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FLOOD RISK ANALYSIS OF EDU LOCAL GOVERNMENT AREA (KWARA STATE, NIGERIA)

ABSTRACT. This study examines flood risk propensity of communities in Edu Local Government Area of Kwara state, with a view to classifying the area into risk zones for better and proper management of the environment for the sustainable living of the people. The three administrative districts of Edu Local Government area were identified as pragmatic areas for the study. In each of the districts, Geographical Information System data capture and analytical tool were used to harvest and treat the data for subsequent interpretation. The coordinates of various locations of interest were taken, contour and slope maps of the area were generated to produce flood risk map for the area. The results revealed three distinct risk zones; High, Moderate, and low-risk areas. Three settlements fall into a low-risk area with elevations above 196 m, two settlements located at between 110 m and 196 m are within moderate risk zone and six settlements in High-risk area with elevations below 110 m. This paper concludes that the people of the riverine communities in Edu LGA are culturally attached to the environment. The study, therefore, recommends public enlightenment on the trend in climate and weather about the flood and its implications, environmental education and then resettlement of these communities. When and where resettlement scheme proves very difficult due to strong cultural attachment, flood prevention mechanism via engineering construction such as dykes, embankments and ditches should be adopted.

KEY WORDS: flood risk, information, resettlement, planning, sustainable development.

INTRODUCTION

Floods were observed as one of the effects of global warming ravaging both the coastal cities and riverine communities in the hinterland. Dilley et al. [2005] reported that floods are among the most devastating natural disaster that has a serious impact on life and properties of the people. As rightly observed and reported by Drogue [2004], the frequency at which flood occur is on the increase in many parts of the world Nigeria inclusive. Flood experience in Nigeria has been towing the world trend. Widespread flooding across the country claimed many lives, displayed millions of people and destroyed properties worth billions of naira. Eludoyin et al. [2007] reported disasters in 1985, 1987 and 1990 in Ibadan, Oyo state, 1992, 1996 and 2002 in Oshogbo Osun state. The flood years in Akure Ondo state were 1996, 2002, 2004 and 2006 just to mention a few of such occurrences in Nigeria.

Prime Times Nigeria [2013] estimated the total value of Infrastructure, physical and durable asset destroyed by the flood was put at N1.5 trillion, 2.3 million people displaced, 363 people killed, and 597,474 houses destroyed. It was reported to be the worst in Nigeria History.

Oriola [1994] was of the opinion that flood in coastal regions might not be unexpected, but an incessant flood in the hinterland and riverine communities has become worrisome. Especially when people are social, culturally and economically attached to such environment. Therefore, it is expedient to probe into how such people and community can have a sustainable environment that will secure their sustenance and life in general.

Flood risk analysis is a crucial element of flood risk management which often provides maps – Flood hazard maps and Flood risk maps. Such analysis also assists in providing flood alert or flood warning if flood water level is rising.

Many times the maps generated from the analysis will show or locate places at higher levels to escape from floods or in flood rescue/flood relief operation. The analysis has been found to be of help in planning irrigation system and water management. Finally, mapping flood-prone areas in developing countries are to provide planners and disaster management institutions with a practical and cost-effective way to identify floodplains and other susceptible areas and to assess the extent of disaster impact [OAS, 1991]. It can be used in sectoral planning activities and integrated planning studies, and for damage assessment.

Embarking on flood risk analysis will help in regulating development in the floodplain; identify the areas that are exposed to flood risk and their level of severity. Then, serves as a template for evaluating streams vulnerability to flood in order to improve the social and economic well-being and sustain the livelihood of the people in general.

Many researchers have carried out flood analysis which yielded relevant results. For instance, Ologunorisa and Abawua [2005] reviewed some of the techniques of flood risk assessment. These techniques are meteorological especially those involving the rainfall data; hydrological parameters involving the use of runoff data; socioeconomic factors, and a combination of hydrometeorological parameters and socio-economic factors, and the use of Geographical Information System (GIS) tool. The study recommended the use of GIS technique for risk assessment of flooding as it is capable of integrating the geomorphological, hydrological, meteorological and socio-economic variables.

