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IDENTIFICATION AND CLASSIFICATION OF AREAS LIABLE TO FLOOD WITHIN GREATER YOLA, ADAMAWA STATE, NIGERIA

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ABSTRACT: Globally, disasters are said to have devastating effect on economic development, livelihoods, agriculture, and health, social and human life. Flood disaster is not a recent phenomenon in Nigeria and its destructive tendencies are sometimes enormous. This study Identification and Classification of Areas Liable to Flood within Greater Yola, Adamawa State, Nigeria. The research design that was employed used both quantitative and qualitative methods. The study found that area is made up of both larger and smaller watersheds with river Benue serving as the major pour point; this is the point on the surface within the study area at which water flows out. The landform of the study area is generally grouped into valley and troughs, upland, plains, lowlands and hills/mountain ranges. The vegetation formations of Adamawa State like most northern States are generally of the savannah type. The study also discovered that the soil formation of the study area is regosol, and the area is well drained by many rivers and most of them are seasonal. The main river is River Benue which cut across Greater Yola. The study also found out that areas that are 0-7km off River Benue are highly vulnerable to flooding. It was also discovered that agriculture and settlements are the land use/land cover mostly affected by flood in the study area. The study found out that the heavy rainfall in the study area usually within the month of June, July and August at an average of 194.2mm, 224.2mm and 198.2mm account for the major cause of flooding in the area. The study further found out that the damage and destruction of properties are the most prominent effects of flood in Greater Yola

Keywords: Flood, climate, rainfall, river Benue, and vulnerability.

INTRODUCTION

Incidents of flood are not a recent phenomenon to people of Adamawa State as they have been living in flood prone areas for centuries. Like most urban areas of the third world, Adamawa has experienced accelerated population growth which has led to changes in the land use activities. Land use changes in particular, have a direct impact on the magnitude and behaviour of floods (Civco *et al.,* 2002). Flash floods are common features in Nigeria during the rainy season (May-October) but the country's flood event of the year 2012 have been described as the most devastating in over 40 years.

In flood events, socio-economic life and livelihood of the affected people may be distorted, in most cases farmlands and livestock are submerged which are the major source of people's livelihood. Flood losses are devastating as many never get recovered after the flood recedes. Vulnerable communities suffer great losses in events of flood, especially when the flood is unprecedented. Hunger, famine, disease and epidemic outbreak are usually resultant impacts of flood (Mmom & Aifesehi, 2003). Malaria and typhoid outbreaks after floods in tropical countries are common. It has been estimated that in India and Bangladesh 300 million people live in areas that are affected by floods (Nott, 2006).

Flood disaster is not a recent phenomenon in Nigeria and its destructive tendencies are sometimes enormous. According to the United Nations Environment Program (UNEP, 2006), flooding is one of the major environmental crises ravaging the universe within the century and the millennium. This is especially the case in most wetlands of the world. The reason is attributed to the general rise in sea level globally, due to the global warming as well as the saturated nature of the wetlands in Nigeria. Periodic floods occur on many rivers, forming a surrounding region known as flood plain. Within the cities, human activities such as rapid industrialization and urbanization, population growth, exploitation of natural resources and location of infrastructures (dams, piers and lands) exacerbates the occurrence of floods. Askew (1999) reiterated that floods cause about one third of all deaths, one third of all injuries and one third of all damages from natural disaster.

The impacts of flood on lives and livelihoods depend on the combination of different types of impact on individual sector. Being essentially agricultural producers, the main consequence of flooding has been the destruction of food crops on farms as well as seeds stores; eventually culminating in a decline in food production. Starvation together with a decline in environmental quality resulting from flood related damage, fuels the desire for migrating out of these rural areas. The reduction in food production resulting from floods also means loss of income for many in these communities which further reduce their ability to purchase food and thereby contributes to increasing the problems of food shortages and starvation within household. In these communities, non-agricultural income opportunities are few. However, social networks can enable residents' to be informed of the existence of opportunities both within

and without the communities. Non-agricultural income can contribute to increase household income and thereby reduce starvation that may result from flooding. Such destruction and physical loss is usually accompanied by generalized destitution and sense of grief among people who have lost loved ones. These together increase the desire of people to move out of these communities in search of safer and more stable means of livelihood. Sometimes, the risks prevailing in the destination of prospective migrants are higher yet, individuals migrate.

