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# ANALYSIS OF FLOOD RISK AND VULNERABILITY ASSESSMENT OF FLOOD PLAIN OF KOGI STATE

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## Abstract

A flood risk and vulnerability assessment of Kogi state, Nigeria was investigated. The objectives were to identify vulnerable flood prone areas, map the vulnerable areas and spatial extent of flood disaster risk areas in the study area. Field observation, geospatial techniques using remote sensing and rainfall data were utilized in the analysis. Results indicate that, majority of the built up areas within - 7.3889994 which are within the stream and river buffer of 1000m distance are likely to be inundated during the event of heavy rainfall and are vulnerable to flooding. This was clearly seen from the flood risk map. After the overlay function of the images were been made (overlaying of major stream network, digital elevation model, river and stream network buffer). It is also observed that most of the built up areas in Lokoja and environs were located on and around the stream network and on the flood plain. The proximity analysis carried out indicate that built up or urban areas within the 1000m buffer zone were vulnerable to flood when there is heavy rainfall, release of water from dam while areas above 1000m buffer zone are less vulnerable under the same condition. It is recommended that building within areas within - 7.3889994 which are within the stream and river buffer of 1000m distance that are likely to be inundated during the event of heavy rainfall and are vulnerable to flooding be discourage among others.

**Key Words:** Flood, vulnerability, risk, settlement.

## Introduction

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. Most floods that occur in Nigeria include flash flood, urban flood, and coastal flood (Ojigi, 2010). These forms of flood cause a lot of catastrophe to those people that are exposed or vulnerable to it. 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. (Ologunorisa, and Abawua, 2005 Ojigi, and Shaba, 2012).

Kogi State experienced a serious flood disaster in the year 2012 and the situation was beyond description and it has attracted humanitarian assistance from NEMA, Red Cross and many among others. It has render millions of people homeless, destroyed thousands of hectares of farmlands, livestock's leaving most settlements inundated. Most of the flooding came as a result of water release from Lagbo dam into River Benue, Shiroro and Kanji Dam in River Niger as well as climate change itself which led to excess precipitation (NEMA, 2012). It was also reported by NEMA that states like Niger, Kwara, Kogi, Benue, Edo, Enugu, Anambra, Rivers, Bayelsa and even some parts of the southwest of Nigeria were affected by this destructive flood. (Jayasselan, 2004)

Application of Geographical Information System (GIS) and remote sensing can be employed in many ways such as identifying and mapping areas that are vulnerable to flooding.

**Aim and Objectives**

The aim of the study is to develop a vulnerability profile to floods using appropriate vulnerability assessment model for decision making and disaster risk reduction.

The major objectives are;

i. To identify vulnerable flood prone areas
ii. To map the vulnerable flood plain and spatial extent of flood disaster risk areas in the study.

**Description of Study Area**

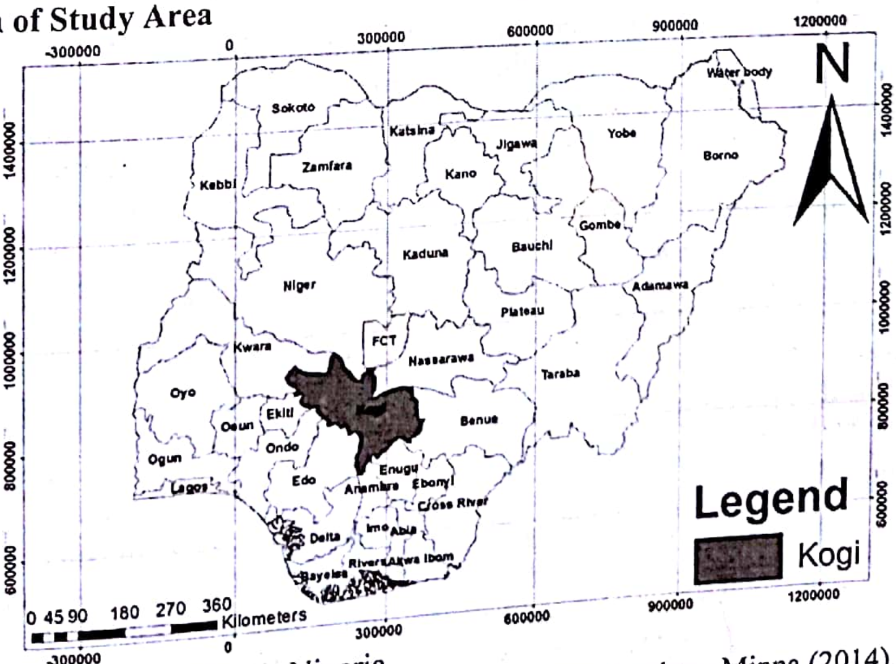


**Figure 1**: Map of Kogi State, Nigeria
**Source:** Geography Department, Federal University of Technology Minna (2014).

