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Determination of Flood Hazard Zones Using Geographical Information Systems and Remote Sensing Techniques: A Case Study in Part Yenagoa Metropolis

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Authors' contributions

This work was carried out in collaboration between all authors. Author ED designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors FEE and FO managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Flood has been a serious hazard for the past decades in Nigeria at large. The incidence of 2012 and 2018 flood disaster in Yenagoa, Amassoma and other parts of the state have not been recover till date and the government is not consigned about the well been of the people. The major causes of the flood are attributed to increased rainfall and lack of drainages including dredging of rivers and disobeying of environmental law and infrastructure failure. Coastal Towns or communities are one of the most affected areas of flood and their farms and fishing implements were washed away by the floodwater in 2012 and 2018 in Bayelsa State. Flood management is needed for provision of time information so quick response can be done as soon as possible. Using SRTM data to produce digital elevation model and IDW Contour, the 3D model from ground data of Yenagoa metropolis using ArcGIS 10.6 to generate and analyze them. As a result of field survey, flood level calculation

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was made to classified flood hazard zones for migration, Agricultural Educational, and construction purpose such as land suitability. This was used in ascertaining the extent of the flooded area. The result reveals that an area of over 5.9888882km2 and riverine and coastal area is flooded, affecting more than 15 coastal and riverine communities. The finding also concludes that remote sensing data like SRTM data and Geospatial techniques seems effective in mapping and identifying areas prone to flooding. Therefore Remote sensing and Geospatial database should be established for proper flood mapping and the government should constantly dredge the area from time to time.

Keywords: Flood hazard zone; SRTM; disaster; IDW; remote sensing; GIS.

1. INTRODUCTION

Floods are a major problem affecting many State in Nigeria and other countries in the world such as Nigeria, Italy, Ghana, etc causing great loss of human life and economic loss [1,2]. The impact of flooding has increased greatly because of the number of factors such as increased developmental activity on the floodplains and rising sea level In most cities of the world, the problems of floods are rapidly growing considering the enormity of this problem, the United Nations Environmental Program(UNEP) in 1991 pointed out that many countries considered uncontrolled stormwater to be their greatest problems as far as the preservation or urban infrastructure is concerned. Such as Bangkok, Calcutta, Dares Salam, Jakarta, Guayanguil, Manila, Lagos, many neighborhoods are flooded at least once a year, and inhabitants have with the water in their dwellings [3,4]. The potential of Geospatial techniques in flood studies cannot be overemphasized. It allows for a proper integration of all physical, socio-economic and demographic data, as data management and map representation capabilities of GIS help in exploring new portions, hence, its integration with remote sensing, enhances the ability for forecasting/predicting of new scenarios and preparation of flood hazard maps [5]. Besides its constraints like technological Knowledge requirements, hardware, and software requirements, GIS can be very useful in flood hazard study and mitigation. Geographic Information System (GIS) has been applied extensively to flood studies. GIS is a technological system that reflects all kinds of spatial data in the real world. It can input, output, store, search, display, analyze and be applied under certain support of software and hardware [4,6]. Guarin et al. [7], carried out a community-based flood risk assessment of San Sebastian, Guatamcla, using three epochs of aerial photographs acquired in 1964, 1991 and 2000, questionnaire and integrated GIS techniques for the study.

2. METHODOLOGY

2.1 Study Area and Geology

The area selected for this study is situated in the central Niger delta sedimentary basin of Southern Nigeria (Fig. 1) in Bayelsa State, Nigeria. The area lies within Latitude 4˚57'30''N - 4˚54'30''N and Longitude 6˚15'30''E - 6˚21'30''E. The area is within Yenagoa Metropolis, with a good road network links to different communities. The topography of the area is low with a maximum of 40 m elevation. The May social economic activities of the locals are farming, fishing and local sand dredging from creeks and rivers. The study area which is the southwestern flank in Niger Delta, Niger Delta geology has been described by Reyment [8], and others. The Niger Delta Basin which is form by failed rift junction with the separation of South American plate with the African plate, which opens the South Atlantic. Rifting in the basin started late Jurassic and ended in the mid-Cretaceous. Several faults occur which are more of thrust faults. The delta covers a land area in excess of 105,000 km^2 [9].

