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Evaluation And Monitoring of Flood Encroachment Along the Floodplain of Kaduna Metropolis, Kaduna, Nigeria.

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Abstract

Urbanization and expansion of structural developments along flood prone areas of settlements in Nigeria are challenges which requires dynamic predictions of inundation among regions; Thus, development for the propagation of flood waves along corridors, floodplain and river bank calls for a quick response. The study investigates on the pattern of the monitoring system, as well as areas vulnerable in relation to reported case of historic flooding using Strategic evaluation and real-time monitoring with remote sensing and GIS to provide a veritable tool of spatial and temporary impact of the existing features and future of land use changes in the study area. The flood gauge as constructed by the National institute of Water Resources Kaduna created on the bases of historic flood events. As calibrated showing colors heights and history as warning to the public and individual residing on the low land and flood plains. The elevation surface, development pattern, and volume for river was investigated and correlated with rainfall precipitation data acquired. The Passed reports of flooding events, historic height was investigated to determine the legitimacy of the monitoring system as reported. Thus, the project proves that Spatial statistical tool can be used to helps in the modification for floodplain development investigation. The land use changes along the flood plain indicating that the Kaduna River is covered with a maximum encroachment rate of 76%, and with kapper coefficient of 68 %. The result of the rainfall data also shows the influences of rainfall to flooding as well as urban encroachment. Places like Kigo road, Barnawa, Narayi, Kamazuo, Kawo, Kudenda, Kakuri, Television, Angwa-Muazu, Sabon, Tudun Wada, Kabala Dokan, Living Faith Church area and parts of Kaduna state stadium are more vulnerable.

Keywords: Flood *Gauge, Urban,* Encroachment, Inundated, *Vulnerability, Elevation, River banks.*

1. INTRODUCTION

Flood, is one of the most catastrophic and destructive natural disasters in the history of environmental research (Ekeu-wei 2018). Flooding is simply described as "water where it is not wanted (Ibrahim and Abdullahi 2016). As a result, it might be either natural or manmade. In most cases, flooding occurs when rivers exceed their banks due to excessive rainfall inundating the soil's capacity, dam failure, and human encroachment obstructing river channels, tributaries of rivers, and bridges. The devastating effect of flood on the means of livelihood, particularly in the developing countries is evident in literature (Ekeu-wei 2018). Damages caused by these (natural or anthropogenic) factor known as flooding to agricultural land use, residential land use and public facilities and utilities around the world runs into several millions of dollars annually base on economic damage (Enaruvbe, 2012). Cities in undeveloped countries are more sensitive to the effects of climate change, particularly variations in rainfall caused by exposure to extreme weather events (Jinadu, 2015). Excessive rainfall causes floods, especially in areas with poor natural drainage systems and areas where bad land use practices hinders drainage systems from channelling excess water away (Enaruvbe, 2012).

The catastrophe of flood in 2012, devastated 23 states out of 36 states Nigeria which cost the country US$16.9 billion, 1.4 percent of the national gross domestic product (UNECA – United Nations Economic Commission for Africa 2015). The track recordings of 1973, 1974, and 1976 for example, shows incidents of flooding in Ilorin (Jimoh, 1999; Mordi, 2011 and Amaize, 2011). The high rate of urbanization together with the challenges of urban sprawl, inadequate and unguided physical development in marginal regions, rising poverty, and infrastructural deficits in emerging nations, has resulted in the build-up of catastrophic risk in our towns and cities. (Jinadu, 2015).

