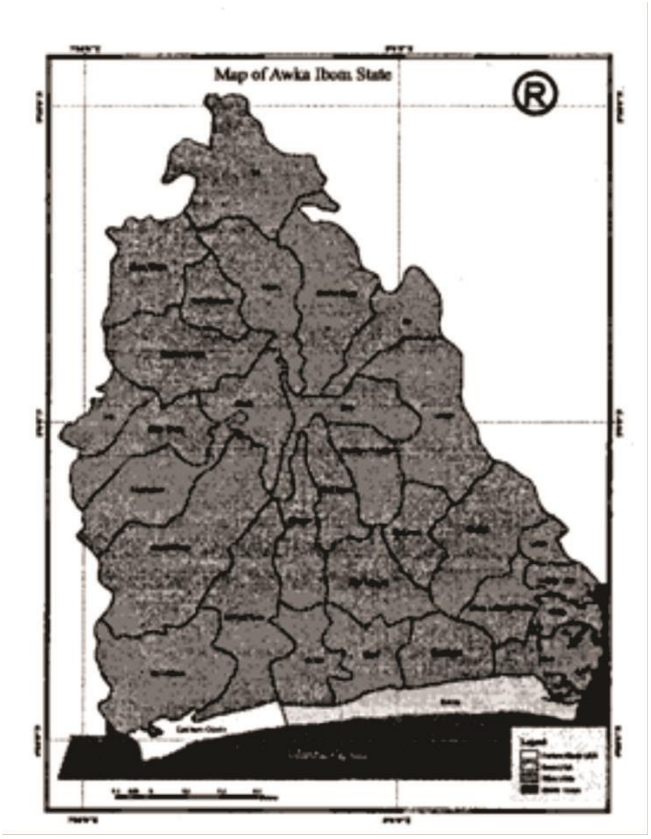



Figure 1.2: Map of Akwa Ibom State

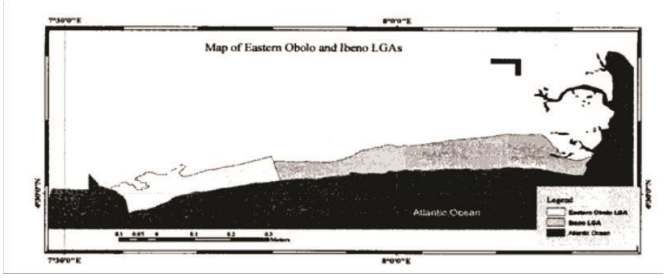



Figure 1.3: Map of Eastern Obolo and Ibeno LGAs

**Materials and Methods**

Data used include Landsat 8 OLI 2017 imagery from www.earthexplorer.usgs.gov, SRTM imagery, shape file of the administrative boundary of Akwa Ibom LGA, the coordinates of sample points of features used for accuracy assessment obtained using handheld GPS and non- spatial data describing the characteristics of features of interest which was collected on ground.

In processing the data, Image Sub-Mapping was carried out using ArcGIS 10.0 in order to cut out the area of interest from the satellite image using the shape file of Eastern Obolo and Ibeno LGA extracted from the administrative boundary of Akwa Ibom local government area. This was followed by identification and definition of various class features. Thus, the following class features in Eastern Obolo and Ibeno L.G.A were identified and defined according to level II classification scheme: built up, mangrove, swamp and water body. This scheme was adopted because of the resolution of the image sets and to ensure that the features are discriminated adequately following the field visits to the study area. Ground truthing was carried out after definition of class categories in order to identify the features on the ground and collect sample points for accuracy assessment. Afterwards, the images were classified using the supervised classification method.

The SRTM image was sub-mapped and filled for sinks in the elevation dataset and was then reclassified into risk elevation class. These categories of risk were created based on the elevation and ground information obtained within the catchment during the grpund truthing. The SRTM was also used to create the slope gradient. Then, the slope gradient obtained from the SRTM was reclassified using the following five classes based on Food and Agricultural Organization (FAO) classification of slopes (www.fao.org). These categories of risk were used to produce the slope map of the area. In order to delineate the different risk level of flooding in the area, four maps were generated by overlaying different categories of slope class and the reclassified elevation class. Through these combinations, the risk zones obtained were:

(a) Slope class (VHR) + Elevation class (VI-IR) = Very High Risk

(b) Slope class (HR) + Elevation class (HR) = High Risk

(c) Slope class (MR) + Elevation class (MR) = Moderate Risk

(d) Slope class (LR) + Elevation class (LR) = Low Risk

The resultant maps produced from a, b, c, and d were overlaid to produce the map showing areas with very high risk, high risk, moderate and low risk. The spatial data sets were vectorized as polygons while the attribute records were structured into tabular database before producing the final map.

