

2024SPSBIC0067

### Assessment of Flood Vulnerability in Suleja Local Government Area of Niger State, Nigeria

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#### Abstract

This study examined the flood vulnerability in Suleja Local Government Area of Niger State. The objectives of the study are to assess the land use land cover change for 15 years as well as to delineate flood vulnerable areas in Suleja L.G.A. Primary data was collected using a handheld GPS to obtain coordinates data of the areas where flood has previously occurred while the secondary data that were used includes the coordinate data, shape-file, landsat images for 2010, 2015, 2020, digital elevation model (DEM), and the administrative map of Suleja L.G.A. The maximum likelihood algorithm of supervised classification in ArcMap software was adopted to classify the land use in Suleja into different classes. The DEM was used to show the elevation of the area. The result from the analysis of land use and land cover satellite imageries revealed that vegetation cover has decreases and built-up area have been on the increase as a result of the influx of people. In terms of vulnerability areas, the western and south western part of Suleja are more vulnerable to flooding because they are located on low elevation, while Ranfi Sanyi, Bakin-Iku, Ibo, Kwamba, Kuchiko, Maji, Numbwa and Tunga Shano are less vulnerable because they are higher elevation areas. In terms of flood occurrences, Ranfi Sanyi and Bakin-Iku usually have flood events every year and the major factors leading to this flood is due to haphazard erection of buildings along water ways rather than natural factors (heavy rainfall and elevation). The study therefore recommends that stiffer measures should be put in place by the relevant law enforcement agencies to check the problem of indiscriminate waste disposals and constructions along the drainage and water ways.

**Keywords:** flood, vulnerability, delineate, land use and land cover change

#### 1. Introduction

The impact of natural disasters to the global environment is becoming more and more severe over the last decades. The reported number of disasters has dramatically increased as well as the cost to the global economy and the number of people and properties affected. Flooding is one of the devastating natural disasters affecting many countries in the world from year to year causing great human, property and economic loss (Harris et al., 2017). Flooding is one of the most occurring natural disasters in Nigeria which have claimed many lives and properties. Generally, flooding is the covering or submerging of normally the dry land with a large amount of water. Eze et al., (2018) further defines flooding as the event which causes devastating livelihood impacts, suffering and economic damages, a natural hydrological extreme event affecting the flow regime of all rivers, particularly during the rainy season. Flood is a body of water which rises to overflow its banks or low-lying areas (Etuonovbe, 2014). All over the world, flood is known to cause great damage to people's lives, belongings and properties. Flood causes one third of deaths, one third of all injuries and one third of all damage from natural disasters (Etuonovbe, 2014). This damage is normally felt by various "receptors" being people, buildings, infrastructure, agriculture, and open recreational spaces. According to Isah (2012), Flood is cause by two major factors such as rainfall and poor drainage network; other causes are relief of the area and construction along drainages. It could also be caused by the intrusion of seawater onto coast lands during cyclonic/tidal surges (Akukwu and Ogbodo, 2015).

Vulnerability however is said to be a set of socio-economic factors that determine people's ability to cope with stress or change, it is described as something that exists within systems independently of external hazards (Eze et al., 2018; Umar et al., 2019). The 2012 flood in Nigeria affected about 23 States

of the Federation with Niger State inclusive. The occurrence of floods is a natural phenomenon and man has to live with it right from the beginning (National Emergency Management Agency, 2012) (NEMA). The 2022 flood also affected many parts of the country (about 18 States), the flood displaced over 1.4 million people and killed over 603 people and injuring more than 2,400 persons. About 82,035 houses were damaged; 332,327 hectares of land were also submerged by the flood (NEMA, 2022). The flooding was caused by heavy rainfall and climate change as well as the release of water from the Lagoon Dam in neighbouring Cameroon (NEMA, 2022).