Urbanization, with its difficulties of urban sprawl, unguided physical development in peripheral regions, rising poverty, and infrastructural deficits in developing nations, has resulted in an increase in disaster risk in our towns and cities (Adeleye and Popoola 2019). As a result of global warming, climate change, and other associated issues, the frequency of hydrological catastrophes has increased over time and therefore high temperatures, such as global warming and the resulting climate change are the main trigger events for a substantial share of disasters worldwide (Jinadu, 2015). The issue of inappropriate planning and assessment of hazard elements is one of the key reasons for exposure to flood hazard in Nigeria (Adeleye and Popoola 2019). The flood gates on the Challawa and Tiga dams were opened to release surging floods along the Niger River in Northern Nigeria, displacing more than two million people (Divine-favour, 2015). At least 300,000 people have been displaced by flooding in Niger State, which has submerged hundreds of communities too (Divine-favour, 2015). Recent decades, flooding has wreaked devastation in several parts of Nigeria, including Anambra in the east, Sokoto in the northwest, Borno in the northeast, Plateau in the northcentral, and Yobe in the North (Divine-favour, 2015). As a result, the study uses Geographic Information System monitoring to measure and analyze the amount of exposure to floodplain regions in River Kaduna.

2. STUDY AREA

Kaduna is located between latitude 100 28' N and longitude 070 19'E, and between latitude 100 37' N and longitude 070 31' E. Kaduna State's whole geographical structure has an undulating Plateau with notable rivers such as the River Kaduna, the River Wonderful in Kafanchan, the River Kogom, the River Gurara, Aso, and the Galma River. (Ijigah.E. A and Akinyemi T.A, 2015). The annual rainfall experience within the Kaduna region is around 1000mm -1651mm during the wet season, which falls around May - October with a maximum downpour between the months of July and September. Kaduna is in a tropical region that is characterized by two seasons, annually known as the dry and raining seasons. (NIHSA ,MESA AND GMES, 2020). (Mccury 1976) Kaduna metropolitan is divided into two main local government areas, Kaduna North and Kaduna South. Kaduna is located in the central northern part of Nigeria (with Kaduna as its capital), and it shares a border with the Federal Capital Territory Abuja to the south-west. It also shares common borders with Katsina, Zamfara, Kano, Niger, Bauchi and Plateau States. The State occupies an area of approximately 48,473.2 square kilometres and has a population of more than 6 million

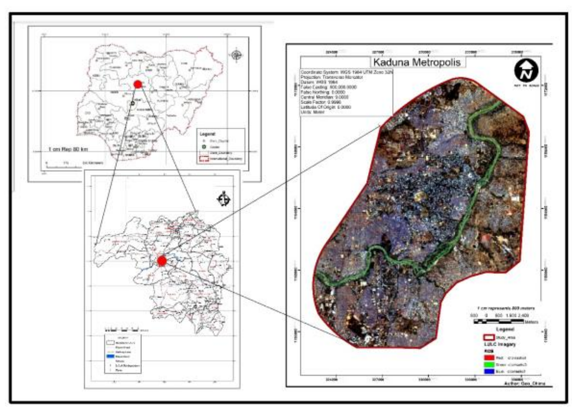


Figure 1 Study Area: Kaduna Metropolis (source: Author 2021)

