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TERRAIN MAPPING/CLASSIFICATION: WATER LEVEL ANALYSIS OF VULNERABLE FLOOD ZONES IN PARTS OF RIVER NIGER, NORTH-CENTRAL NIGERIA

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Abstract
The study area is situated in the North-Central part of Nigeria, geographically located between UTM-Zone 32N, Northing (885012 to 912575) and Easting (224620 to 252021) coordinates covering a total surface area of 768.94 km^2. Floods are caused by many factors: Heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tide, tsunamis, or failure of dams, levees, retention ponds, or other structures that retained the water. In this study, a Shuttle Radar Topography Mission (SRTM) DEM image was used to classify terrain and model water level with respect to elevation which reveal decrease in elevation from the west to east within the study area, significantly towards river Niger. Water level image analysis shows that newly developed areas along the river Niger are flood prone to include the people of Budan, Apaata, Ekpu, Aisawa, Adamagu, Agbodo, Atada, Idoji, Emoa, Kpapazi, Ajara, ozahi, Panda, Chukanuku and Akanu. These settlements and the NW-SE trending busy Abuja-Lokoja road parallel to river Niger will also be greatly affected when water level rises up to 50m above ground level.
Key Words: *Floods, settlements, SRTM, River Niger and Water level*

Introduction

Flooding around Lokoja is gradually becoming a re-occurrence event yearly. This problem is driven by heavy rainfall from upstream dams like Shiroro, Kainji, and Jebba area. Climate change, and human factors such as wetland degradation and poor urban planning also contribute to excess rainfall. These floods cause destruction of property, farmlands, and infrastructure such as roads, displace communities often lead to loss of life. Research on flooding around the study area identifies several interconnected problems to community's vulnerability from excess water in River-Niger leading to flooding. Inadequate infrastructure and governance policies leading to poor drainage and land-use planning, devastating socio-economic and environmental impacts of floods on populations, agriculture, and infrastructure necessitate this research to identify flood-prone areas accounting for mitigation efforts for safety. The fact that planning activities has moved away from the traditional, rudimental and labour intensive activities to the modern-day computer aided technology was fully demonstrated in the work of Ferreira and Wiggins (1993). This gave birth to a combined Digital Terrain Model (DTM) with geographic information system (GIS) as an approach for this study to classify flooding around river Niger north-central Nigeria. The Niger River originates from the Guinea Highlands in South-Eastern Guinea, flows a distance of about 4,180km through Mali, Niger and Nigeria before discharging into the Atlantic Ocean in the Niger Delta Area of Nigeria. It is a principal river in West Africa and the third longest in Africa, after the Nile and the Congo Rivers. The Benue River on the other hand originates from the Adamawa Plateau of Northern Cameroun and flows for 1,400 kilometers westwards through the Lagdo reservoir in Cameroun and into Nigeria before meeting the Niger River at point of confluence in Lokoja. The confluence floodplain floods yearly beginning in September, peaking in November and receding from May (World Bank, 2012). Riverine settlements are specifically prone to flooding due to the following reasons: (1) The terrain elevation in relation to sea level been normally low, (2) Areas of relatively low terrains are easily over-run by rampaging water that breaks its banks, (3) The level of urban planning been usually poor, (4) Their building design, material and technological approach are rudimentarily and extremely vulnerable to even minor flood. Nigeria is well endowed with water resources,

both surface and underground water abound in the country. The total annual surface water of Nigeria has been estimated to be 193 x 10^9 of cubic meters, or about 6,120 cubic meters per second. Others have, however, estimated it to be about 10, 000 cubic meters per second or about 315 x 10^9 cubic meters per annum (UNDP, 1996).

Study Area

The study area is located in Lokoja, Kogi State, North-Central part of Nigeria, geographically located between UTM-Zone 32N, Northing (885012 to 912575) and Easting (224620 to 252021) coordinates covering a total surface area of 768.94 km^2. The study location is about 20km south of confluence of River Niger and Benue (Figure 1).

