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

FLOOD RISK CHARACTERIZATION IN GOMBE METROPOLIS, GOMBE STATE, NIGERIA

Abashiya, M.; Didams G. and Sule S.
Department of Geography, Gombe State University, Gombe, Nigeria
Corresponding Author Email: E-mail: mabashiya@gmail.com +2348029106846

Abstract:

Flooding in urban areas is increasing at alarming rate globally with devastating effects on the population and on the Gombe metropolis in particular. The paper focused on flood risk zoning in Gombe metropolis with specific emphasis to examining the flood hazard area, the vulnerability area and the population at rist. The use of geospatial technique embedded in ArcGIS10.5 was employed for the classification of flood hazard, vulnerability and risk. The results of flood hazard map showed five classes of hazard areas; very low hazard 13.42%, low hazard 11.18%, moderate hazard 15.35%, high hazard 40.19% and very high hazard 19.86%. The vulnerability map results showed five classes; very low vulnerability 31.15%, low vulnerability 8.11%, moderate vulnerability 13.05%, high vulnerability 9.13% and very high vulnerability 38.56% The flood risk map result revealed that areas of very low risk covered 26.46%, low risk 14.99%, medium risk 13.47%, high risk 18.19% and very high risk 26.89%. The total area of low risk to very high flood risk covered, 73.54%. This implies that Gombe metropolis is about 70% at flood risk. The authors recommended proper adherent to urban infrastructural development guidelines in Gombe metropolis.

Keywords: Flood Risk, Gombe Metropolis, Hazard, Risk Characterization, Vulnerability

1. Introduction

Until recently, most urban flooding research, planning and policy has focused on fluvial or coastal flooding (Guerreiro, Glenis, Dawson Kilsby, 2017). However, urban or pluvial flooding; ponding or overland flow that overwhelmed the natural or artificial drainage capacity (Carter *et al.*, 2015) has emerged as a critical issue in urban water management. Many contemporary cities are vulnerable to pluvial flooding and its associated risks are projected to increase as the global climate changes (Abaje *et al.*, 2016), urban populations grow and existing infrastructure ages. Despite its importance, pluvial flooding has received limited attention in both research and practice compared to other types of flooding for several years. Flood risk map may be defined as a special thematic map that represents the characteristics of a hypothetical flood graphically. Flood risk zones map are therefore the basic tools and starting point of regional flood intervention policy. Flood risk can be investigated by mapping the areas at risk of flooding. While risk of flooding is the exposure to the damage of a flood, the potential threat to flood that leads to the realization of a hazard is the disaster. When a disaster is of a high magnitude, it becomes a catastrophe. Hazard is defined as a potential damaging physical phenomenon or human activity that may cause the loss of life, injury or property damage, social and economic disruption or environmental degradation (Abaje *et al.,* 2015). It can be characterized based on location, intensity, frequency and probability of occurrence. Flood as a hazard can be described by different parameters such as flood extent, water depth, flow velocity duration and the rate at which water rises. Flood depth, velocity and duration are crucial factors in flood damage but velocity and depth affects the personal safety and damage to infrastructure and agricultural

Farmlands.

A flood hazard seeks to identify areas subject to particular hazard, such as deep or fast-flowing water, and to assess the likelihood of its occurring both now and in the future. A hazard does not automatically lead to a harmful outcome but identification of a hazard implies that there is a possibility of a harm occurring with actual harm depending on the characteristics of the receptor. Man on one hand and the urban environment on the other are at the receiving end.

Many communities in Nigeria are exposed to flood hazards in varying degrees depending on several socio-economic, cultural, educational, developmental and religious factors inherent in such communities (Abaje *et al.,* 2016). The stage-damage function, velocity, duration and intensity that can cause damage by overflow stream and the extension of the field in the water flow constitute the determinants of flood damage magnitude. Hazard refers also to hydro climatic phenomena and their impact on the flow of water. Geomorphological characteristics including slope, drainage density, soil types (Meraj, Romshoo, Yousuf,Altaf and Altaf 2015) and rainfall because it is the intense rainfall that triggered flooding and are the various factors taken into account in the mapping of the hazard. The hazard map will show all areas susceptible to flooding. Vulnerability is the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. People are vulnerable when they are unable to adequately anticipate, withstand and recover from hazard. Vulnerability to flood disasters may constitute different forms: exposure to floods as a result of locating in flood-prone areas, occupying a dwelling which has little resistance to floods, the quality of buildings, inadequate protections from floods, weaknesses of the population as related to age, gender, health status and infirmity. The inability to avoid or recover from a flood disaster and low levels of protection or assistance are also contributing social factors. Vulnerability expresses the level of anticipated consequences of a natural phenomenon on issues and on the other hand is the most crucial component of risk in that it determines whether or not exposed to a hazard constitutes a risk (Ouma and Tateishi, 2014). Flood vulnerability mapping is the process of determining the degree of susceptibility and exposure given place to flooding. These issues include people, goods and socio-economic activities likely to be affected both quantitatively and qualitatively by a natural phenomenon. The vulnerability to flooding for this paper consists of two parameters; population density and landuse; the percentages of people per wards and the physical aspect of vulnerability in terms of built up. The ability of an urban area and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity. The relevant “disturbance” may be the occurrence of an intense rain event or anthropogenic activities. A city that is resilient to this hazard may not experience urban flooding in response to an intense rain event or (Abaje *et al.*, 2015), if flooding does occur, is able to maintain or quickly restore its essential systems (e.g., transportation, housing, economic, and ecological). The resilient city would also have knowledge systems in place that allow stakeholders to learn from their experiences with extreme rain and urban flooding and adapt their essential systems for the future.