Kogi State is located in the central region of Nigeria, and lies between 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 (population census) in the year 2006 which was the 24$^{th}$ in the ranking of most populous state in Nigeria. It is popularly called the confluence state because of the confluence of River Niger and River Benue is at its capital. Lokoja was the first administrative capital of modern-day Nigeria. The state was created in 1991 from parts of Kwara State and Benue State. There are three main ethnic groups and languages in Kogi; Igbala, Ebira, and Okun (Part of Yoruba) with other minorities like Bassa, a small fraction of Nupe mainly in Lokoja, Gwari, Kakanda, Owuro people ( similar to Yoruba) Ogori, Mangogo and the Eggan community under Lokoja Local Government Area.

Kogi state is surrounded by many other states which are; Federal Capital territory (Nigeria) to the North, Nassarawa state to the Northeast, Benue state to the South, Enugu state to the Southeast, Anambra state to the south, Edo state to the Southwest, Ondo and Ekiti to the West, Niger state to the North and Kwara to the Northwest. Kogi state contains 21 of Nigeria's 774 Local Government Areas, They are; Adavi, Ajaokuta, Ankpa, Bassa, Dekina, Ibaji, Idah, Igalamela- Odolu, Ijumu, Kabba/Bunu, Kogi, Lokoja, Mopa-Muro, Ofu, Ogori/ Mango, Okechi, Okene, Okmaboro, Omala, Yagba East , Yagba West.

The topography of the land show that it rises from about 300 metres along the Niger-Benue conflute, to the height of between 300 and 600 metres above sea level in the uplands. Agbaja plateau, which ranges from 335 to 336 metres above sea level, and the much higher Okoroagbo hills at Ogidi in Ijumu Local Government Area are some of the predominant of land forms of the state. The state is drained by the Niger and Benue rivers and their tributaries. The lower Niger River has wide flood plains 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, 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 dry season last from November to March, with dusty and cold as a result of the north-easterly wind which brings harmattan (Adelekan, 1998)

## Materials and Methods:

### Data Source and Data Acquisition

The data used for this study were obtained from both primary and secondary sources. The Field observation/measurement involved the use of GPS receiver/handler to obtain the coordinates of the state affected by the flood. The secondary data used include the shuttle radar topographical mission (SRTM) with resolution of 90m which were used for the generation of contour lines and Digital Elevation Model (DEM). Land SatETM image with resolution of 30m were used for the Land use and land cover map (LULC) over Kogi state obtained from Global land cover facility (GLCF) in July 2010. Rainfall data of 1985 to 2008 were also acquired.

## ...ospatial Analysis and Method of Data ...esentation

The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale were used to generate the most complete high-resolution digital topographic database of the Earth. The integrated land and water information system (ILWIS) is image processing software which was used to integrate image, vector and thematic data in one unique and powerful package. The ILWIS software was used for combination and radiometric enhancement of the Landsat bands. The Supervised classification using maximum likelihood of land use land cover map of Kogi state were also used. Band 1, 2 and 3 of the Landsat 7 ETM were combined, radiometrically enhanced and rectified. Data set projection was done in World Geodetic Survey (WGS) 1984, Universal Transverse Mercator (UTM) Zone 32N. In this study, the imageries were classified using supervised classification into four major features namely, vegetation, built-up areas, bare exposed land and water body. ArcGis 9.2 GIS software written and developed by the Environmental Systems Research Institute (ESRI) is a geographic information system (GIS) tool for working with maps and geographic information. In the process the ArcGIS and Arc-Catalogue were used in this work for Vectorization of images, creating of personal geodatabase and Shape files used in performing overlay function, measuring, marking, generation of contour lines, creating of Digital Elevation Model (DEM) and creating of Digital Terrain Model (DTM).

### Data Processing and Georeferencing

Area of interest in the Shuttle Radar Topographical Mission (SRTM) satellite and Landsat imagery were extracted using Integrated Land and Water Information System (ILWIS). Imagery was zoomed to a satisfactory resolution and was masked and joined through a process known as Mosaicing. Georeferencing of the satellite image were required so as to bring them to the same ground coordinates. The Georeferencing of the satellite image were done using the ArcGis software with GPS coordinates obtained during the field survey. The projection of the datasets was projected to WGS 1984, Universal Transverse Mercator, Datum 100 Minna - Nigeria, Zone 32°N.