3. METHODOLOGY

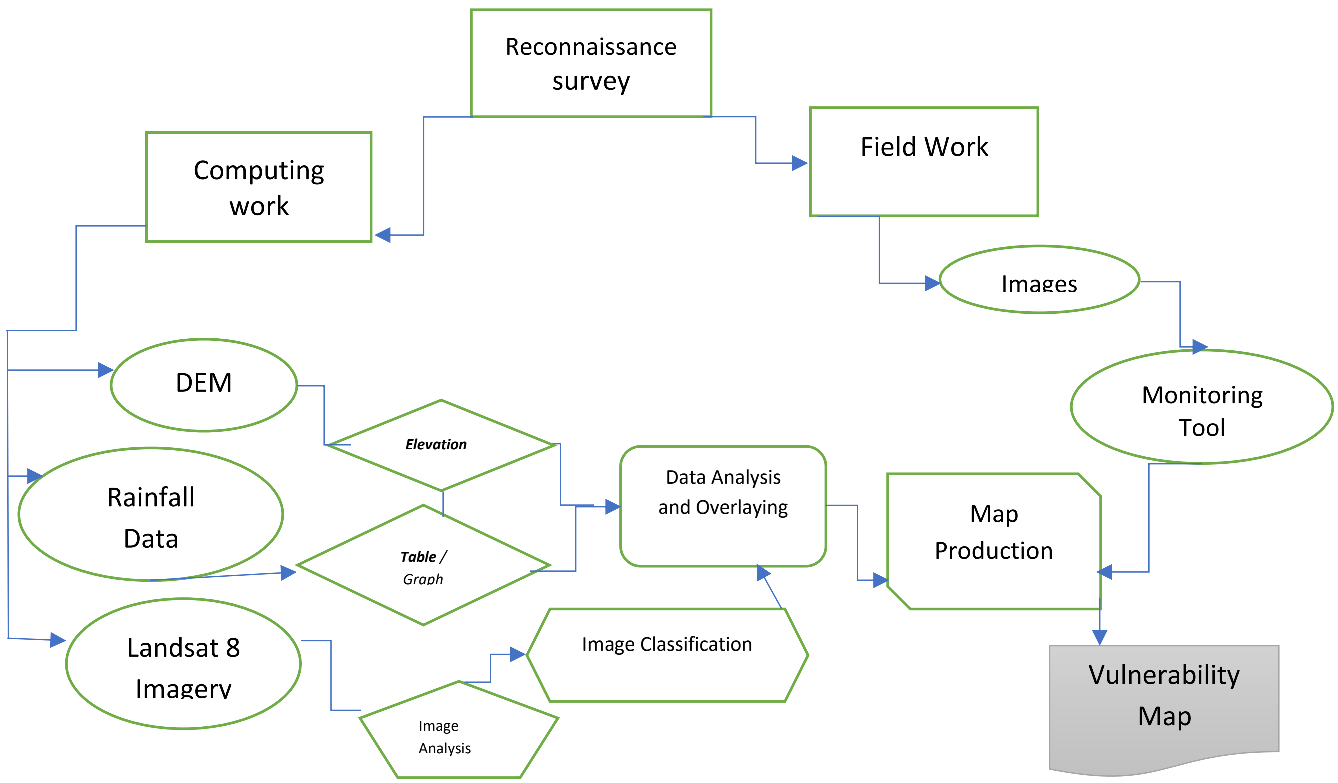
The Methodology applied in this research is based on a descriptive nature which involves the use of GIS and Remote Sensing. Such as Satellite Imagery (Landsat 8 OLI 30m resolution), (Digital Elevation Model DEM of 15m resolution) and

Manual Flood gauge monitoring tool Located at River Kaduna and Hand held GPS. The results were summarized in frequency tables, charts and logical technique. Other data employed includes Soil data, Rainfall Precipitation Data as well as other relevant information represented in Maps. The Digital Elevation Model (DEM) of 15m resolution was used to determine the various elevations in the study area for assessment flood encroached area.

The DEM was also used together with the rainfall data for analysis and evaluation of the Manual flood gauge heights.

Data and Sources: The data for the study area was acquired using both primary and secondary data; Primary Data was obtained by ground thruthing and using information on the existences of the monitoring system used in the study area while the secondary data are satellite imagery acquired for the purpose of analysis.

Flow Chart



4. RESULTS AND DISCUSSION

Table 4.2: Geomorphology

SOIL ID	SOIL NAME	COVERAGE (sqm)	PERCENTAGE (%)
Lf	Ferric Luvisols	24521	66.01%
I	Lithosols	7010	18.87%
Lg	Gleyic Luvisols	3885	10.46%
Be	Eutric Camisoles	1730	4.66%
sum	**Total**	**37146**	**100.00%**

Source: The FAO-UNESCO Soil Map of the World

The study area is identified to be dominated by Ferric Luvisols which covers about 66.01 % and its capacity is (1 M NH4OAc at Ph 7.0) = < 24 cmol(+)kg-1 clay start at 100cm from surface soil zone is overlain with loamy sand. This simply means that soil is washed down from surface to accumulate at horizon depth, unconsolidated material budget analysis of clay profile state that surface soil is lost through erosion, its greyish brown and sensitive to slaking and erosion. Geomorphologically, it is a landform composed primarily of unconsolidated depositional material derived from sediments being transported by the stream in the study area which is sensitive to flood and erosion. Hydrologically, it is best defined as a land with different return periods of the parent stream. A combination of these (characteristics) perhaps comprises of the essential criteria for defining the floodplain (Schmudde, 1968).