Some potential migrants are aware of the risks associated with migration while others are not aware. In the agricultural impacts, increase in agricultural labour results in a corresponding increase in agricultural activities (productivity) which in turn amplifies food production. When food production increases, the risk of starvation is minimized. Less starvation suggests that individuals become less susceptible to diseases. More agriculture activities lead to a rise in food production which in turn enhances the likelihood of seed storage as seen in the livestock impacts. Food production and non-agriculture income feed into household income which in turn influences the means of livelihood for the communities. When the means of livelihood in the community grinds down, it triggers exodus of community members into urban centres in search of new and better income opportunities; eventually this situation reduces the strength of the ability to reduce vulnerability of the flood as well as health and social impact. Onset of floods could lead to incidents of disease which potentially could lower the ability to impact of the flood.

Flood has negative impacts on the sector of health and education also. During flood the flood water increases the chances to get different types of water born disease. Especially child and elderly people are more vulnerable to these impacts. For affecting different health problem, these may impact the economic factor for treatment cost. The destruction of crops by the floods makes it imperative for the community members to shift dependence on agriculture income to non-agriculture income or diversify their agricultural livelihoods. In the non-agricultural income, flood events simultaneously trigger reduction in income level production (farms of fish or cow are destroyed and agriculture lands become inundated and unsuitable for cultivation for most of the staple foods within the study area leading to reduction in household income). It must be emphasized that existing bad sanitation practices within the communities also feed into the outbreak of the disease. Infected individuals

in most cases lack the capacity to contribute to non-agriculture labour. The total process of this cycle is depending on one another. Within this circular process if any part is affected the other part automatically get affected.

A flood disaster can have two main effects on a society and economy; the total or partial destruction of physical assets, resulting in subsequent changes or losses to economic flows in the affected area (including the interruption of services) conceptually, it is important to mote the difference between flood damages and flood losses. In order to reduce vulnerabilities of the natural and built environment, the understanding of the social, economic and financial implications of disasters is becoming a priority. Since 1972, the United Nations Economic Commission for the Latin America and the damage loss assessment (DaLA) methodology a Caribbean (UNESCAP, 1972) developed has been improved to capture the closest approximation of damage and loss due to disaster vents and into a globally recognized and applied tool to quality the impacts of flood disasters and determine the financial resource necessary to achieve reconstruction and recovery. This methodology helps to identity the socio-economic effects of flood disaster as well as exposure of sector assets (UNECLAC, 2003).

The term flood damage refers to the physical damage caused to the public and private assets such as infrastructure, houses, crops and vehicles as a result of contact with flood waters. This entails total or partial destruction of physical assets existing in the affected area. Damage occurs during and immediately after the natural phenomenon that causes the disaster and is measured in physical units (GFDRR, 2010). Monetary value is expressed in terms of replacement cost prevailing just prior to the event. Dutta *et al.* (2003), classified flood related damages as tangible and intangible. According to them, tangible damages are further grouped into direct and indirect. Direct damages are caused by contact with flood for example, agricultural and environmental damages. Similarly, indirect damages are the ones cause by the impact of floods on regional or national economy such as business interruption. Intangible damages on the other hand are negative impacts that can be easily quantified such as biodiversity or aesthetic impacts; health, for instance, injuries, stress and anxiety. Thus, intangible damages are very often taken into account in the monetary evaluation of damage (Lekuthai & Vogvisessom, 2001). Further, Huang *et al* classified properly loss due to this as they computed flood damages in monetary terms having classified properly loss due

to flood as a direct tangible damage and income loss. Income loss is obtained by calculating the difference in income between the year before the flood and the year of the flood (i.e. indirect tangible damage).

Floods occur in Nigeria in three main forms; coastal flooding, river flooding and urban flooding. Coastal flooding occurs in the low lying belt of mangrove and fresh water swamp along the coast (Folorunsho & Awosika 2001; Ologunorisa, 2004). It is typically a function of storm surge, waves (driven by wind) and heavy rainfall. River flood is a function of rainfall and run off volumes within the river valley. It occurs in the flood plain of larger rivers where sudden short-lived flash floods are associated with rivers in the land areas where sudden heavy rains can change them into destructive torments within a short period (Folorunsho & Awosika 2001; Ologunorisa, 2004). Urban flooding on the other hand occurs in towns, on flat or low lying terrains especially where little or no provision has been made for surface drainage or where existing drainage has been blocked with municipal waste, refuses and eroded soil sediments (Ali, 2005). Oderrerho (2004) and Nwafor (2006) identified twelve (12) causes of urban flooding. They include; Surcharges in water level due to natural or man-made construction of flood paths, sudden dam failures, inappropriate land use, deforestation of catchment basins, reclamation, construction sites and solid waste, inadequate drainage capacity to cope with urbanization and excess encroachment in flood ways. Urban flood problem is a global experience but the management practices differ according to prevailing technologies and aptness in planning concern.