GIS and Remote Sensing techniques have become indispensable tools for mapping flood-risk vulnerability providing evidence for early warning and emergency response systems (Eze et al., 2018). Many nations experience fatalities and injuries, property damage, economic and social disruption resulting from natural disasters. Natural disasters, such as earthquakes, hurricanes, flash floods, volcanic eruptions, and landslides have always constituted a major problem in many developing and developed countries. However, floods is a crucial national issue as a great number of African countries lack the resources, both financially and technologically to fight the effects and impacts of flooding.

## 2. Literature Review

Floods have been the topic of investigation for many decades in Nigeria and abroad. Many researchers have studied flood as an event with reference to various disciplines such as hydrology, geography, geomorphology, geology, water resources, economics, sociology, natural hazard and many more. A number of studies have attempted to determine flood vulnerability and to delineate between areas that are more prone to or less prone to flood hazard in various part of the world. Ojigi et al. (2013), for example delineated and mapped 2012 flood in some parts of central Nigeria (Niger, Benue & Kogi). The flood extent of the event was mapped using a combination of RADARSAT, Infoterra SAR, SPOT-5 imageries, Shuttle Radar Topography Mission (SRTM) (DTM) with field information provided during the flood. The results show that about 566 thousand person were displaced by the flood, while crops were ravaged and transportation routes severed in the affected communities. The natural boundary of the flood plain was not exceeded during the flooding, but due to strong affinity to the flood plain by the communities in a claimed reverence to their ancestral heritage of economic survival, there was huge avoidable socio-economic loss to the floods. Spatial analysis such as buffer was used to categorize the flood hazard extent using GIS and GPS data. In another study, Jeb and Aggarwal (2008) utilized remote sensing and GIS, Digital Elevation Model (DEM) integrated with flood stage data results from Gumbel's Extreme distribution model to estimate the extent of flood inundations in different flood return periods in Kaduna Metropolis. The study revealed that most of the areas lying close to the River Kaduna's flood plain are under severe threat to flooding in different flood return periods. With this model, flood area extent was delineated and classified to different classes of risk. Adegbola et al. (2021) made use of GIS Application of Markov Chain Model and ArcGIS in Land Use Projection of Ala River Catchment in Akure, Nigeria.

The study generates previous and present land use of Ala watershed and project the future land use using Markov chain model and ArcGIS software (version 10.2.1). Landsat 7, Enhanced Thematic mapper plus image and Landsat 8 operational land imager with path 190 and row 2 used to generate land use and land cover images for the years 2000, 2010 and 2019. Six LULC classes were considered as follows: developed area, open soil, grass surface, light forest, wetland and hard rock. Markov chain analysis was used in predicting LULC types in the watershed for the years 2029 and 2039. The veracity of the model was tested with Nash Sutcliffe Efficiency index and Percent Bias methods. The model results show that the study area is growing rapidly particularly in the recent time. This urban expansion results in significant decrease of wetland coverage areas and the significant increase of developed area. This implies reduction in the available land for dry season farming and incessant flood occurrence. Geospatial techniques were also applied by Nkeki et al. (2013) to map vulnerable zones within Niger-Benue basin. MODIS time series image, integrated with the digital elevation model were used to extract the flood plain within the basin. Various cities, states and communities that are vulnerable to flood hazards were mapped using population data; this was integrated with the flood hazards map to delineate

the population at risk of flood disaster in the basin using overlay analysis. Overall, the results show that 13,703 km<sup>2</sup> of landed area was submerged by the flood disaster and the effect of the flood hazard is spread across 58 LGAs of 14 States. The result of the analysis indicates that Taraba state is the most affected with 3830 km<sup>2</sup> of its land territory submerged in 6 LGAs. This is followed by Kogi with 2787 km<sup>2</sup> of its land sub-merged in 9 LGAs and next to this is Niger with 1502 km<sup>2</sup> of its land submerged in 6 LGAs. Another group of high flood impact areas are Anambra, Adamawa, Benue and Nassarawa with submerged land territories of 1279 km<sup>2</sup>, 1109 km<sup>2</sup>, 1109 km<sup>2</sup> and 932 km<sup>2</sup> respectively. Others are Delta-323 km<sup>2</sup>; Edo-315 km<sup>2</sup>; Kwara-300 km<sup>2</sup>; Rivers-128 km<sup>2</sup>; Bayelsa-48 km<sup>2</sup>; Enugu-31 km<sup>2</sup> and Imo-9 km<sup>2</sup>.

