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Geospatial Analysis of Flood Risk and Disaster Management in Kogi State, Nigeria

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Abstract: **A flood risk and vulnerability assessment of Kogi state, Nigeria was investigated. The objective is to identify the risk lives and vulnerability level of the settlement to flood disasters. Geospatial techniques using remote sensing data and GIS was utilized in the analysis. Results indicate that, majority of the settlements are very vulnerable to flooding. It can be seen from the second flood risk map. After the overlay function has been made (overlaying of major settlements, stream network, digital elevation model, river and stream network buffer). It was observed that most of the settlements in Lokoja and environs are located on and around the stream network and on the flood plain. Any discharge or release of water in any form over this terrain, will lead to accumulation of water in the stream network expanding its course and increase in sea level rise, which may likely result to devastating flood events. A proximity analysis was carried out; a query was done to check the proximity of features to the stream networks. it is seen that built up or urban areas within the 1000m buffer zone are areas that are vulnerable to flood when there is extreme release of water in any form (heavy rainfall, release of water from dam or dam failure) but areas above 1000m buffer zone are areas that less vulnerable under the same condition. Building challenges, rainfall impact and water releases from hydropower dam were identified as major causes of floods in the study area. It is recommended that continuous inventorying of hydroclimatic variables at dam reservoirs be intensified and adherence to site selection for building should continuously be enforced to reduce the risk levels and safeguard the settlement from flood disasters.**

Keywords: **Climate Change, Flood, Geographical Information System, Vulnerability, Disaster.**

I. Introduction

Flooding is a general temporary condition of partial or complete inundation of normally dry areas from overflow of inland or tidal waters or from unusual and rapid accumulation or runoff (Adeoye *et al*, 2009).

Floods are among the most devastating natural disasters in the world, claiming more lives and causing more property damage than any other natural phenomena (Ramnoop, I995).

In the period 1963 to 1992, the world suffered from 202 floods with more than 1,000,000 (one million) victims, most of them are flash flood recorded as torrential rains, monsoon floods, headwater flood or landslide (Kwak, and Kondoh, 2008)). The largest flood catastrophe on the list was the flash flood in June 1991 with more than 5,000 victims in Afghanistan (Ramnoop, I995 and inyangorok, 2011)

In Africa, flood displaced 2.5 million people in 2009, and more than a million in 2007. Over all African flood fatalities increased by a factor of ten from 1950 to 2009, over 15,000 people died during the decade 2000 to 2009 (Olorunfemi (2011). Many countries in Africa have been affected by devastating flood but to mention few, in August 2006, the Dechatu River in Ethiopia burst its banks in the city of Dire Dawa near Somalia. Buildings were destroyed in some cases and sweeping away homes, trees and fences and more than 350 people are reported to have been killed and about 3,000 others displaced by flash floods. (CBS News World, 2010).

In Nigeria, flood has been the major natural disaster experienced from the time past till now, claiming lives and properties, inundating houses, rendering inhabitant homeless, causing health implications and socio-economic problem to people affected. (Ojigi*et al* 2013). Many inhabitants in the country are prone to possible flood disaster because people build houses on flood plains and drainage channels, riverbanks and coastline due to accumulation of silt over the area for farming purposes, irrigation and fishing purposes, and also the act of indiscriminate dumping of refuses on the drainage channel and many among others.

Kogi state experienced a serious flood disaster in the year 2012 and the situation is beyond description and it has attracted humanitarian assistance from the National Emergency Management Agency (NEMA), Red Cross and many among others. It has render millions of people homeless, destroyed thousands of hectares of farmlands, live stocks leaving most settlements inundated (Ojigi*et al*, 2013). This flooding came as a result of water release from laggo dam into river Benue, Shiroro and kanji dam into river Niger as well as climate change itself which led to excess precipitation (NEMA, 2012).

