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Prof. I. M. Dankani

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ASSESSMENT OF THE LEVEL OF FLOOD VULNERABILITY AND MITIGATION STRATEGIES IN SHIRORO LOCAL GOVERNMENT AREA, NIGER STATE, NIGERIA

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Abstract

The Vulnerability of Communities to flood hazards has increased globally in recent times evident to climate related risk crises. This study assessed the level of flood vulnerability and mitigation strategies in Manta and Galadima Kogo Communities in Shiroro Local Government Area, Niger State, Nigeria by extracting the Digital Elevation Model (DEM) of the study area and developing a flood risk vulnerability map. The data were subjected to statistical analysis using SPSS version 20.0 software. The finding revealed that about 32.02% of the study area is highly vulnerable to flood, while, 10.40% are in no-risk zones. The DEM generated shows that South-Western part is on low elevation which fall between 0-173m above Mean Sea Level (MSL) and is an indication of high level of flood susceptibility, while the North-Eastern part with an elevation between 174-608 m above MSL and considered less vulnerable to flooding. The study identified a few mitigation strategies used by the communities to respond to flood disasters, such as moving away from flood-prone zones to higher ground, using other sources of income, and dry season farming. The study concludes that the communities are highly susceptible to floods, which causes the destruction of crops in the study area. The study therefore, recommends the adoption of early warning system and flood forecasting, as well as training of local volunteers, enacting an effective by-law to regulate indiscriminate deforestation along river banks and flood-prone zones and promoting of Indigenous Knowledge System for more effective flood mitigation strategies in the study area.

Keywords: *Flood Vulnerability, Risk Zone, Mitigation Strategies, Flood Forecasting and Early Warning*.

Introduction

The global increase in natural disasters is at an alarming rate and linked to climatic related hazards in which flood tops with severity and consequences on communities. Recent studies have indicated an upward rise in flood events affecting thousands of vulnerable communities. For example, Surminski and Elderdges (2017) opined that flooding poses the extreme natural disaster threat in England, and its risk is projected to rise as the climate continues to change. Jevrejeva *et al*. (2018) observed that floods is occurring more frequently than other natural hazards, such as earthquakes, extreme precipitation, and droughts, while Duan *et al*. (2022) stated that as climate change accelerates globally, flooding has emerged as a significant natural hazard, endangering human lives, disrupting economic growth and hindering sustainability efforts, the findings showed that there is intensification in global flood risk between 2005 and 2020, with the proportion of areas classified as high-risk increasing significantly during this time. The study by Njock *et al.* (2020) also shows that floods have become one of the major disasters affecting people's lives and property all over the world.

Salazar-Briones *et al*. (2020) find out that floods are among the most recurring and devastating natural hazards, impacting negatively on human lives and causing severe economic damage throughout the world. Flooding caused by natural forces or human activities often results in both

voluntary and forced resettlement, leading to widespread displacement and increase human suffering (Nazir *et al*, 2024). However, the impacts on developing countries are usually more devastating and severe comparing the level of adaptation strategies to developed world. Understanding of global future flood risk is essential for the quantification of climate change impacts and designing effective adaptation strategies, Intergovernmental Panel on Climate Change (IPCC, 2012).

Wang *et al*. (2021) equally assessed that flood disasters have appeared more frequent in recent years due to climate change and urbanization, and Integrated Flood Risk Management (IFRM) has emerged as an effective way to reduce damage from these floods. The study examined IFRM methods in three aspects: flood risk identification of high-risk areas, flood risk assessment to quantify economic losses, and flood risk management to identify structural measures with the greatest engineering benefits, the results showed that the Zuoan-Road was a high-risk area with economic losses. Five structural measures in Zuoan-Road area with engineering benefits ranging from 0.97 to 1.60 over different return periods, and the one with the greatest engineering benefits had a fifty-year return period.

In times of loses, flooding also stands as the most frequent natural disaster globally and accounts for the highest number of related fatalities. The potential for catastrophic flood-related losses remains high due to widespread deforestation and the growing concentration of populations near coastal areas, river basins, and lakeshores (Doocy *et al.*, 2013).