The result of the analysis also shows that the methodology of flood risk detection developed in this study is effective and suitable application to identify the flood vulnerable areas and estimate the population at risk along the Niger-Benue basin. In Samagba area of Bayelsa State, Mmom and Ayakpo (2014) determined the vulnerability of the communities to flooding using elevation and remote sensing image data. Analytical Hierarchical Process (AHP) was adopted to assign weights to various contributory factors such as elevation, land use, rivers and roads to determine the most vulnerable zones within the area; these were integrated using re-classification and overlay analysis in GIS to determine the flood affected areas. The study revealed that on the bases of closeness to rivers, pattern of land use, low relief, and drainage; some areas like Adagbabiri, Aduku, Bulu Orua, Osiana, Sagbama, etc, are very highly vulnerable to flood while communities like Agbere, Agoro, Asamabiri Elemebiri, Tungbo, etc, are highly vulnerable. Communities like Angalabiri, Ebedebiri, Kabiamia, etc, are moderately vulnerable while communities like Kenan, Oborogbene and Borutugbene are lowly vulnerable to flood. The study therefore recommends that flood plain habitation be discouraged. Also, in the construction of social infrastructures and facilities, previous flood benchmarks should be noted and constructions should be done on elevations that are sustainable.

The aim of this study therefore is to assess the flood vulnerability pattern and to delineate between areas that are more vulnerable and areas that are less vulnerable to flood hazard in Suleja Local Government Areas of Niger State, Nigeria. To achieve this aim, the study assesses the land use land cover change for 15 years using the data for 2010, 2015, and 2020 as well as to delineate flood vulnerable areas in Suleja L.G.A.

### **3. Methodology**

#### **3.1 Study Area**

The study was conducted in Suleja L.G.A of Niger State, which lies between Longitude 7°10'20.25" East and Latitude 9°12'1.17" North. It shares boundary with Gurara to the North-West, Tafa to the East in Niger State and Gwagwalada, Zuba to the south, in Federal Capital Territory. It covers a land area of 136.33 km<sup>2</sup> and a population of 216,578 at the 2006 census (National Population Commission, 2006) the increase in population over the years has brought about rapid development in physical structures and its micro economy at large.