Oriola and Bolaji [2012] identified areas at risk of urban flood along Aluko river Basin in Ilorin and provided information on flood risk implications on the city dwellers. Data sets on roads, rivers, dump sites and contour lines were extracted from Ikonos Imagery and Topographical map of Ilorin. The study area was eventually classified as high, moderate and low flood risk zones, based on approved setbacks and previous flood range. Buffering, Overlay Operations, Digital Terrain Modelling, Flow Accumulation and Spatial Search were the spatial analyses carried out using ArcGIS 9.3b. The study provided information that would be of help in regulating development in a flood plain, identified the number of buildings that are exposed to flood risk and their level of severity. It also serves as a template for evaluating urban streams vulnerability to flood. Abah [2013] similarly applied Geographic Information Systems (GIS) in mapping flood risk zones in Makurdi Town. His study draws its relevance from the importance of a GIS database in tackling flood-related problems. He employed ArcView GIS package to digitize a topographic map and other relevant themes of the study area and through GIS overlay and manipulative functions, he created a Digital Elevation Model of the study area; and a classification map of flood risk zones in Makurdi town. The map generated shows that Makurdi town is susceptible to flooding, and physical development is still going on in the 'highly susceptible' areas. The study, therefore, recommended the need for town planners to be proactive in their duty to avoid disaster. Njoku et al. [2013] applied the concept of integrated data analysis, using GIS to determine the implications of flooding in Aba metropolis. The Digital Elevation Model developed for the area showed the variation in height as the areas ranging from 35 m–39 m, and 43 m–48 m are likely to be prone to flooding, being that runoff from the areas of higher elevations tends to concentrate on the areas of lower elevations. He, therefore, recommended that some stormwater routes should be rerouted in Aba metropolis.

The goal of this paper is to generate adequate and relevant data on the physical environment which the people have been culturally attached, analyzed them to determine the level of flood risk the people are exposed to. Such information will be relevant for planning and developing the area and ensure an enabling environment for sustainable livelihood.

THE STUDY AREA

Edu, the study area, is located between longitude 4°54′15″East and 50 31′ 00″ East of the Greenwich meridian and latitude 80 35′ 38″ North and 90 15′ 00″ North of the Equator (Fig. 1), It covers an area of 2,542 km^2. Edu is one of the sixteen Local Government Areas in Kwara State with Lafiagi as headquarter (Fig. 1). The Local Government Area has a population of 201,469 as reported in the 2006 population census. It has three administrative districts: Lafiagi, Tsaragi, and Shonga, Bello and Makinde [2007], reported that the study area has a mean annual rainfall and temperature of 300 mm and 29°C respectively. The Average Relative Humidity is about 78.6 % and this varies seasonally with the lowest reaching as low as 69.99 %. The study area is characterized by the alternate dry and wet season, the rainy season starts towards the end of March and lasts till October while dry season commences in November and ends in early March.

The study area falls within the peneplain of the river Niger trough, which stretches from Jebba to Eggan on a topography that is relatively flat, lying near the River Niger and rises to the crystalline upland in the south to an elevation of less than 150 m above sea level [Bello and Makinde, 2007]. The River Niger and its tributaries, Oyi and Oro, drain the land. An overflow of the Niger and its tributaries during rain often floods the area and on recess deposits sediments on the flood plain.

Edu LGA is dominated by Nupe speaking people, they live close to river banks and engage in agriculture as the major economic activity. Fish farming and rice cultivation are the two major activities of the people in the study area.

MATERIALS AND METHODS

Handheld Global Positioning System (GPS) was used to take the location coordinates of each sampled settlements [see Oriola and Chibuke, 2016]. These are settlements