Naz and Saqib (2021) asserted that gender and vulnerability are important issues to examine in the context of flooding caused by climate change due to the fact that men and women around the world adapt differently to climate change effects and natural disasters. Both quantitative and qualitative methods were used to assess men and women's vulnerabilities, including three indices of vulnerability measuring access to livelihood assets were used. A hierarchical regression model was used to perform a gender-based analysis and the result shows that male respondents were less vulnerable than female respondents which affect men and women's ability to respond and recover from floods and adapt to new opportunities when disaster strikes.

Huq and Hossain, (2015) observed that flood is one of most prominent natural disasters causing colossal damage to human and properties almost every year in Bangladesh. Relevant literature and vulnerability framework for reducing damage caused by flood was developed. This study adopted Turner (*et al*., 2003) vulnerability framework and distinguishes three main components (exposure, susceptibility and resilience) which allow more in-depth analysis and interpretation of local indicators.

The framework was built upon four major factors related to the flood vulnerability which include economic, social, exposure and susceptible elements and coping strategy and the result indicates that vulnerability framework might be helpful to reduce damage due to flood and policy makers in managing flood disaster. Vulnerability equation: Vulnerability = Exposure + Susceptibility – Resilience.

Also, Ghosh and Ghosa (2020) indicated that the resilience factors in households like education, workforce opportunities, health, and institutional accessibility are highly uneven, which have been causing hindrances to the adaptive capacity to flood. In the communities where overall vulnerability to climate change was found to be high, the adaptive capacity was found to be low. Concurrently, in those villages, the sensitivity was found to be high.

A study by Peker *et al.* (2024) revealed that floods are among the most devastating disasters in terms of socio-economics and casualties. Though, managing these natural disasters and minimizing their effects can be done by flood Modelling performed before the occurrence of a flood. Therefore, the study integrates Hydrologic Engineering Centre – River Analysis System

(HEC-RAS) and Hydrologic Engineering Centre – Hydrologic Modelling System (HEC-HMS) with Geographic Information System (GIS) in Flood Modelling and Flood Hazard Mapping which was developed for the Göksu River Basin, Mersin, Türkiye while flood hazard and risk maps were prepared by using GIS, HEC-RAS, and HEC-HMS.

According to IPCC (2014), flood mitigation measures is: "the process of adjustment to actual or expected flood and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities, whereas in natural systems, human intervention may facilitate adjustment to expected flood and its effects". The perception of personal responsibility is one of the key factors motivating individuals to take proactive measures for hazard protection. The adaptive capacity is 'the ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC, 2014).

However, developing country's mitigation and adaptation strategies to flood hazards has been found to be very weak which tends to increases the level of flood susceptibility, prompting a more effective approaches in reducing its impacts on vulnerable communities. Adaption strategies to all forms of human induced and natural disasters equally varied in respect to gender, age and economic status of individual. The female gender adapts less to disasters and considered more vulnerable than the male, while in children and the aged, the level of vulnerability is equally high due to weak adaption strategies to disasters.

Material and Methods

The Study Area

The study area falls within the 25 local government area in Niger state, Nigeria. Shiroro is located on a geographical coordinate between longitude 6° 51′ 00″ E to 6° 75′ 10″ E and latitude 9° 58′ 00″ N to 9° 65′ 25″N of the Greenwich Meridian with a total land area of about 5,015km square. It has an elevation of about 500 meters above sea level, downstream of river Kaduna in Niger State (Usman and Ifabiyi, 2012). The administrative headquarter of the Local Government Area is located in Kuta which has 15 political wards. These includes; Allawa, Bassa/Kukoki, Bangajiya, Egwa/Gwada, Erena, Galadima Kogo, Gussoro, Kato, Kushaka/Kurebe, Gurmana, Kwaki/Chukwuba, Manta, Pina, She and Ubandoma ward.