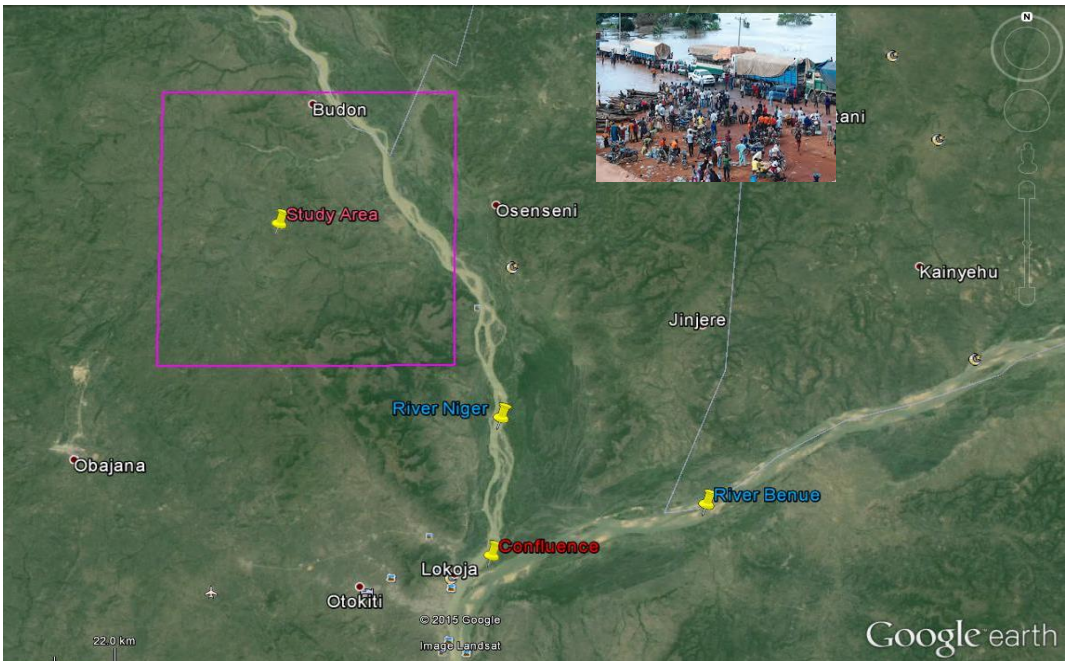


Figure 1: Satellite image map showing the study area (insect; one of the effects of flood)

The Concept of Flood

Flood is too much water in the wrong place, whether it is an inundated city or a single drain. Many scholars have proposed many definitions of flood. Ologunorisa (2004) reports that the European Union (EU) Flood Directory (2003) defined flood as a covering by water of land not normally covered by water. Oyegbile (2008) defined flood as an over flow of water that submerges land. This definition by Oyegbile appears to narrow flood as a land phenomenon only. This is not entirely so as rivers and seas also experience flood. Flooding is the unusual presence of water in a place to an intensity which has a disruptive effect on normal activities. Flooding arises mainly due to heavy rain over a short duration and over flowing of rivers. In the sense of "flowing water" flooding many also be applied to the inflow of tide on land and may also result from the volume of water within a body of water, such as a river or lake, which flows or breaks levees, with the result that some of the water escapes its boundaries. It may also be due to accumulation of rainwater on saturated ground in an area. (Oyegbile, 2008). An unusual inflow of sea water onto land is called ocean flood. Ocean flooding can be caused by storms such as hurricanes (storm surge), high tides (tide flooding), seismic events or large landslides (sometimes called tsunami). While the size of a lake or body of water will normally vary with seasonal changes in precipitation and snow melt from climate change, it is not

significant a flood unless such escapes of water endanger land areas used by man like a village, city or other inhabited areas.

Causes of flooding

Generally, floods are caused by many factors: Heavy rainfall, highly accelerated snowmelt, severe winds over water, unusual high tide, tsunamis, or failure of dams, levees, retention ponds, or other structures that retained the water. Flooding can be exacerbated by increased amounts of impervious surface or by other natural hazards such as wildfires, which reduce the supply of vegetation that can absorb rainfall (Welch *et al*., 1977)

Methodology

The Shuttle Radar Topography Mission (SRTM) data was used to generate a near-global digital elevation model (DEM) of the Earth using radar interferometer. The Shuttle Radar Topography Mission (SRTM) data sets which results from a collaborative effort by the National Aeronautics and Space Administration (NASA) and the National Geospatial-Intelligence Agency (NGA - previously known as the National Imagery and Mapping Agency, or NIMA), as well as the participation of the German and Italian Space Agencies, to generate a near-global digital elevation model (DEM) of the Earth using radar interferometry is acquired with the aid of global mapper to generate terrain elevation data and analyze mean sea level within the study area. The SRTM instrument consisted of the Space borne Imaging Radar-C (SIR-C) hardware set modified with a Space Station-derived mast and additional antennae to form an interferometer with a 60- meter baseline. A description of the operational mechanism of SRTM mission can be found in (Farr *et al.,* 2007). The DEM covering the study area was acquired with the aid of global mapper software to generate terrain elevation data, regional drainages and 10 m contours maps. This was done by downloading existing global DEMs via online sources, then exporting the desired area, load a shapefile for the area of interest, zoom in, and export the DEM using "Layer Bounds", "Create Elevation Grid" and then carry out "Terrain Analysis". After the selection and defining of the study area in term of spatial coverage, the river Niger flowing in a north to south direction through the country was clearly shown with combined SRTM-DEM image and topographic map (Koton-Karfe, Sheet 227 SW) of scale 1: 50,000 (Acquired from OSGOF, 2008). Data from the Global Mapper software were taken to ArcGIS for further processing.