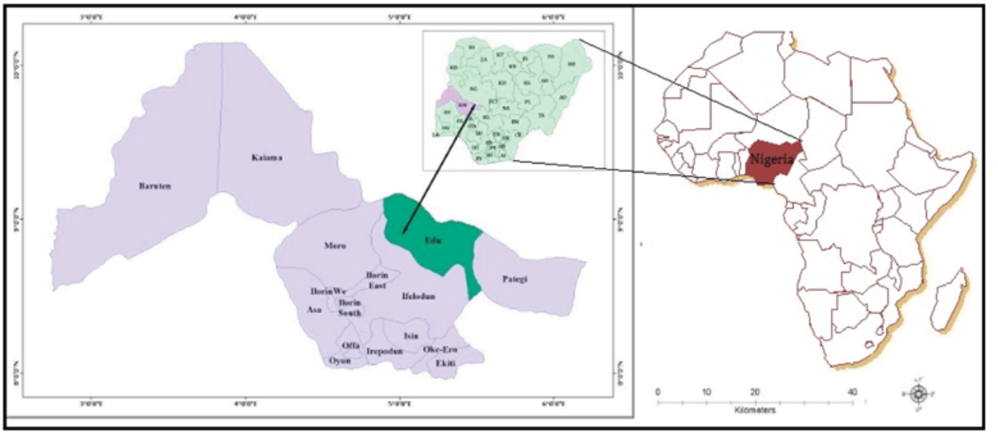

Fig. 1. Map of Kwara State Showing the Study Area, Edu Local Government

that fall within the riverine area of the Local Government Area. Data acquired through the GPS were used to map the area and risk zones were demarcated.

Geo-referencing and extraction of study area location

The Satellite Image of Edu Local Government Area was georeferenced, and supervised classification carried out on the image identifies six (6) different land use classes: water bodies, built-up areas, cloud cover, shrubs (vegetation), unclassified and bare surfaces (see Fig. 2). The built-up areas are comprised of lands where varying degree of anthropogenic activities are being carried out and have modified the natural vegetal cover of the study area; such activities include farmlands, schools, houses, rural roads among others.

The digitized Satellite image highlighted prominent features in the area. They include locations, districts, settlements, rivers (River Niger and streams Oyi & Oro), main roads among others displayed (see Fig. 3.). The River Niger trough that stretches from Yelwa to Edogi-dukun presents a relatively flat topography. While Rivers Oro and Oyi, present in this area flow North-easterly to join River Niger.

Methods of Data Analysis

The satellite image of Edu Local Government Area was georeferenced and re-sized. The study area was then extracted using the ArcGIS Arc-toolbox. Furthermore, the Satellite Image was classified to ascertain the different land use classes in the area. Digitizing of the satellite imagery was also done to highlight prominent features such as settlements, rivers, and roads.

The elevation coordinates were used to prepare a contour, relief and slope maps as well as a 3D elevation image of the study area.

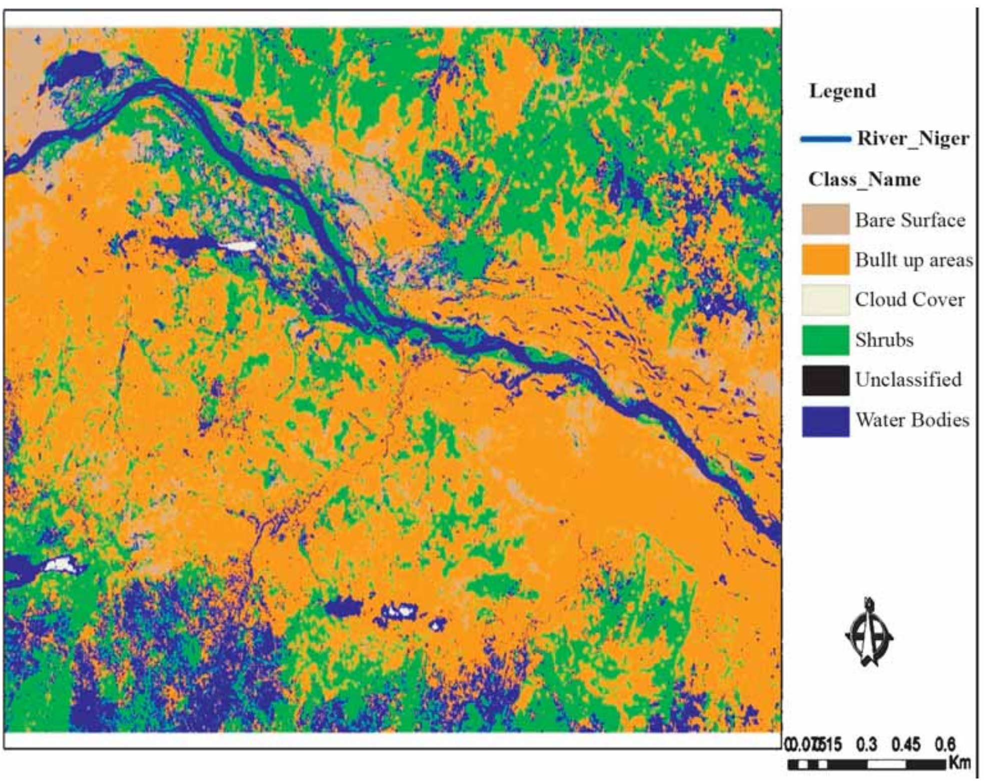

Fig. 2. Land use Map of the Study Area including River Niger.