According to National Population Commission (NPC, 2006), total population figures of the study area was 235, 665 people. However, the projected population of the local government area from 2006-2020 was put at 269, 482 people using a projection rate (growth rate) of 2.5%. The major tribe that dominates this area are the Gbagyis and it is the major indigenous language spoken in the study area, while other tribes such as Bassa, Gussoro and Gurmana are also predominant. Also, tribes representing the diverse socio-cultural groups are equally found in this area, the Hausa, Fulani, and Igbo. The rich fertile soil of the study area has a linked to the predominant occupation of the people which is farming and also the major occupation of the Gbagyi speaking people, while other inhabitants earn their living through fishing due to the presence of the Shiroro dam which is located downstream of River Kaduna.

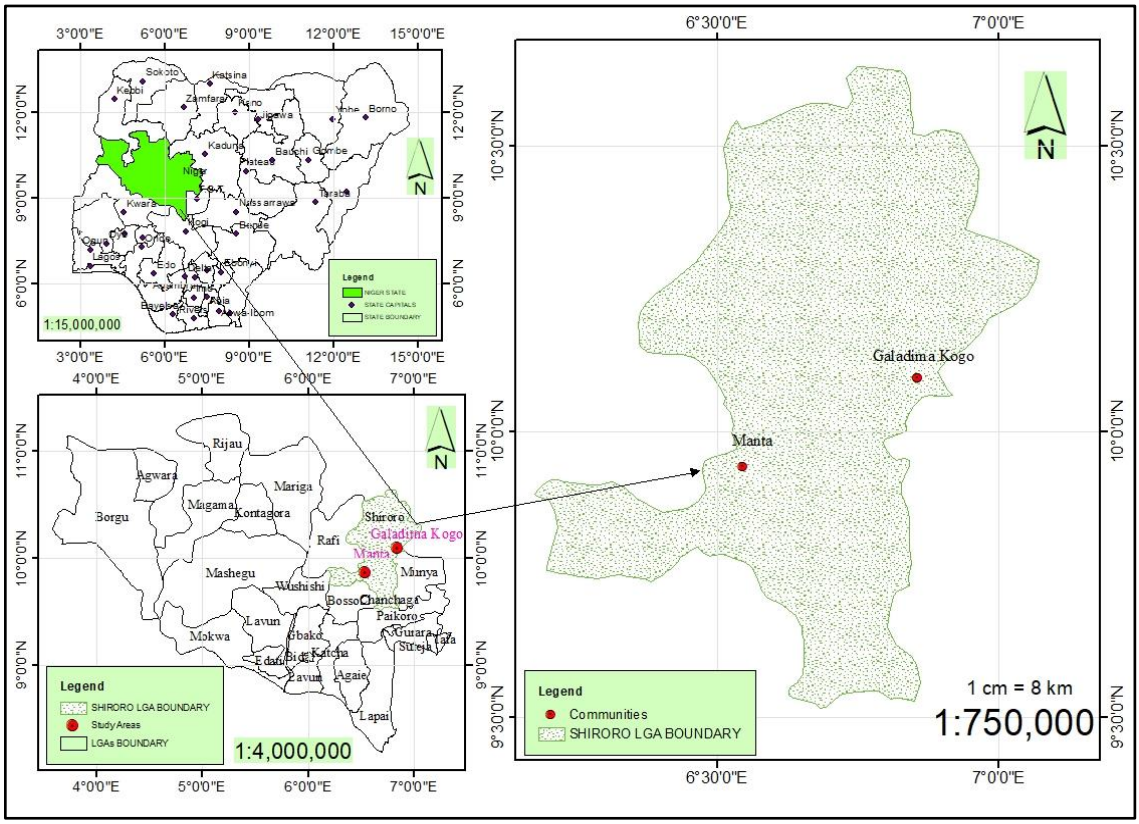

Figure 1: The Study Area (Manta and Galadima Kogo, Shiroro LGA, Niger State)
Source: Department of Geography (Remote Sensing Unit), FUT Minna

Data Used and Sources

Qualitative and quantitative data were sourced through field survey, Digital Elevation Model (DEM) was sourced with the aid of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) with 30m resolution radar of the affected communities in order to check the level of community's vulnerability to flood hazards, the DEM map was processed using ArcGIS. Production of relief and drainage maps for the study area, photographs, as well as Check-list for the study and administration of questionnaires to the affected communities that formed within the sample frame to identify their adaptive and mitigation strategies to flood events in the study area.