Base on reported cases of flood in Kaduna metropolis the following are the years and months with heavy rainfall as identified with the red spot on (table 2) from the 2000 – 2019

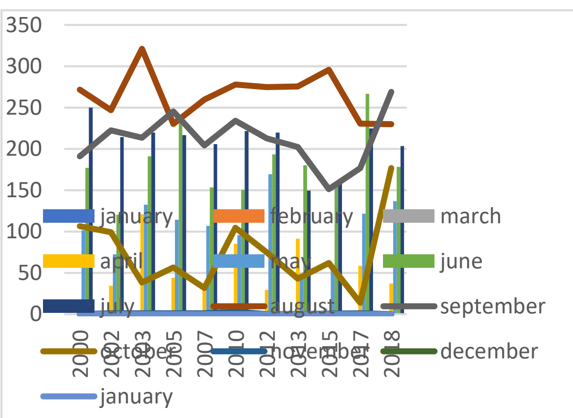


Figure 2: Rainfall data and flood monitoring according to historical years of reported priority *Source: National Water Resource Institute Kaduna NWRI*

The graph indicates the relationship between rainfall and inundation of flood in Kaduna metropolis. As identified in graph presentation above, the year 2003, 2010 and 2015 was indicated as the highest precipitation points at 321.1,278 and 295.8 respectively at the month of August. The table identified that it was at its lowest in the years 2013 with a grand total of 991 mm but a report was stated by the NEMA 2013 that there was a flooding. literature Stated that on the 23rd of August 2003 a heavy downpour of rainfall causing Kaduna river to overflow its banks which displaces about 5000 people and 30,000 houses were damaged in the following Malali, Barnawa, A/Rimi, Kujama road and L.G. Areas such as Kaduna North/South LGA, Chikun LGA, jaba, sabo, kujemaá,kudanda, and Zaria LGA.

To construct a continuous raster for the research region, the yearly rainfall data for 2019 was evaluated and interpolated using kriging. (Figure 4.2): is the resultant map. Within the Study area, the boundary between Kaduna North and Kaduna South has substantially more precipitation than the west, however the difference between the highest and lowest precipitation values is small. Which is about 259.6 – 159.6.

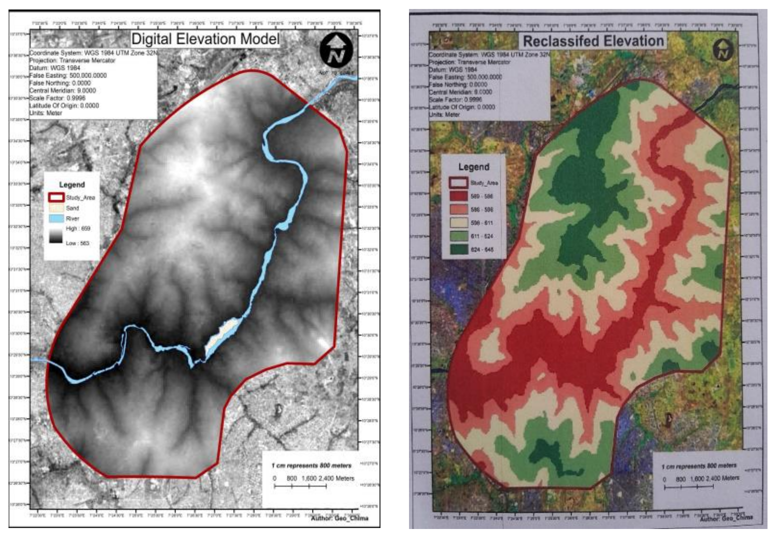
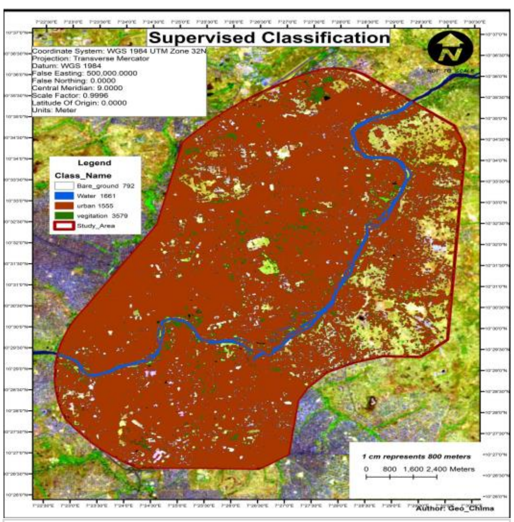


