Gombe Journal of Geography and Environmental Studies (GOJGES)

Vol. 1 N0.3 Dec. 2020

e-ISSN: 2714-321X

p-ISSN: 2714-3201

http://www.gojgesjournal.com

Gombe Journal of Geography and Environmental Studies (GOJGES) Vol. 1 N0.3 Dec. 2020, e-ISSN: 2714-321X; p-ISSN: 2714-3201

ANALYSIS OF FLOOD PRONE AREAS IN GOMBE METROPOLIS, NIGERIA USING GIS TECHNIQUES.

[1]Yahaya, I [2]Bappi, A [3]Jibril, B. A
[1 2] Department of Geography, Gombe State University, Gombe State Nigeria
[3]Department of Geo-informatics, National Center for Remote Sensing, Jos.
P. M. B 127, Gombe State, Nigeria
Corresponding Email:yahayaibrahim1455@gmail.com yahayaibrahim32@gsu.edu.ng

Abstract

Natural risk vulnerability mapping is considered one of the most important steps in disaster risk reduction because it identifies areas vulnerable to disaster so as to plan for disaster risk management. The research is primarily aimed at assessing the flood prone areas in Gombe metropolis. The objectives followed were to produced and identify various landuse and landcover types for the study area, establish various criteria for flood modeling, produce flood inundation model, identify elements at risk in the study areas. The data used in this study were landsat-8 OLI and SRTM. Remote sensing and GIS tools were used in producing landuse and landcover map using maximum likelihood classification algorithm. Flood inundation factors such as Overland Flow Length, Terrain Wetness Index DEM and Proximity) were derived using DEM hydro-processing. According to the classified vulnerability model, vulnerability class cover 1057.5Ha of land which is equivalent to 6.6% of the total study area; upon which build up areas covers 1.21%, farmland 4.52%, fadama 0.19%, bare surface 0.50%, shrubs 0.17% and woodland 0.02%. The research recommended that government should provide more infrastructural facilities to flood prone to moderate the risk of disaster.

Keywords: Analysis, Flood Prone Areas, Remote Sensing, GIS, Gombe Metropolis,

1. Introduction

Floods happen in varying locations and at varying magnitudes giving them markedly different effects on the environment. Flood hazard comprises many aspects which include structural and erosion damage, contamination of food and water, disruption of socio economic activity including transport and communication, as well as loss of life and property (Hewitt and Burton, 1971). Some of the causal factors of flood disasters in Nigeria include land inundation from heavy rainfall, climate change, and blockage of drainages with refuse, construction of buildings across drainages, inadequate drainage networks, and population increase in urban areas. These factors do not act independently and flood disasters usually occur from a combination of several of them (Adeoye et al, 2009). There is a relationship between urbanization and hydrological characteristics; decreased infiltration, increase in run-off, increase in frequency and flood height. Adequate geographic information on hazards and areas vulnerable to hazards is required to be able to prepare for disasters. Hazard risk vulnerability mapping is considered one of the most important steps in disaster risk reduction because it identifies areas vulnerable to disaster so as to plan for disaster risk management.

Nigeria has been slow to realize the potential possessed by remote sensing and GIS in flood disaster management. This is confirmed by the response to the recent flood disasters that have affected more than 23 states of the country, that claimed many lives and properties, and threatened the ecological biodiversity. Mitigation of flood disaster can be successful only when detailed knowledge is obtained about the expected frequency, character and magnitude of hazardous events in an area as well as the vulnerabilities of the people, buildings, infrastructure and economic activities in a potentially dangerous area. Unfortunately this detailed knowledge is always lacking in most urban centers of the developing world like Nigeria (Ishaya et al., 2009). Goel et al. (2005) presented the technique for preparation of flood hazard maps which include development of digital elevation model and simulation of flood flows of different return periods. Bhadra et al (2011) proved that GIS technique is effective in extracting the flood inundation extent in a time and cost effective manner for the remotely located hilly basin of Dikrong, where conducting conventional surveys is very difficult. Thilagavathi (2011) used GIS to demarcate the flood hazard prone areas in the Papanasam Taluk into five zones of varying degrees of flooding. Moreover, Orok (2011) stated that a flood risk map should be able to identify the areas that are most vulnerable to flooding and estimate the number of people that will be affected by floods in a particular area. In Nigeria, hazard vulnerability maps for many areas are lacking and the available ones are obsolete. Ishaya et al (2009) created digital terrain maps and flood vulnerability maps of Gwagwalada in Abuja showing the areas that were highly vulnerable, less vulnerable and areas vulnerable to flood disaster. Muhammad et al. (2013) used remote sensing and GIS techniques to produce flood map of the middle course of river Kaduna and they classified the area into three zones of high, moderate and low risk. Jeb and Aggarwal (2008) carried out a study with the aim of analyzing flood risk and modeling plans for flood abatement in Kaduna metropolis. Given the recurrent nature of the flood problem in Kaduna metropolis, they recommended further research for efficient risk management system which could estimate the lives at risk due to flooding. This paper presents flood vulnerability map in Gombe metropolis. Gombe metropolis is considered due to its topography, streams and history of flood occurrences that devastate settlements around the area. Gombe metropolis has suffered severe flood disasters as results of heavy rainfall, drainage system and topography. Among the recent floods were in August, especially the floods of 2004, 2009 and the one of 2014 resulted in the loss of 46 lives, destruction of 180 houses, washing away of 50% of farmland and destroyed houses. Adebayo, (2007) (National Sun Daily 27th August 2007).

The research is therefore aimed at analyzing the flood prone areas in Gombe metropolis, with specific objectives of Identify factors responsible for flooding in the study area, produce flood inundation model in the study area and determine elements at risk in the study area.

2. The Study Area

Gombe town is located between latitudes 10^o to 10^o20^1 N and longitudes 11^o01^1 E and 11^o19^1E (Figure 1). It shares common boundary with Akko LGA in the South and West; Yamaltu-Deba to the East and Kwami to the North. It is the capital of Gombe State and occupies an area of about 45km2 (Ministry of Land and Survey, Gombe, 2008).