In Gombe metropolis, most of the rainfall is within the months of July, August and September and as a result of this substantial increase, in rainfall the urban soil infiltration capacity, particularly in the month of July, August and September where the antecedent precipitation index (API) can be as high as 166.62mm, thus increasing flow of runoffs and possible flooding (Abashiya *et al.* 2017, Abashiya, *et al.*, 2019). Hence the needs for flood risk characterization in the study area to assist the relevant authority in taken proper action for flood control.

2. Study Area

Gombe metropolis is located between Latitudes $10^{0}14'10''$N and $10^{0}19'00''$N of the Equator and Longitudes $11^{0}07'00''$E and $11^{0}12'50''$E of the Greenwich meridian. Kwami LGA bound it to the North, Akko LGA to the Southwest and Yamaltu-Deba LGA to the East. Gombe metropolis is a low-lying, landscape sloping from Akko escarpment to Liji hill that is the highest point 600m high. Some inselbergs and cuestas dotted the northern and southern part of the metropolis. When approaching the metropolis from the west, it looks like a community in a basin.

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

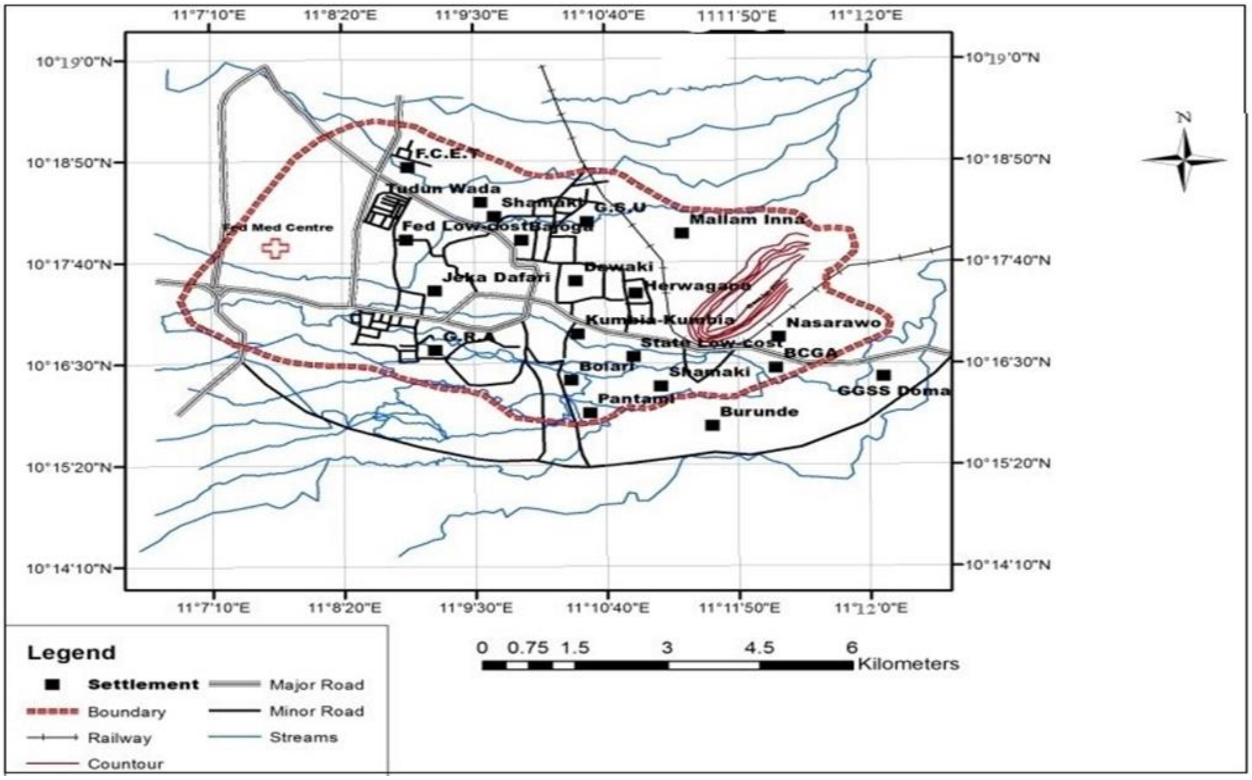

Fig 1: Gombe Metropolis
Source: Adapted from Ministry of Lands and Survey Gombe State

The climate of the area is characterized by two distinct seasons (Dry and wet seasons), with an average annual rainfall of 850mm. Temperature is between 35-40^{O}C in the month of March and April while minimum temperature is recorded during the harmattan period (Abashiya, *et al.,* 2019).