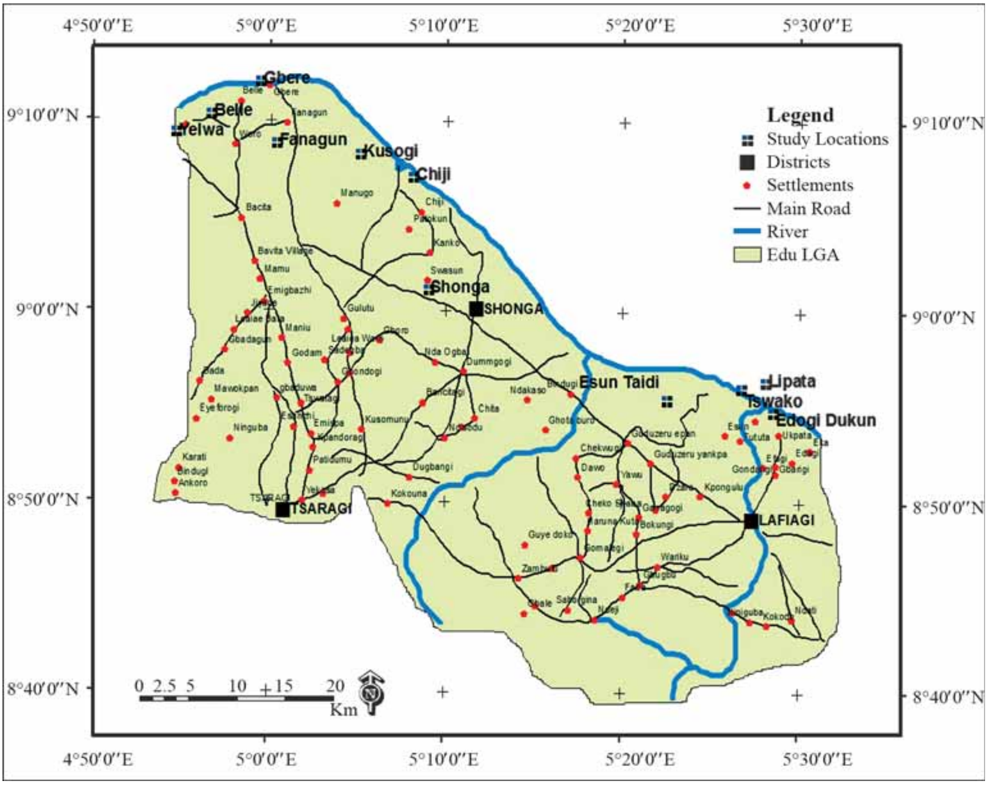

Fig. 3. Settlement map of Edu Local Government Area

- Contour Map of Edu LGA Riverine Areas was developed, using the Shuttle Radar Thematic Map (SRTM) Image obtained from Geotech Consults in Abuja.

- Similarly, slope Map of the study area was created to measure the changes in surface value over distance, to ascertain the angle of curvature using the hydrological analysis tools in ArcGIS 10.1.

- Surfer 8 software and 3D Analytical tool in Arc GIS10.1 was used to develop the Digital Elevation Model.

Finally, Flood risk mapping of the study area was done using overlay, buffer and hotspot analysis tools of Arc 10.1 Spatial Analyst Software to show and identify areas liable to flood. Spatial Queries were carried out to determine the risk zones using proximal search; phenomena search (features within zones) and susceptibility analysis. The map of flood risk zones was prepared using the DEM [Abah, 2013] and proximity to water bodies. Different parts of Edu Local Government Area were mapped, and the three risk zones were demarcated and classified.