The study applied Taro Yamane formula (Yamane, 1973) with 0.05 degree of freedom. The projected population using the growth rate of 2.5% per annum was put at 269,482 people. Household heads, chiefs, women leaders, youth leaders and other leaders of organized groups were sampled for investigation using purposive sampling techniques.

The Taro Yamane formula is presented as follows;

$$n = \frac{N}{1 + N(e)^2}$$
$$1$$

Where: n = Projected population sample size, N = Total size of projected population

1 = Constant, e = Error degree of tolerance 0.05, N= Total projected population of communities.

Population and Sampling Procedure

Where: n = Sample size, N = Size of Population, 1 = Constant, e = Error degree of tolerance 0.05

Therefore, $n = \frac{269{,}482}{1 + 269{,}482(0.05)^2}$

n = 400 respondents

The Checklist was used on the field to guide the researcher on the information collected such as effect of flooding on farmlands, residential building and other social amenities as well as mitigation strategies used by the communities in coping with flood disasters. The purpose of the checklist was to check if there is relationship or link between the result obtained from the study through the application of questionnaire and the researcher's physical observation on the level of flood vulnerability in the study area.

Method of Data Analysis and Presentations

Socio-Demographic Characteristics of the Respondents

A total of 400 questionnaire was administered to the respondents of the study area, with 387 (96.75%) accounting for retrieved questionnaire, while 13 questionnaire (3.25%) were not retrieved due to misplacement by the respondents.

The results shows that majority (87.08%) of the respondents were male, while few (12.91%) were female. This is due to the fact that male respondents are readily available for responses compared to the female respondents. The implication of having 87.08% male respondents to 12.91% female respondents is that major occupation of the respondents in these communities is farming and male dominate the practices in the study area. Also, religion factor and culture played role in the determinant of respondents in the study area where female do have a few chances for interactions. This result is equally similar with the work of Ibrahim *et al*. (2020) whose findings shows that 89.67% of the respondents were male, while 10.33% were female. Age of the respondent was also assessed in figure 2 which shows that majority (41.9%) of the respondents aged between 26-40 years, while few (3.9%) aged 61 years and above. The implication of this finding having high percent aged between 26-40 years is due to the fact that the population of this communities largely engaged in subsistence farming activities as a major occupation, while also active youthful age of this farmer falls between 26-40 years. Also, at this youthful age, they contribute and participate more to the major occupation of the rural setting (that is subsistence farming) than other age bracket, and formed the active age.