The metropolis is drained by ephemeral streams in a dendritic pattern such as Kundulun, Kurba, and Arawa in the northeast and Bagadaza, Pantami and Bogo, in the south, which take their sources from the Akko escarpment and flow eastwards. There are also ravines and gullies that serve as waterways, "death traps" during sudden storm events particularly in the months of July-September (Abashiya, *et al* 2017). Soil distribution reflects the climatic conditions and the geological structure of the area. Gombe metropolis has light textured, sandy soils, which drain rapidly with low moisture retention capacity that may lead to leaching of plant nutrients. The alluvial deposit of fine-coarse sands, silts and clays are found in layers, which formed the floodplains along the lower course of stream channels. The soils are formed from the intensive weathering of the Basement Complex rocks (Obaje, 2009). They consist of unconsolidated wind-blown or water deposited sand and clay-rich mostly to the southeast of the metropolis along the valley of Pantami catchment (Mbiimbe, *et al.*, 2019). There is extensive leaching, low plant nutrients and susceptible to water erosion that has left scars of gullies in the metropolis.

The vegetation is the Sudan savanna type, which has replaced the guinea savannah of the 1970s due to anthropogenic activities and climate change with many tree species becoming extinct (Mbaya, 2016). The population of Gombe town in 1919 was only about 300 people. In 1986, the figure rose to 130,000 people (Balzerek *et al.,* 2003). Over the years, the metropolis has witnessed a drastic increase in infrastructural development such as roads and residential buildings (Makadi, Didams, Abashiya, Dan and Yason, 2017), to enhance better living standard. According to the National Population Census report (2006), Gombe metropolis had a population of 266,844 people. Using the exponential method of projection as recommended by the National Population Commission (NPC) with growth rate of 3%, the figure was projected to 377,341 for 2017.

3. Materials and Method

The thematic layers of flood risk influencing factors were developed in the GIS environment weighted and overlaid using the principle of pair wise comparison and Multi-Criteria Evaluation technique in order to arrive at flood hazard, flood vulnerability and flood risk maps of Gombe metropolis. Attribute database were generated from the previous analyses of the thematic factors through digitization. These were then classified into domains class group of hazard magnitude, Vulnerability magnitude, and area in square metres, area in square kilometres and then area in hectares. These attributes data generated formed the basis for further analysis that included assigning of class weights.

The generation of flood hazard map of Gombe metropolis was carried out by integrating the thematic maps of geomorphological characteristics that influence flooding using Arc GIS10.5 software which include; slope map, drainage density map, soil map, geology map and rainfall map since it is the heavy rainfall that triggers flooding in urban areas. Geomorphological characteristics including slope, drainage density, soil types, geology (Meraj, Romshoo, Yousuf, Altaf and Altaf, 2015) and rainfall, because it is the intense rainfall that triggered flooding, thus the various factors taken into account for hazard mapping.

The vulnerability map was obtained by overlaid of land use and population density maps using ArcGIS10.5 software. Flood vulnerability is the process of determining the degree of susceptibility of a given place for flooding. The flood vulnerability map of the study area was generated through the integration of population density and land use/landcover maps using weighted overlay analysis (Danumah, *et al.* 2016). The weighted overlay is a tool in-built in ArcGIS software and this tool was used to perform an overlay analysis. The weighted overlay tool overlays several raster using a common measurement scale and weights each according to its important.

The result of overlay analysis was classified into five classes of vulnerability zones as very low, low, moderate, high and very high zones. The parameters in form of thematic maps used to produce flood risk map include slope map, soil map, geology map, drainage density map, rainfall map, landuse/ landcover map and population map which are the combination of hazard and vulnerability maps using map-crossing technique in ArcGIS 10.5. Using Quantum GIS software, the factor weights from the Analytical Hierarchy process (AHP) were incorporated to produce flood risk map of five classes, namely; very low risk, low risk, medium risk, high risk and very high risk.

4. Results and Discussion

4.1 Flood Hazard Map of Gombe Metropolis

The hazard map shows the spatial extent and potentially exposed areas to climatic hazards that can cause flooding. The result of flood hazard map of Gombe Metropolis is presented in Figure 2 and the statistics in Table 1

.