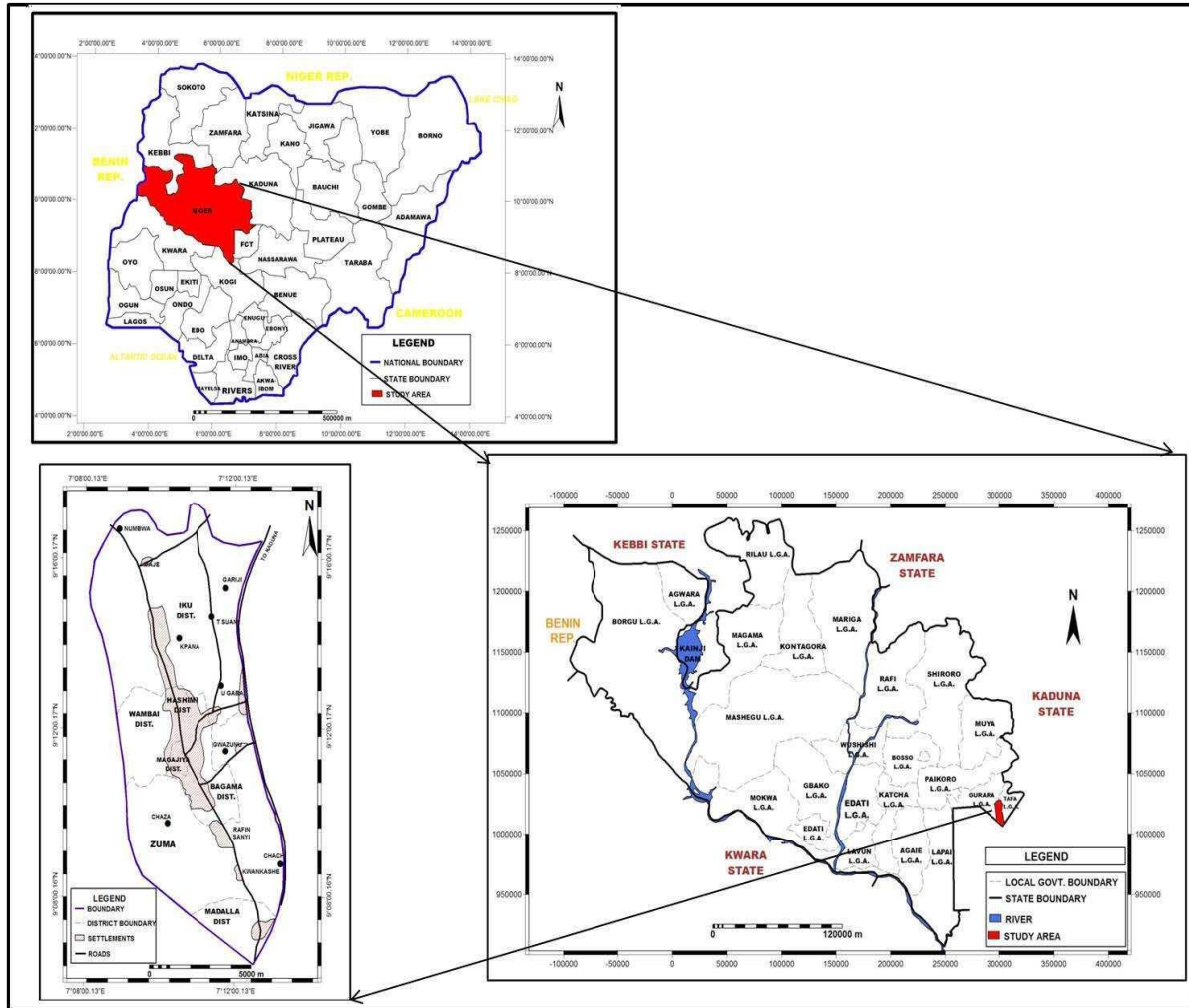


Figure 1: Map of the Study Area  
Source: Geography Department, FUT Minna (2023).

*Primary Data and Sources:* Coordinates of the areas where flood has previously occurred were collected using a handheld Global Positioning System.

*Secondary Data and Sources:* Map of Suleja was extracted from topographic map of Niger State. Information from United States Geological Survey (USGS website) about the land use land cover change Landsat images and Digital Elevation Model (DEM), was download. Shape-file and the Administrative map of the study area was gotten from the Department of Geography, Federal University of Technology, Minna. The characteristics of the satellite data used is presented in Table 1.

Table 1. Summary of Landsat Data

S/N	Product ID	Sensor Type	Date Acquired	Cloud Cover (%)
1.	LE07_L1TP_189053_20100307_20161215_01_T1	Landsat 7 TM	07/03/2010	10

2.	LE08_L1TP_189053_20150430_20170409_01_T1	Landsat 8	30/04/2015	10
3.	LE08_L1TP_189053_20211210_20161215_01_T1	Landsat 8	10/12/2020	00

Source: USGs, 2020

#### 4. Results and Discussion

##### 4.1 Land Use and Land Cover of Suleja L.G.A

The land use and land cover map give an account of the spatial distribution and areal extent of various categories of land use and land cover, such as the built up areas, water bodies, vegetation cover and bare land of Suleja L.G.A within the years under study. The result is presented for the years 2010, 2015, and 2020.