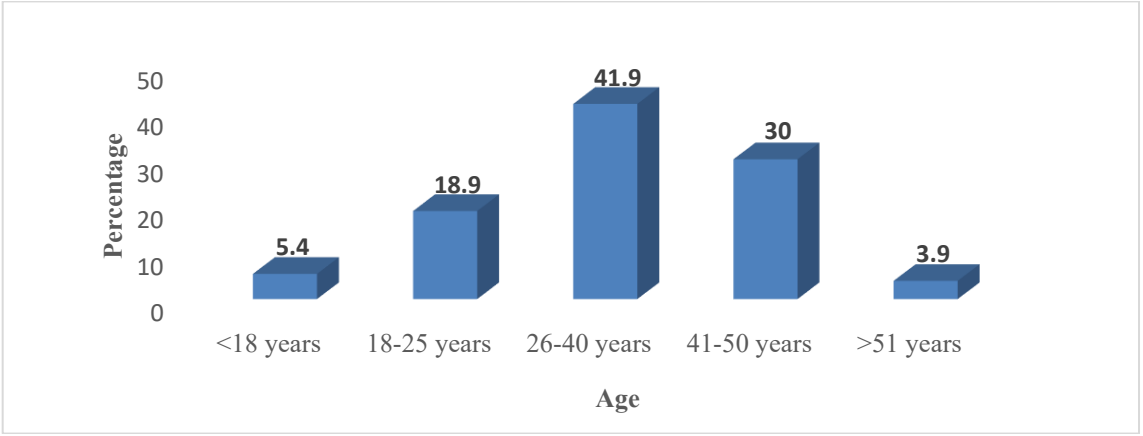

Figure 2: Age Distribution of the Respondents

The study also observed that majority (58.7%) of the respondents were farmers, while few (5.7%) were civil servants as indicated on Table 1. This is as a result of the fact that major population of the rural communities engaged actively in farming activities. The rural communities are highly responsible for promoting food security through their relevant skills in the cottage industries by partaking in different king of agricultural production and also improving the economic status of their household and the nation at large. This result agreed with the finding of Adegboye (2021) who observed that major occupation of rural dwellers is farming. The rural people are well known for their engagement in the cottage industries most especially agriculture which help to provide food for the immediate family needs and also improving the food security. This farming type is usually done at a subsistence scale.

Table 1: Occupation of the Respondents

Occupation	Frequency	Percentage (%)
Farming	227	58.7
Business	62	16.0
Student	42	10.9
Others	34	8.8
Civil Servant	22	5.7
Total	**387**	**100**

Level of Flood Vulnerability

Level of flood vulnerability of Manta and Galadima Kogo were assessed by making a relief and drainage map of the study area. Digital Elevation Model (DEM) map was equally produced to shows the level of differences in height above Mean Sea Level, and flood risk vulnerability map of the study area which was categorized into high and low risk areas to flood hazard in the communities. The high-risk areas to flood hazards are indicated in red colours and are the most vulnerable to flood. This occurs as a result of variations in level of relief and drainage of the area which is based on susceptibility of settlements and farmlands to flooding in the study area. This was also in conformity with flood vulnerability observation checklist. The farmlands are located along flood plains and continues inhabitation of these flood plain areas by the communities increases their risk of being affected by flood impacts.

Digital Elevation Model of the Study Area

The Digital Elevation Model (DEM) of the study area shows the differences in height between 173m to 608m above sea level (Figure 3). It shows that western and south-western parts of the study area depicted in blue colours has the lowest elevation lying between 0-173 m above MSL. This is an indication of high level of vulnerability to flooding, and communities located in this susceptible zone includes; Gunigo, Layi, Jiko, and Manta. However, the north-eastern and the eastern part (Galadima Kogo) with the following communities; Dnasa, Iburo, Gwofa, Bwisidna and Galadima Kogo has the highest elevation (reliefs) lying between 174-608 m above Mean Sea Level (MSL) and it is depicted in green colours, an indication of low level of flood vulnerability compared to the other parts of the study area. The DEM revealed that north-eastern and eastern part is less susceptible to flooding and its effects on human life, agricultures and socio-economic activities, while the DEM of western and south-western parts of the study area has low topography, making it highly vulnerable to flood.