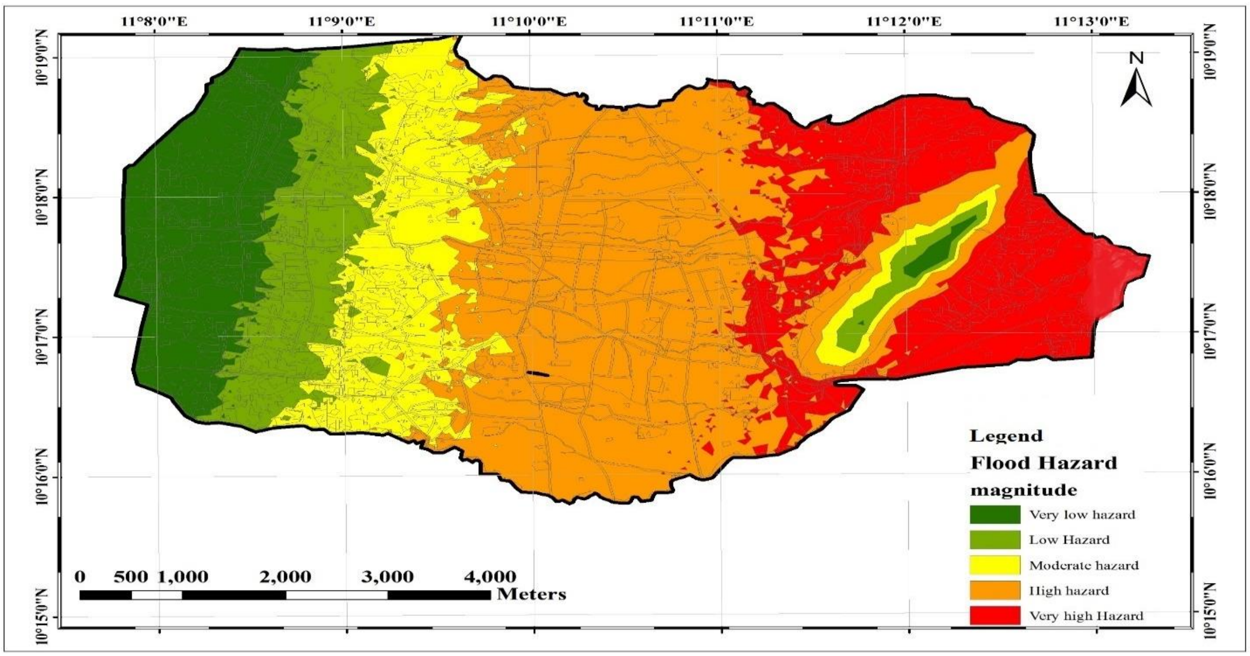

Figure 2: Flood Hazard Map of Gombe Metropolis
Source: Author's GIS Analysis (2020)

Table 1: Flood Hazard Area and Percentages

Degree of Hazard	Area_Ha	Area_Sqm	Area_sqkm	area_%	hazard risk weight
Very low hazard	559.67	5596744.97	5.60	13.42	3
Low Hazard	466.27	4662658.21	4.66	11.18	6
Moderate hazard	640.04	6400356.12	6.40	15.35	9
High hazard	1675.76	16757585.99	16.76	40.19	12
Very high Hazard	828.21	8282090.06	8.28	19.86	15
Total	**4169.95**	**41699435**	**41.70**	**100**	

Source: Author's GIS Analysis (2020)

The results showed five classes of hazard areas namely; very low hazard 13.42%, low hazard 11.18%, moderate hazard 15.35%, high hazard 40.19% and very high hazard 19.86% covering areas like Bajoga, Jekadafari, Pantami, Yelanguruza and Nasarawo. A general observation revealed that 60.05% of Gombe metropolis is within high and very high flood hazard zone.

4.2 Flood Vulnerability Map of Gombe Metropolis

It is the vulnerable population and the critical infrastructures exposed to flood risk that suffers the consequences of flood risk. The infrastructure failure of any idealized geographical area is estimated from the potential vulnerability of its critical facilities in the face of flood disaster.
The result of flood vulnerability map of Gombe Metropolis is shown in Figure 3 and the statistics in Table 2.