Incidents of flood are not a recent phenomenon to people of Adamawa State as they have been living in flood prone areas for centuries. Like most urban areas of the third world, Adamawa has experienced accelerated population growth which has led to changes in the land use activities. Land use changes in particular, have a direct impact on the magnitude and behaviour of floods (Civco *et al.,* 2002). Flash floods are common features in Nigeria during the rainy season (May-October) but the country's flood event of the year 2012 have been described as the most devastating in over 40 years. Two major events took place between the months of September and October 2012 in Nigeria, namely the Ladgo Dam flood in Adamawa State, and the River Benue and Niger adjoining States floods (Niger and Benue States). The event pushed most of the country's rivers over their banks and submerged hundreds of kilometres of urban and rural land. This resulted in widespread devastating

flood disaster that hit the country cutting across major cities in about 14 states that borders the Niger-Benue River. The flood submerged houses and several transportation routes throughout the affected areas nationwide. Overall, an estimated 1.3 million people were displaced and about 431 people lost their lives with several hectares of farmland destroyed (MISNA, 2012). Despite the expected increase in frequency and magnitude of flood in the Nigeria and invariably Adamawa, few impact assessment studies on the socio-economic livelihood of the people have been undertaken to establish the underlying causes of their vulnerability. It is thus on the premise of this background that this study was aimed at Identifying and classifying areas liable to flood within Greater Yola, Adamawa State.

METHODOLOGY

Description of the Study Area

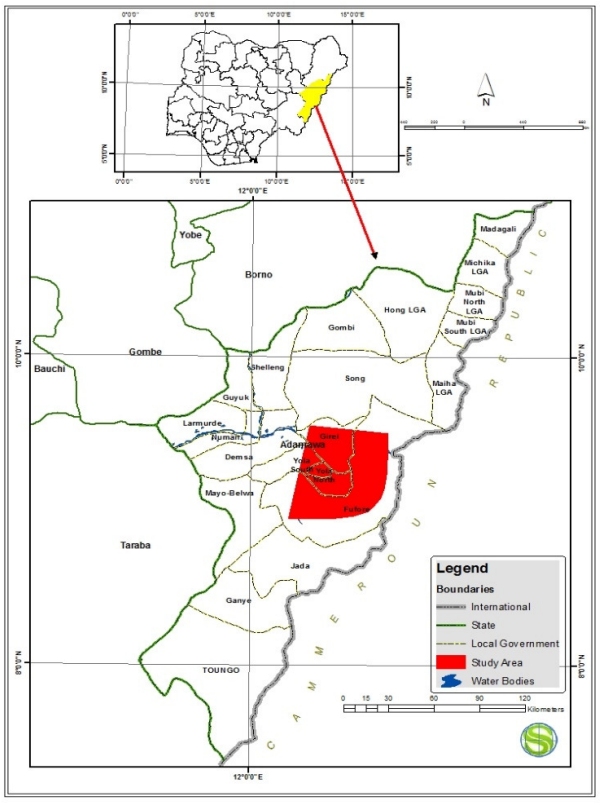

Figure 1: Map of the Study Area

Adamawa State is located in the North Eastern part of Nigeria. It lies between latitude 7° 11 and 7° 30 North of the Equator and between longitude 11° 14 and 11° 10 East of the Greenwich Meridian. The state covered a total land

area of about 39,972 square kilometres. It shares boundaries to the South and West by Taraba State, Northwest by Gombe State and to the North by Borno State. The State also shared an international boundary with the Cameroun Republic along its Eastern border. The State is divided into 21 Local Government Areas. Specifically, the areas under study were communities within the greater Yola and environs. It traverses through four local government areas of the state namely: Yola North, Yola South, Girei, and Fufore Local Government Areas. The area is made up of the major flood plains of Adamawa state with major concentration of people and settlements. The delineated area under study spatially lies between 12°13'25.588"E, 8°56'48.721"N and 12°53'4.746"E, 9°33'54.652"N covering an area of 3,605.816183 Square Kilometres.

