VOL. 26 NO. 4
ISSN: 2196-1789
SEPTEMBER, 2022

African Scholar Publications & Research International

African Scholar Journal of Built Env. & Geological Research (JBEGR-4)

Flood Vulnerability Assessment in the Gbako River Basin, Niger State, Nigeria

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Abstract
Floods are among the most devastating natural disasters and cost many lives every year. It is reported that flood disasters account for about a third of all natural disasters (by number and economic losses). Nigeria is no exception to countries that experienced flood in recent time. Flood vulnerability of the communities inhabiting the flood plain of the Gbako River, Niger State, Nigeria was investigated. The study employed both qualitative and quantitative approach such as field survey, interview, questionnaire and geospatial techniques to achieve the objectives. The geospatial techniques was utilized to generate flood vulnerability map and create a Digital Elevation Model (DEM) of the study location. Questionnaire was also randomly administered to ascertain the adaption strategies and coping capacities of the communities in the study area. The result indicate that a greater number of families, household, cultural heritage are all prone to flood and that flood events impacted on the peoples livelihood by way of destruction to farm produce, food and cash crop, water and sanitation, low and poor harvest with dire consequences on socio-economic lives of the populace. The results also indicates that the area with elevation of between 42 meters and 123 meters above the sea level are vulnerable to flood with severe consequences for the inhabitant of the study area. The result also revealed that migration, evacuation, relocation to higher ground of the safer area are the adaption strategies to flood events in the study area. Conclusively, with the percentage of the inhabitant and community affected by flood and the critical infrastructure that are damaged, the study location and its habitants are severely vulnerable to flood. It is therefore recommended that flood control structures or buffer zone should be created in areas of high and moderate vulnerability effect and Multi-sectoral approach to flood mitigation as opposed to single sector should be promoted as there are inter-linkage in terms of flood effect on various aspect of society.

Keywords: *Flood, Flood vulnerability, Gbako River, and Flood plain*

Introduction

Floods account for approximately one third of global natural hazards and more people are adversely affected by flooding than any other geophysical phenomenon (Smith and Ward, 2018). On average, 20,000 people lose their lives due to flooding each year and it affects 75 million people globally, most of whom become homeless (Smith, 2015). Floods are one of the most common, costly natural disasters worldwide. For example, in the US, floods caused 8.17 billion in damages and 89 deaths annually over the period 1983 to 2012 (National Weather Service, 2014).

Nwilo *et al.* (2012) explained that floods are among the most devastating natural disasters and cost many lives every year. It is reported that flood disasters account for about a third of all natural disasters (by number and economic losses). Nigeria is no exception to countries that experienced flood hazard in recent time. Many communities have suffered losses due to flood problem. Niger State have being experiencing flood disaster which destroyed farmlands and claimed lives and properties (Nwilo *et al.*, 2012).

Flood disaster is not a recent phenomenon in the country, and its destructive tendencies are sometimes enormous. Akani and Bilesanmi (2016) reports how a Lagos flood forced Lagosians to relocate as a result of heavy rain of 7th and 8th of July 2011 not knowing there was going to be a more devastating torrential rain that will result in "more disastrous floods in Lagos Metropolis" in the following week, (Mordi, 2011; Amaize, 2011). According to literature there seems to be a real demand for continuous monitoring and planning to better cope with flood events in the future. The integration of the social dimension is taken into consideration as a main part of the flood vulnerability assessment.

The risks and damages caused by flood disasters in terms of loss of life, property, displacement of people and disruption of Socio-economic activities as well as the loss of valuable agricultural land due to the attendant inundation of floodplains from floods can never be overemphasized. Flood is gradually becoming a serious environmental problem in Nigeria. Several areas along the major and minor river channels (floodplains) of the study area (Gbako River Basin) are affected by floods every year. To gain better understanding of the flood disaster, there is need to study the nature, type, extent, causes, the impact of flood on socio-economic activities as well as flood vulnerability factors in the study area. There is usually less or limited concern by government and other affected communities in this regard. There is however, need to embark on flood prevention and control/mitigation measures that would ensure free flowing drainage systems, as well as good operation and maintenance of hydraulic structures such as dams and reservoirs. These however will form the basis of the study, and it is hopeful that findings and

suggestions from the study will enable people in the flood prone areas to live with the flood, appropriate its positive elements and mitigate the adverse effects associated with the flood disasters. Therefore, the aim of this paper is to assess the vulnerability of the inhabitants of the Gbako River Basin to flood.