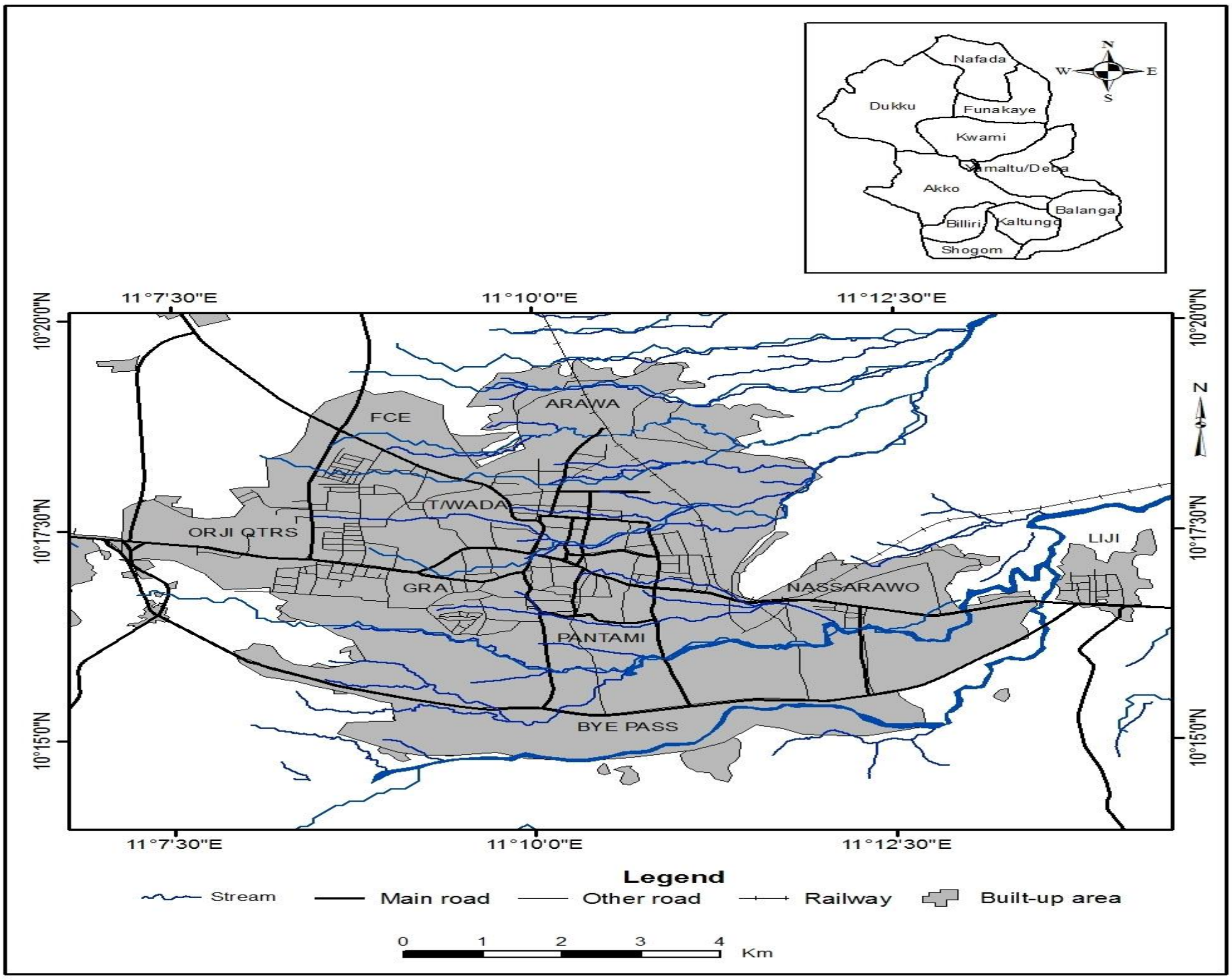

Figure 1: Map of Gombe state showing study area
Source: GIS Lab Gombe State University

3. Material and Methods

3.1 Production of Landuse and Land cover Map

Supervised classification technique was employed in producing landuse and land cover map covering the study area. The statistical signatures file generated and the Landsat image served as input data in the Maximum Likelihood Classification tool in ArcGIS 10.3 and finally give out the land use and land cover map of the study area as shown in figure 3.1 below:

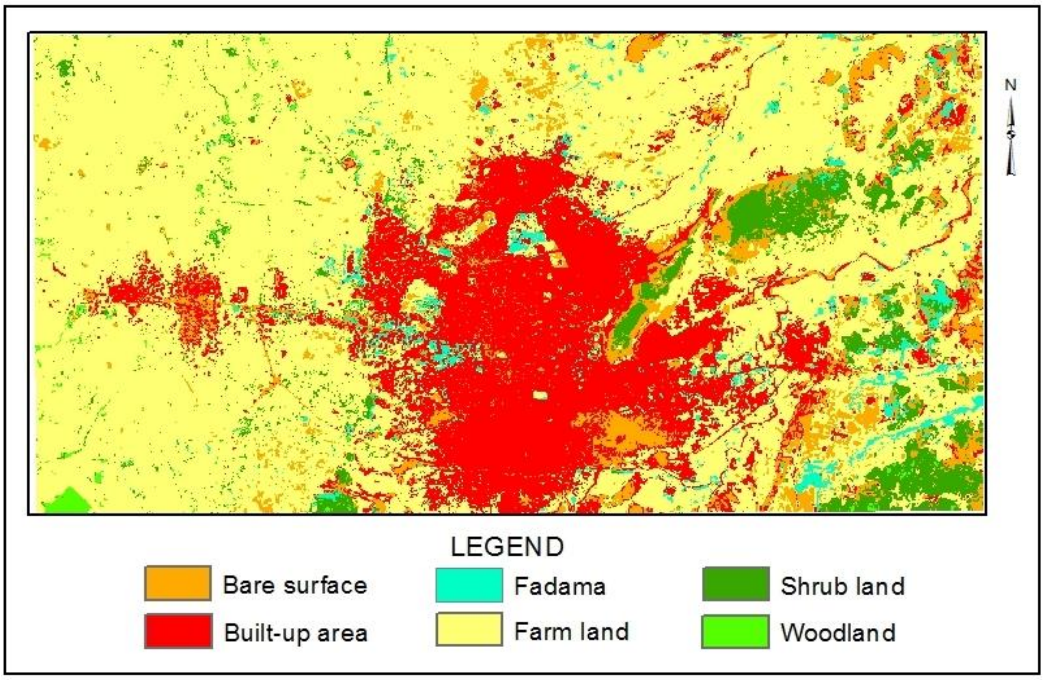

Figure 2: Landuse and Landcover of the Gombe Metropolis.