Nature and Source of Data

The study employed the use of secondary data. The secondary data comprises of mostly qualitative data such as existing topographic maps, soil data, rainfall data, hydrologic data, lands at satellite imageries, digital elevation model, slope data, and related literatures that bother on causes and effects of flood on the local and broad global perspectives. River Benue and other water bodies were extracted from the classified landuse map. Because most of the settlements are formed along the river coast, this feature played a major role in identifying and classifying areas liable to flood. in times of heavy downpours and the release of Lagdo Dam when river banks are overflown. Slope data, elevation data, and watershed analysis were derived from Digital Elevation Model (DEM) also acquired from the USGS. These information were crucial in the analysis of the vulnerabilities.

Method of Data Analyses

The data collected for the study were analysed via the use of Microsoft Excel and SPSS statistical tools. For the spatial data collected, a Geographical Information Systems (GIS) based multivariate analysis was undertaken to first produce factor maps for flood vulnerabilities. Each factor in question was modelled through rasterization and reclassification to produce a single variable vulnerability map for each factor based on expert's judgment. In the reclassification process, pixels of each factor were regrouped into three (3) namely: vulnerable, moderately vulnerable, and not vulnerable. Because one factor alone might not give a true picture and explanations for flood vulnerabilities, a multifactorial approach was deployed in a GIS to combine all single-factor vulnerability map using weighting and scoring in spatial

analyst raster calculator of ArcGIS. The result yielded one single map with four vulnerability status namely: highly vulnerable, vulnerable, moderately vulnerable, and not vulnerable.

RESULTS AND DISCUSSION

From Figure 2, its areas in green such as Tundu Wada, Njoboliyo, Hamdalla, Dougerei, Rugange, and Fufore, among others, are vulnerable to flood. The areas in purple such as Kwanan Waya, Kauwa, Girei, Bapola, Yokasala, and Mbamba Kona are moderately vulnerable, while the areas in orange such as Sabongari, Wuro Ardo, Jubaw, Puro, Wuro Amsami, Jabbi Lamba etc. are not vulnerable to flood. Areas that are 0-4km off River Benue are highly vulnerable to flooding, while area that are 4-7km off Rivers Benue are vulnerable to flooding. However, areas that are 7-13km off River Benue are only moderately vulnerable to flooding.