Classification and Mapping of Flood Vulnerable Areas
Terrain classification

Terrain classification was done to note general elevation view of the study area, running from E-W, WSW-ENE and NW-SE. Six (6) prolife line drawn as A-B, A-C, A-D, A-E, A-A & B-B as shown in Figure 2, 3 and 4 to superimposed on topographic map, SRTM atlas shader and HSV shader DEM images respectively. Terrain path view of the six (6) profiles were also shown in Figures 5-10.

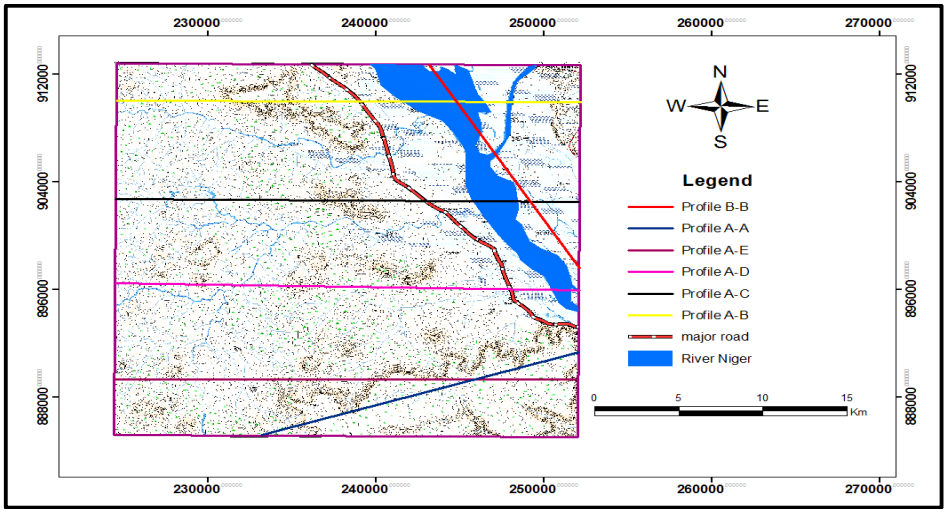


Figure 2: Topographic map covering the study area (Koton-Karfe sheet 227 SW)

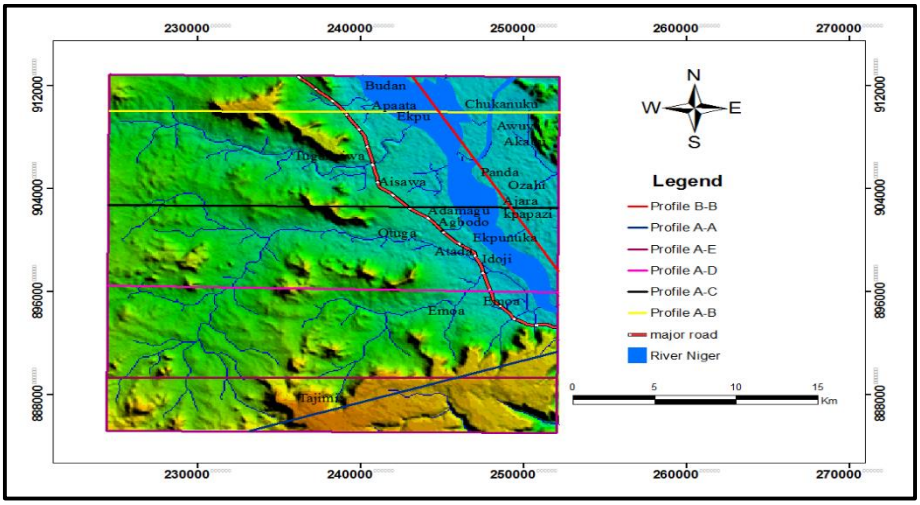


Figure 3: SRTM DEM (Atlas Shader) image covering the study area, also showing tributaries