2.2 Aim

The study focuses on determining Flood hazard Zone and predicts area for migration using Geospatial techniques (remote sensing and GIS).

2.3 Objectives

1. Understanding the general topography of the area.
2. To detect the vulnerability of the study area
3. To produce a flood hazard zone map
4. To determine the database for future flood disaster planning which includes risk mitigation of the area

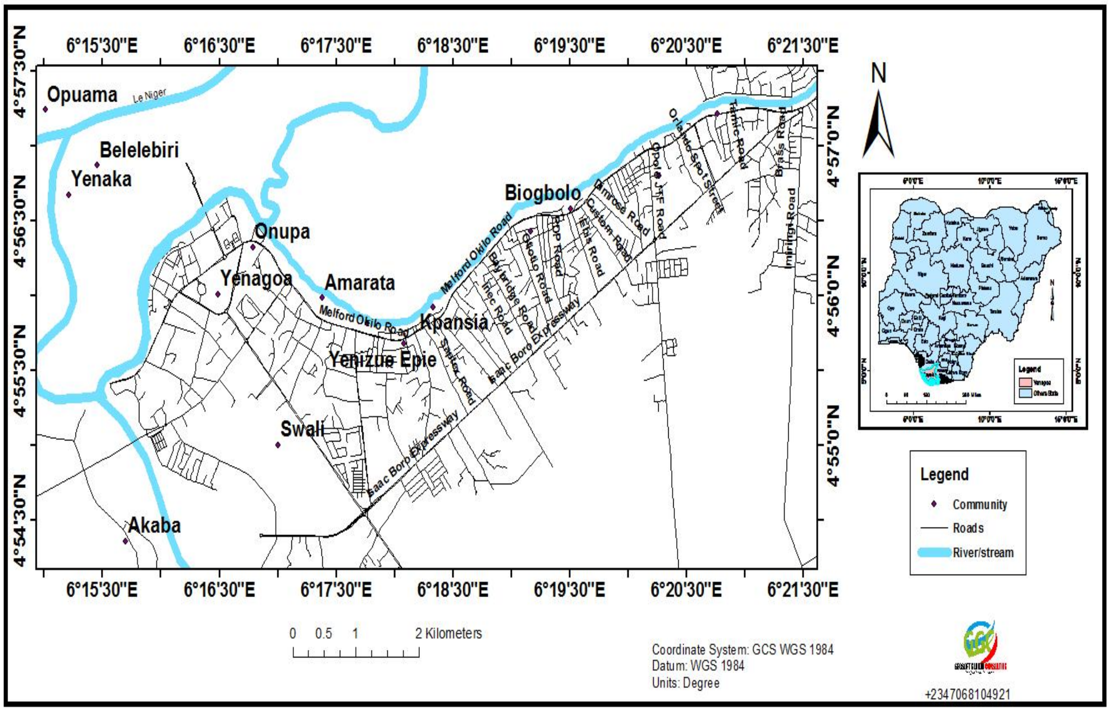


Fig. 1. Map of study area

2.4 Data Collection

The following materials and data were collected for Digital Elevation Dataset from Shuttle Radar Topographical Mission (SRTM) downloaded from USGS explorer, prior and the spatial locations of some flooded communities were also acquired by the use of Garmin72 GPS, an administrative map from where political boundaries and roads were digitized. Fieldwork with GPS and notebook were also used for the acquisition of coordinates of the communities respectively.

3. DATA ANALYSIS

3.1 Geographical Relief of the Study Area

The essential geographic relief attributes examined in this study were the digital terrain model.

3.2 Topography of the Study Area

Contour lines (Fig. 5) connects areas of equal elevation were generated at 2 m intervals. The spot height tells the direction in which water flows through. From the map, the contour of the study area ranges from -5-28.