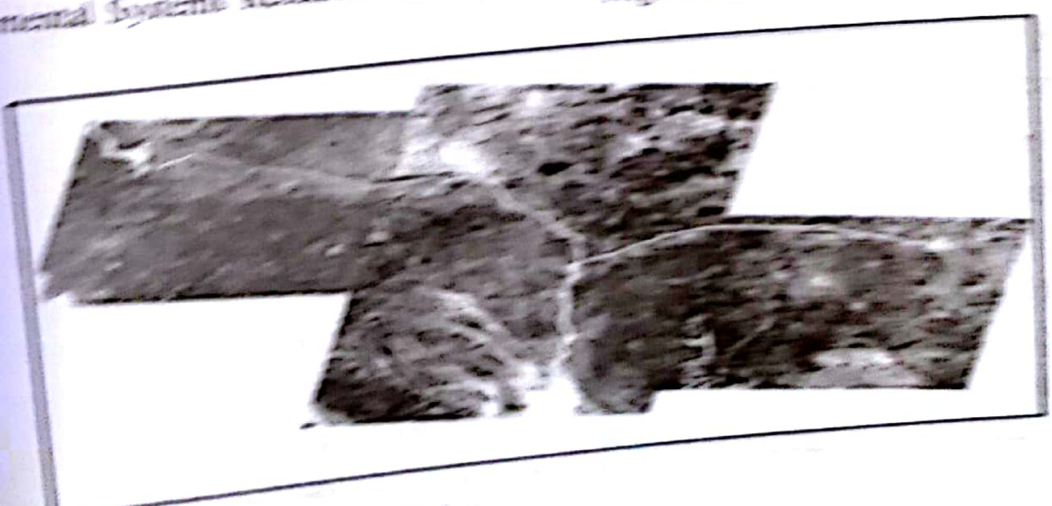

**Figure 2: Mosaiced Landsat imageries**

This is the Landsat image of the flood plains of Kogi state obtained from Global Land Cover Facility (GLCF) which was Mosaic using ArcGis for completion and proper visualization of the state.

**Classification of slope and reclassification**

The Digital Elevation Model (DEM) and contour lines are generated from the Shuttle Radar Topographical Mission (SRTM) imagery which was mosaiced in Figure 3 in the Arcmap environment. The slope angles of the Digital Elevation Model (DEM) were calculated using the spatial analyst tool and filling of sinks in the DEM. In furtherance, reclassification into three categories was performed in other to display the elevation of the region showing areas of low and high lands. The categories include; Areas with slope angles above 51 (High slope areas), Areas with slope angles between 7.38 and 51 (medium slope areas), and Areas with slope angles below 7.38 (low slope areas). The basic spatial analysis employed during this work was done in ArcMap;

**The classification of rainfall variation**

**Proximity Analysis (Buffering)**

Buffers of specific distance were done 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 the created stream network to the built-up areas were identified and mapped. Also, the study area was classified into zones of most vulnerable, less vulnerable, non vulnerable region.

**Overlay of layers and creation of flood risk map**

The determination of slope, creation of stream buffer areas and river buffer areas, the draping of these layers on each other produces a new layer showing the three risk zones. Areas within the stream buffer zone and in the low land area are classified as higher risk zones, Areas within the stream buffer zone and medium slope areas are the medium risk areas and also areas within the stream buffer zone and high slope areas are the less risk areas.

**Table 1: The rainfall variation classification adopted from McKee *et al.*, 1993)**

| SPI Values | Conditions |
|---|---|
| 2.0+ | Extremely wet |
| 1.5 to 1.99 | Very wet |
| 1.0 to 1.49 | Moderately wet |
| -0.99 to 0.99 | Near normal |
| -1.0 to -1.49 | Moderately dry |
| -1.5 to -1.99 | Severely dry |
| -2 and less | Extremely dry |