In this work, the use of geospatial techniques and disaster management cycle will be employed solving this devastating flood that has render people homeless and infrastructures and farmlands destroyed in Kogi state. The stated techniques above will help in the monitoring and managing subsequent flood disasters occurrence in the future.

II. Study Area

Kogi state is found in the central region of Nigeria, located on the latitude 7° 30´N and longitude 6° 42´E with a total land area of 29,833km^2 (11,519sq mi) and has a population of 3,595,789 in the year 2005 which was the

24th in the ranking of most populous state in Nigeria (NPC, 2006). It is popularly called the confluence state because of the confluence of River Niger and River Benue at its capital. Lokoja is the first administrative capital of modern-day Nigeria.

The bigger rivers have wide flood plains such as the portion of the lower Niger in Kogi state, which is more than 1,600 metres wide at lokoja, while the small streams have narrow valleys. The general rainfall is undulating and characterized by high hills, Jos plateau and numerous inselbergs and elongated ridges. The state has an annual rainfall of between 1,100mm and 1,300mm. The rainy season last from April to October and which dry season last from November to March, is very dusty and of cold as a result of the north-easterly winds which brings in the Harmattan.

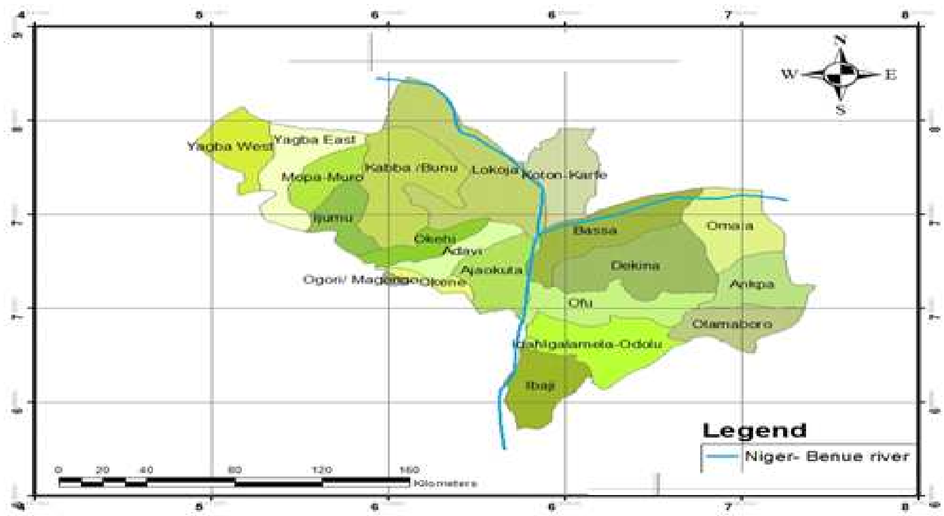

Figure.1: The study area (Kogi state) Nigeria

III. Materials and Methods

I. The data used for this study were obtained from both primary and secondary sources. The primary sources involved the use of GPS receiver/handler to obtain the coordinates of areas affected by the flood. The secondary data used include the shuttle radar topographical mission (SRTM) with resolution of 90m which was used for generation of contour lines and Digital Elevation Model (DEM) and Landsat image with resolution of 30m was used for the Land use and land cover map (LULC) over Kogi state was obtained from Global land cover facility (GLCF) in July 2010.

II. The ILWIS software was used for combination and radiometric enhancement of the Landsat bands, supervised classification using maximum likelihood and embellishment of land use land cover map of Kogi state.

III. ArcGIS 9.2 GIS software was used in this work for Vectorization of images, creating of personal geodatabase and Shape files used in performing overlay function, Mosaicing, masking, generation of contour lines, creating of Digital Elevation Model (DEM) and creating of Digital Terrain Model (DTM).Hydrology extension tool was used, and its functionality in this work includes; delineation of drainage basin, determination of flow direction, determination of flow accumulation, and creation of stream network.