3.2 Derivation of Criteria for Flood Vulnerability Modeling

The criteria were derived from the comparative study review of other works on flood vulnerability mapping. The maim criterion is DEM from which fill sink, Terrain Wetness Index (TWI), and Overland Flow Length were generated. The other criterion considered is proximity to hydrological channels. The mentioned factors for the identification of flood vulnerable areas were produced using DEM hydro-processing tools in ILWIS 3.8 software. Figure 3 below demonstrates the processes followed in producing the factors.

.

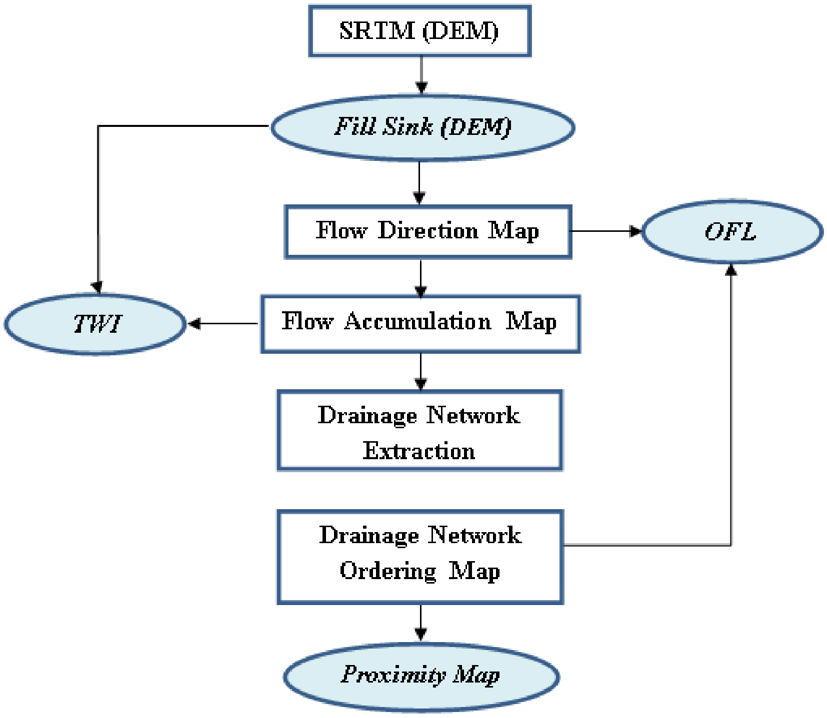

Figure 3: Flow Chart for the Creation of Flood Vulnerability Factors

3.3 Flow Determination Parameters
Prior to the derivation of flood vulnerability factors, flow determination parameters were first determined.

3.3.1 Fill Sink
The height above the mean sea level of a particular place helps determine the level of vulnerability of such places to sea rising or flood occurrences, areas with low elevation can be vulnerable to flooding than areas with appreciable height, is an operation that rounds up elevation to the nearest integer values.

3.3.2 Flow Direction
The direction of flow is determined by the direction of steepest descend. Flow direction was calculated for every central pixel of input blocks of 3 by 3 pixels,

3.3.3 Flow Accumulation
Flow accumulation operation performs a cumulative count of the number of pixels that naturally drain into outlets using the flow direction dataset.

3.3.4 Drainage Network Extraction
The Drainage Network Extraction operation was performed to extract basic drainage network using Boolean operation.

3.3.5 The Drainage Network Ordering
This operation examines all drainage lines in the drainage network map, to find the nodes where two or more streams meet, and the streams that only have a single node.

4. Flood Vulnerability Factors

The above four flow determination parameters (DEM, flow direction, flow accumulation and drainage network raster data set) were used in deriving the main flood vulnerability factors.

4.1 Terrain Wetness Index

This tool was used in identifying susceptible saturated land surfaces and areas that carries the potentials of producing overland flow. Higher wetness index (values) in the output result (figure 3) signifies places of high flood hazards and vice versa. This factor was chosen to check the level of soil wetness in the study area and the relative reaction if there is an addition at a given time

4.2 Overland Flow Length

This operation calculates for each pixel the overland distance towards the 'nearest' drainage according to the flow paths available in the flow direction map. The tool produces a raster map (figure 3) that contains the overland down-flow distances towards the nearest drainage into which a pixel would drain according to the flow direction map.

4.3 Proximity to Rivers and Streams

The Distance operation was used for assigning each pixel the smallest distance towards the nearest drainage pixel. The tool calculated for each pixel the distance to its neighboring pixels using a 3 * 3 matrix. The result (figure 4) gives distances as the crow flies (Euclidean distance) in the projection units (meters) of the drainage network.