3.3 Data Processing

Arc GIS 10.6 spatial analyst extension was used to generate the height information from SRTM DEM (Digital Elevation Model). The data were collected using handheld Global Positioning System (GPS) in degree, minute, second and imported into Microsoft Excel where the data was converted to degree decimal and transferred to Geographical Information System environment in Data Base Format before point map was generated alongside Contour, Inverse Distance weight using the 3D analysis tools in Arc map were created before using the algebra map calculator to subtract IDW from DEM and the result was classified using raster calculator to determine flood level Zone and reclassify and import it to arc scan environment for 3D view.

4. RESULTS

The cross-section map makes us know the elevation at the line of the cross section A-B at each point (Fig. 4). Where A has a coordinate of N6.249 and E4.916 while B has N6.36 and E4.948 with a corresponding length of 12,828.91 meters

The contour has a minimum altitude value of 4 m and maximum value of 28 m, with 2 m interval the spot height represents the direction of water flow through. The contour map of study area ranges 4 m to 28 m.

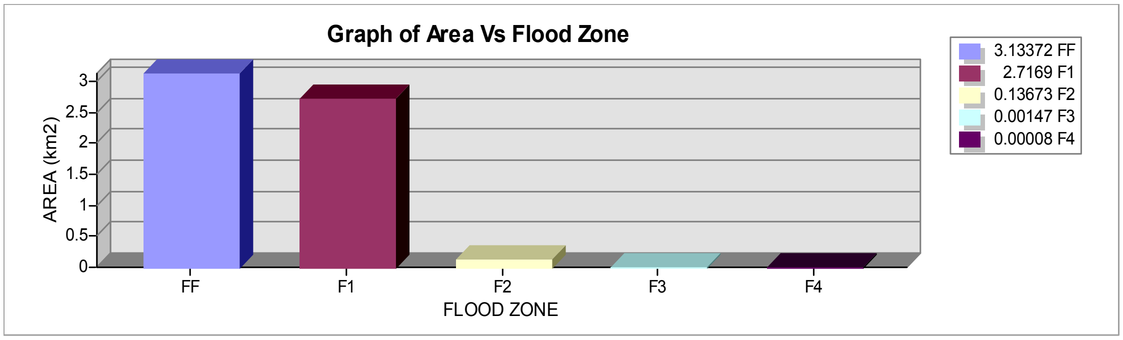


Fig. 2. Showing area against flood zone

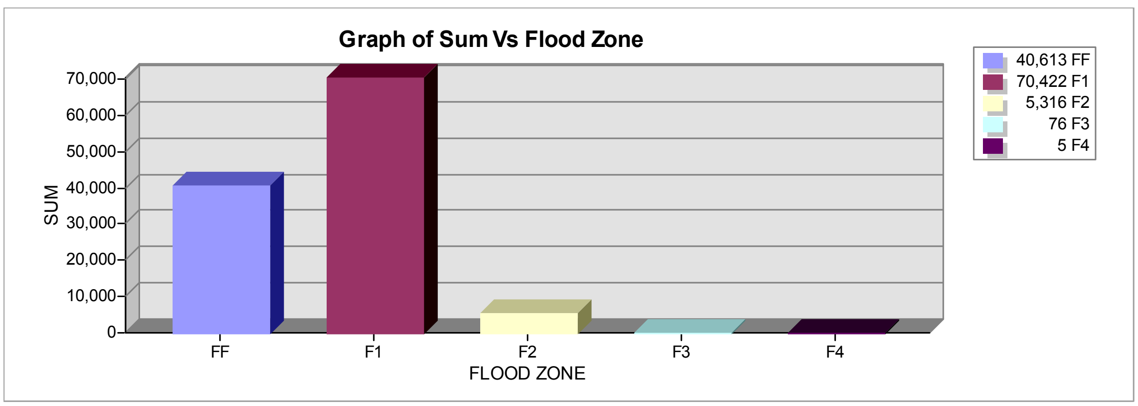
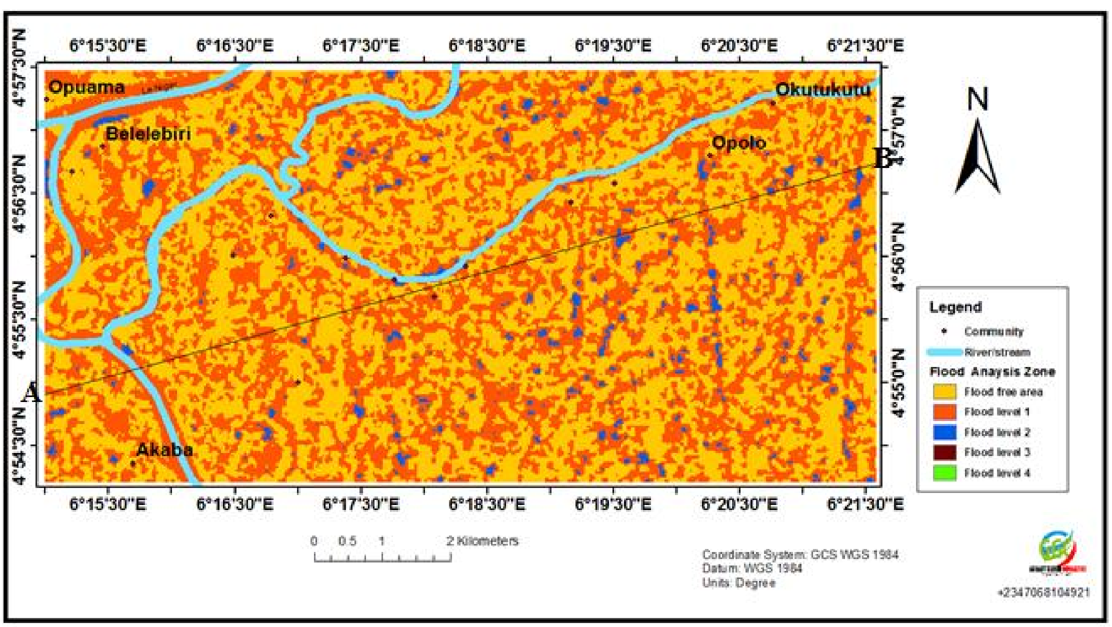