Gbako River Basin is to be found as parts of the greater middle section of the Niger basin. It is located in the south western part of Niger State with elevation in height between (300 meters) lying between latitude 6^0 20''30N to 7^0 15''60N of the equator and longitude 5^0 40''10E to 6^0 33''15E of the Greenwich meridian.It has area coverage of 1,698km^2. The area geographically it transverses boundaries with Gbako Local Government,Lavun Local Government Area, and Katcha Local Government Areas(Gobo and Abam, 2011).

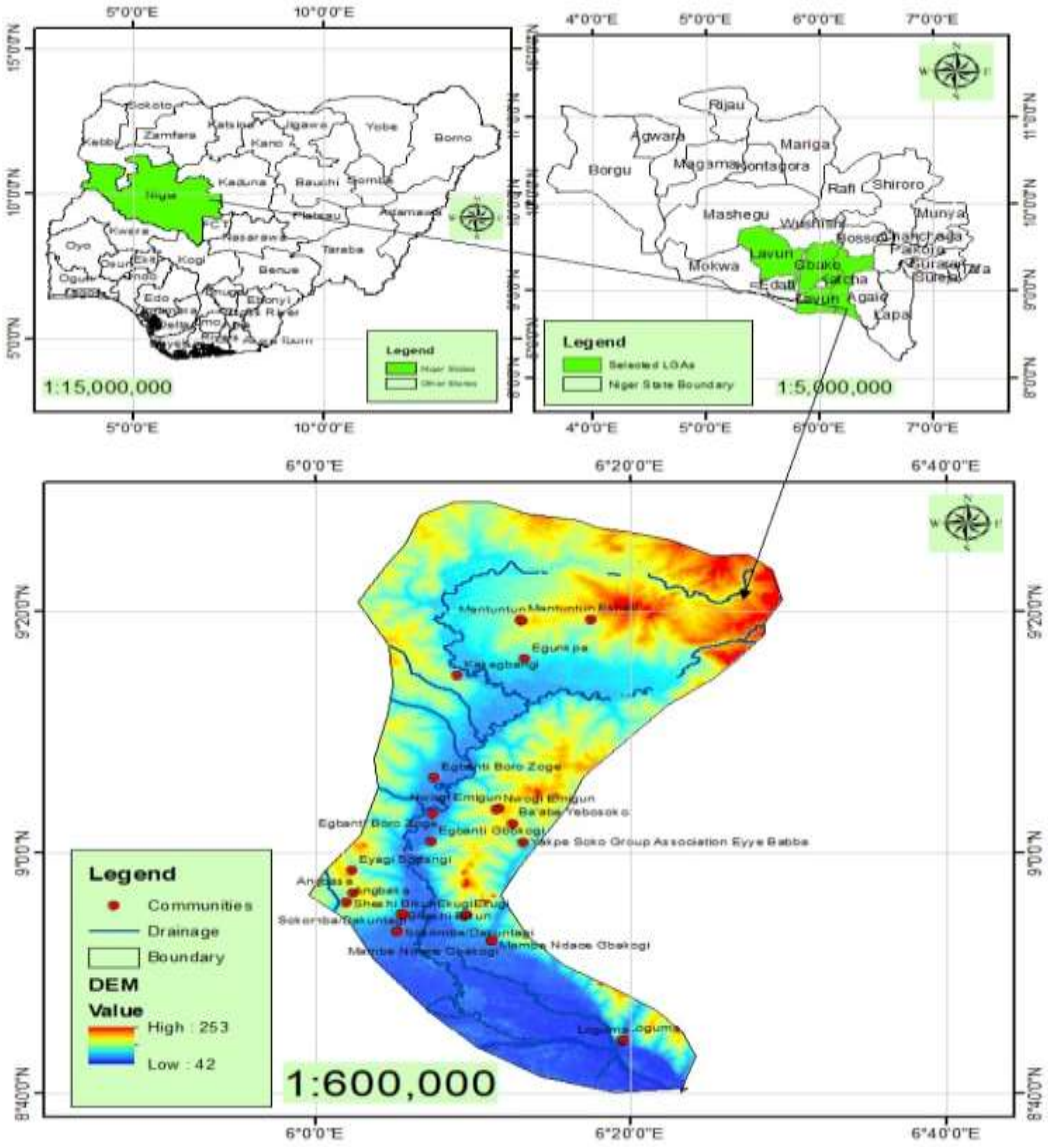

Figure 1: The Study Area (Gbako River Basin, Niger State Nigeria)
Source: Niger State Geographic Information System (2021)

Materials and Methods

The sources of data for this study include primary and secondary data sources. The primary sources of data include questionnaire administration, field survey and oral interview. Secondary data including rainfall data and records of flood damage in the affected areas (within the temporal scope of the study: 2011-2020) were collected from reports made available by hydro-meteorological agencies like the Nigeria Hydrological Services Agency (NIHSA) and the Niger State Emergency Management Agency (NSEMA). The flood and socioeconomic data were used in determining the flood vulnerability factors, flood impact on socio-economic activities of the study area and the adaptation strategies put in place to reduce flood vulnerability in the study area. Other secondary data sources used for the purpose of the study include: 2018 satellite image of Moderate Resolution Imaging Spectrometer (MODIS) on Natural Aeronautic and Space Administration, drainage systems, Digital Elevation Model (USGS DEM), Maps, Newspapers, Magazines and Journals.

The study respondents were 399 and convenient sampling was used to distribute the questionnaires among the respondents. Two hundred and fifty (252) questionnaires were returned for data analysis. The methods of data analysis include factor analysis, frequency percentage and 3-point Likert type scale.

Results and Discussion

Generate a flood vulnerability map for Gbako River Basin

This occurs as a result of variations in degree of relief and drainage of the area; the map was based on susceptibility of settlement to flooding in the study area. The Digital elevation model (DEM) of the study area shows differences in height between 253 m to 42m above sea level across the flood plain. It shows that the northern and eastern part of the study area has highest elevation, lying between 151m and 153m above mean sea level depicted in green colour. The Centre towards the South eastern part of the study area has a moderate elevation between 99m to 123m while the southern part towards to the river Gbako, has the lowest elevation between 42m to 74m above mean sea level as shown in Figure 2 of the study.