4.4 Reclassification of Factor Criteria

Reclassification of factors was carried out due to the fact that values in the various input maps have different meanings, factors were standardized using reclassify tool in Arc Map 10.4.1 Values in the factor maps were reclassified by grouping the range of input values into zones using standard deviation method, and the vulnerability values were assigned to each category. See figure 5 - 8

Gombe Journal of Geography and Environmental Studies (GOJGES) Vol. 1 N0.3 Dec. 2020, e-ISSN: 2714-321X; p-ISSN: 2714-3201

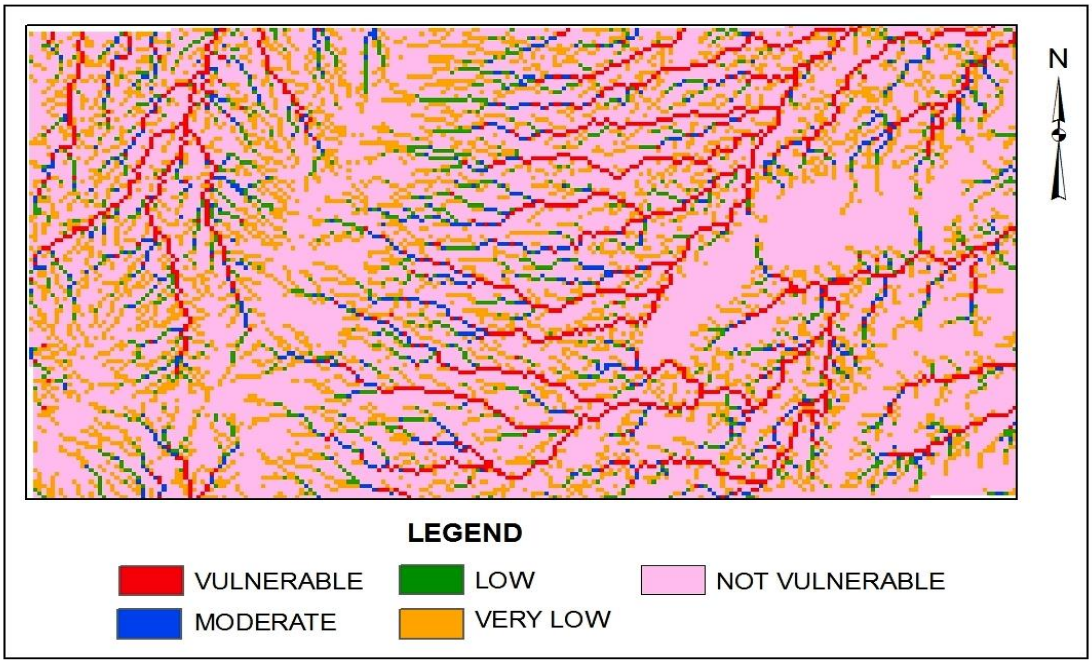

Figure 4: Terrain Wetness Index of the study Area

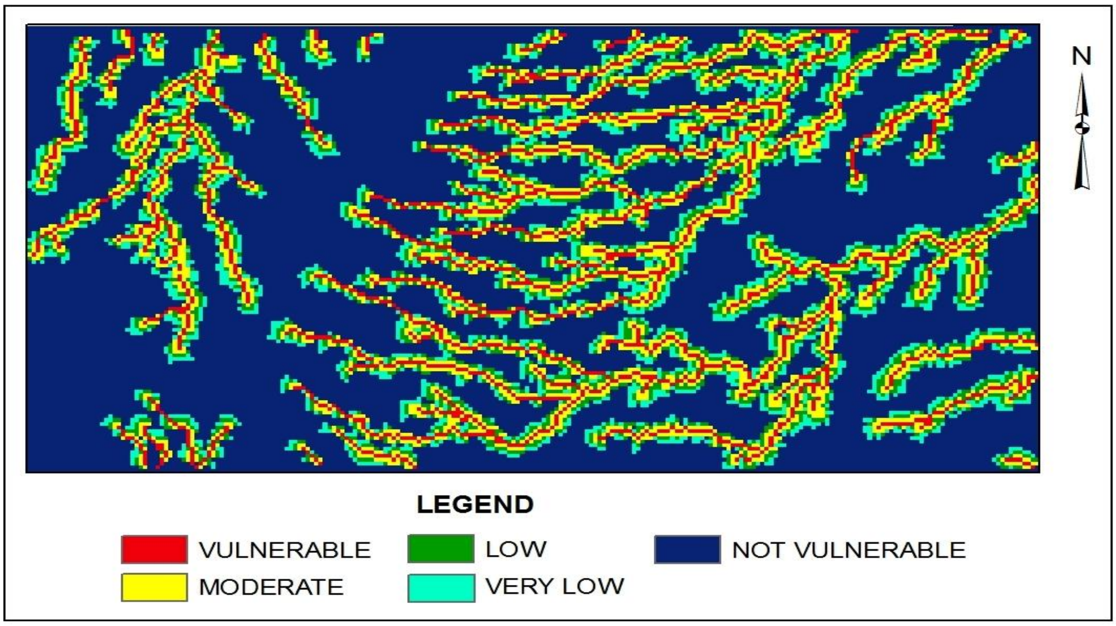

Figure 5: Overland Flow Length map of the Study Area

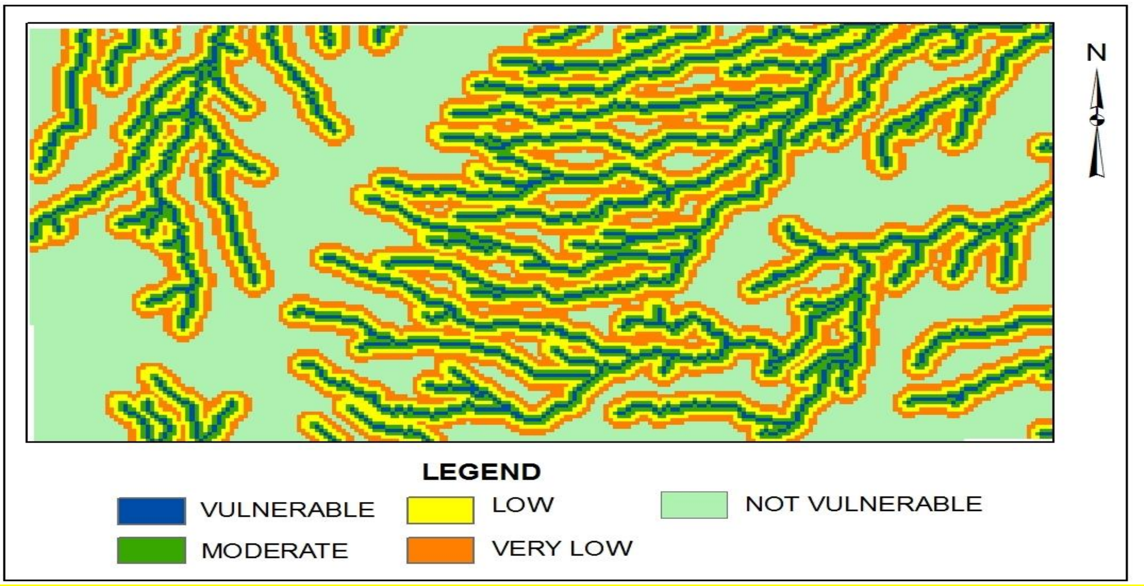

Figure 6: Proximity to River map.