Fig. 3. Showing sum against flood zone



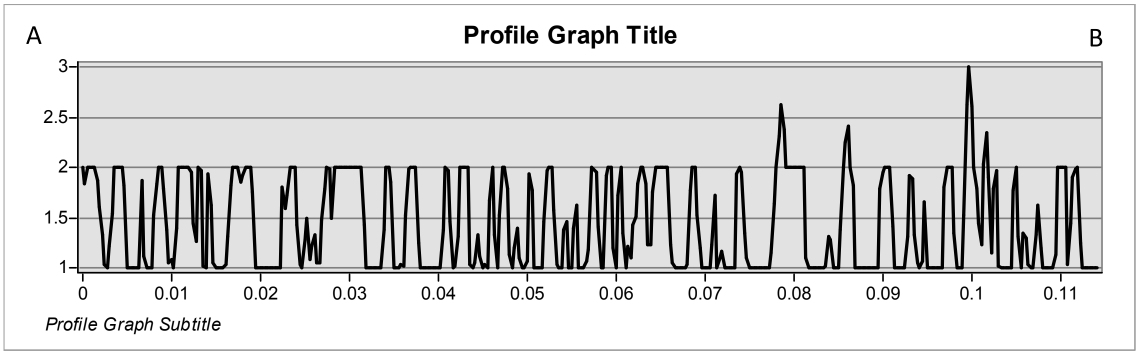


Fig. 4. Cross section map A-B

Table 1. Statistical data from process flood analysis zone

Flood zone	Count (m)	Area (Km^2)	Sum (m)
FF	40613	3.133719	40613
F1	35211	2.716898	70422
F2	1772	0.136728	5316
F3	19	0.001466	76
F4	1	0.000077	5
Count	5	5	5
Minimum	1	0.000077	5
Maximum	40613	3.133719	70422
Mean	15523.2	1.197778	23286.4
Standard Deviation	18371.29	1.417538	28020.1977

FF: Flood Free area, F1: Flood level 1, F2: Flood level 2,Flood level 3, Flood level 4