## Result and Discussions

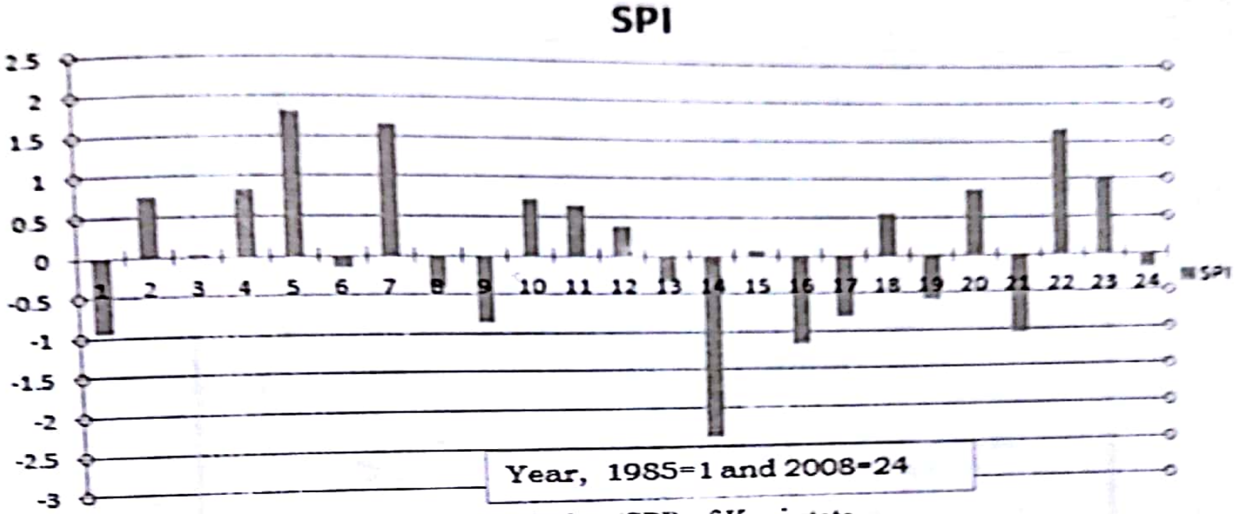


**Figure 3**: Standardized precipitation index (SPI) of Kogi state

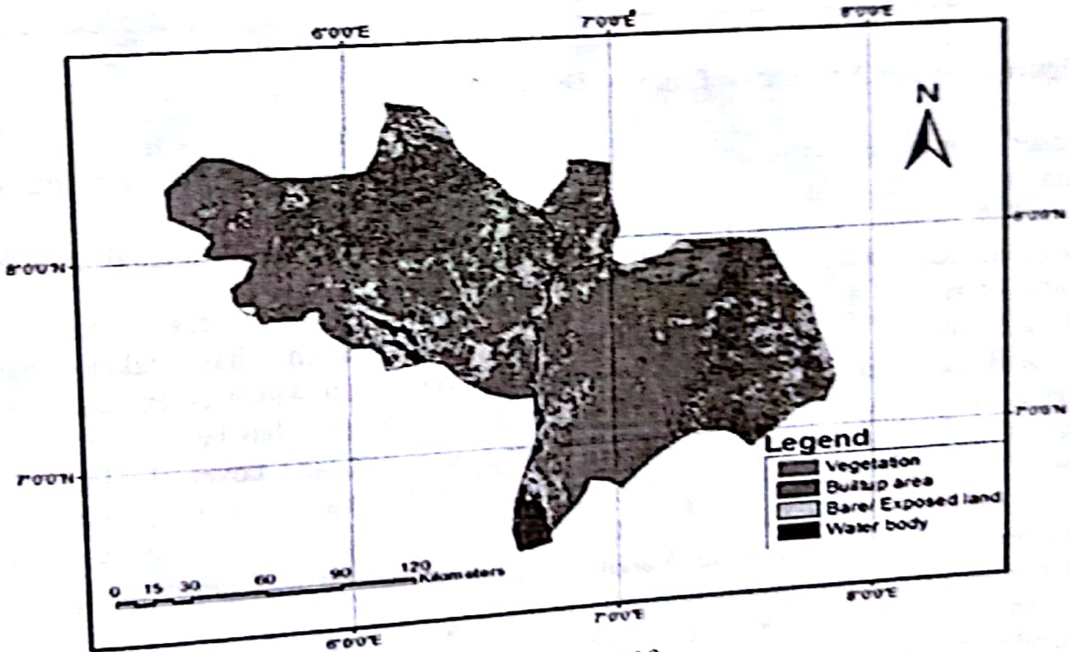


**Figure 4:** kogi state land use and land cover (LULC) 2010

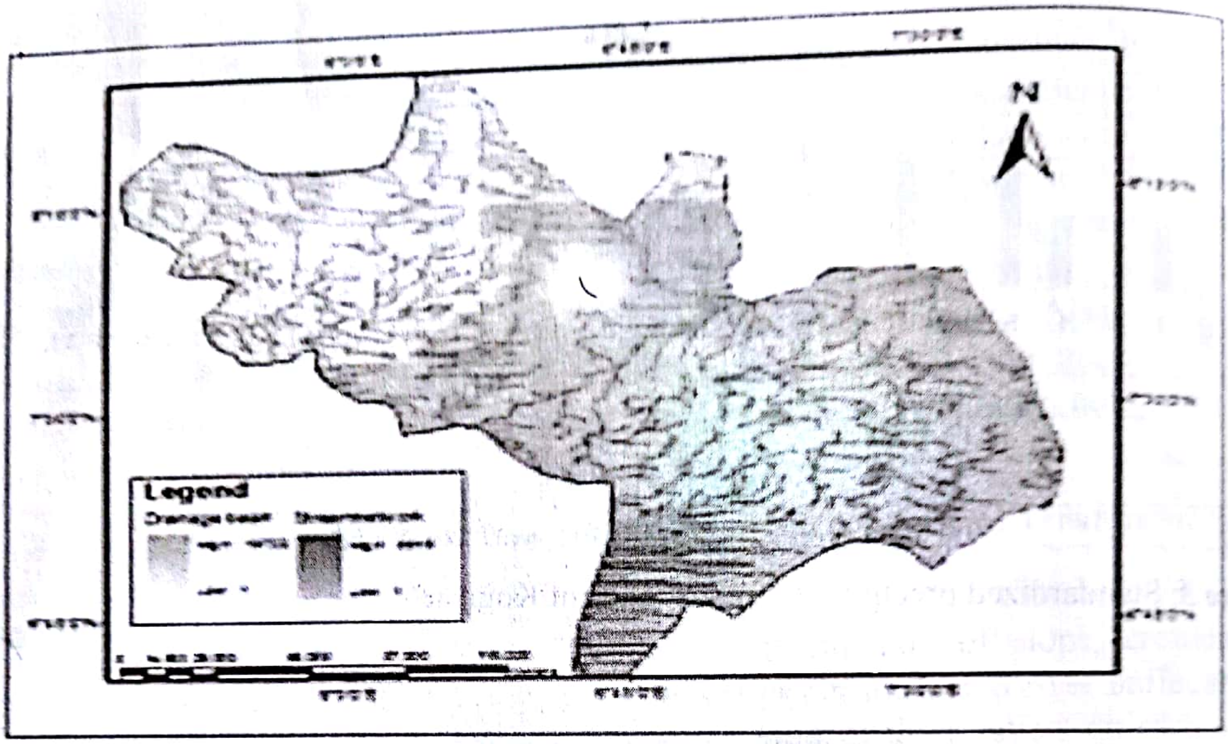


**Figure 5:** Stream Network on Drainage Basin of Kogi state 2010

Under normal circumstances the mean rainfall of Kogi state is expected to be 97.08mm which is the climatologically mean derived from the 23 years (Annual Mean of rainfall data) but as a result of climate change, the deviation from this climatologically mean has occurred. The figure above shows the annual rainfall pattern and Standardized Precipitation Index (SPI) or Rainfall Anomaly. 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.

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 cover available in the study area serving as carbon sink.

As shown in figure 5 above the Land Use Land Cover (LULC) Map of Kogi state, the region 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.

In the stream network map (figure 6), a specify threshold of any pixel more than 2000 pixels made up part of the stream network. Water released through this stream network will leave at the lowest part (pour point) of each of the drainage basin separated from adjacent basin by the drainage divider. Settlements or urban areas on or around these stream networks are likely to be submerged or inundated when there is a high release of water in any form. In other to show areas that are most and less vulnerable. A proximity analysis was carried out; a query was done to check the proximity of features to the stream networks. The query results as shown respectively.