RESULTS AND DISCUSSION

Determination of Flood Prone Areas

a. Contour Map of Edu LGA: Fig. 4 presents the surface analysis of the terrain of the study area. The contours range from 30 m–330 m. The legend shows the contour lines of spots from 241–330 m as areas that are free and have no probability of flooding while the contour lines joining locations from 30–60 has the highest probability and a concentration of flood and floodable areas, followed by 61–120 m, 121–180 m, 181–240 m. A similar

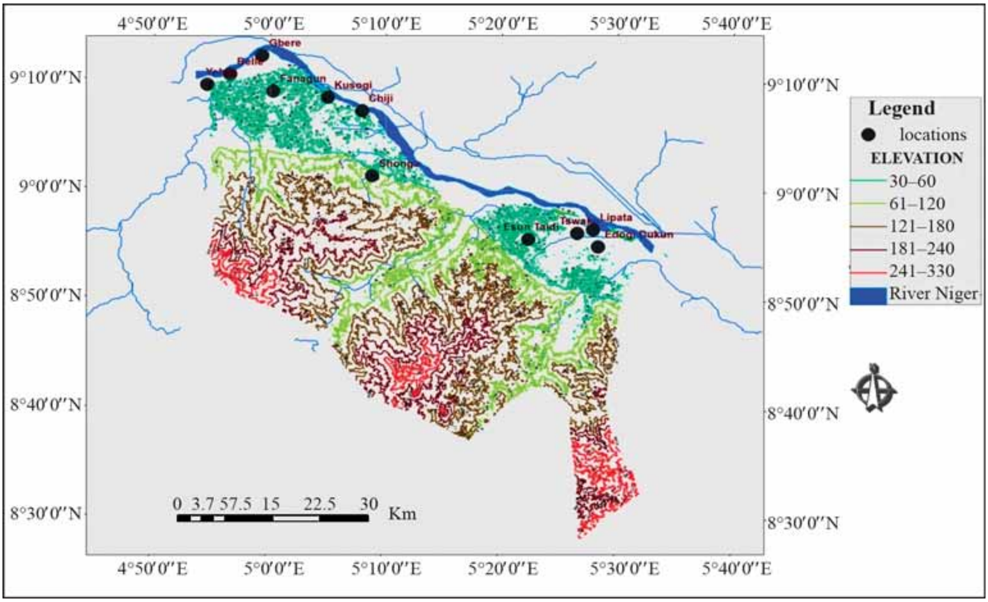

Fig. 4. Contour Map of Edu Local Government Area

result was recorded and reported by Njoku et.al, [2013] in Aba metropolis.

b. Slope Map of Edu LGA Riverine Areas: Areas of depression and those of elevation in the study area were shown on the Slope Map of Edu LGA Riverine Areas with contour map displayed in tandem. Therefore, areas that are within 0 – 2.2 degrees of the slope are low terrain while the areas of 11.76–46.57 degrees of the slope are high (Fig. 5). The nature of the slope in terms of the degree

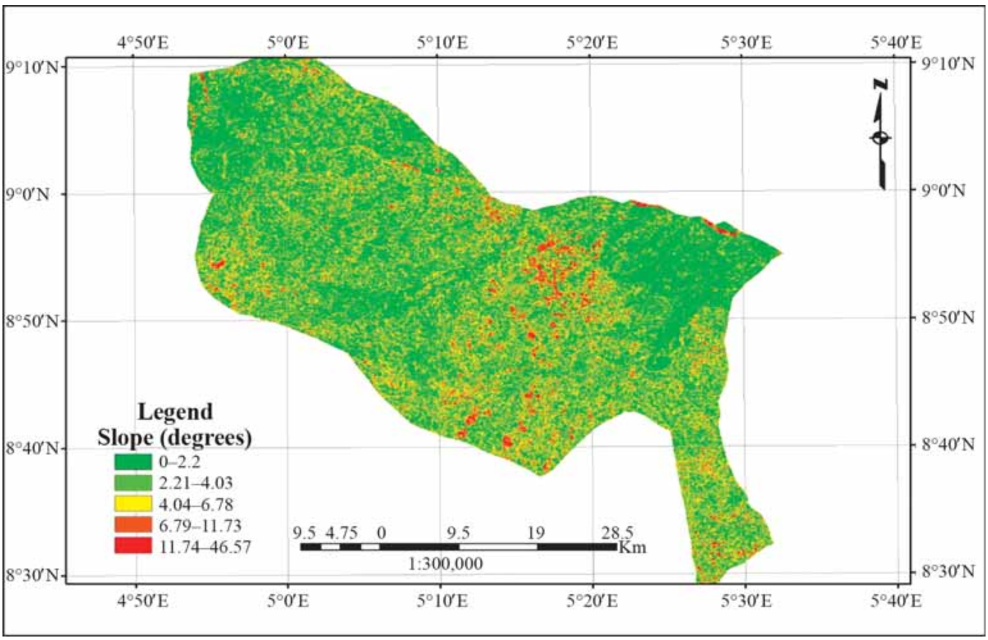

Fig. 5. Slope Map of Edu Local Government Area.