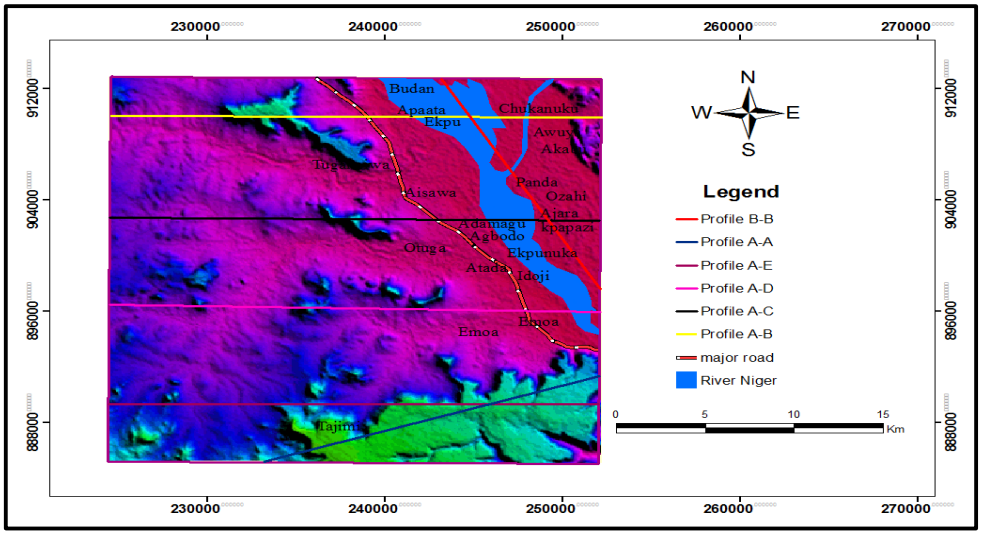


Figure 4: SRTM DEM (HSV Shader) image covering the study area

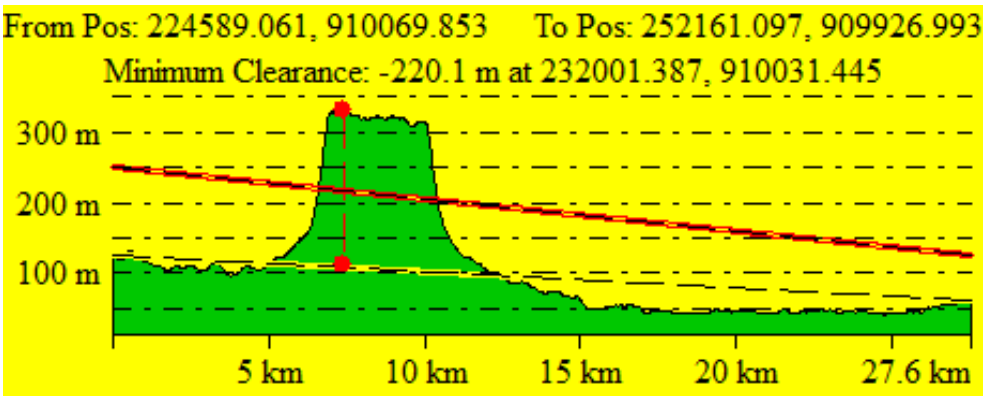


Figure 5: Terrain path view from profile A to B (i.e. from West to East from the study area)

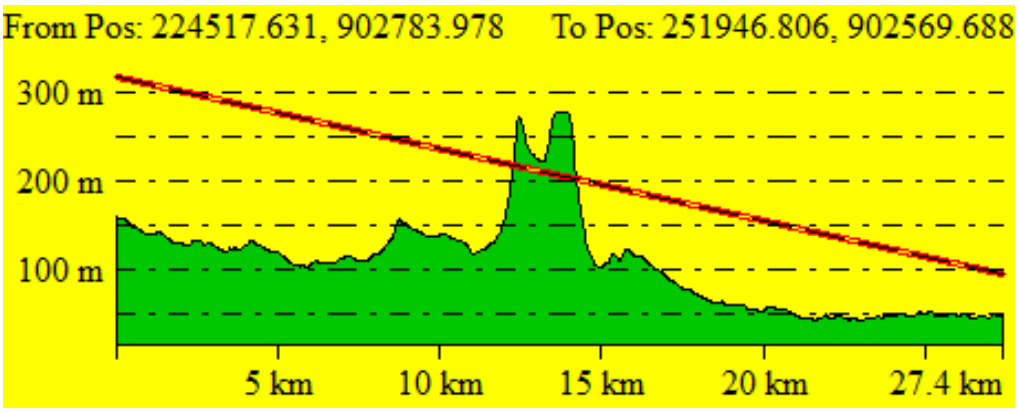


Figure 6: Terrain path view from profile A to C (i.e. from West to East from the study area)