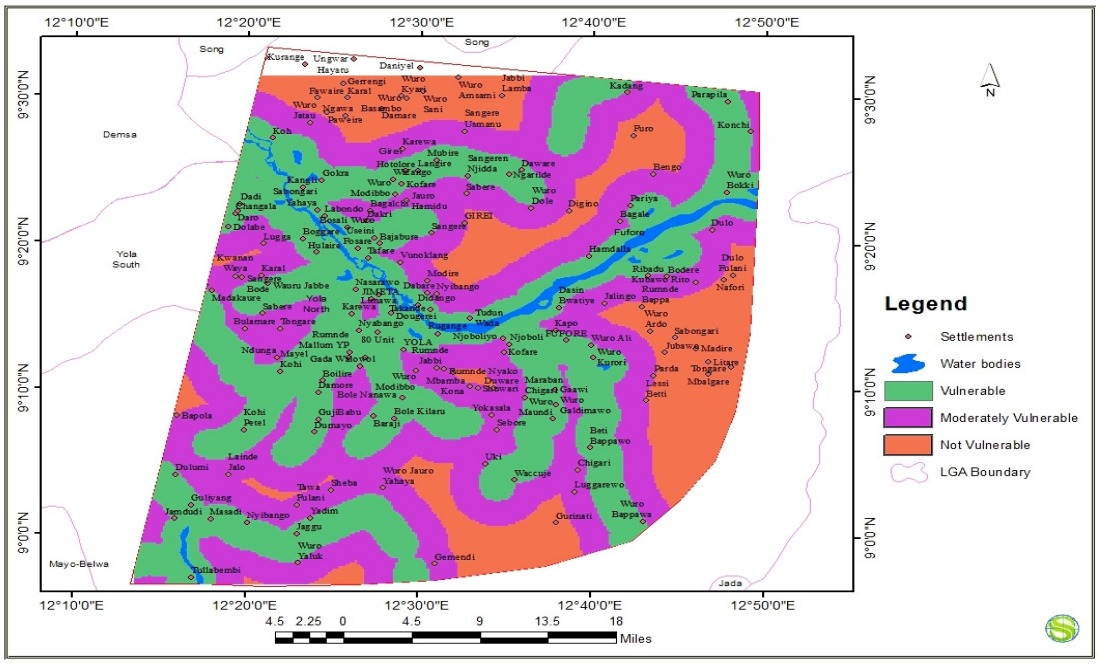

Figure 2: Vulnerability Map of the study area to flooding

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Watershed

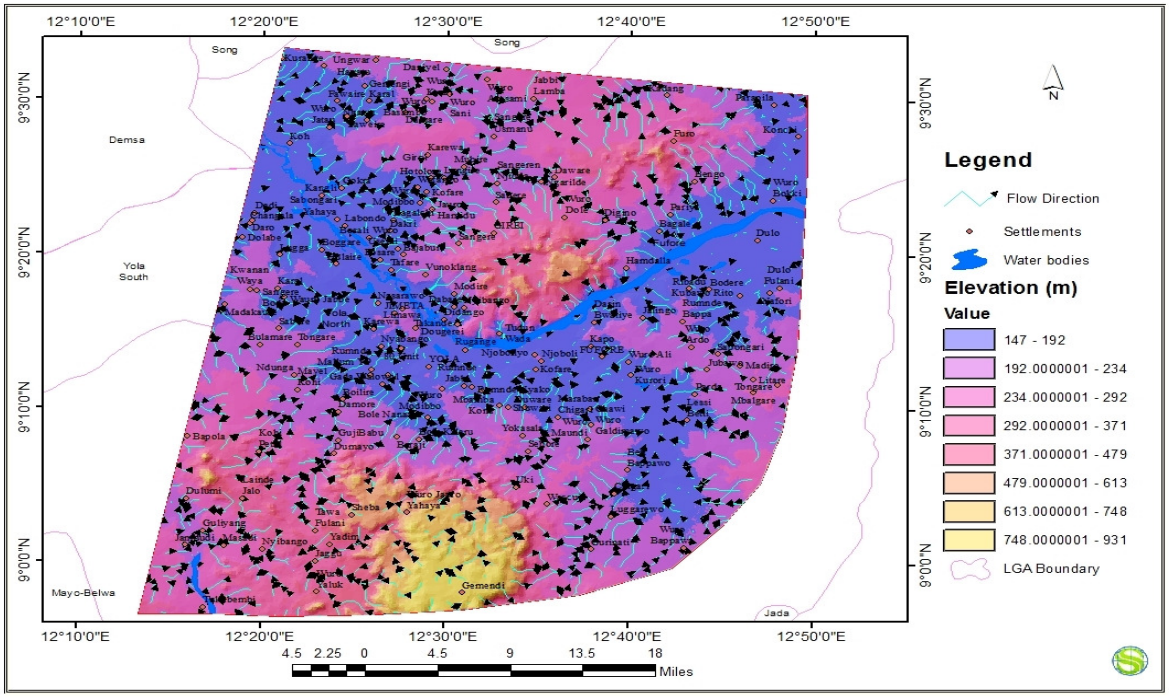
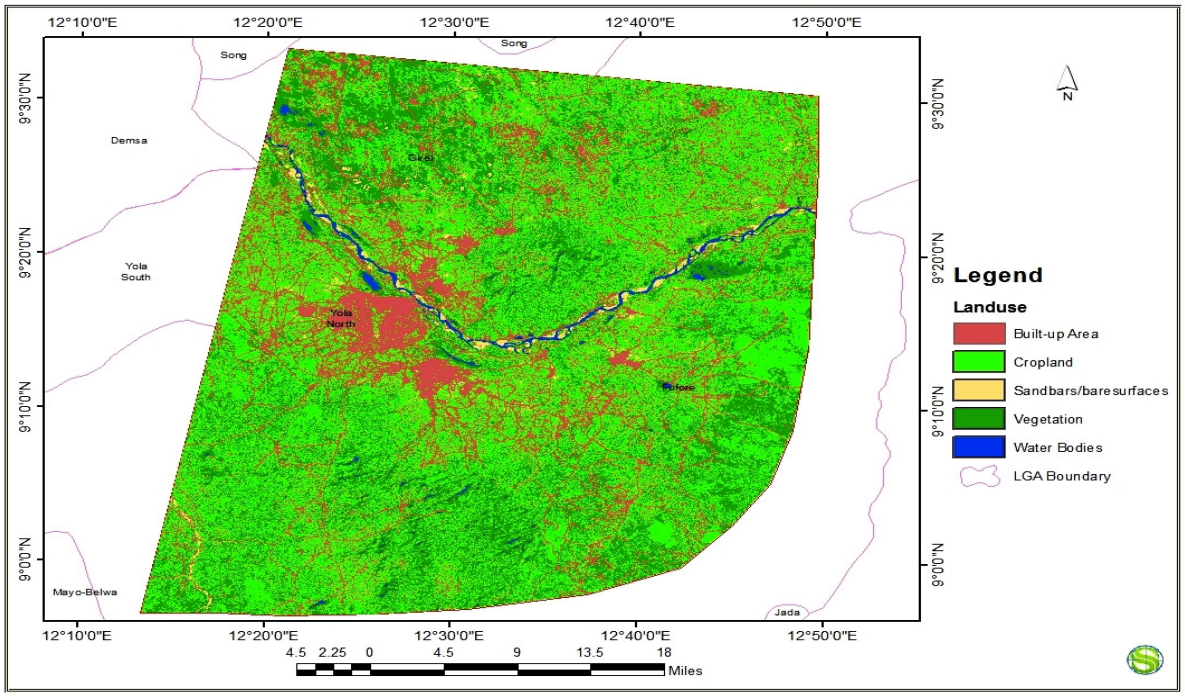