IV. The Proximity Analysis (Buffering**)** of specific distance was created around the Niger- Benue River and created stream network so as to determine areas at flood risk. However, the proximity level of the river and created stream network to the built-up areas are identified and mapped. Proximity analysis was performed via query to know the proximity level of features to flood prone areas. Also, to classify areas into zones of most vulnerable, less vulnerable, non vulnerable region.

IV. Result and Discussions

Table 1; (McKee *et al*, 1993) Table was adopted for the classification of rainfall variation

SPI Values	Conditions
2.0+	Extremely wet
1.5 to 1.99	Very wet
1.0 to 1.49	Moderately wet
-.99 to .99	Near normal
-1.0 to -1.49	Moderately dry
-1.5 to -1.99	Severely dry
-2 and less	Extremely dry

The table derived from McKee 1993 was used to classify the variation in rainfall into extremely wet, very wet, severely dry, extremely dry and so on. Under normal circumstances the mean rainfall of Kogi state is expected to be 97.08mm which is the climatological mean derived from the 23 years (Annual Mean of rainfall data) but as a result of climate change, the deviation from this climatological mean has occurred.

Year, 1985=1 and 2008=24

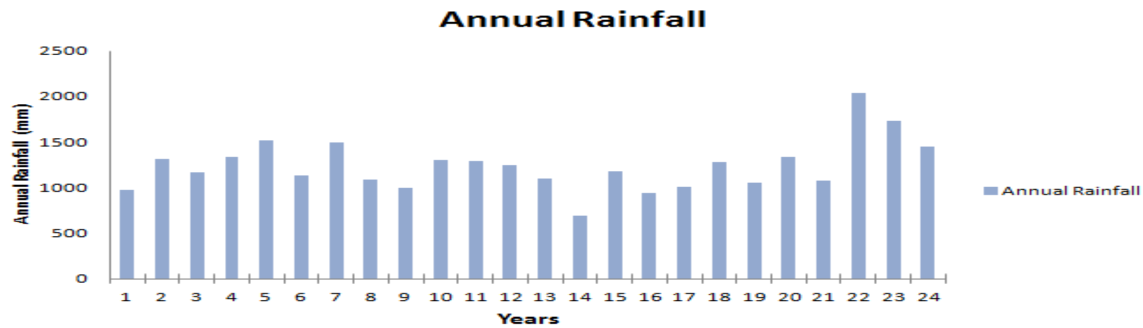

Figure 2: Annual Rainfall distribution of Kogi state between 1985 and 2008

SPI/ Anormally index

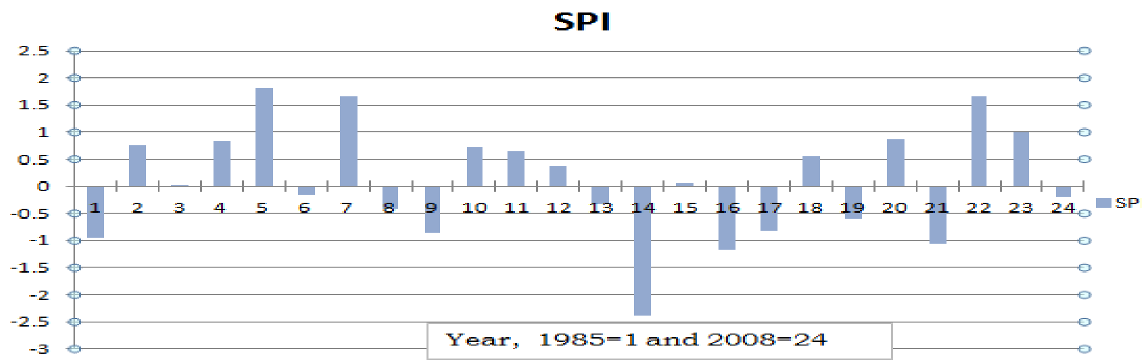

Figure 3: Standardized precipitation index (SPI) of Kogi state within the period of 1985 to 2008