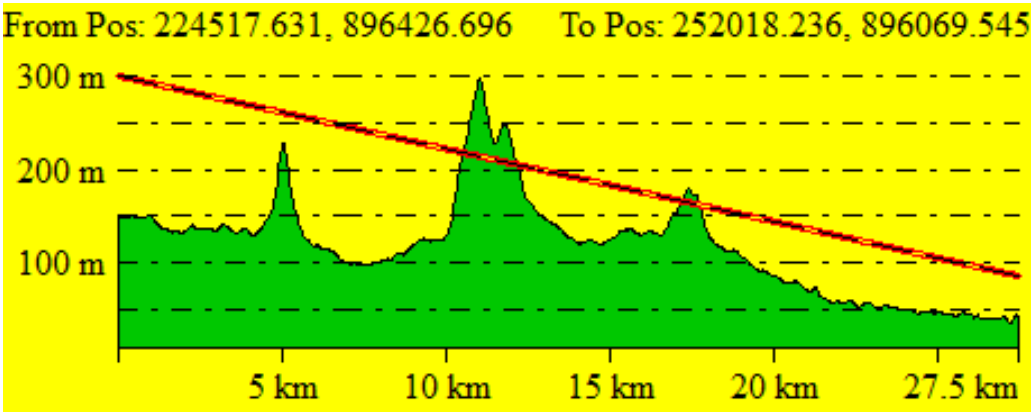


Figure 7: Terrain path view from profile A to D (i.e. from West to East from the study area)

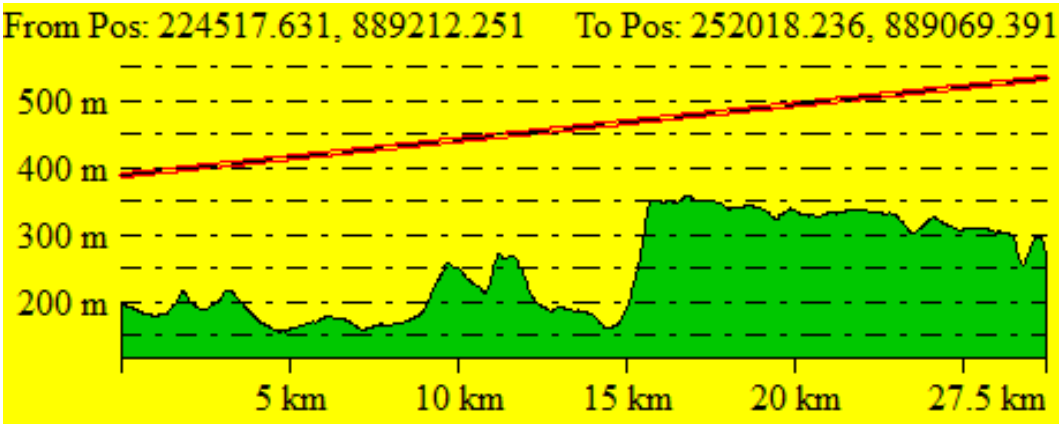


Figure 8: Terrain path view from profile A to E (i.e. from West to East from the study area)

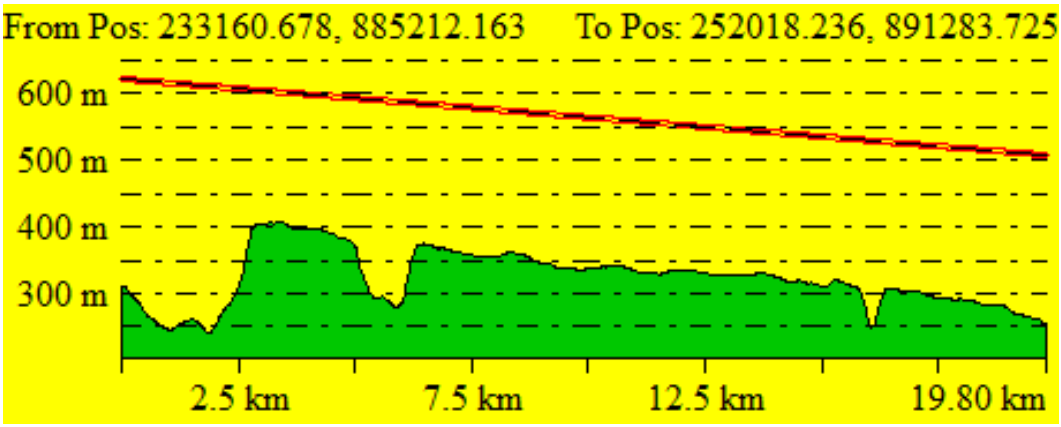


Figure 9: Terrain path view from profile A to A (i.e. WSW to ENE from the study area)