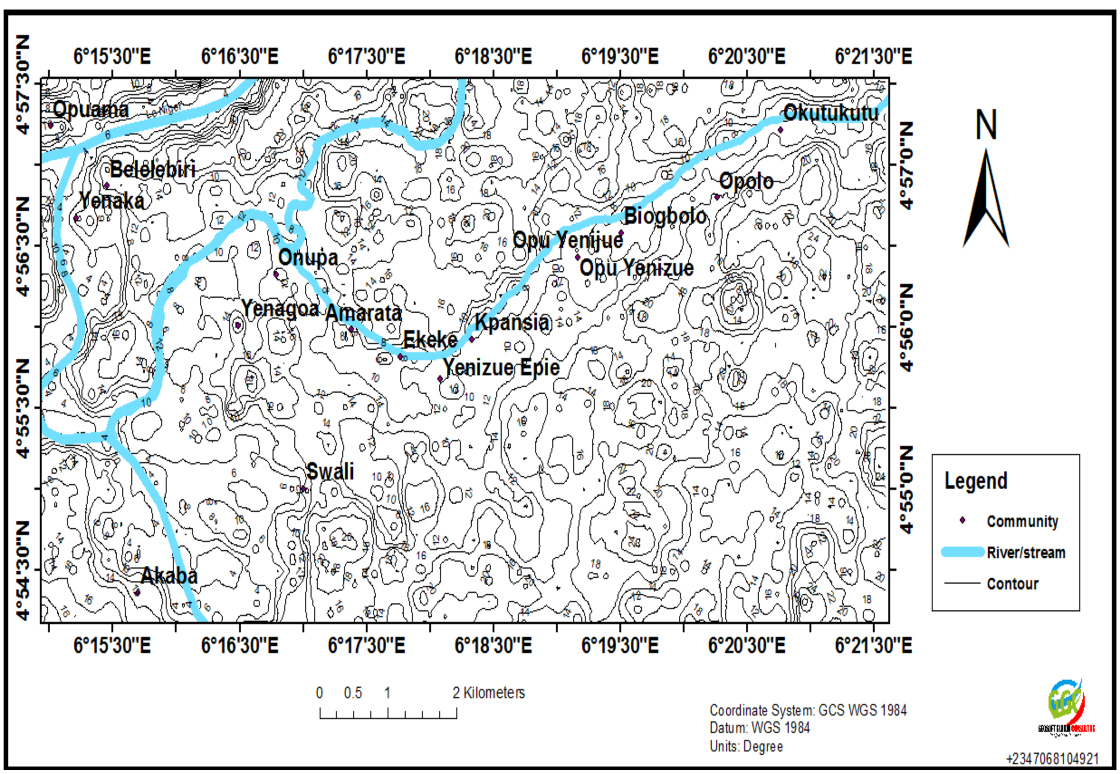


Fig. 5. Contour of the area

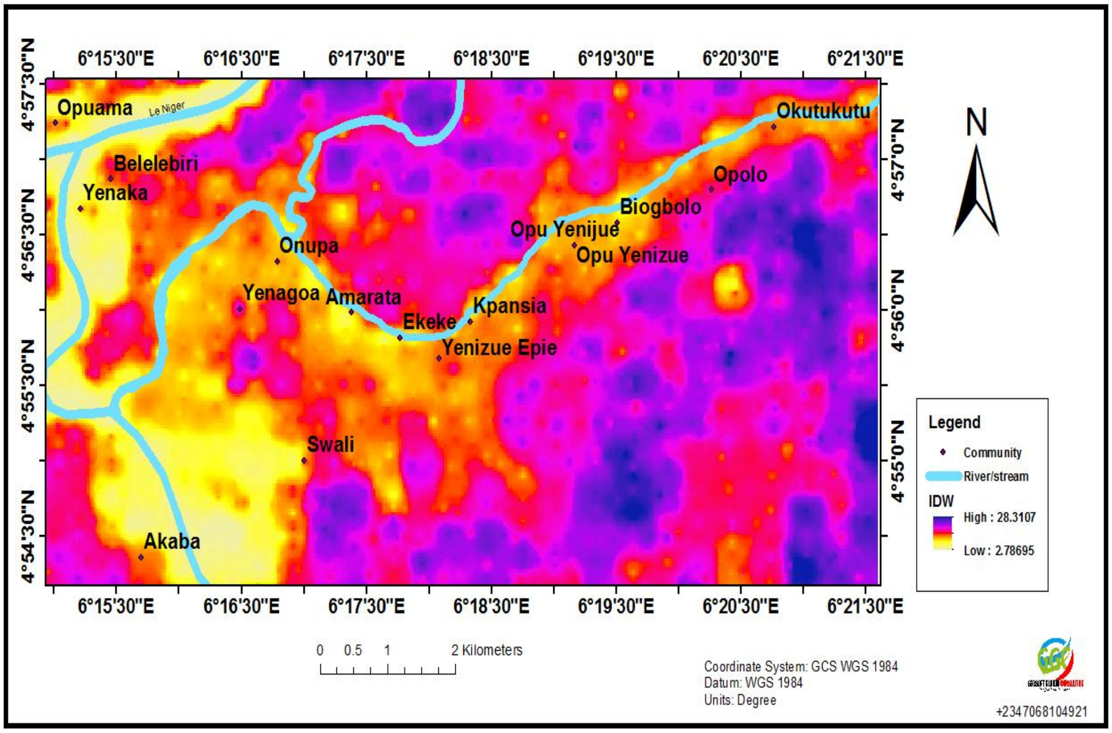


Fig. 6. Inverse distance weight from DTM