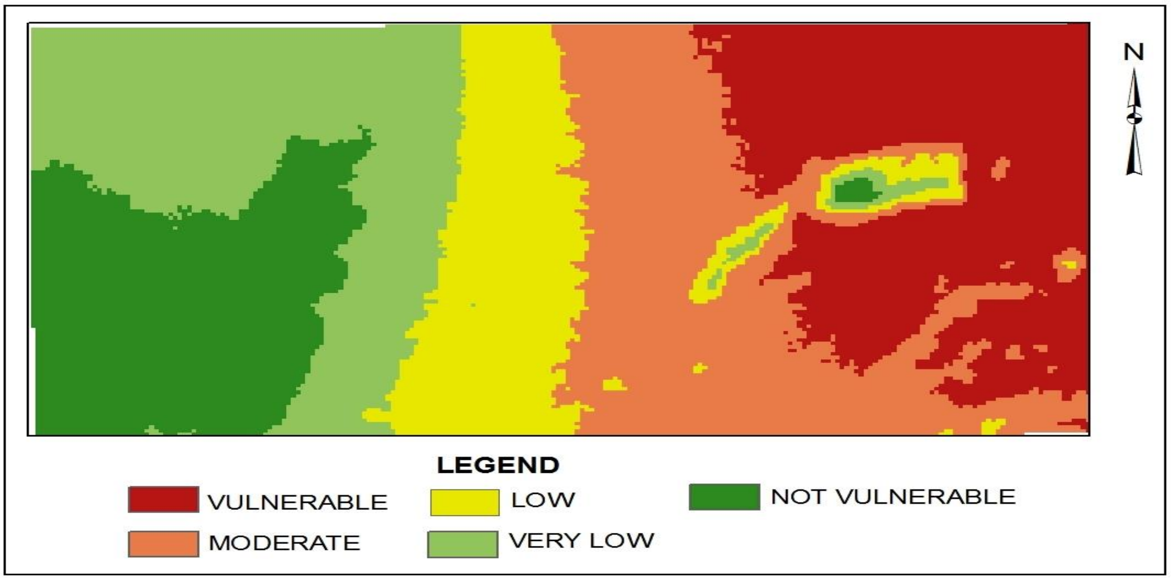

Figure 7: Classified DEM Covering the Study Area

5. Multi-criteria evaluation for flood vulnerability mapping

The Multi-Criteria Evaluation (MCE) was used to map flood vulnerable areas using weighted overlay analysis tool in Arc Map 10.4.1. The tool integrates reclassified OFL, TWI, DEM and proximity to the rivers factors into a single flood vulnerability index surface raster data (figure 8). Prior to the overlay analysis, factors were weighted in IDRISI 17.0 where their percentage of influences calculated using Analytical Hierarchy Process (AHP), as shown in figure 11. Then the index map categorized from low to highly vulnerable class (see figure 9). Finally, the land use/cover map was crossed with the reclassified flood vulnerability map where the most vulnerable elements (features) at risk were determined (figure 10). Figure 3.10 shows a procedure followed for the MCE.