Figure (2) DEM and (3) Reclassified DEM: Kaduna Metropolis (source Author 2021)

The elevation explains the height for better visualization and assessment. the representation and reclassification Dem show the relative equal level in 5 colour symbology. As shown, the maximum heights of DEM in the figure 2 above is indicate 659m. however in reclassified DEM areas or region that fall in the green region of with height within 659 - 624m are less vulnerable to flooding which is in respect with flood gauge in plate 1.

Also, regions that fall within the yellow area as shown in the figure 3, with Elevation height relative 611 - 598m. Have be recorded to be vulnerable, during high rainfall precipitation. Which also was spotted on the flood gauging system as calibrated on plate 1 and 2. which indicates 617.64m as flood inundation height of 2012 and 618.77m in 2015. Therefore, the yellow regions are vulnerable regions. The most vulnerable regions are the place with the reddish color with the elevation of 598-563m as indicated with the reddish color is dominantly major along the river bands, natural tributary and place of equal height, which can be inundated easily. Flat topography increase water flow, resulting in significant infiltration where there is open soil or stagnation. impervious surface, resulting to water logging.



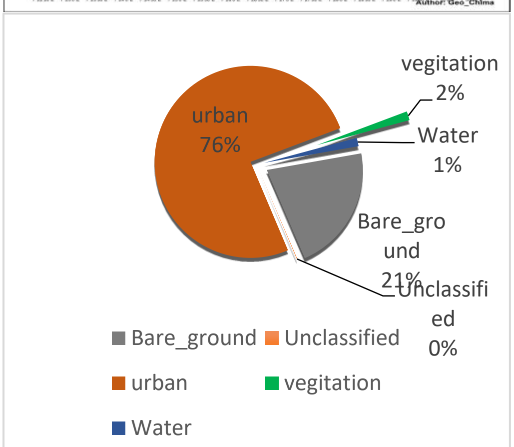


Figure 4 landuse land cover: Kaduna Metropolis (Landsat 8 OLI 30m resolution)

The Landsat 8 as classified using Envi 4.5. Indicate the following: Urban, water body, bare ground and vegetation of which are represented in the following colors respectively brown, blue, fallow and green.

Land cover percentage chat: The study as classified in (figure 4), is indicated as follow: water cover 1% of the study area while vegetation is at 2%, bare-ground at 21% while urban development covers major part of the land at 76%. Thus, it shows that there is a larger increase in urban development and encroachment toward the flood plain of river Kaduna. Urban sprawl has been proven to be the part that is most prone to flooding because of its nature of hard surfaces in relation to water absorption in soil and water outflow due to it built up nature within building and obstruction of natural tributary. Therefore, the impermeable nature of the of urban area of the study is considered at high risk most vulnerable, as well as the nature of bare surface which triggers inundation.

Plate 1 and 2 Source: National water resource institute Kaduna NWRI

The above Plates shows the flood gage 1 and 2 warning system with colour yellow and red as alert identifying the volume of water as identified in the field. The flood gage was constructed by the National institute of Water Resources Kaduna. The flood gage was created on the bases of relatively passed flood events. The image of the calibrated flood guage 1 as show in Plate 1 and 2 indicates height with color yellow and red as warring to the public and individual residing on the low land and flood plains. Red indicates that flood inundation has taken place within the low land with relative height of 611- 617.