Figure 3: Watershed and Topography of the study area

A watershed is the upslope area that impacts flow of water to a common outlet as concentrated drainage. The study area is made up of both larger and smaller watersheds with river Benue serving as the major pour point; this is the point on the surface within the study area at which water flows out. It is the lowest point along the boundary of the watershed. Other rivers (apart from river Benue) within the study area form some drainage divided giving rise to sub-basins. The physical characteristics of the area under study such as, vegetation, soil, watershed, drainage. The drainage system shows that the area is well drained by series of rivers, streams and natural drainages that drain in to River Benue having impacted by Furo hill at the Northern flank of the study area, Bagale hills at the middle flank, and Yadim hills at the Southern flank respectively. Settlements along sub-basins of the Northern flank comprise of Kadang, Jabbi Lamba, and Wuro Usmanu. Others are Damare, Paweire, Karal, Wuro Jatau West of the flank. Settlements at the middle flank are drained by Mayo Gireithese are: Wuro-Dole, Hamidu, Batare, Wafango. Still within the flank are those drained by Mayo Jiberuand Usmanu the settlements are: Daware, Ngarilde, Sangeren Njidda, Mobire, Langirei, Dakri and Kangli. The settlements that are drained by Mayo Rowo

are Mallam Madugu and Wuro Amsami. Except for few rivers, such as Mayo Jibiro, Shematata and Mayo Girei that had their sources from the Gagure, Movido and Bagale hills in the south eastern part of the area, most rivers and their tributaries in the area originate from the Tambo and Nguntutun-Zama-Biam hills and ranges. This is why the direction of streams flow in the area is mostly in the North-South direction. The areas also have natural lakes such as Lake Gokra and Falai Girei (Ray, 1999). East of the Bagale – Furohills at the middle flank are Hamdalla, Pariya, Bagale, Wuro Bokki, Dulo, Ribadu, Bodere, Kubawo Rito all lying within Wuro Bokki-Dulo sub-basin. At the Southern flank, Yadim – Uki mountain ranges impact Lessi Betti – Fufore sub-basin. Settlements within this basin include Chigari, Betti Bappawo, Alaraba, Gaawi, Fufore, Njoboli, Njoboliyo, and Rugange. Within the same flank is Bole – Yolde Pate basin with settlements such as Bole Nanawa, Shagari, Yola, Rugange, Yolde pate, and Gujibabu are not drained by any river, as such are liable to flood.

Figure 4: Vegetation Map of the Study Area



Vegetation

The vegetation formations of Adamawa State like most northern States are generally of the savannah type. Based on the climatic condition of the State, the

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vegetation formations have been grouped into three namely: southern guinea savannah, northern guinea savannah and the Sudan savannah. The region northern guinea savannah vegetation is one of the most extensive vegetation in the study area which stretches from the Taraba River in the south to River Yedzeram in the northern part of the State. It has a mean annual rainfall between 900, and 1100 mm and the rainy season last for about 4-5 months. The region is