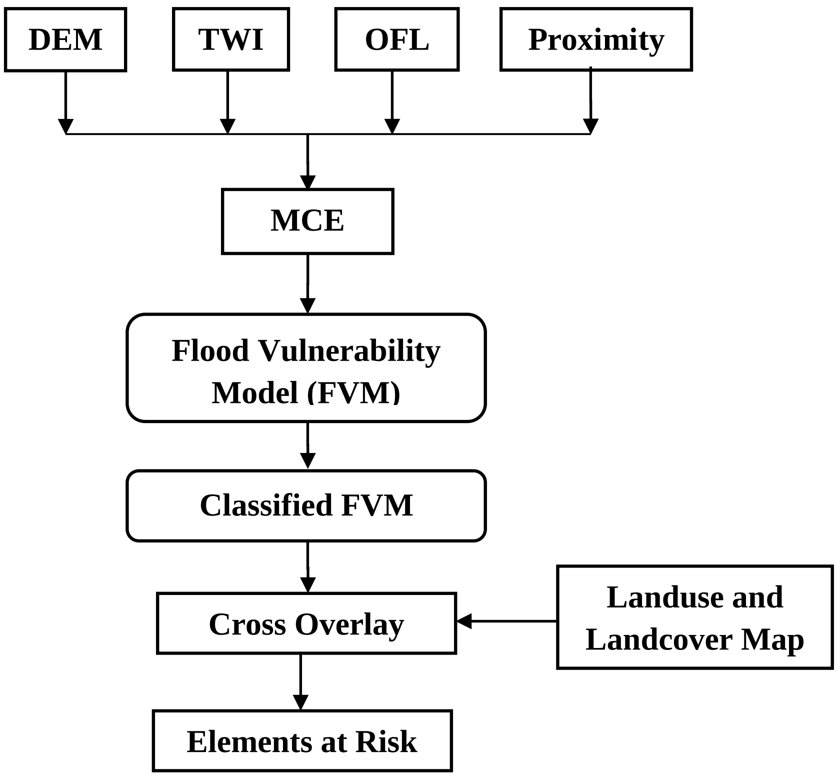

Figure 7: Flood Vulnerability Model

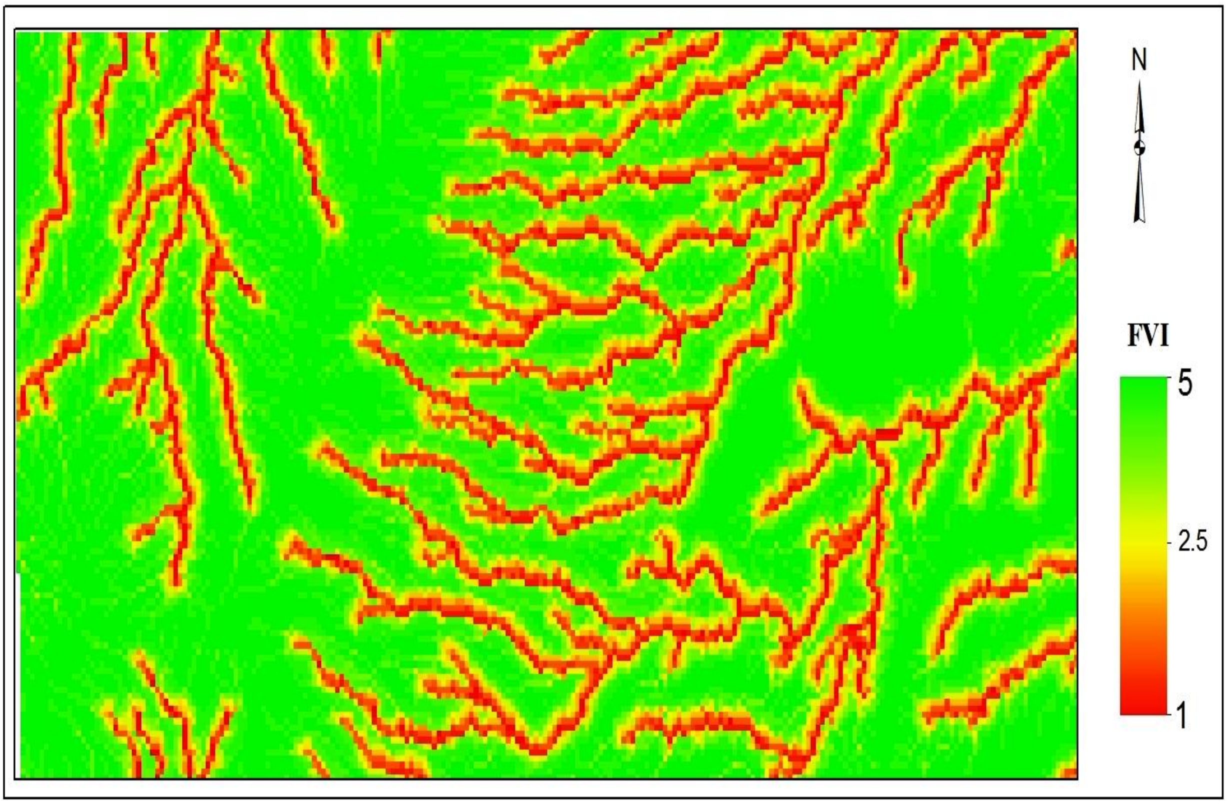

Figure 8: Flood Vulnerability Index of the study area.

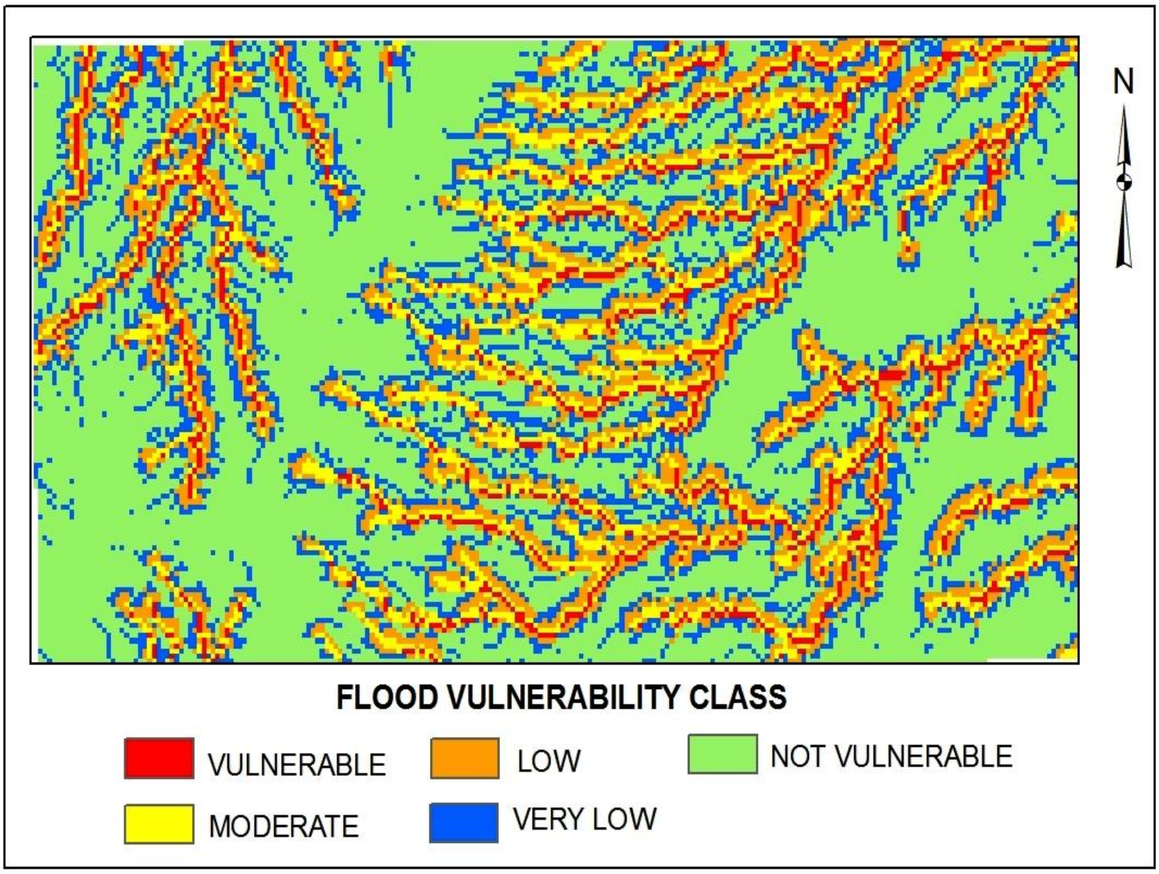

Figure 9: Classified Flood Vulnerability Map of the study area.