##### 4.1.1 Land use and Land Cover Classification of year 2010 for Suleja L.G.A

The result for the classified land use and land cover for the year 2010 is presented in Figure 2. The map shows four (4) categories of land use and land covers; built up areas, water bodies, vegetation cover and bare land. The area extent of these classes reveal that the dominant class is vegetation cover which covers 6646.87 km<sup>2</sup> (55.18%), followed by bared land with 3114.50 km<sup>2</sup> (25.85%), built up areas with 1382.65 km<sup>2</sup> (11.47%), this is seen more at the eastern, north-central, southeast and other parts of Suleja L.G.A, and water bodies with 901.57 km<sup>2</sup> representing (7.48%) of the total area as the less dominant land use and land cover class. This result shows that there is high vegetation cover and less built up area in Suleja L.G.A.

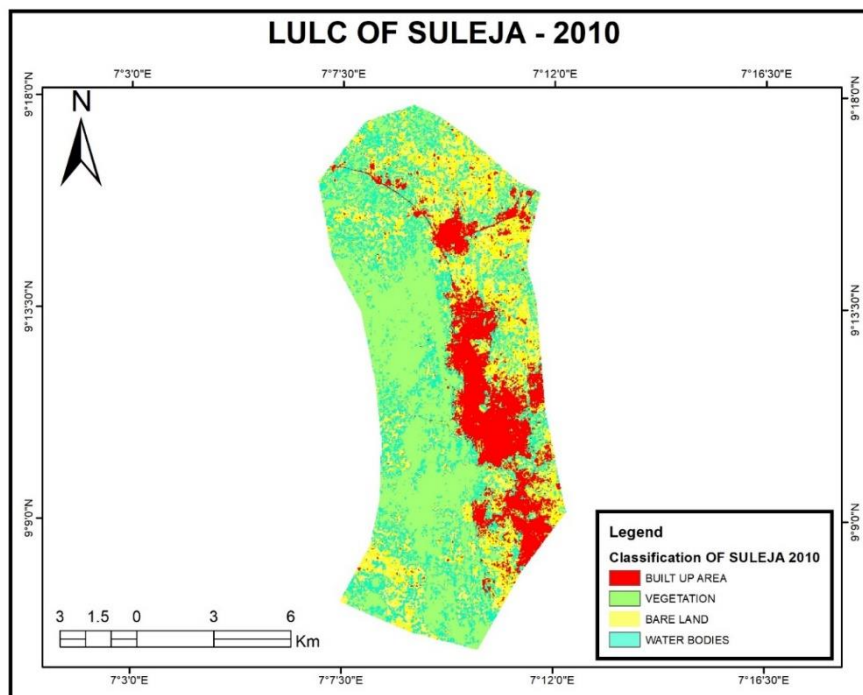


Figure 2: Land Use and land Cover Map of Suleja L.G.A for 2010

#### 4.1.2 Land use and Land Cover Classification of 2015 for Suleja L.G.A

The land use and land cover map of Suleja L.G.A for year 2015 reveals that there was an increase in built up areas and reduction in the vegetation cover (Figure 3). Result shows that built up area increase from 1382.65 km<sup>2</sup> (11.47%) in 2010 to 2245.14 km<sup>2</sup> (18.18%) in 2015.