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**Classification**

The classification results of Eastern Obolo and Ibeno LGAs in 2017 indicate that Vegetation in Eastern Obolo and Ibeno accounts for 46.49% and 50.04% respectively, which corresponds to 4672.53 and 10615.77 hectares coverage respectively. Built up area in Eastern Obolo and Ibeno had 30.09% and 31.71% with covering areas of 3024.9 and 6726.96 hectares respectively. Mangrove in Eastern Obolo and Ibeno had 11.84% and 9.78%, covering an area of 1189.62 and 2074.5 hectares respectively. Lastly water bodies in Eastern Obolo and Ibeno had 11.58% and 8.47%, covering an area of 1164.42 and 1797.75 hectares respectively. The summary of area covered by landcover/landuse features in Eastern Obolo and Ibeno is shown in Table 1 and Figure 3.0.

**Table 1: Landcover/Landuse distribution of Eastern Obolo and Ibeno Local Govt. Area 2017**

| Eastern Obolo L.G.A. | | | Ibeno L.G.A. | | |
|---|---|---|---|---|---|
| Class Name | Area (Hectares) | Percentage (%) | Class Name | Area (Hectares) | Percentage (%) |
| Water Body | 1164.42 | 11.58 | Water Body | 1797.75 | 8.47 |
| Mangrove | 1189.62 | 11.84 | Mangrove | 2074.5 | 9.78 |
| Vegetation | 4672.53 | 46.49 | Vegetation | 10615.77 | 50.04 |
| Built Up Area | 3024.9 | 30.09 | Built Up Area | 6726.96 | 31.71 |
| Total | 10051.47 | 100 | Total | 21214.98 | 100 |

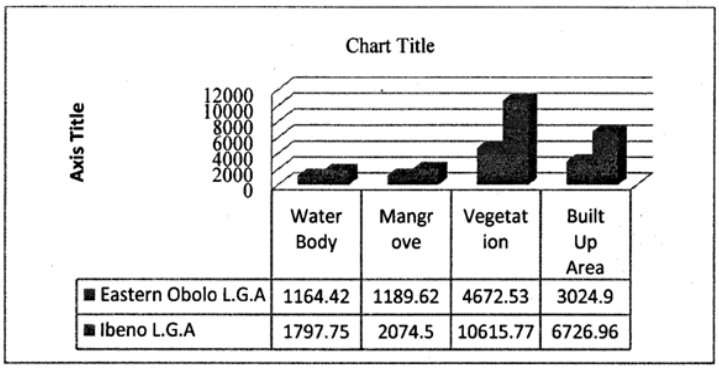



**Figure 3.0: Histogram of Landcover/Landuse distribution of Eastern Obolo and Ibeno Local Govt. Area 2017**

Mapping flood risk class distribution in both Eastern Obolo and Ibeno L.G.A as presented in Table 2 shows that Very high risk covers a total area of 7137.16 hectares (22.83%). High risk also takes up a total coverage of 7414.12 hectares (23.71%) in the area. Moderate risk covers 8016.31 hectares (25.64%) while Low risk covers a total area of 8698.86 hectares (27.82%).

| **Risk Class** | **Eastern Obolo L.G.A** | **Ibeno L.G.A** | **Total Area** | **Percentage (%)** |
|---|---|---|---|---|
| Very High Risk | 1836.42 | 5300.74 | 7137.16 | 22.83 |
| High Risk | 2139.62 | 5274.5 | 7414.12 | 23.71 |
| Moderate | 3000.53 | 5015.78 | 8016.31 | 25.64 |
| Low Risk | 3074.9 | 5623.96 | 8698.86 | 27.82 |
| **Total** | **10051.5** | **21215** | **31266.5** | **100** |

Table 2: Risk zone distribution in Eastern Obolo & Ibeno L.G.A.

Consequently the results also indicates that a total area of 6038.96 hectares (60%) is at high risk of coastal flooding in Eastern Obolo while a total area of 9996.74 hectares (47.12%) is at high risk of coastal flooding in Ibeno (Figure 3.1).

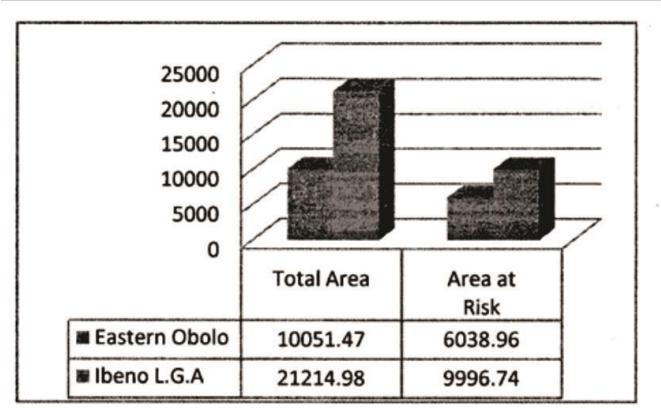



Figure 3.1: Histogram of total area against area at risk in Eastern Obolo & Ibeno L.G.A

Significantly, if 60% of land coverage in Eastern Obolo is at risk of coastal flooding and 47.12% is at risk of coastal flooding in Ibeno, there is an urgent need to develop contingency and evacuation plans for the inhabitants in case of emergency and also be able to manage the after effects of flooding events.