The SPI is an index based on the probability of precipitation for any time scale. Variation in rainfall pattern and distribution over a region is best explained using the Standardized Precipitation Index to show variation and different conditions caused either by excess or deficiency in precipitation. There is variation in rainfall pattern over this region and also based on McKee classification, Kogi state has been experiencing extremely wet condition. Moreover, the rate of occurrence of this very wet condition is higher than the rate of occurrence of very dry and extremely dry condition. However, this very wet condition is likely to result into flooding. This possible variation could be through industrial activities which contribute to high rate of emission of greenhouse gases most especially Carbon dioxide (CO_2) into the atmosphere. However, as a result of urbanization, deforestation has taken place; the vegetation which is expected to serve as carbon sinks has been destroyed. The land use and land cover (LULC) map of the study area shows the extent of vegetation serving as carbon sink.

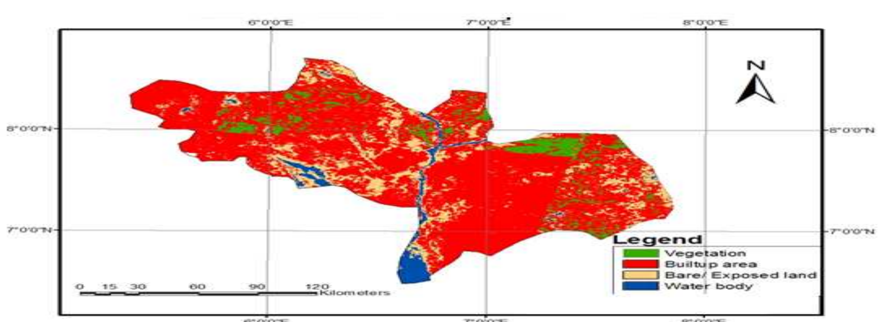

Figure 4: shows kogi state land use and land cover(LULC)

It was shown from figure 4 that the Land Use Land Cover (LULC) Map of Kogi state is dominated with Built up areas, low amount of vegetation and bare/exposed land. The presence of this built up areas render the land surface impervious, which makes it difficult for water on the surface to infiltrate into the ground, thereby contributing to the increase in surface run off.

Digital Elevation Model (DEM) of Kogi state

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The Hydrology DEM shows the DEM generated from the SRTM imagery (figure 5) in which all the sinks exist, meanwhile most sink is as a result of error in the data, and before the drainage basin must be delineated, the sink must be filled to obtain a depression less DEM, so the hydrology DEM in this study is DEM which the sink has not been filled. The DEM shows the elevation of Kogi state which ranges from the highest elevation of 89.72 metres to the lowest elevation of 0 metres above mean sea level.

In the hydrological model tool in ArcGIS, before the delineation of a drainage basin can be done, all sinks need to be filled which is a readily available process of Arc Hydro. The sink areas are pixels which have heights that are lower than neighboring pixel values. For drainage analysis to proceed, the Agreed DEM produce in Figure 6 is the DEM used in the determination or computation of flow direction and flow accumulation of water. As shown in figure 5 and 6 , the hydrology DEM and agreed DEM are similar, but the only difference is that the sink in the Agreed DEM has been filled; now all the runoff from the Agreed DEM will reach its edges.