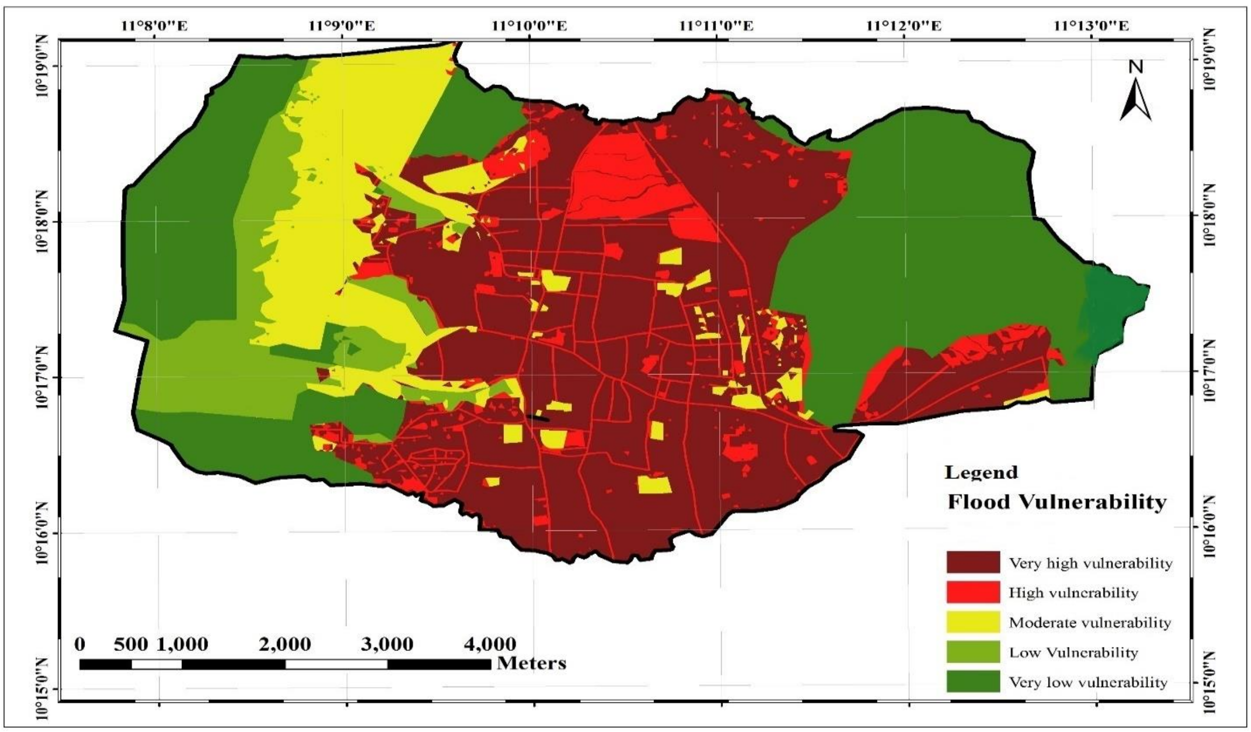

Figure 3: Flood Vulnerability Map of Gombe Metropolis
Source: Author's GIS Analysis (2020)

Table 2: Flood Vulnerability Area and Percentages

Degree of vulnerability	area_sqm	area_sqkm	area_ha	percentage	weights
Very low vulnerability	12934495.06	12.93	1293.45	31.15	3
Low Vulnerability	3365918.46	3.37	336.59	8.11	6
Moderate vulnerability	5417590.63	5.42	541.76	13.05	9
High vulnerability	3790342.21	3.79	379.03	9.13	12
Very high vulnerability	16008291.04	16.01	1600.83	38.56	15

Total	**41516637.39**	**41.52**	**4151.66**	**100.00**

Source: Author's GIS Analysis (2020)

The results showed five classes of vulnerability as; very low vulnerability 31.15%, low vulnerability 8.11%, moderate vulnerability 13.05%, high vulnerability 9/13% and very high vulnerability 38.56% covering areas like Jekadafari, Shamaki, Madaki, Yelanguruza and Bogo This implies that about 50% of the study area lies within highly vulnerable flood prone areas

.

4.3 Population at Flood Risk in Gombe Metropolis

The population at risk is presented in Figure 4 while the statistics for the percentage population at flood risk is shown in Table 3.