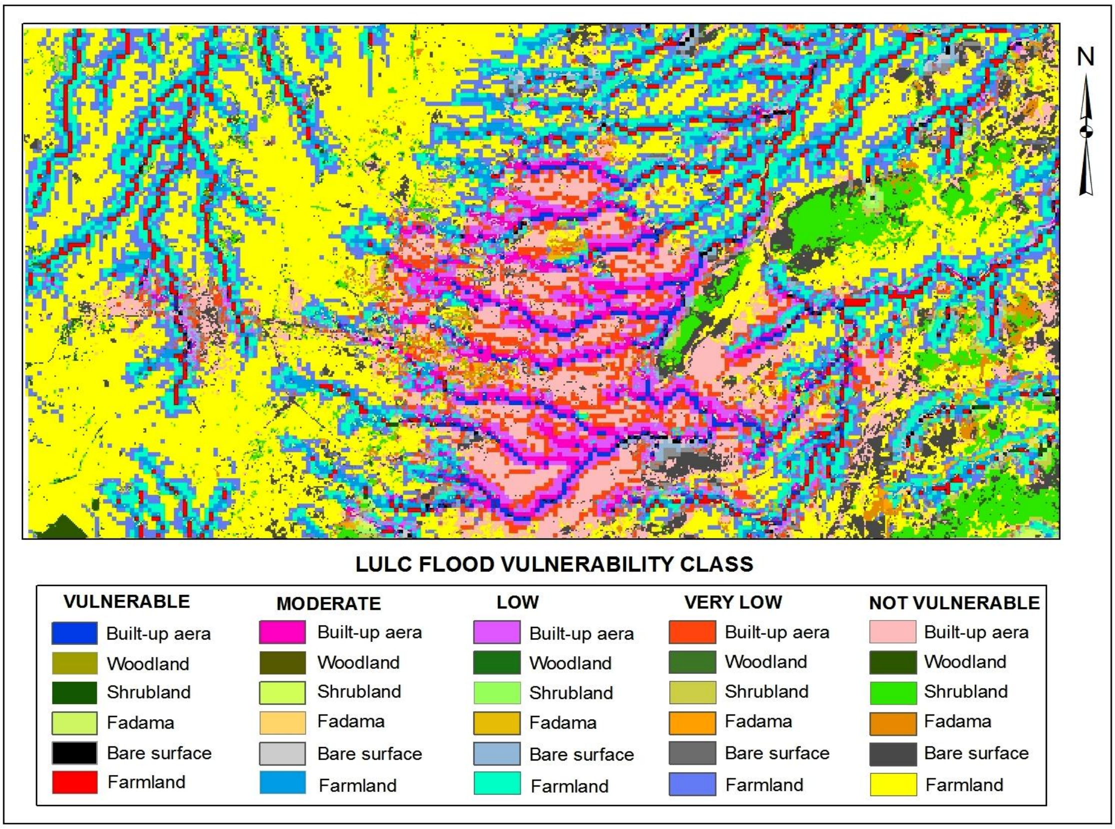

Figure 10: Flood Vulnerability Map of Landuse and Landcover classes in the study area.

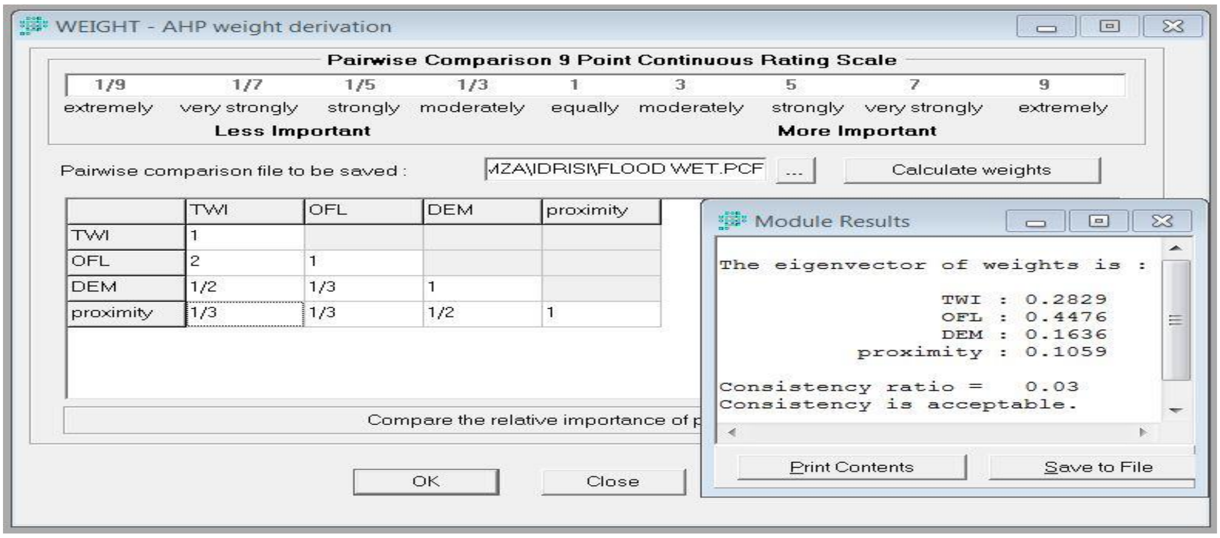

Figure 11: Analytical Hierarchy Process.