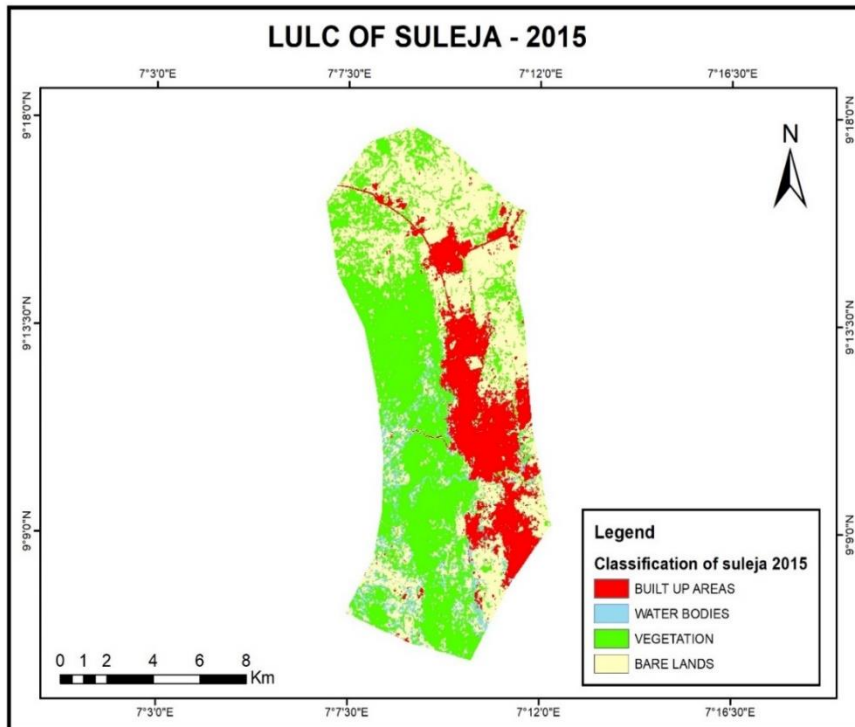


Figure 3: Land Use and Land Cover Map of Suleja L.G.A for 2015

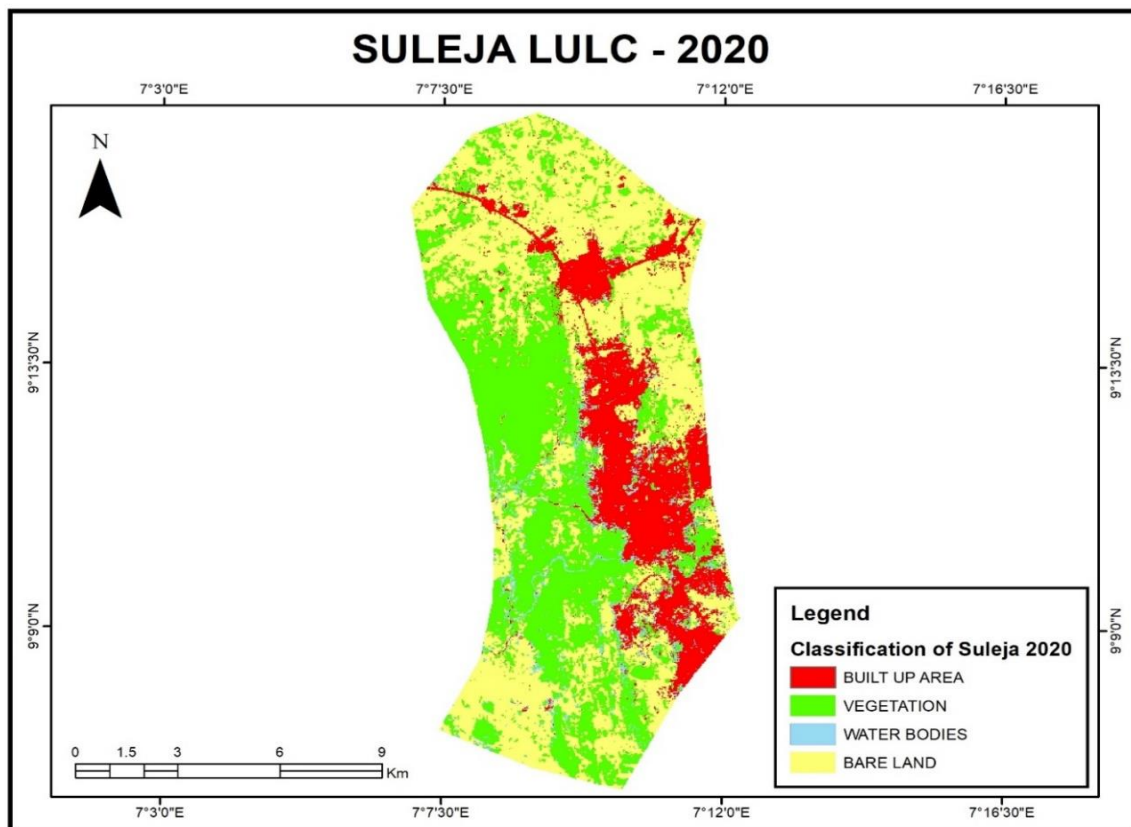
The built up expands towards the eastern and northern section of the map due to continuous influx of people to the area who are mostly engaged in commercial activities, this increase is attributed to increase in population growth. The result reveal that vegetation cover decreases from 6646.87 km<sup>2</sup> (55.18%) in 2010 to 5569.96 km<sup>2</sup> (45.10%) in 2015. Furthermore, water body witness a slight decrease from 901.57 km<sup>2</sup> representing (7.48%) in 2010 to 870.94 km<sup>2</sup> (7.05%) in 2015 respectively, while built-up areas cover 18.18% showing an increase from the last five (5) years. There is also an increased in the built-up areas towards the river banks (eastern parts) even with the occurrences of flooding around those axes. However, there is an increase in bare land area as findings indicated that bare land areas increased from 3114.50 km<sup>2</sup> (25.85%) in 2010 to 3664.08 km<sup>2</sup> (29.67%) in 2015, this may be attributed to privatization leading to private ownership of land, opening of new areas for construction, and for transportation routes. These findings agree with the work of Ejaro and Abdullahi (2013) who carried out research on the spatio-temporal analysis of land use land cover changes in Suleja Local Government Area, which results revealed that there are both positive and negative changes in the land use and land cover categories.