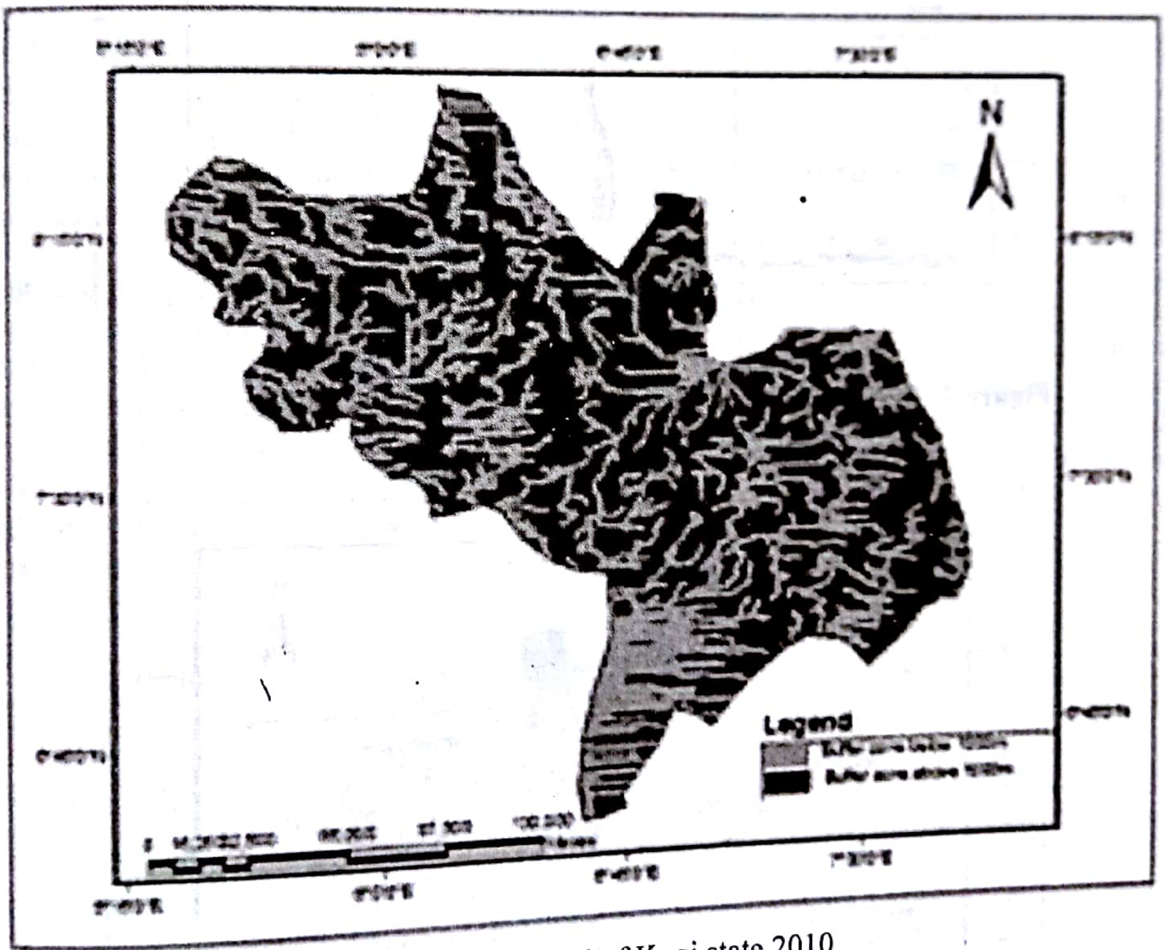


**Figure 6:** Buffered zone of the Stream Networkof Kogi state 2010

From figure7 above, itrevealed 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.