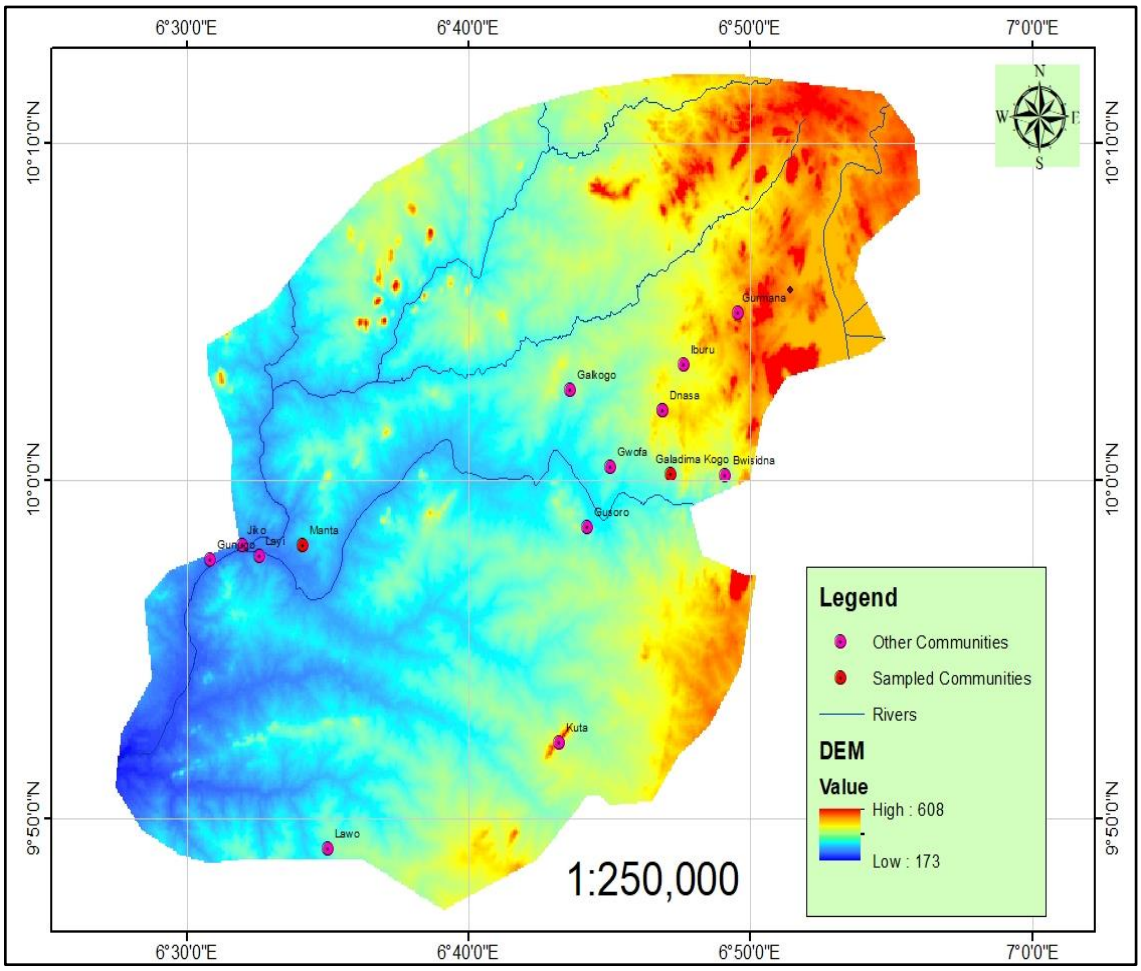

Figure 3: Digital Elevation Model of the Study Area

Modelling of flood is highly influenced by topographic data (DEM) which are all associated with the nature of relief of an area.

This finding agreed with Komolafe *et al*. (2020) who stated that low elevation (DEM) indicates high accumulation of water, which reveals the potential of the area to flooding. The result equally agreed with the study of Vignesh *et al.* (2020) who reported that flood occurs in the low elevated area due to the down-ward accumulation of water from the higher region. They find out that north and northeastern sides with significant high altitude in elevations (DEM) as moderately vulnerable to flood, whereas southern, south-western parts which belong to a low elevation (0-727 m) were highly flood-prone region.

Flood Risk Vulnerability Zones

The areas marked as highly vulnerable/susceptible to flooding were mostly in the south-western part of the study area, flooding is experienced in most areas in this classification yearly. The areas are characterized by low relief and water-logged soils. Figure 4 is a classified risk map of the study area which shows the area occupied by each level of vulnerability. The result from the classified flood risk map on Table 2, shows that about 457.03 square kilometres (32.02%) of the area is on highly vulnerable area which is evidence of recurrent flooding in the study area (mostly the South-Eastern parts), whereas about 573.18 square kilometres (40.16%) are moderate risk areas. Also, 248.66 square kilometres (17.42%) are on low-risk areas, while 148.42 square kilometres (10.40%) is classified on no risk areas.

Table 2: Flood Risk Vulnerability Zones

Vulnerable Areas	Area (Km^2)	Percentage (%)
highly vulnerable area	457.03	32.02%
moderate risk areas	573.18	40.16%
low risk areas	248.66	17.42%
no risk areas	148.42	10.40%
Total	**1,427.29**	**100**

Therefore, the western and south-western of the study area which are located downstream is generally more prone to flood occurrence compared to the eastern and north-eastern parts which are located in the upstream. Areas vulnerable to flooding affect agricultural production in the study areas as result risk of losing farm produce and farmlands thereby affecting the resident's socio-economic activities, prompting food insecurity in the region. A population without food security are tends to be vulnerable population.