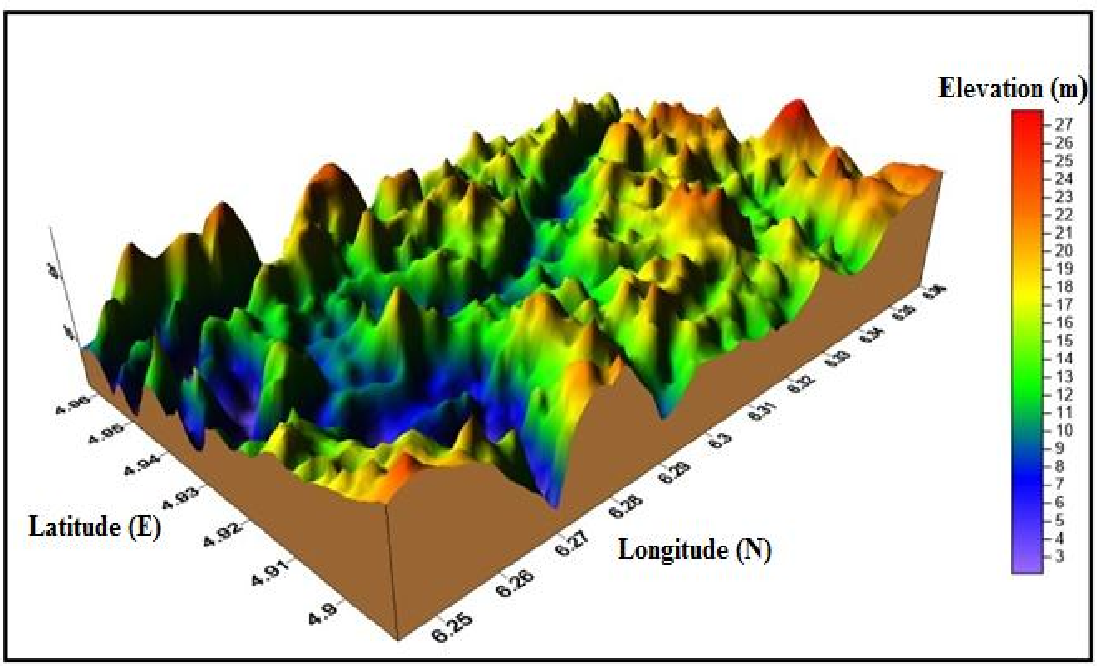


Fig. 7. 3D Model of the area

This represents generally the terrain of the area.