From the combined results of the image classification and risk class classification of Eastern Obolo and Ibeno, the coastal flood risk maps of Eastern Obolo and Ibeno LGAs showing the general overview, are shown in figures 3.2 and 3.3.

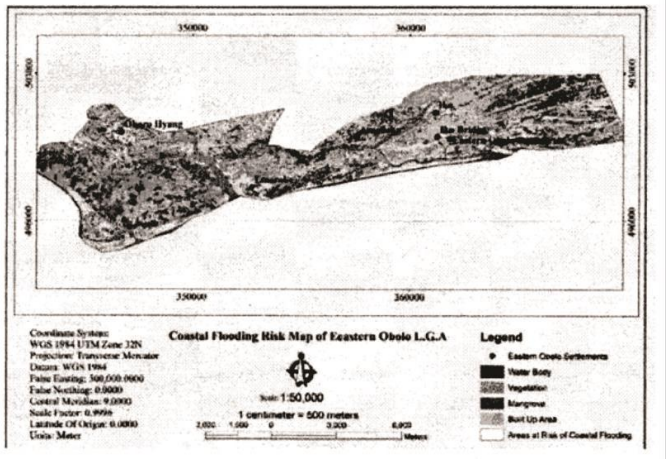



Figure 3.2: Coastal Flood risk Map of Eastern Obolo L.G.A

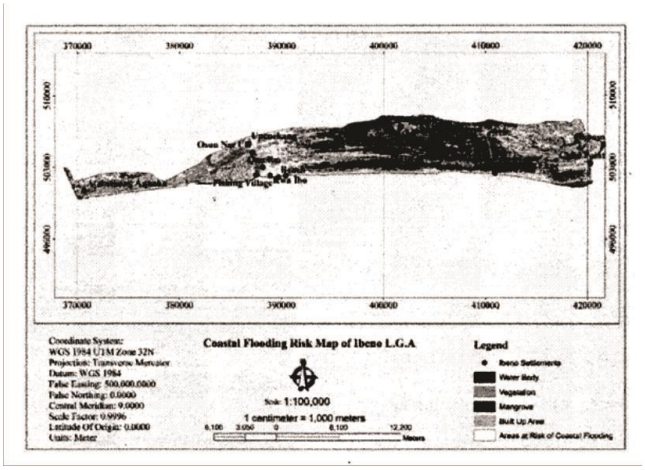



Figure 3.3: Coastal Flood risk Map of Eastern Ibeno L.G.A

This result is in line with the outcome of the study by Ho et al., (2010) on flood hazard mapping using satellite imagery and SRTM DEM in Vu Gia Bon Alluvial Plain, Central Vietnam, to generate a flood hazard map based on geomorphologic approach employing Shuttle Radar Topographic Mission (SRTM) DEM and satellite image data (ASTER and LANDSAT).The result reveals that there is close relationship between water saturated areas, elevation ranges, and flood condition, where the areas with elevation lower than 4m were seen as flooded areas.

These coastal flood maps are important tools for urban planners, residents and civil security agencies as they indicate to the communities the level of risk, so as to help them prepare for the worst, take steps to mitigate against coastal flood hazards, and protect themselves, families and properties.

Since flood is a natural phenomenon and in some cases difficult to predict, the goal of the coastal flood risk maps is to aid in timely decision making, before or during flood events. This will help minimize the damaging effects to life and property. The map will provide the needed information for evacuation purposes during coastal flood occurrence. Evacuation camps can then be set up at low risk areas identified from the map, to be a safe zone, safe from coastal flooding, where people affected by any emergency flooding can be looked after.

**Conclusion and Recommendations**

This study has demonstrated the potential of Remote Sensing, SRTM, Satellite Imageries and GIS technologies in identifying areas with very high, high, moderate and low risk of coastal flooding. Landsat-80L1 image and SRTM data were acquired before performing image classification, reclassification and accuracy assessment, delineating flood risk zones, delineating areas at risk of coastal flooding and producing a coastal flood map of the area. Landsat-80L1 image of 2017 was used to classify the area and a combination of elevation and slope from SRTM data was used to delineate coastal flood risk zones. Consequently the results indicate that a total area of 6038.96 and 9996.74 hectares are at high risk of coastal flooding in Eastern Obolo and Ibeno LGAs respectively, meaning that 60% and 47.12% of the land mass are at risk of coastal flooding in Eastern Obolo and Ibeno LGAs respectively.

**Based on the results and analysis obtained, it is recommended that;**

i. A more comprehensive research should be carried out on the effect of coastal flooding and the extent of water level rise during coastal flood in the coastal areas of Akwa Ibom state by siting a hydrometric gauging (water level monitoring) stations in the low risk areas along the coastal lines to monitor the level of rise in coastal water which brings about coastal flood.

ii. A research on the suitability of site for siting an evacuation centers be carried out in the coastal areas of the state to house people displaced in case of emergency of coastal flood occurrence.

iii. Further research should be carried out in this area with regular data collections, i.e regular measurement of water levels and flow rate within the river basin, hydro-meteorological areas, in order to have enough data to prepare contingency and evacuation plans in the event of flooding.

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