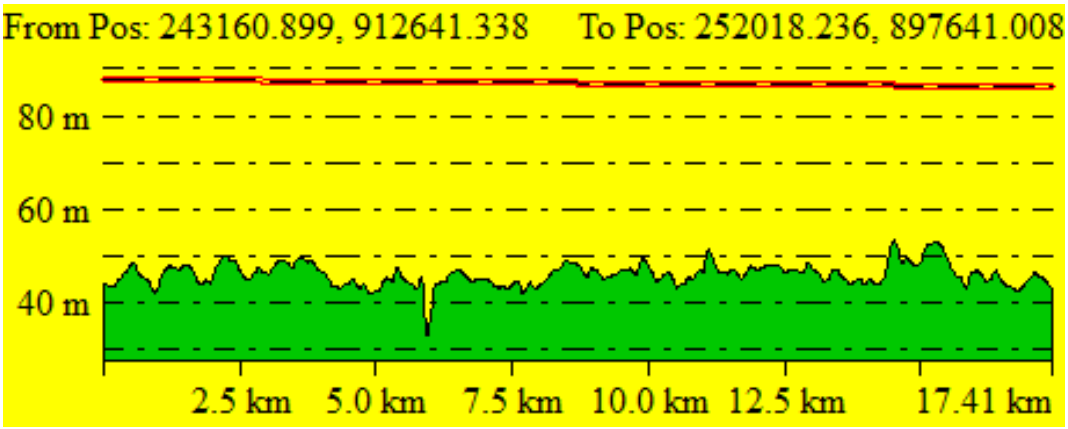


Figure 10: Terrain path view from profile B to B (i.e. NW to SE from the study area)

Water level rise modeling

Assumption made here is that the study area is a close system and water can duly rise, however this assumption will be significant when the river flow is hindered either by natural or artificial barriers or due to release of water from dam upstream without proper preparation and sensitization. The principle that governs how fluid moves in the subsurface is known as Darcy's law. Darcy defines the ability of a fluid to flow through a porous media such as rock to rely on the fact that the amount of flow between two points is directly related to the difference in pressure between the points, the distance between the points, and the

interconnectivity of flow pathways in the rock between the points. In this view, zones with relatively the same elevation will be affected by flood when interconnected. This forms the basis for water level modeling to connect potential flood zones of equal elevation within the study area. Five (5) water level models at various elevations as 50m, 100m, 200m, 300m and 400m were configured in Figure 12, 13, 14, 15 and 16 respectively.

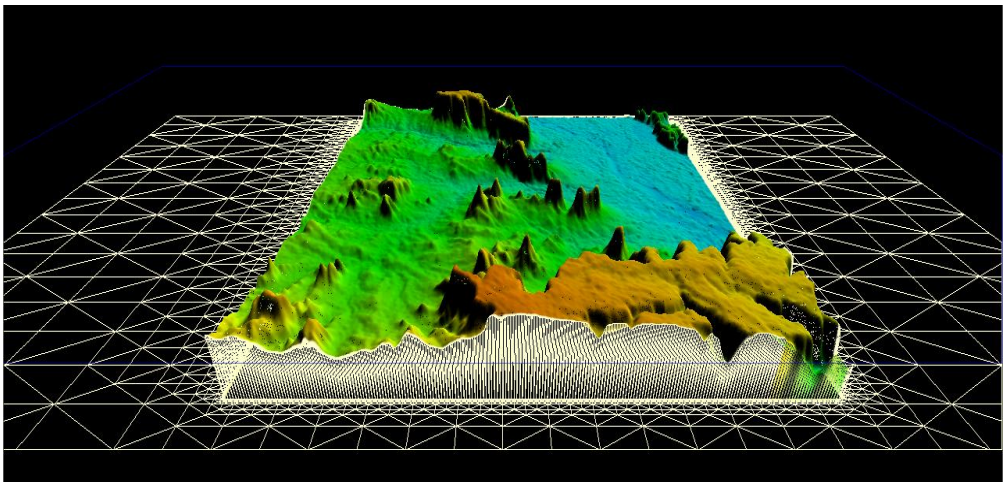


Figure 11: 3-D wireframe view of the study before rise of water level (Vertical exaggeration =10m)