This result conformed to the study of Komolafe *et al*. (2020) who find out that flood hazard map showed a higher exposure to floods in the downstream, while the low flooding areas are in the upstream part. They further stated that areas with high flooding risk are dominated by low slope, low elevation, large water bodies and high rainfall incidence.

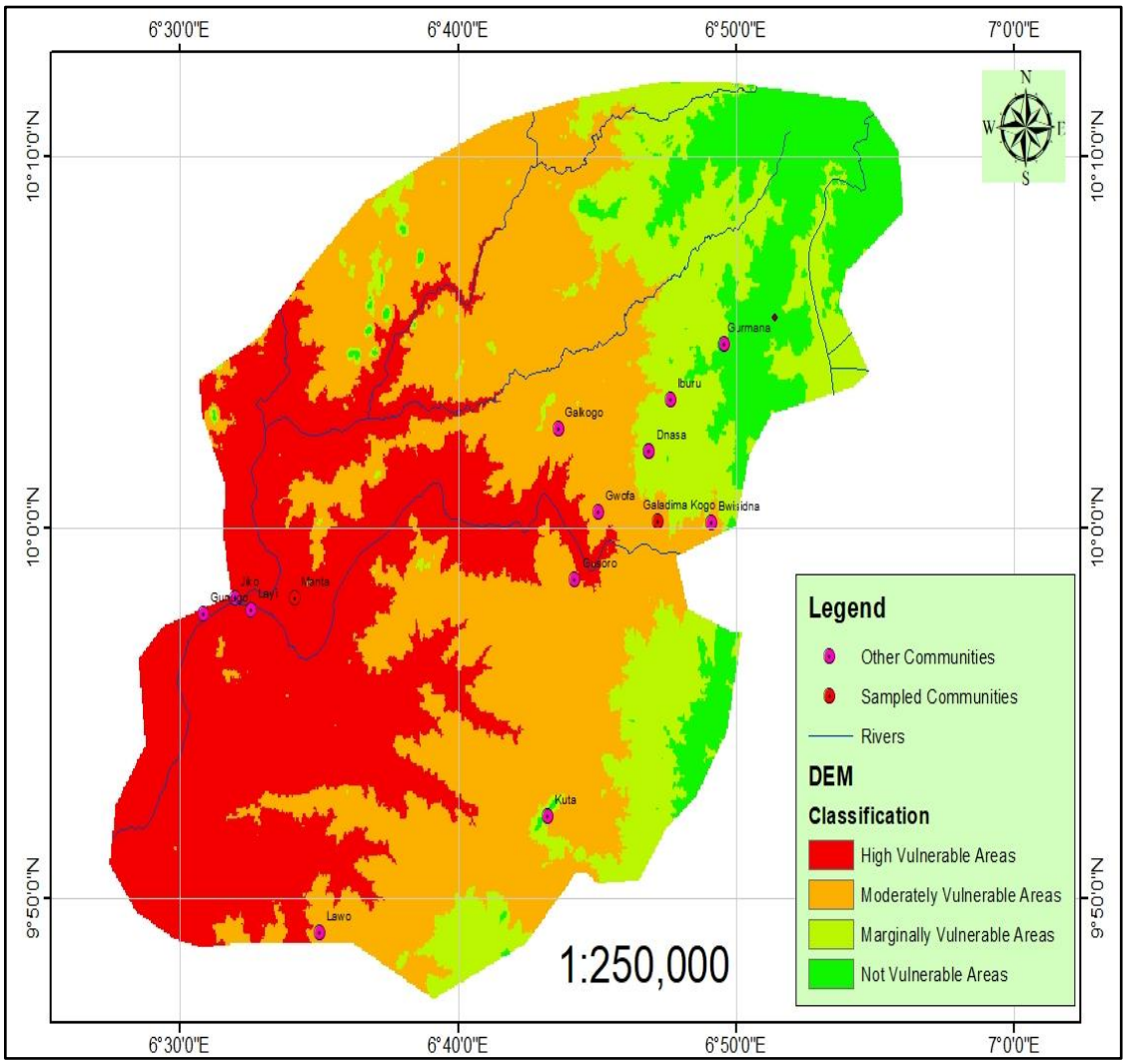

Figure 4: Risk Map of Flood Vulnerable Zone of the Study Area

The finding revealed that the study area is susceptible to flooding because areas most especially the western and south-western parts are in low elevation. These have been attributed to some degree of susceptibility. This was also confirmed through by a ground truth exercise. The classification of flood risk zones in the area was mainly based on the interaction of relief and drainage.

As presented, there are variations in the degree of susceptibility to flooding in Manta and Galadima Kogo, and these include high flood risk zone, Moderate flood risk zone, Low and No flood risk zones. Plate I shows highly exposed community located at the high flood risked river bank in the study area. The location of this settlement is associated or linked to the community's major occupation which is farming because of the presence of vast fertile land for agricultural cultivation. Also, some member of the community equally engaged in the fishing industries, with this by helping to diversify their livelihood and providing source of protein for the member of the community. However, these has not help in reducing the level of vulnerability of the settlement to flooding because of its location on the high-risk zone.

Plate I: Highly Exposed Community to Flood Vulnerability in the Study Area (Manta)

Mitigation Strategies to Flood Occurrence in the Study Area

Mitigation strategies to flood identified by the respondents in the study area. The results revealed that relocating to high land, making fallows, raising the floor of the house with Mean Score 3.51, 3.33, and 3.26 respectively and considered as major mitigation strategies to cope with flood disasters, while construction of drainages, planting of trees, and making sand banks scored 2.68, 2.56, and 2.52 respectively and also considered with less mitigation strategies to flood disasters in the study area.

Table 3: Mitigation Strategies to Flood Occurrence in the Study Area

Adaptive Strategies	*5	4	3	2	1	MS
Relocating to High Land	34	93	37	87	136	3.51
Making fallow	60	93	25	76	133	3.33