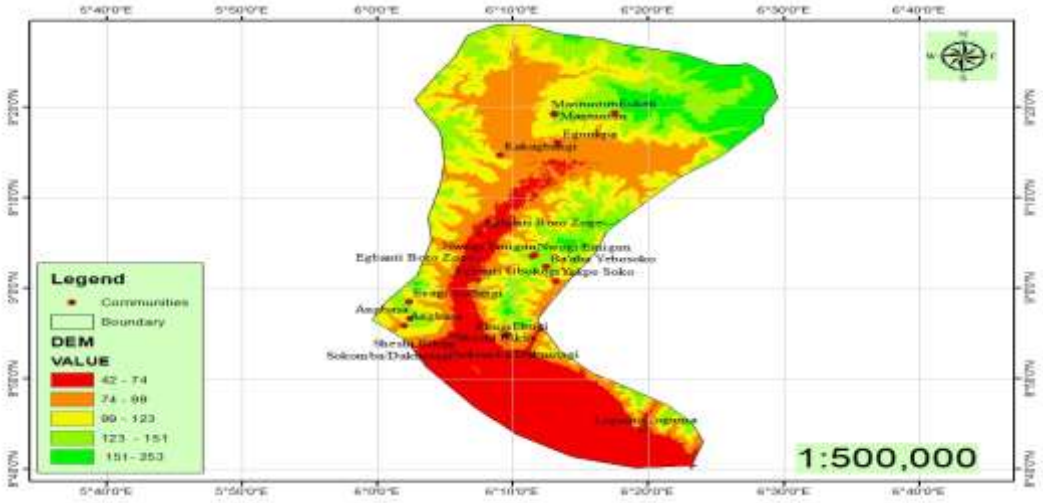

Figure 2: DEM of the study area
Source: Author's Analysis, 2022

Figure 3 shows digital elevation model of the study area. The DEM of the area revealed that the northern and eastern part of the area has high topography that is prone to gully erosion as a result of runoff. The DEM further revealed that the study area is generally more susceptible to rain induced flash floods as well as river floods. As presented, there are variations in the degree of susceptibility to flooding in the study area, these include high flood risk zone, Moderate, Low and No flood risk zones.

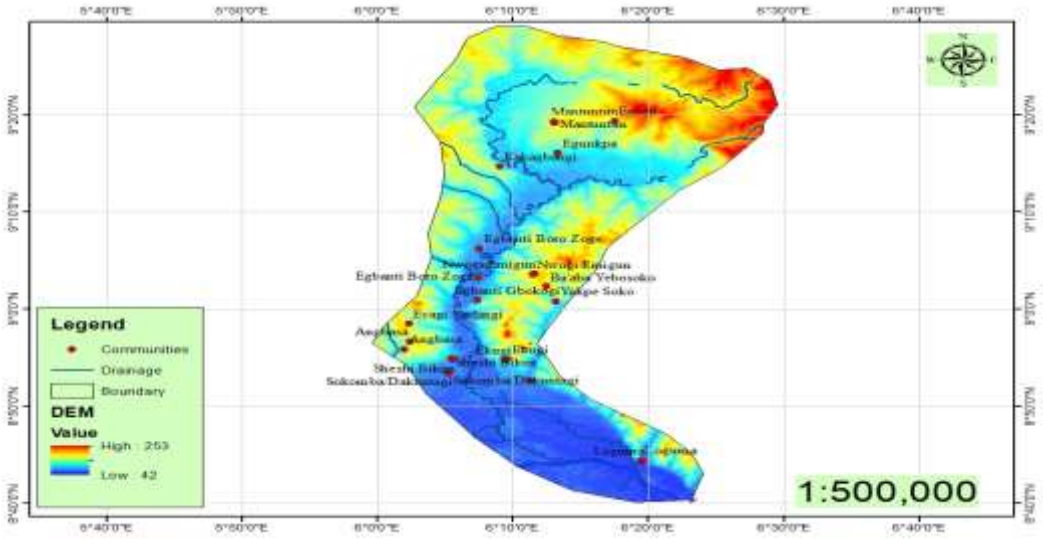

Figure 3: Digital Elevation Model of the Study Area
Source: Author's Analysis, 2022

Figure 4 shows the flood risk zones of the study area, it has revealed that the study area is in fact susceptible to flooding. This statement is drawn from the fact that several areas most especially the southern parts and the settlements are in low elevation. These have been attributed to some degree of susceptibility. This was also confirmed through a ground truth exercise. It is therefore necessary to create awareness and steer away development from areas highly susceptible to floods to areas with lesser susceptibility in the area. The classification of flood risk zones in the area was mainly based on the interaction of relief and drainage.

The areas marked as highly susceptible are mostly the areas closet to the River Niger. Flooding is experienced in most areas in this classification yearly. The areas are characterized by low relief and water-logged soils. Figure 4.9 is a classified risk map of the study area which shows the area occupied by each level of vulnerability. The result from the classified DEM shows that about 575.72square kilometer (23.73%) of the area is on very high vulnerable area which is an evidence of recurrent flooding in the study area. then about 590.78square kilometer (24.35%) are highly vulnerable risk areas and 626.63square kilometer (25.83%) are moderately vulnerable risk areas , 448.21square

kilometer (18.48%) and finally 184.47square kilometer (7.60%) are no vulnerable risk areas . it can be therefore conclude that the study area is generally a flood plain area.