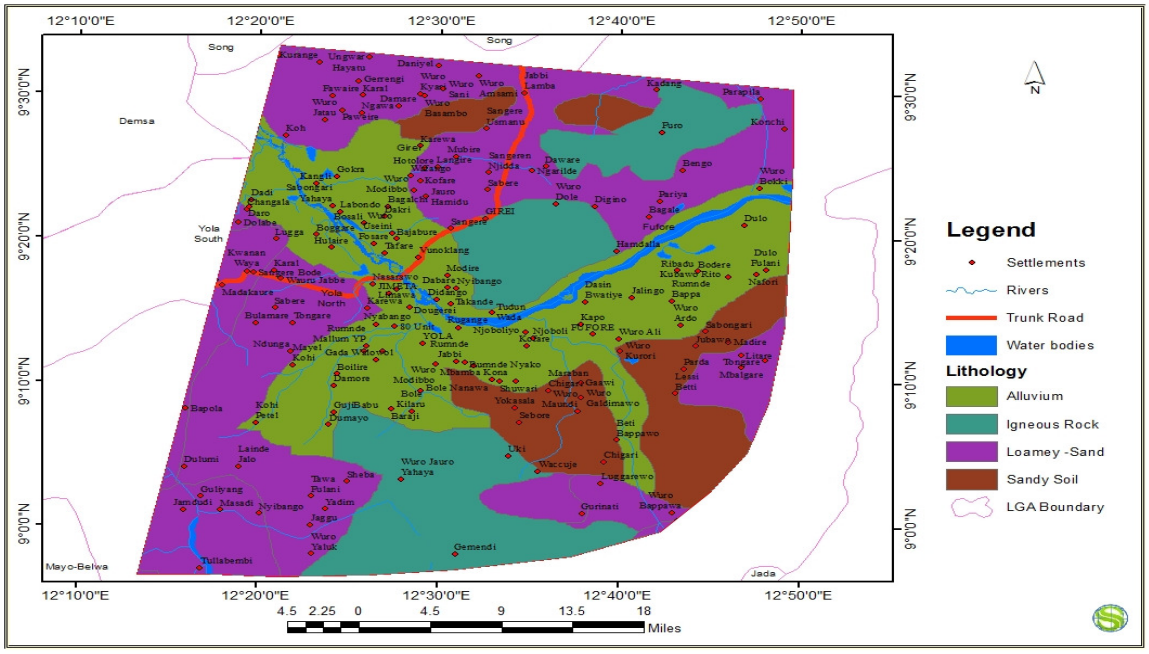
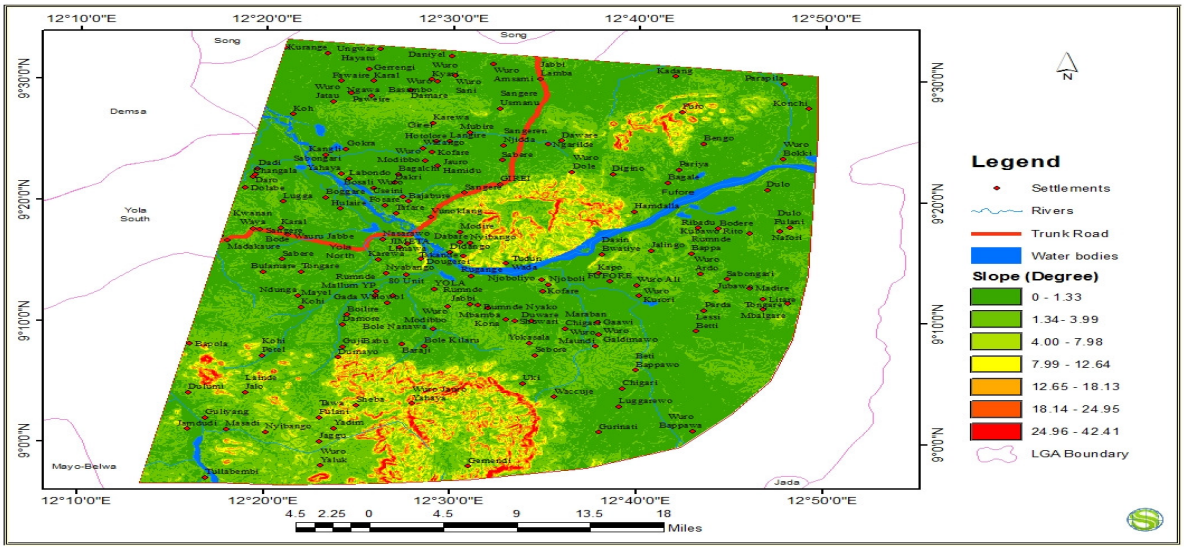


Figure 5: The Soil Map of the study Area

characterized with prominent trees namely, *Afzelia africa, Viterllari aparadozla, Terminlia laxiflora, Terminalia glaucescens, Annonas enegalensis, Burkea africana, Albizia zygia* (Akos'im *et al.,* 999). In terms of the landuses, building area and cropland appear to be close to the River Benue. This suggest that human activities are always located to water and so, such landuses are mostly liable to flood.