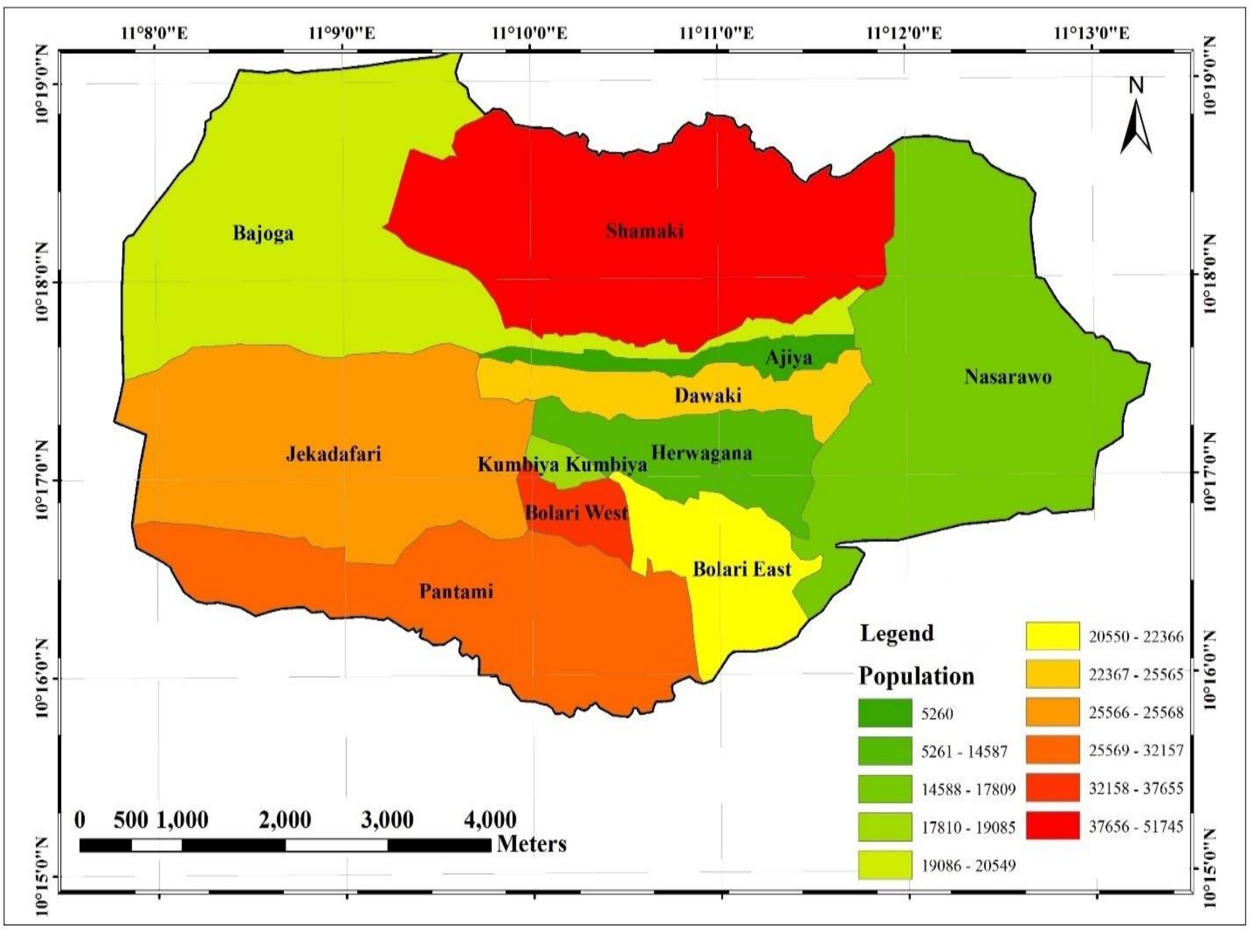

Figure 4: Population at Risk of Gombe Metropolis
Source: Author's GIS Analysis (2020)

Table 3: Very High Flood Risk Areas by Wards

Ward	Area exposed _ha	Area exposed sqm	Area exposed_sqkm	%
Jekadafari	10.28	102766.61	0.10	0.89
Bajoga	21.41	214126.64	0.21	1.86
K/ kumbiya	22.05	220489.15	0.22	1.95
Ajiya	44.76	447585.25	0.45	4.00
Nasarawo	47.19	471913.72	0.47	4.17
Bolari West	60.80	607971.21	0.61	5.41
Dawaki	123.18	1231761.33	1.23	10.91
Herwagana	146.80	1468022.77	1.47	13.04
Pantami	151.52	1515226.08	1.52	13.49
Bolari East	179.55	1795465.66	1.80	15.97
Shamaki	318.80	3187987.83	3.19	28.31
Total	**1126.33**	**11263316.26**	**11.27**	**100.**

Source: Author's GIS Analysis (2020)

The population density map is shown in Figure 4 while the percentage coverage per ward of very high flood risk are as follows: Jekadafari 0.89%, Bajoga 1.86% ,Kumbia-kumbia 1.95%, Ajiya 4.00%, Nasarawo 4.17%, Bolari-west 5.41%, Dawaki 10.91%, Herwagana 13.04%,Pantami 13.49%, Bolari-East 15.97% and Shamaki 28.31%. These areas such as Herwagana, Yelanguruza, Kumbia-Kumbia, Pantami, Madaki, Unguwar/Uku, Nasarawo and Bogo are known for significant past flood records. The flood events of 2004, 2011, 2012, 2014 and 2018 in Gombe Metropolis had a significant blue print in these areas (Abashiya *et al.*, 2019).

Flood Risk Map of Gombe Metropolis

The flood risk map result defined five classes of risk, ranging from very low risk, low risk, medium risk, high risk to very high risk. The flood risk map of Gombe Metropolis is presented in Figure 5 and the statistics in Tables 4.