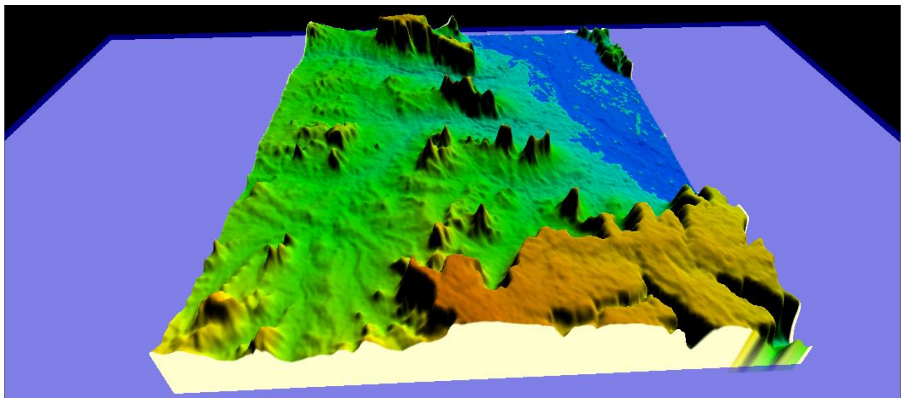


Figure 12: Water level at 50m elevation above ground level (Vertical exaggeration =10m)

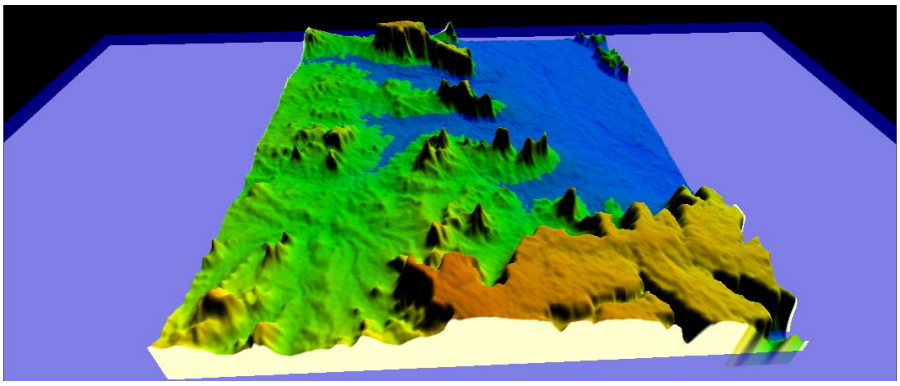


Figure 13: Water level at 100m elevation above ground level (Vertical exaggeration =10m)

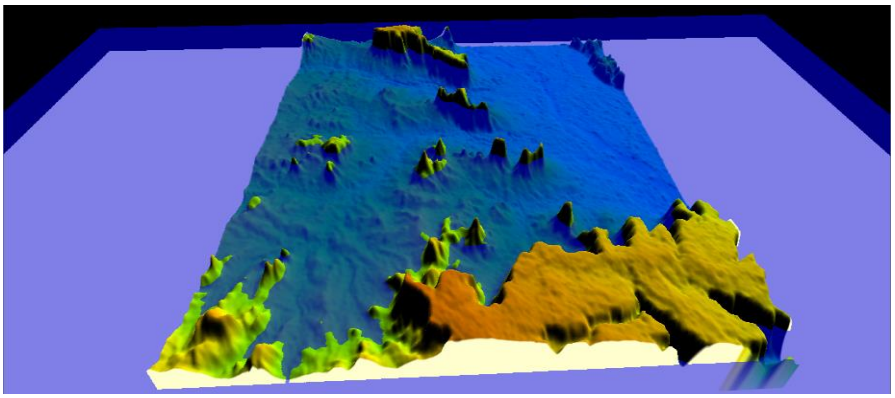


Figure 14: Water level at 200m elevation above ground level (Vertical exaggeration =10m)