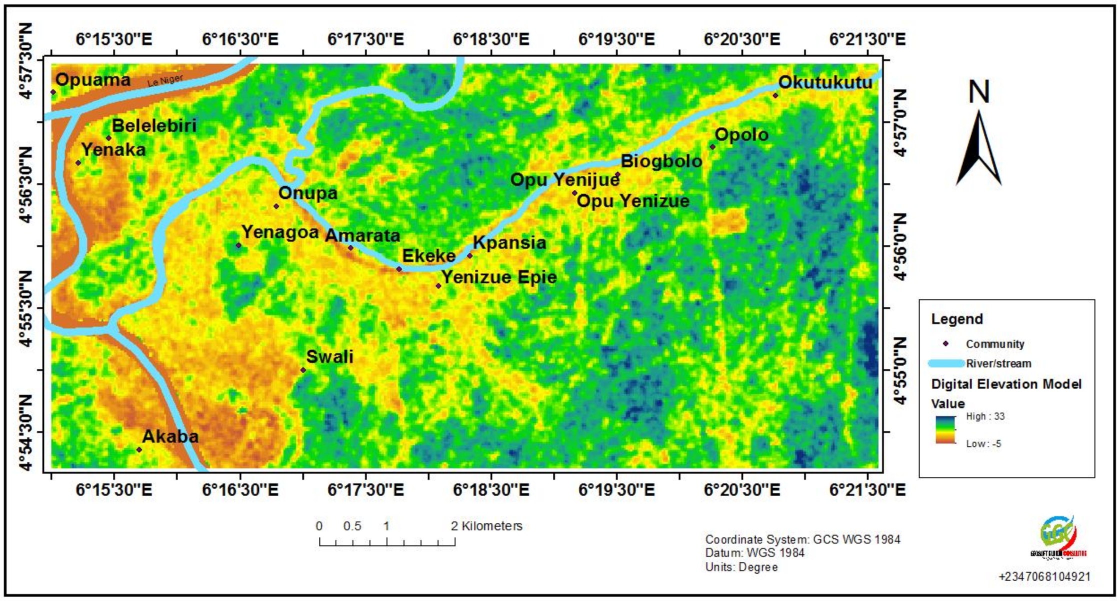


Fig. 8. Digital elevation model

5. DISCUSSION

The noble approach uses to discover the major sources of flooding in the area are explained such as digital elevation model (DEM) generated from the SRTM Data 30 m is shown in Fig. 8. The Figure shows that elevation in most parts of the area, is generally less than 33 m above sea level and digital elevation model has a minimum value of -5 m is highly flooded hazard zone and the maximum value of 33 m which are flood free but generally the area are prone to flooding (Figs. 2,3). The low elevation of the area, coupled with its proximity to le River including Epie creek may have further communities in the flooding. Many of the communities in the of the within the study area fishing communities. The general contour (Fig. 5) tells us how that area is including the general trend on water flow direction. The IDW (Fig. 6) makes us get more information like the low and high area i.e low area has a minimum of 2.78695 with light yellow color which indicates flood hazard area, middle with red color and dark blue which is the maximum with a value of 28.3207is the flood free area. The 3D model (Fig. 7) makes one see the proper view on how the area is which from the legend we can see that area with blue color indicate flood risk area before green, yellow, red.