#### 4.1.3 Land use and Land Cover Classification of 2020 for Suleja L.G.A

In terms of the land use and cover map of Suleja L.G.A for year 2020, the result shows that vegetation cover was still the most dominant land use and land cover, however there was a decrease across the vegetation cover in Suleja L.G.A, an indication of increase in population expansion. The vegetation cover decreased drastically from 5569.96 km<sup>2</sup> (45.10%) in 2015 to 4876.56 km<sup>2</sup> (35.78%) in 2020. The reduction in the percentage of the areas covered with vegetation, water bodies, and an increased in the built-up areas has been associated with population increase in Suleja L.G.A. The result further shows that built up area increase from 2245.14 km<sup>2</sup> (18.18%) in 2015 to 2502.86 km<sup>2</sup> (18.36%) in 2020 (figure

4). The built up expands towards the city southeastern, northeast and eastern section of Suleja L.G.A as more people influx the area which make the inhabitants to encroached the river bank. It is also important to note that Suleja L.G.A is one of the most important L.G.A in Niger State owing to its close proximity to FCT Abuja, its commercial activities and transportation network. Most of the people that lost their houses during the early days of Obasanjo administration relocated to Suleja and likewise many of the civil servant working in Abuja reside in Suleja owing to the cheap cost of living.

Figure 4: Land Use and land Cover Map of Suleja L.G.A for 2020



Suleja spare of influence interms of economic activities expands to most part of the north central state of Kogi, Nassarawa, Benue, Abuja and even Minna the capital of Niger State on goods they mostly have competitive advantage upon (textile, electronics and food stuff). The town also link most of State across the country owing to its robust transportation route and strategic location. All these and many more factors that come with urbanization exact a great deal of pressure to the land and other natural resources available in the town, and these make Suleja a town for everyone. In terms of bare land, the results shows that there was an increase as it occupies more land area than other land use category in 2020. Findings shows that bare land increased from 3664.08 km<sup>2</sup> (29.67%) in 2015 to 5737.90 km<sup>2</sup> (42.10%) in 2020 (figure 4). Similarly, vegetation cover also witnesses a further decrease from 5569.96 km<sup>2</sup> (45.10%) in 2015 to 4876.56 km<sup>2</sup> (35.78%) in 2020. The decreased is attributed to increase in population of people living in the area which require more construction of building for shelter and business activities as well as exploiting other forest resource such as fuel wood, planks and other resource in the area. In addition, water body decreased drastically to 512.64 km<sup>2</sup> (3.76%) in 2020 respectively.