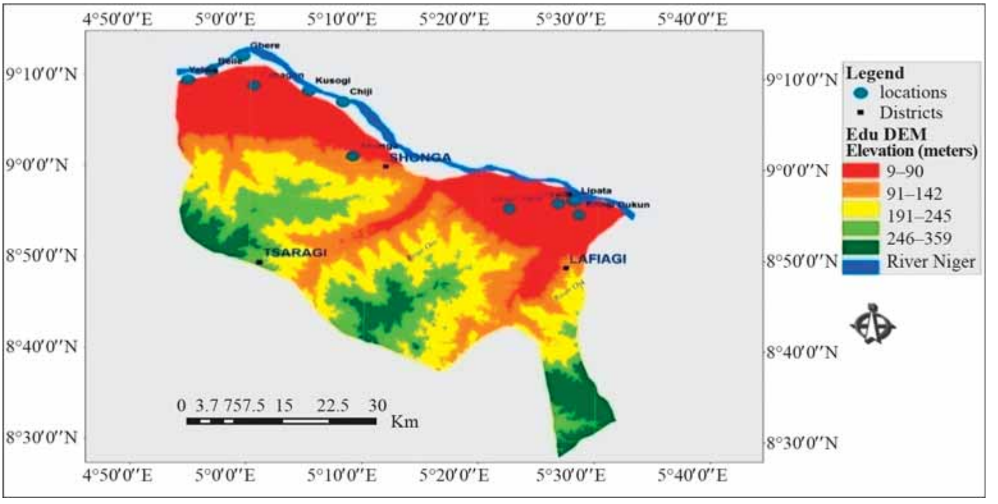

Fig. 6. Digital Elevation Model (DEM) of Edu Local Government Area

has a direct implication on how high or low the plain is and their vulnerability to flood. Most of the communities in the study area are within the low terrain (0–2.2 and 2.21–4.03 degrees of slope), indicating that the communities are at high risk and vulnerable to flooding (Fig. 5). This observation is in line with the work of Abu and Mursheda [2013] in Sirajganj, Bangladesh where they reported downward movement of water to areas of low terrain.

c. Digital Elevation Model of Edu Riverine Areas: The Digital Elevation Model (DEM) of Edu Local Government Area presented in Fig. 6 enhances the chromatic and ophthalmic view of the study area. The result revealed that riverine areas in Edu LGA are areas of flat, featureless (peneplain) plain. The figure shows elevation in meters, with the highest point between 246–359 meters, while the point of entry into the riparian communities is between 9–90 meters and this is the hub and crux of the River Niger. The decreasing nature of the elevation of the floodplain according to [Oriola and Bolaji, 2012] has a direct implication on speed, intensity and erosive capacity of the flood water along the plain as shown in Fig. 6. Apart from Shonga district and its communities that fall within a height range of 91–142 m, other communities in the study area fall within the height range of 9–90 m. Areas around 91–142 meters may be prone to flood while areas within 143–190 meters and 191–245 meters are slightly elevated region but may also be liable to flood risk. The only safe zones in the study area are between 246–359 meters and none of the settlements selected for the study fall within this height range.

The 3D Flood Inundation Model presented in Fig. 7, reveals that when the water level is at 130 m, the whole eleven sampled communities will be submerged due to the fact that their elevations are below 110 m. It also shows that the study area is liable to flood due to its surface characteristics.

Flood Risk Classification and Zones

Edu LGA can be classified into three risk zones as presented in the flood risk maps (Fig. 8 and 9). The high-risk zones are areas that are likely to be inundated in a flooding event while the low-risk areas are the least liable to flood. Obviously, this could be explained by the geomorphology, slope, and steepness of the area. A further explanation could be because of the slight slope angles of the area which suggests that all fields are situated very close to water levels.