Raising Floor of the House	52	78	77	76	104	3.26
Dry Season Farming	98	76	15	73	125	3.13
Construction of Drainage Channels	96	98	70	81	42	2.68
Early Warning System	79	129	62	79	38	2.66
planting of Trees	110	99	69	69	40	2.56
Making Sand Bank	73	155	79	44	36	2.52

This mitigation strategies can be easily adopted by the rural communities directly affected by flood due to non-capital intensive. However, construction of drainage channels, and building of flood dykes and reservoirs requires large amount of capital which need government intervention and cannot be easily done by the rural dwellers because of their low level of income as they largely engaged in subsistence farming. Planting of trees also need a campaign for the locals to be fully aware of its environmental benefits to flood mitigation. This finding agreed with the results of Aloma *et al.* (2018) who opined that planting of trees with low mitigation measures to flood disasters by rural dwellers found in the various communities as a self-help effort on the impact of flooding were observed. They attributed that few rural dwellers have adopted the planting of trees as an adaptation measure towards mitigation of flood disasters in their communities.

Conclusion

Flood constitutes to environmental hazards and has continued to posed serious threats to Manta and Galadima Kogo communities owing to high level of vulnerability to flooding in the study area. Activities of dam construction (that is overflow from dam), building/farming activities on the flood plain areas as well as low vegetation cover along the river banks is an evident of recurrent inundating in the study area, leading to submerging of farmlands, destructions of crops and other available insufficient social amenities. Ineffectiveness of flood control management, low mitigation and adaptive strategies to flooding increase the level of flood susceptibility of the communities in the study area. This study therefore, concluded that the most part of the communities (32.02%) is highly susceptible which is an evident of recurrent flooding in the study area, whereas (40.16%) are on moderate-risk areas, while only (10.40%) was classified on no-risk zones. In order to reduce flood vulnerability, the result obtained from this study can be useful to policy makers by formulating flood mitigation and adaptation strategies, raising awareness and effective early warning system in the study areas.

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