Soil

Figure 5 shows that the soil formation of the study area are regosol (Clay, loamy sand, Rock-outcrop, Sandstone and Shale) these are immature weakly developed soils consisting of rock fragments which occur in isolated hill areas and derived from basement complex (Ray, 1999). Apart from loamy sand, most other soil types in the area do not easily absorb water which makes most of the area flood prone. Areas in Greater Yola prone to flood in respect of soil



composition include all settlements along the Benue valley within a distance of 1km from River Benue centreline: (Wuro Useini, Modire, Dabore, Didango, Takande, Dakri, Labondo, Sabongari, Koh, Tabongo, Gereng); and others along river Daniel whose soil type is alluvium. The alluvial soil is said to be clayey in nature and has the capability of retaining surface water because of its semi-impervious nature. Other settlements that fell within the marginally vulnerable zone include Girei town and others at the Northern flank of the study area.

However, soil alone, is not enough a regional factor that determines absolute vulnerability status of an area to flooding but a combination of different factors analysed above. In addition, none of the four factors considered can stand in isolation at regional level to represent as a criterion for flood vulnerability analysis, rather, a scientific system of fusing all the multi-criteria vulnerabilities into a single spatial vulnerability map based on weighting and scoring of each criterion using map algebra or the conditional tool in ArcGIS spatial analyst tool. The soil of the area close to the River Benue appear to accommodate many landuses such as cropping grazing due to the level of fertility. Hence, any invent of flood along the channel or River Benue, such landuses become liable and prone to flood.

Slope

The slope vulnerability analysis was performed in ArcGIS Spatial analyst extension by reclassifying all the slope values (in degrees) of the slope map into

classes that define three vulnerability dynamics (i.e. Not vulnerable, marginally vulnerable, and Vulnerable). The values of slope between 0 – 1.3 is considered as flat areas that are not well drained and can lodge surface water for a very longer period in an event of heavy downpours; hence, it is classified under slope parameter as Vulnerable to flooding. Slope values ranging from 1.35 – 4.5 are reclassified as marginally vulnerable because such areas have ability to drain water to some extent, while slope values from 4.51 – 32 as observed in the slope map are reclassified as not vulnerable within the boundary of Greater Yola. From the slope classification in Figure 4.8, it is very clear that areas close to the River Benue fall within the flood vulnerability slope. This implies that human activities based on land uses that are close to the River Benue within Greater Yola are at a higher risk of being flooded.

CONCLUSION

The effects of floods in one sector can affect other sectors of society. Under the health section, the outbreak of different diseases such (malaria, diarrhoea and coughing) was attributed to the impact of floods on water sources and sanitation facilities. The issue of water contamination of the river at the pick of floods and the handling of water from the borehole increase the health risk. Furthermore, although health facilities were damaged due to damage of the road and transport due to floods, accessibility to health services was a problem due to infrastructure (roads and bridges) damage as discussed under the housing section. In addition, school attendance was disrupted due to impassable roads as discussed under the education section. Communities should be encouraged to build houses using durable materials and away from the flood prone area as a way of coping with the floods. Furthermore, the Ministry of Agriculture should through the Extension Services, encourage the communities to increase the area cultivated on the upland to enhance the food security at household level. Input support programme for the vulnerable but viable farmers should be considered. Clearly, there is need to develop better and appropriate measures to prepare and mitigate the effects of the floods. Above all, the aim must be to involve all the stakeholders to enhance communities' resilience to floods.

There should be a deliberate policy to compel communities, especially in rural areas, to build house using durable materials and away from the flood prone areas as well as the height from the flood level must be considered. Furthermore, Multi-sartorial approach to flood mitigation as opposed to single

sector should be promoted and should be link it to the impacts of flood on various aspects of society. Government should ensure proper dredging of the river Benue, so as to deepen the channel in order to accommodate more water rather than allowing the water to flood the environment.

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