The flood risk map produced based on the elevation of the study area presented in Fig. 8

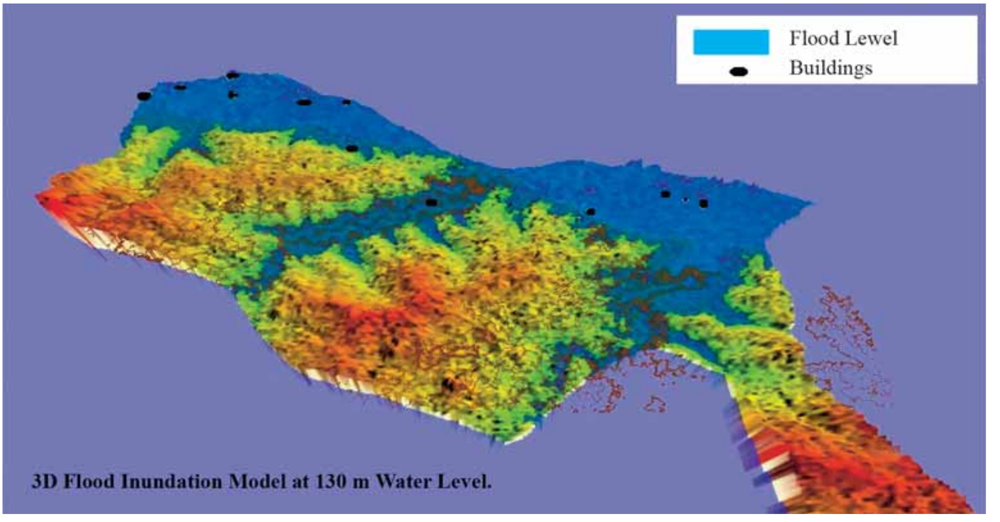

Fig. 7. 3D Flood Inundation Model of Edu Local Government Area

clearly shows three (3) zones with the level of risk and their proneness to disasters. All locations with height less or equal to 110 meters above sea level are considered to have a very high risk. Coincidentally, all the sampled communities fall within this elevation while the areas that fall between 110 and 196 meters are as areas of moderate flood risk and the land areas from 196 to 360 meters above sea level are considered to be in a low-risk zone. By implication, these last two zones are prone to flooding, but they are not likely to experience a severe flood that the high-risk areas are liable to experience. However, areas above 360 meters above sea level are considered safe with varying degrees of safety