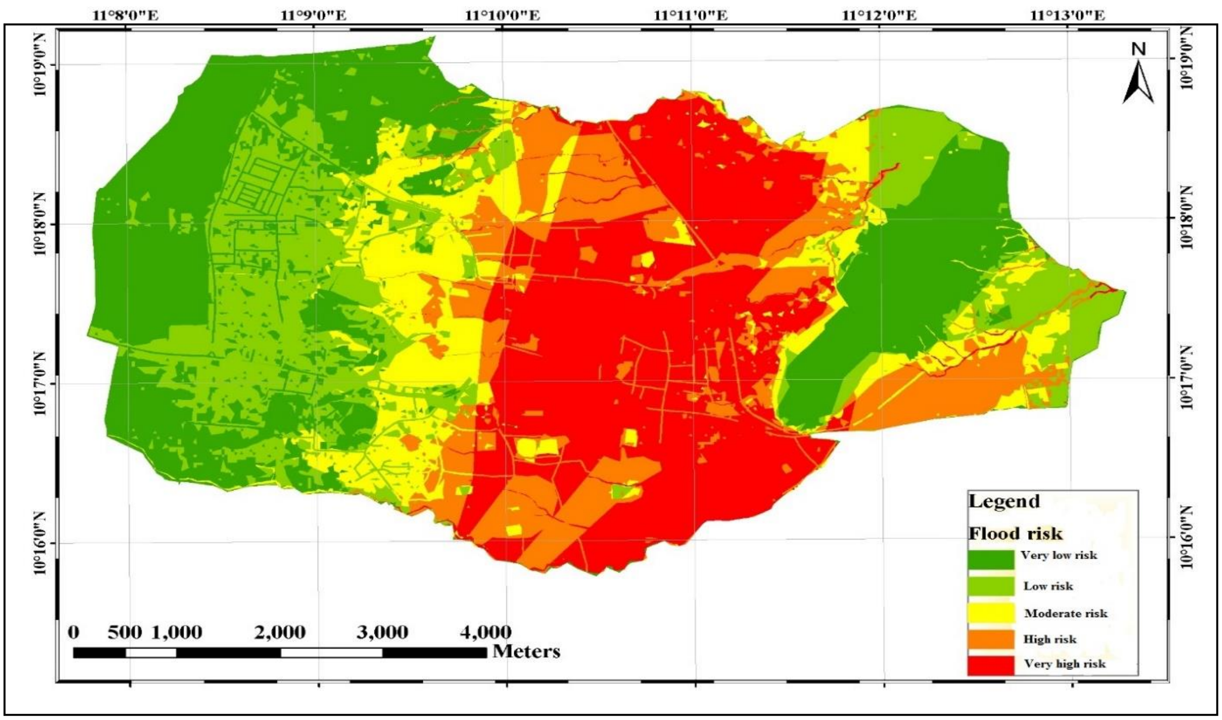

Figure 5: Flood Risk Map of Gombe Metropolis
Source: Author's GIS Analysis (2020)

Table 4: Flood Risk by Magnitude of Gombe Metropolis

magnitude	area_ha	area_sqm	area_sqkm	percentage
Very high risk	1126.33	11263316.26	11.26	26.89
High risk	762.15	7621500.06	7.62	18.19
Medium risk	564.37	5643652.39	5.64	13.47
Low risk	628.25	6282496.43	6.28	14.99
Very low risk	1108.07	11080693.01	11.08	26.46
Total	**4189.17**	**41891658.16**	**41.88**	**100.00**

Source: Author's GIS Analysis (2020)

The result revealed that areas of very low risk covered 26.46%, low risk 14.99%, medium risk 13.47%, high risk 18.19% and very high risk 26.89% as shown in Table 3. The areas of very low risk are high elevations including Akko escarpment and Gombe hill west and East of the metropolis respectively. The results also revealed that the total percentage of low to very high risk of flooding covers, 73.54%, this implies that about 70% of Gombe metropolis is at flood risk. These are areas with flat to gentle slopes that allow water ponding, have shale and clay geological formation and soil type of low permeability, low vegetation cover and high drainage density.

5. Conclusion

Gombe metropolis lies 60.05% within high and very high flood hazard zone, 60.74% lies within flood vulnerable zone, 50.67% is low-lying and 70% lies within flood risk zone. This implies that 70% of Gombe metropolis lies within area of urban flooding. Flood risk map that is the major output of this study defined five classes of risk, ranging from very low risk to very high risk. The result revealed that areas of very low risk covered 26.46%, low risk 14.99%, medium risk 13.47%, high risk 18.19% and very high risk 26.89%. The areas of very low risk are high elevations including Akko escarpment and Gombe hill west and east of the metropolis respectively. The total area of low risk to very high flood risk covered, 73.54%. This implies that Gombe metropolis is about 70% at flood risk. These are areas with very low slope that allow water ponding, shale and clay geological formation and soil type of low permeability, high drainage density, high population density that put pressure on landuse/landcover against the inadequate urban drainages. These areas of flood risk, correspond with Pantami, Madaki, Yelenguruza, Bogo, Nasarawo, Herwagana, Shamaki and Arawa that are known with past flood records. This was carried out to regulate land use by flood zoning in order to reduce flood damages in Gombe metropolis. Flood risk mapping, being an important non-structural flood management technique, will go a long way in reducing flood damages in areas prone to pluvial flooding.