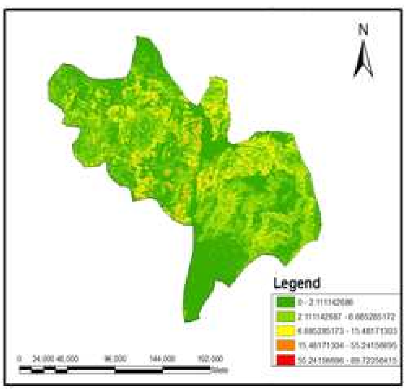

Figure 5: shows hydrological digital elevation model (DEM) of kogi state

Figure 6: shows Flow Direction on Digital Elevation Model (DEM) of Kogi state

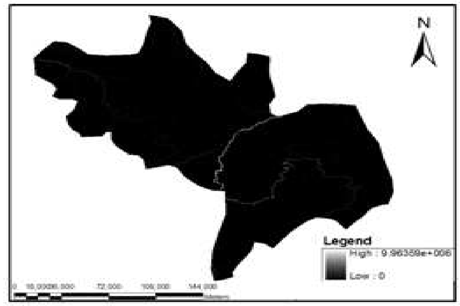

Figure 7: shows Flow Accumulation on Digital Elevation Model (DEM) Kogi state

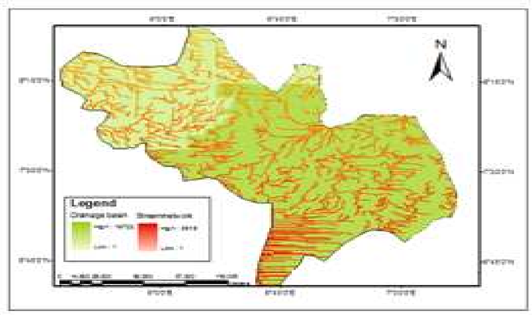

Figure 8: shows Stream Network on Drainage Basin of Kogi state

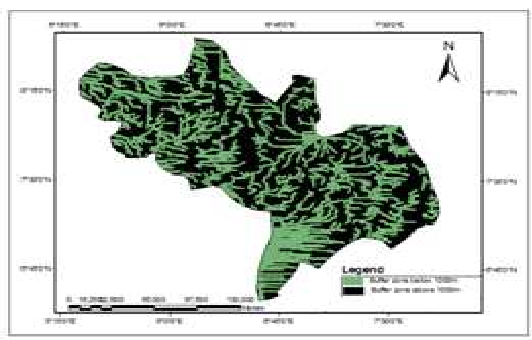

Figure 9: shows buffered zone of the Stream Network of Kogi state

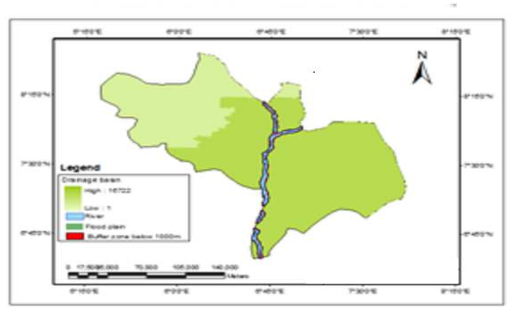

Figure 10: shows buffered zone of the Niger-river in Kogi state

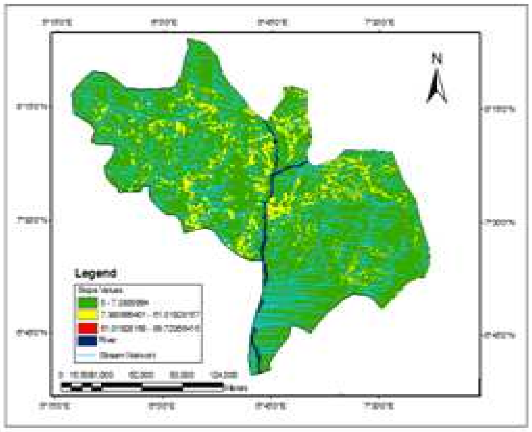

Figure 11: shows map of slope on DEM of Kogi state

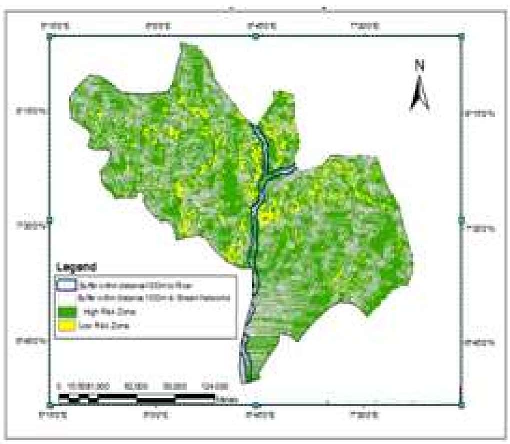

Figure 12: shows flood risk map of the study area

The hydrology analysis in Figure 5, computes the flow accumulation. This is a function that takes as input a flow direction grid in figure 6 and computes the associated flow accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid. Figure 5 shows the cells that have the greatest accumulation (areas of concentrated flow) of water flowing on the surface of the elevation model which are used to identifying stream channel in figure 9. The accumulated flow grid shows the white lines as the cells which have the highest accumulated flows and as such shows the path water will follow to get to lower grounds.

From figure 9, it was seen that areas displayed in green colour falls within the 1000m buffer and areas displayed in black falls within areas above 1000m buffer. With this result, it is seen that built up or urban areas within the 1000m buffer zone are areas that are vulnerable to flood when there is extreme release of water in any form (heavy rainfall, release of water from dam or dam failure) but areas above 1000m buffer zone are areas that less vulnerable under the same condition.

Another important factor to consider in determining vulnerable areas is the distance of the river to built up areas and the flood plain areas, from figure 11above, it was seen that the river is displayed in blue colour, flood plain in green and buffer zone in red. The red symbolizes areas within the 1000m river buffer zone. Settlements and built up within the red area are most likely to be inundated or submerged under extreme condition of rainfall. However, the flood plain is not visible based on the fact that, the buffer zone has covered the flood plain, which shows the buffer zone has put into account all analysis that was expected to be done on the flood plain.