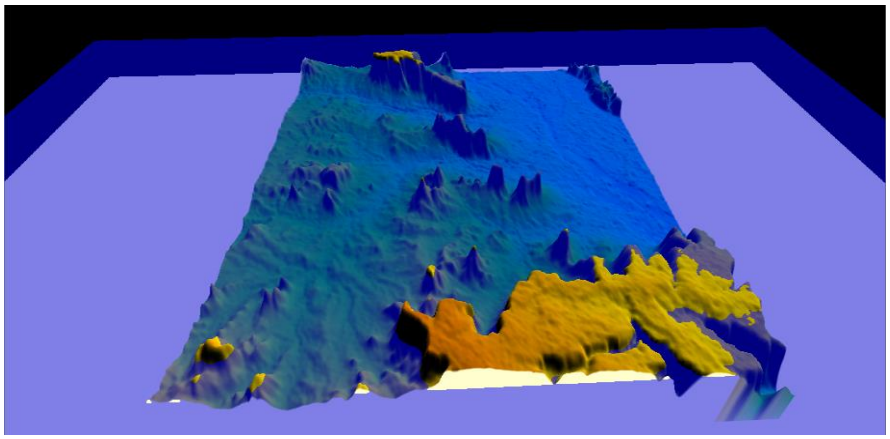


Figure 15: Water level at 300m elevation above ground level (Vertical exaggeration =10m)

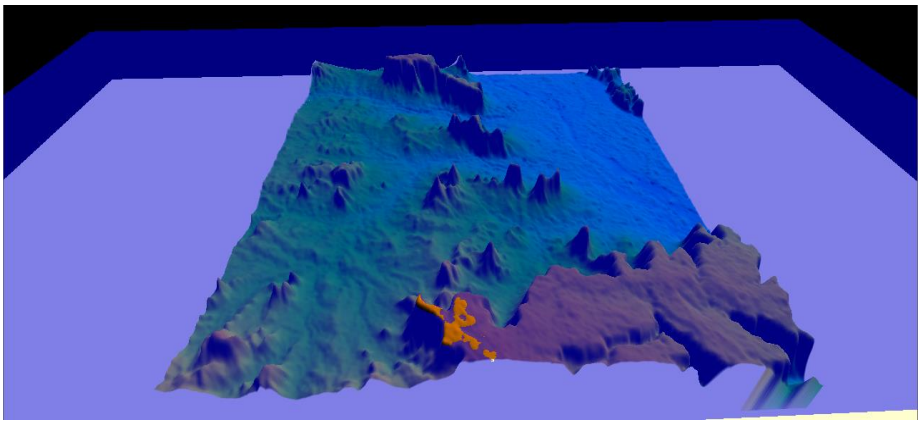


Figure 16: Water level at 400m elevation above ground level (Vertical Exaggeration =10m)

Discussion of Findings

Terrain path view shows that elevation generally decreases from the west to the east within the study area, significantly towards river Niger. On the issue of flooding, it become obvious in this study that newly developed areas along the Niger River are flood prone as indicated in the water level image analysis. Water level at 50m elevation above ground level (Figure 12) reveal that almost all the north-eastern part of the study area will be flooded which has the following settlements Budan, Apaata, Ekpu, Aisawa, Adamagu, Agbodo, Atada, Idoji, Emoa, Kpapazi, Ajara, Ozahi, Panda, Chukanuku and Akanu. Also, the NW-SE trending Abuja-

Lokoja road parallel to river Niger will also be greatly affected. Water level at 100m elevation above ground level (Figure 13) which covers about 45% of the study area will be affected by the people of Tungangiwa, Emoa and Otuga. By 200m water level above ground (Figure 14), the study area would have been covered by about 75%. The people of Tajimi in the middle southern part of the study area stand to escape water level of 300m (Figure 15) above ground level which appears to have covered about 90% of the study area. No identified settlement within water level of 400m (Figure 16) but appears to have covered about 98% of the entire study area.

Conclusion

Research into the classification of flood zones around River Niger in Lokoja, Kogi State was carried to classify terrain and model water level with respect to elevation. Water level image analysis shows that newly developed areas along the river Niger are flood prone to include the people of Budan, Apaata, Ekpu, Aisawa, Adamagu, Agbodo, Atada, Idoji, Emoa, Kpapazi, Ajara, ozahi, Panda, Chukanuku and Akanu. These settlements and the NW-SE trending busy Abuja-Lokoja road parallel to river Niger will also be greatly affected when water level rises up to 50m above ground level. Meanwhile, new development activities are growing along the river banks that may be unstable and should be watched out for. It is thus recommended that people should concentrate their building or construction works towards the western part of the study area to seek for high elevation and less affected flood zone.

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