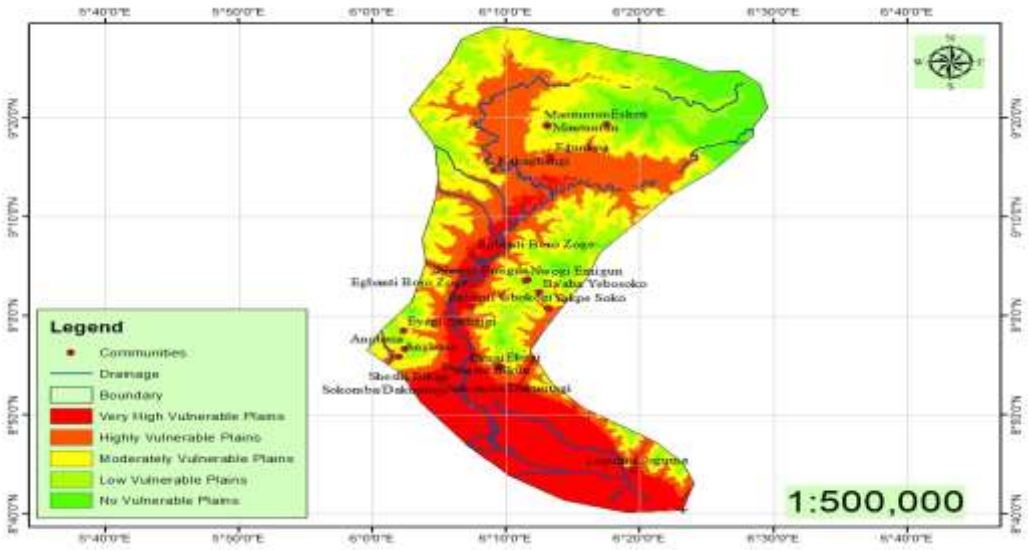

Figure 4: Map of flood Risk Zone of the Study Area
Source: Author's Analysis, 2022

Figure 5 shows the loss of farm produce during flood events in the study area. Sampled population who agree that they lose their farm produce during flood events constitute 78% while those disagree constitute the remaining 22%. This shows that majority of the sampled population lose their farm produce as a result of frequent flood events across the study area.

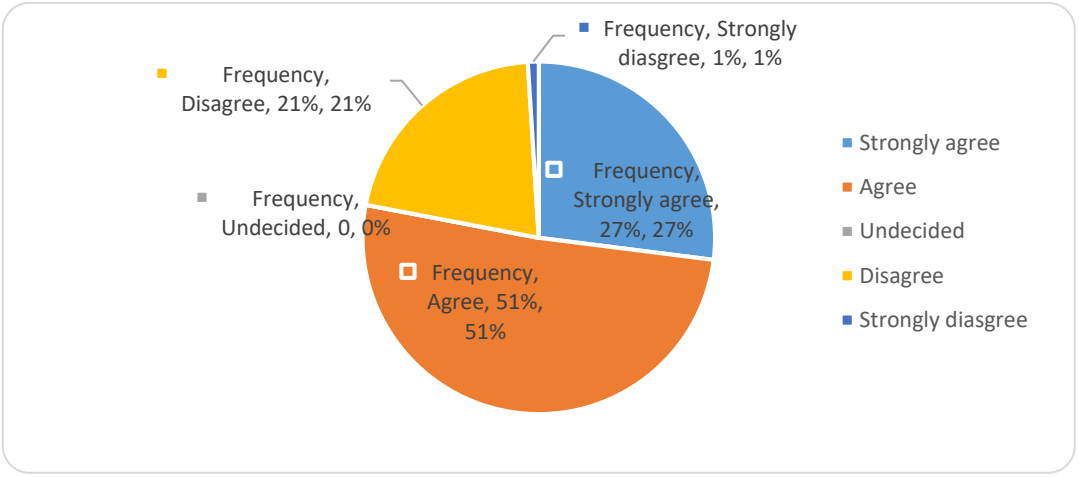

Figure 5: shows the loss of farm produce during flood events in the study area

The type of agricultural crop damaged during the past flood events include cash crops, food and cash crops and food crop only as indicated in Table 1 of the study. Sampled population who loss food and cash crops constitute 57.9% while those who loss cash crop

ranked the least with 6.8%. This shows that majority of the sampled population loss food and cash crops which has affected their standard of living through increased in poverty level.