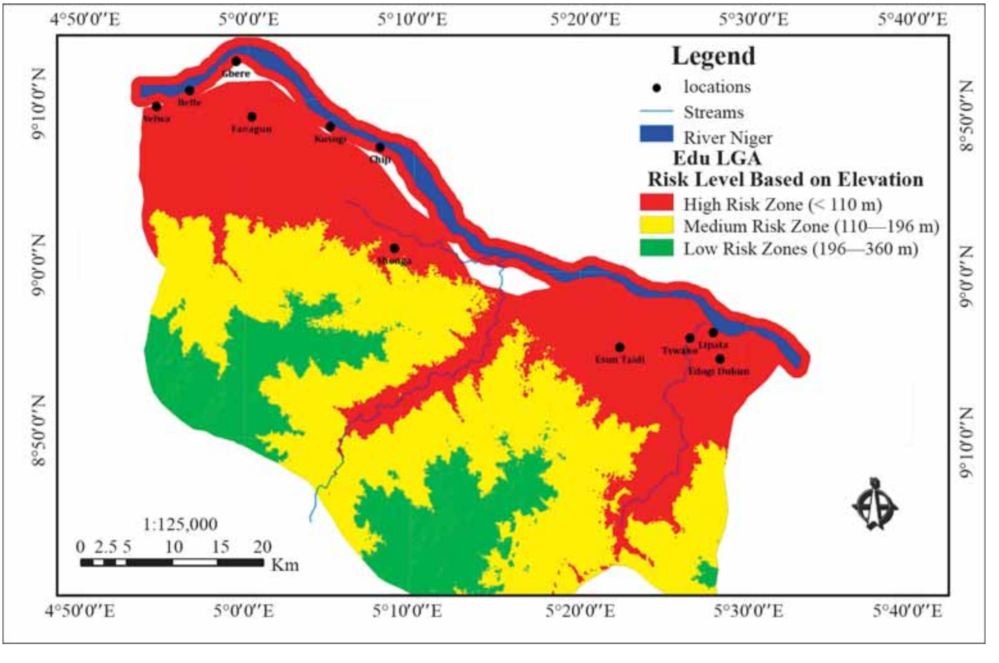

Fig. 8. Flood Risk Level based on Elevation

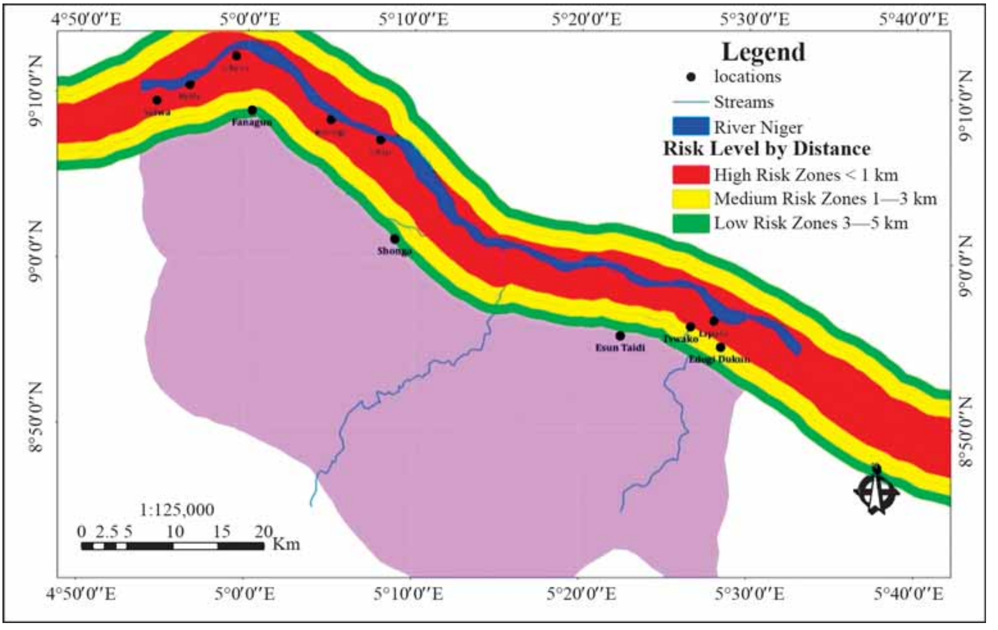

Fig. 9. Flood Risk Level based on Proximity to Water Bodies

attached to them, based on their height above sea levels. Decreasing nature of the elevation of the floodplain according to Oriola and Bolaji [2012] had a direct implication on speed, intensity and erosive capacity of the flood water along the plain. This was also observed and reported by Njoku et al. [2013] in their study of the flood in low elevation areas in Aba, Nigeria.

Proximity Analysis

Based on proximity to water bodies, floods risk areas were also demarcated [Oriola and Chibuike, 2016] (Fig. 9). This was made possible with a buffer distance of less than 1kilometer, 1–3 kilometers and 3–5 kilometers benchmarks. The map revealed that Yelwa, Belle, Gbere, Kusogi Chiji, Lipata fall within the High-Risk Zone; Tswako and Edogi Dukun are within the Medium Risk Zone, the low-risk zone has Fanagun, Shonga and Esun Taidi settlements (Fig. 9) as observed and reported by Oriola and Chibuike [2016]. The location of Tswako and Shonga beside Oro and Oyi Rivers respectively may increase their susceptibility despite the fact that they are considerably far from the main river (River Niger) if the plain is not properly managed and protected. Oriola and Bolaji [2012] made this observation in their study of river Aluko in Ilorin metropolis, Nigeria. In the study, they reported the high risk of residential, commercial, educational and religious buildings along the river channel in Ilorin. A similar observation was made by Abah [2013] in Makurdi where areas closest to the River Benue and characterized by very low relief (0 to 72 m), are highly susceptible to flooding.

CONCLUSION

This study utilized Geographic Information System to analyze flood hazard in riverine communities of Edu Local Government Area of Kwara State for a better understanding of the phenomena and proactive steps in mitigating flood hazard in such environment. The paper recommends public enlightenment on the trend in climate and weather about the flood and its implications, environmental education and then resettlement programs for the communities. When and where resettlement scheme proves difficult due to strong cultural attachment, flood prevention mechanism via engineering construction such as dykes, embankments and ditches should be adopted.

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