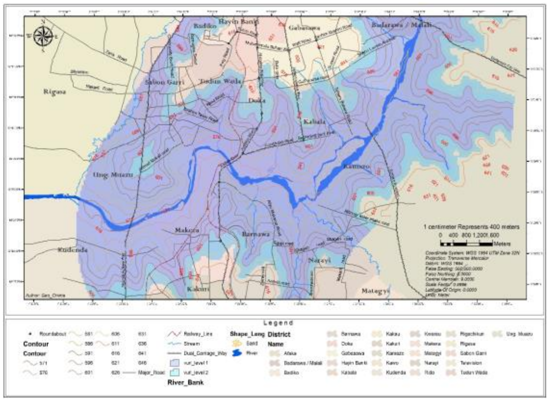


Figure 5 Author's Map 2021

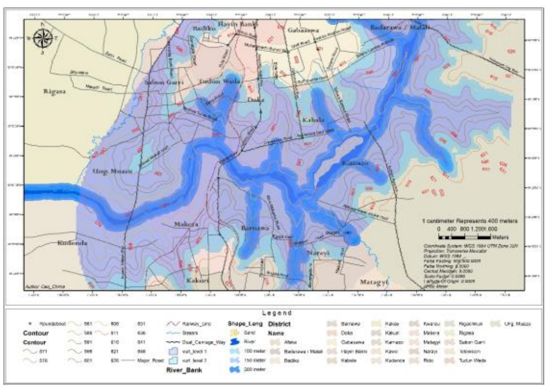


Figure 6 Author's Map 2021

The figure 5 and 6 shows the level of inundation in the study area.

5. CONCLUSION

The intensity of inundation plays a crucial role in mitigation strategies, The land cover most susceptible to flooding is found closer to the river flood plain, according to the research as shown in (figure 4). From the flood vulnerability map, the whole study area with the relative height of 569 - 611 can be considered as a flood plain as the terrain is quite sloppy in nature. The figure 5.1-5.5 with setback / buffer of 100meters-200meters area such as Kigo road Barnawa, Narayi, kamazo, kawo kudenda, kakuri, Television, Angwa-Muazu, sabon, Tudun wada Kabala Doki, Living Faith Church area and parts of Kaduna stadium in relation to how close buildings are to the floodplain, natural tributaries and adjoining river channels are vulnerable. The accuracy level of the monitoring system and report in the Flood risk map, plays a crucial role in land use planning development, particularly in flood plain areas. This can help city planners and administrators prioritize their mitigation or relief response. To efficiently monitor and identify development encroachment toward the River Kaduna flood plain. However, urban encroachment can be linked to failure in follow planning guidelines. Rainfall plays an important role in the study area as a significant role in the inundation of flood but considering the duration and its seasonal differences in precipitation and months of pick points. Thus the approach of relocating people within flood plains cannot be used here since it would entail relocating a population of thousands of people. Furthermore, because the rainy season lasts just four months out of the year in the northern Nigeria, migration becomes unfeasible. This implies that alternative methods of combating persistent floods are required. The following are some suggestions for dealing with the problem. (a) The removal of sediments and debris from the bottom/ edges off the river can also help in reducing rick of flood, this can be referred to as the dredging of rivers. (b) By Reducing blockages sure as debris and waste in drainage systems. (c) The Channeling of city drainages in harmony with natural runoffs and river catchment. (d) Creating of basins or small reservoirs to retain rainwater in the city during the pick hour of high precipitation rainfall.

However, the common threat about the danger of climate change which plays an important role in global landscape, temperature, rise in sea level as well as rainfall accumulation of 5, 10, 25, 50 and 100years which possess potential threats of flood inundation among the global landscape as was as the study area. Regions have to be analyzed by planners using GIS techniques to predict areas that are likely to be flooded. The GIS monitoring system provides significant benefits to sensitive regions. As a result, a GIS monitoring system can assist in determining and preparing an evacuation strategy that can be prepared before any flooding occurs. Flood control policymakers should prioritize extremely susceptible areas, and money should be distributed based on the frequency of floods in impacted areas to ensure appropriate management.

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