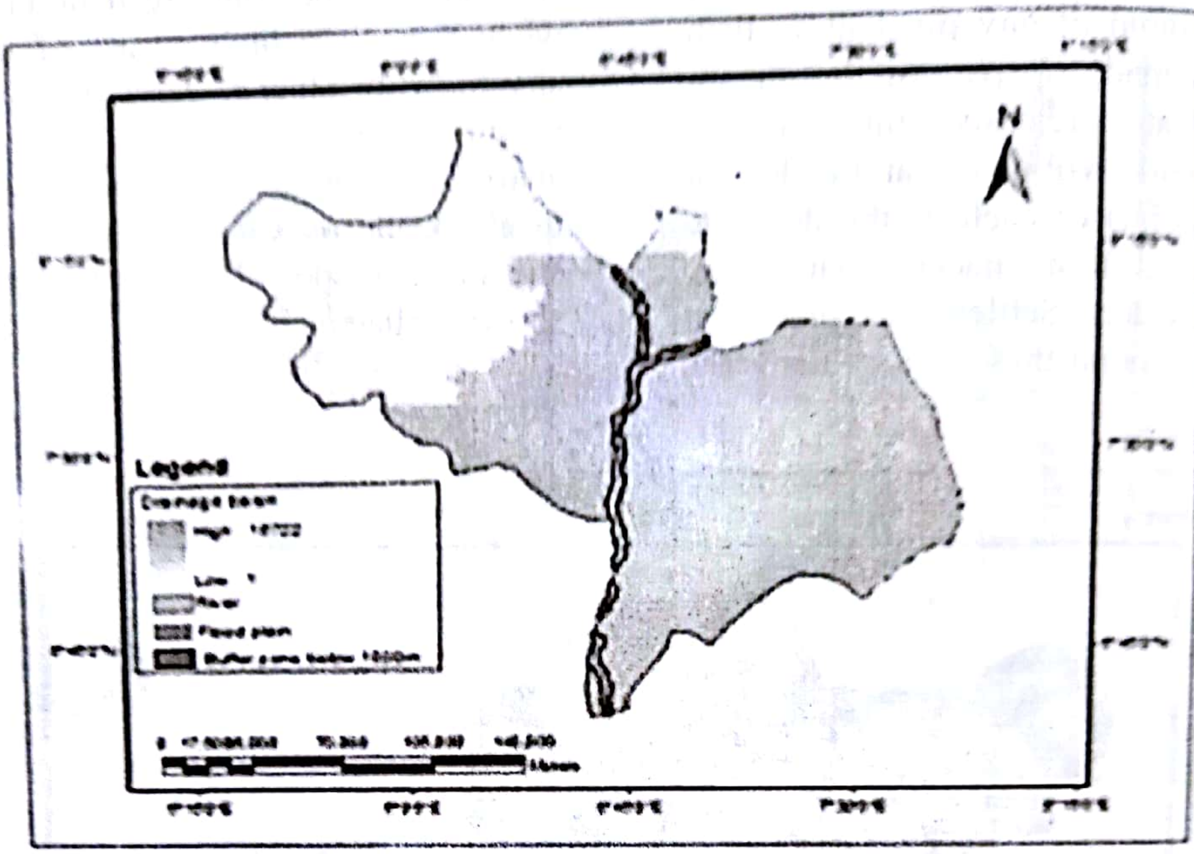


**Figure 7:** Buffered zone of the Niger-river in Kogi state 20100

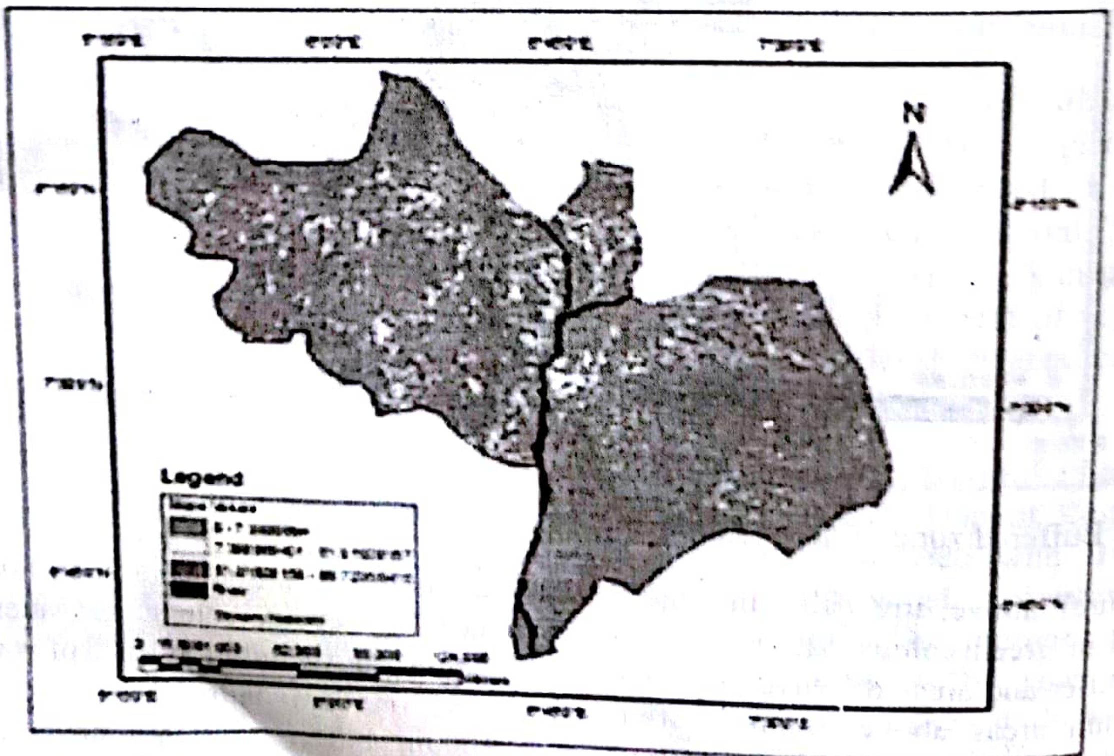


**Figure 8:** Map of slope on DEM of Kogi state 2010

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 figure8 above, 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. The 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, Figure9 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. However, under the same condition, areas with slope values above 7.3889994 shown in the figure above which are also within the buffer of 1000m distance from stream network and the river are likely not to be submerged/ inundated.