6. Results and Discussion

The aim and objectives of this research was to identify factors responsible for flooding, produce flood inundation and determine element at risk in Gombe metropolis. Using simple method involving, DEM Hydrological Modeling. The following analysis was carried out. A supervised classification technique was used to produce land use land cover map Fig. 1. DEM was used to derive flood vulnerability map modeling with TWI, OFL and Proximity to river (see Fig. 4 to 5).

Table 1: Shows the Flood Vulnerability Table of Landuse and Landcover classes in the study area

Class	Built-Up	Wood	Shrub	Fadama	Bare surface	Farmland	Total	%
Vulnerable	193.68	3.42	26.46	30.24	80.37	723.33	1510.53	6.60
Moderately Vulnerable	660.51	8.19	46.44	78.66	172.62	1417.59	2330.98	10.18
Low Vulnerable	975.42	10.08	85.05	115.02	291.6	2268.99	3241.54	14.16
Very Low Vulnerable	989.19	19.89	142.74	106.56	332.19	2630.25	4020.82	17.57
Not Vulnerable	1860.03	119.7	928.8	277.38	1215.72	7381.35	11782.98	51.48
Total	4678.83	161.2	1229.49	607.86	2092.5	14421.51	22886.85	100.00

Goel et al. (2005), also presented the technique for preparation of flood hazard maps with DEM and simulation of flood flows. However, Muhammad *et al.*, (2013), uses GIS and remote sensing in producing flood map of middle course of river Kaduna, which were classified into high, moderate and low risk area.

Jeb and Aggarwal (2008), conducted a study to analyzed flood risk and modeling in Kaduna metropolis which were classified into high, low and moderate risk.

The result of vulnerability classes after cross overlay with the land use land cover maps shows that, Vulnerable class covers 6.6% which is equivalent to 1510.53Ha of the total study area. Moderate Vulnerable class covers an area of 2330.98Ha (10.18%). Low vulnerable class goes with 3241.54Ha which corresponds to 14.16% of the study area. Very low vulnerable class has the value of 4020.82Ha equivalent to 17.57% of the study area. 11782.98Ha equivalent to 51.48% of the total study area was classified as not vulnerable. Furthermore, the classified vulnerability model classes shows that the affected landcover and landuse features that falls within the vulnerable flood class covers 1057.5Ha which is equivalent to 6.6% of the total study area, upon which

build up areas 1.21%, farmland 4.52%, fadama 0.19%, bare surface 0.50%, shrubs 0.17% and woodland 0.02% (See Table 1).
(Figure 10), shows the land use land cover vulnerability classes in the study area to be vulnerable, moderate, low, very low and not vulnerable and areas were shown in (Table 1.)

Moreover, Orok, (2011), clearly stated that flood risk map should be able to identify areas most vulnerable to flood and estimate the number of people that will be affected by flood.
Also Thilagavathi, (2011), uses GIS to demarcate flood hazard prone areas in Taluk into Five zones.

7. Conclusion

The study was carried out with the aim of analyzing flood prone areas in Gombe metropolis. Remotely sensed imagery Landsat-8 OLI and SRTM was used in the analysis within ArcGIS 10.3 environment. DEM was processed which gives out flood vulnerability factors which integrated in the multi-criteria evaluation for flood vulnerability mapping. A cross overlay with land use and land cover map was performed which produced five flood risk zones within the study area.

8. Recommendations

Remote sensing and GIS if well applied in developing nation will help a long way in curtailing disaster risk management. After analysis of the study, the following recommendations were made. These include;

1. Residential building should be monitored within the vulnerable areas.
2. More infrastructural facilities should be sited within low and not vulnerable areas, so as to manage disaster risk damage.
3. Enforcement of building plan permits along the vulnerable areas should be restricted.

References

Adebayo, A. A. (2007): Global warming and its Impact on the environment. Paper presented at the symposium on Global Warming organized by Adamawa State Polytechnique, Yola. September, 13, 2007.

Adeoye, N. O., Ayanlade, A. and Babatimehin, O., (2009), Climate change and menace of floods in Nigerian Cities: Socio-economic implications, Advances in Natural and Applied Sciences, 3(3), pp 369-377.

Bhadra, A., Choudhury, S. and Kar, D., (2011), Flood Hazard Mapping in Dikrong Basin of Arunachal Pradesh (India), World Academy of Science, Engineering and Technology 60, India.

Goel, N. K., Than, H.H. and Arya, D. S., (2005), Flood Hazard Mapping in the Lower Part of Chindwin River Basin, Myanmar, International conference on innovation advances and implementation of flood forecasting technology, Tromsø, Norway.

Hewitt, K. and Burton, I., (1971), The hazardousness of a place: A regional geology of damaging events, University of Toronto, Department of Geography Research Publication, 5, p 154.

Ishaya, S., Ifatimehin, O. O. and Abaje, I. B.,(2009), Mapping Flood Vulnerable Areas in a Developing Urban Centre of Nigeria, Journal of Sustainable Development in Africa, 11(4), pp 180-194.

Jeb, D. N. and Aggarwal, S. P., (2008), Flood Inundation Hazard Modeling of the River Kaduna Using Remote Sensing and Geographic Information Systems, *Journal of applied sciences research*, 4(12), pp 1822-1833.

Muhammad I. and Iyortim O.S. (2013): Application of Remote Sensing (RS) and Geographic Information Systems (GIS) in flood vulnerability mapping: Case study of River Kaduna. *International Journal of Geomatics and Geosciences*.Volume 3, No 3, 2013

Orok, H., (2011), A GIS based flood risk mapping of Kano city, Nigeria, Universityof East Anglia, Norwich.

Thilagavathi, G., Tamilenthi, S., Ramu, C. and Baskaran, R., (2011), Application of GIS in Flood Hazard Zonation Studies in Papanasam Taluk, Thanjavur District, Tamilnadu, Advances in Applied Science Research, 2 (3), pp 574-585.