6. Recommendations

Thus, suitable measures such as coordinating flood management can greatly reduce the risk of these vents. Therefore, basin wide coordination of flood activities and proper adherent to urban infrastructural development guidelines in Gombe metropolis is very crucial.

References

Abaje,I. B., Ishaya, S. and Abashiya, M. (2016). Evidence of Global Warming From Statistical Analysis of Temperature Data of Kaduna State, Nigeria.*Nigeria Geographical Journal 1(1),125-140*

Abaje, I. B., Ogoh, A. O., Amos, B. B. and Abashiya, M. (2015). Climate Change, Flood Disaster Assessment and Human Security in Katsina State, Nigeria. *American Journal of Human Ecology. 4(4): 47-56.*

Abashiya, M. Abaje, I. B. Iguisi, E. O. Bello, A. L. Sawa, B. A. Amos, B.B. and Musa, I. (2017). Rainfall Characteristics and Occurrence of Floods in Gombe Metropolis, Nigeria. *Ethiopian Journal of Environmental Studies and Management, 10(1): 44-54.*

Abashiya, M; Abaje, IB; Musa, I; Sule, S; Kollos, PN; Garba, HA (2019), *Hydrogeomorphic Characteristics of Urban Flood Triggers in Gombe Town, Nigeria as Monitored in 2014.* Journal of Applied Science and Environmental Management Vol. 23 (10) 1887-1892.

Abashiya, M.; Sule, S.; Kollos, P.N; Sadeeq, A and Adamu. M.B.(2019). U*rbanization, Climate Change and their Implications on Pluvial Flooding in Gombe Metropolis, Gombe State, Nigeria. Gombe Journal of Geography and*

Environmental Studies. A publication of Department of Geography Gombe State University, Gombe

Balzerek, H., Werner, F., Jürgen, H., Klaus-martin, M., and Markus, R. (2003). Man Made Flood Disaster in the Savanna Town of Gombe/NE Nigeria. The Natural Hazard of Gully Erosion Caused by Urbanization Dynamics and their Peri-Urban Foot-prints Erdkunde, 57(2), 94-109. http://dx.doi.org/10.3112/erdkunde.2003.02.02

Carter, J. G., Cavan, G., Connelly, A., Guy, S., Handley, J., and Kazmierczak, A. (2015). *Climate Change and the City: Building Capacity for Urban Adaptation. Progress in Planning,* 95 (Suppl. C), 1–66. https://doi.org/10.1016/j.progress.2013.08.001

Danumah, J. H., Odai, S. N., Saley, B. M., Szarzynski, J., Thiel, M., Kwaku, A., Kouame, F.K. and Akpa, L. Y.(2016). Flood Risk Assessment and Mapping in Abidjan District Using Multi-Criteria Analysis (AHP) Model and Geoinformation Techniques. *Geoenvironmental Disasters3 (10):1-13.*

Guerreiro, S.; Glenis, V.; Dawson, R.; Kilsby, C. (2017). Pluvial Flooding in European Cities-A Continental Approach to Urban Flood Modelling. *Water 9, 296.*

Makadi,Y. C., Didams, G., Abashiya, M., Dan,Y. and Yason,B. (2017). Intra-Urban Traffic Flow Problems in Gombe Metropolitan Area,Nigeria. *International Journal of Research and Development in Social sciences,3(12),149-169).*

Mbaya, L. A.(2016).Climate Change Induced Tree Mortality in the Savanna Woodland and its Implication on Rural Livelihoods in Gombe State, Nigeria.*Nigerian Journal of Tropical Geography 7(1)pp952-968.*

Mbiimbe, E.Y., Tabale, R.P. and Barka, J. (2019). Geology of Gombe State. In: Mbaya, L.A., Wanah, B. B., Dan, Y. and Ahmed, B. Y. (eds). Gombe: People, Environment and Development. Pp50-58.Nonimod J. Ventures Jimeta-Yola, Nigeria. ISBN:978-978-976-413-6.

Meraj, G., Romshoo, S. A., Yousuf, A. R., Altaf, S. and Altaf,F. (2015). Assessing the Influence of Watershed Characteristics on the Flood Vulnerability of Jhelum Basin in Kashmir Himalaya. *Natural Hazards 77: 153–175.*

NPC (2006) Census Report. National population commission, Gombe office.

Obaje, N. G. (2009). *Geology and Mineral Resources of Nigeria.* Springer Publishers, Dordrecht Heidelberg, pp65-68.

Ouma, Y. O and Tateishi, R. (2014). Urban Flood Vulnerability and Risk Mapping Using Integrated Multi-parametric AHP and GIS: Methodological Overview and Case Study Assessment. *Water, 6(6): 1515–1545*