Table 1: Type of Agricultural Crop Damaged

Options	Frequency	Percentage (%)
Food crop only	89	35.3
Cash crop only	17	6.8
Food and cash crops	146	57.9
Total	252	100

Plate I: Damaged rice farm in the study area

Table 2 shows the effects of flood events on the sampled population in the study area. Sampled population with low and poor harvest constitute 34.1%, increased poverty constitute 27.8%, migration and displacement constitute 23.4% and landscape changes constitute 14.7%. This shows that major effect of flood event on the sampled population was low and poor harvest which leads to increased poverty.

Table 2: Effect of Flood Events on the Sampled Population

Options	Frequency	Percentage (%)
Migration and displacement	59	23.4
Landscape changes	37	14.7
Low and poor harvest	86	34.1
Increased poverty	70	27.8
Total	252	100

Flood hazard adaptation strategies for the study area include Engineering Scheme, Flood Abatement Schemes, Flood-Protection Scheme, Public Relief Funds, Flood Insurance, Flood Forecasting and Warning Schemes and Floodplain Zoning as revealed in Table 3.

Table 3: Flood Adaptation Strategies Adopted by the Communities

S/No	Adaptation Strategies	VG	G	NG	Total	Percentage (%)
a	Engineering Scheme	10	1	0	11	4.4
b	Flood Abatement Schemes	4	3	0	7	2.8
c	Flood-Protection Scheme	39	7	0	46	18.3
d	Public Relief Funds	88	20	0	108	42.9
e	Flood Insurance	0	0	0	0	0
f	Flood Forecasting and Warning Schemes	48	12	0	60	23.8
g	Floodplain Zoning	9	11	0	20	7.9
	Total	198	54	0	252	100

Source: Field Survey (2022)

As indicated in Table 3, public relief funds ranked the highest with 42.9% of the sampled population, flood forecasting and warning schemes ranked second with 23.8% of the sampled population and flood abatement scheme constitute the least with 2.8%. The implication of this finding is that public relief fund either from government or private donor is the major flood adaptation strategy in the study area. Engineering Scheme include river training, works designed to prevent local bank erosion, flood embankments, channels enlargement, flood-relief channels and flood storage reservoirs; Flood Abatement Schemes include afforestation and reducing the land-to-channel runoff; Flood-Protection Scheme: stocking of suitable shields to be placed in position at doors and windows prior to a flood, raising of building above the flood level and inclusion of pumping facilities in basement and Floodplain Zoning include Prohibitive Zone, Restrictive Zone (All buildings should be flood proofed and establishment of Game reserve) and Warning Zone.

Conclusion

Flood vulnerability consists of the three factors exposure, susceptibility and lack of resilience. These factors consist of indicators which assess different characteristics of vulnerability and they all shows that the study area is vulnerable to flood events.Floods are natural phenomena which cannot be prevented. However, anthropogenic activity is contributing to an increase in the likelihood and adverse impacts of extreme flood events. The possibility to identify and predict flood prone areas on ungauged rivers is the major advantage of this method. The present study shows a simple way of using geographical information science and remote sensing for generating flood vulnerability factors (FVF), flood vulnerability zones (FVZ) and flood risk map (FRM) from the available remotely sensed data sets and the outcomes of this study can contribute towards an efficient flood risk management decisions towards sustainable development.

The produced vulnerability maps can give planners and managers a valuable tool for assessing flood vulnerability. Therefore the IFVI tool has been applied for post-flood evaluation to identify areas of risk and the associated probable vulnerability. The outcomes generated in the form of maps can help approaches to rehabilitation and mitigation. However, flood mapping is also possible along with other diagnostic tools like a GIS.

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