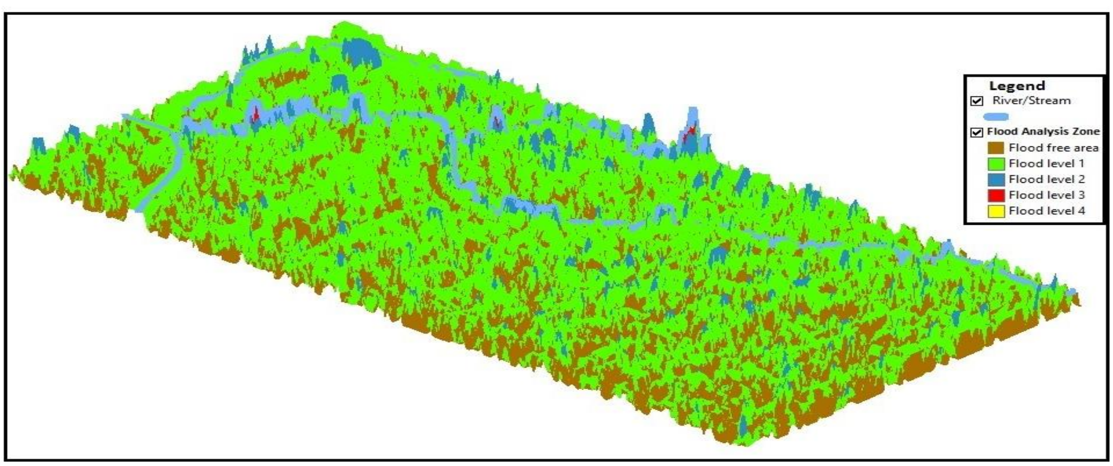


Fig. 9. 3D view of flood analysis map

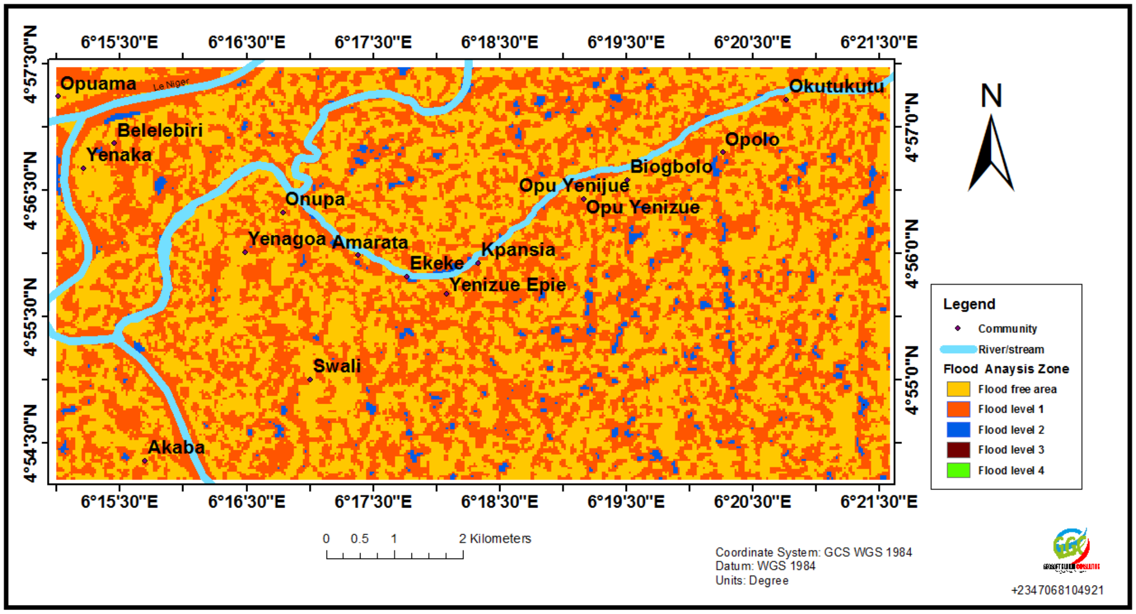


Fig. 10. Flood analysis map

The flood analysis Zone covers a land area of 5.9888882km^2 which are classified into five zones i.e flood free zone which cover 3.133719 km^2 in the area, flood level 1 with 2.716898 km^2, flood level 2 cover 0.136728km^2 area, flood level 3 0.001466 km^2 and flood level4 7.72E-05 km^2. From Figs. 9 and 10 base on the criteria IDW was subtracted from DEM to obtain the result before reclassification. The flood free zone is suitable for settlement for flood relief centers like some part of Opuama, Yenagoa, Belelebiri communities and flood level 1 to 4 are prone from the elevation within the area are generally low [10].

6. CONCLUSION

Flood analysis mapping is a component for mapping flood-prone areas using the noble approach of remote sensing and Geospatial techniques to determine area that area flood free zone and area that flood risk zone. It creates easily read, rapidly accessible charts and maps that can facilitate administrators and planners to identify areas at risk and prioritize their mitigation and response efforts. The aim is to Analysis Flood zone using remote sensing and GIS. The use of GIS-based overlay analysis tool to determine spatial flood hazard levels in the. The area reveals that due to low relief, closeness to rivers, and lack of proper urban planning, most are proving to be highly vulnerable to flood hazard due to the area have low altitude see Figs. 6, 7 and 8.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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