Other factor to consider in flood risk mapping is the slope steepness of the elevation. The lower the elevation of a particular area or region, the closer is the area to water level and vice versa, Figure 12 shows the result of the slope values of the study area terrain. Areas with slope values between 0- 7.3889994 which are within the stream and river buffer of 1000m distance are likely to be inundated during the event of heavy and sudden discharge of water or rainfall..

Discussion

This result above shows that majority of the settlements are very vulnerable to flooding. It can be seen from the second flood risk map in figure 12, after the overlay function has been made (overlaying of major settlements, stream network, digital elevation model, river and stream network buffer). It was observed that most of the settlements in Lokoja and environs are located on and around the stream network and on the flood plain. Any discharge or release of water in any form over this terrain, will lead to accumulation of water in the stream network expanding its course and increase in sea level rise, which may likely result to devastating flood events.

V. Conclusion and Recommendations

In this study, geospatial techniques was integrated for mapping and analysis of flood extent and vulnerable areas. The study cleared delineated the flooded areas, classified the vulnerable areas and pointing out the risk zones. This study generated a flood risk map for Kogi state. The particular focus of this paper is to identify areas which are less and most vulnerable to flood events based on digital elevation model and hydrological analysis putting into consideration settlements on or around the stream network and flood plain. It was deduced from the hydrological analysis, that most of the settlements in this area are located on low lands, and also on the stream networks and flood plain. Any excessive discharge/release of water on this terrain may lead to increase in volume of the stream networks and extension of the river to the flood plain which is disastrous to inhabitants in most vulnerable areas.

It is therefore recommended that ,

1. The construction of hydrological infrastructures like buffer dams for temporary storage of excess river flow from up-stream of a rivers, and also well constructed spill ways to avoid collapse of dams.
2. Communities should be strongly discouraged from settling within the flood plains despite their ancestral, regions or cultural norms and beliefs

3. Discouraging deforestation and promoting Afforestation, and preserving mangrove forest along the river bank as natural shield from flood disaster
4. Sensitization programs on flood disaster risk management and mitigation should be flogged up and promoted by governmental and non-governmental organization (NGOs) for settlements in flood plain environs and the society at large.

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