The overlaying of the reclassified agreed DEM of the study area, buffer zone within 1000m to the stream network and the river are used in classification of different vulnerable areas or flood risk zones. But overlaying of the flood plain show the result of built up areas which are within the flood risk zones Kogi state. The built up areas within these risk zones are likely to be inundated under very high torrential rainfall or release of water in any form over the terrain. Figure 8 and 9 show the flood risk maps of the study areas with built up areas.

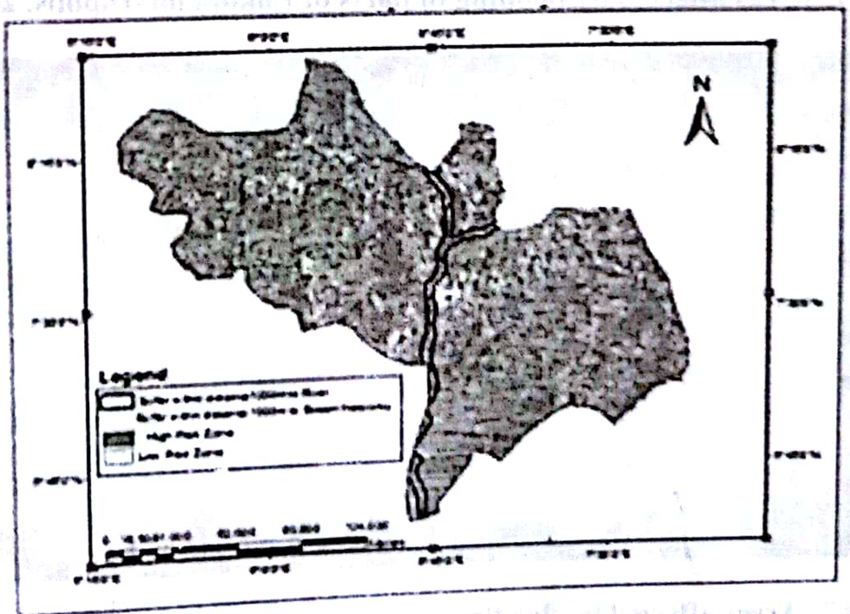


**Figure 9:** Flood risk map of the study area, 2010

The result above shows that majority of the settlements are very vulnerable to flooding. It can be seen from the flood risk map in figure10, 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.

**Plate 1: Areas affected by flooding in parts of Lokoja metropolis, 2014**

**Plate 2: Areas affected by flooding in parts of Lokoja metropolis 2014**

## Conclusion and Recommendations

This paper identify and map areas vulnerable to flooding in Kogi state, through the use of geospatial techniques incorporated with vulnerability assessment in identifying flood plain in the 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 places on or around the stream network and flood plain. It reveals that 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 rainfall. It also reveal from the hydrological analysis, that most of the built up areas 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 may be disastrous to inhabitants in most vulnerable areas.

The recommendations from this researcher are listed below.

i. 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.

ii. Settling in the area between 0- 7.3889994 which are within the stream and river buffer of 1000m distance that are likely to be inundated during the event of heavy rainfall should be discourage.

## References

Adelekan, I O (1998), "Spatio-temporal variations in thunderstorm rainfall over Nigeria" *International Journal of Climatology*, 18, pages 1273 – 1284

Jayasselan A. T., (2004), Drought and Floods Assessment and Monitoring Using Remote Sensing and GIS, *Proceedings of the Training Workshop on Satellite Remote Sensing and GIS Applications in Agricultural Meteorology*, World Meteorological Organization, Geneva, pp. 291-313.

National Emergency Management Agency (NEMA) (2012), Home, available at www.nema.gov.ng, last assessed December 17, 2013

Ojigi, M. L., (2010). Flood Hazard and Risk Mapping of Birnin Kebbi and Environs, Using Geospatial Techniques. *Journal of Geographic Information Science Vol.1 no.1 (Maiden Edition). 2010. A technical/scientific publication of Geoinformation Society of Nigeria (GEOSON) (in press).*

Ojigi, M. L. and Shaba, A. H.,(2012). Integration of Synthetic Aperture Radar (SAR) Imagery and Digital Terrain Model for Determining Flood Water Threshold in Sokoto and Environs, Nigeria. Proceedings of *the Geoinformation Society of Nigeria (GEOSON) & Nigerian Cartographic Association (NCA) Joint Annual Workshop/Conference held at Regional Centre for Training in Aerospace Surveys (RECTAS) Obafemi Awolowo University . Ile-Ife, Nigeria.19th–22nd November, 2012.* Pp. 291-303

Ologunorisa, T. E. and Abawua, M. J., (2005). Flood risk assessment: a review. Journal of Appl. Sci. Environmental Management, 9 (1), pages 57 – 63.