**Table: 2 summary of land use and land cover data**

LAND USE TYPES						
	2010		2015		2020	
Land use	Area (Sq.Km)	%	Area (Sq.Km)	%	Area (Sq.Km)	%
<b>Built-up</b>	1382.64	11.47%	2245.14	18.18%	2502.86	18.36%
<b>Vegetation</b>	6646.87	55.18%	5569.96	45.10%	4876.56	35.78%
<b>Bare-ground</b>	3114.50	25.85%	3664.08	29.67%	5737.90	42.10%
<b>Water bodies</b>	901.57	7.48 %	870.94	7.05%	512.64	3.76%
<b>Total</b>	12045.58	100	12350.11	100.00	13629.96	100.00

**4.2 Flood Vulnerable Area in Suleja L.G.A**

Figure 5 indicate places in the study area that are more vulnerable (very high, high, low, and very low) to flood hazard based on the level of elevation above mean sea level. The light green colour represents very high vulnerable area. These are low elevation areas which make them more vulnerable and high risk zone in the study area. The green colour represents high level of vulnerable area to flood. The brown colour represent low level of vulnerable area and they include; Ranfi-Sanyi, Bakin-Iku, Ibo, Kwamba while the white colour represent very low vulnerable areas to flood hazard. This areas are in high elevation which make them less vulnerable and low risk zone in the study area and they includes; Kuchiko, Maji, Numbwa, and Tunga Shanu. From the result in figure 5, it can be seen that the western and south-western part of Suleja L.G.A are the most vulnerable to flood because they are in low elevation or low altitude, moreover there are less or few built-up area found in this axis, this build up are either temporary buildings, abandon buildings, farm stead etc. while the eastern and part of the north have low vulnerability, the north-eastern and part of the north in Suleja L.G.A have very low vulnerability in Suleja L.G.A. The major implication of this findings is that, since area that are in very high flood vulnerability risk level in Suleja LGA have less or very few and scattered built-up, flood hazard occurrence have lesser impact in terms of life and properties damage, resulting to less prioritization of flood mitigation.

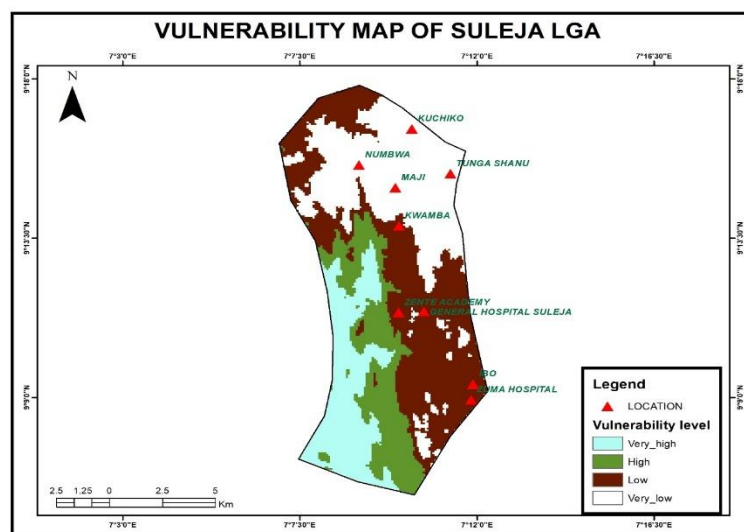


Figure 5: Vulnerability Map of Suleja L.G.A

#### 4.2.1 Flood Occurrence Location in Suleja LGA

Figure 6, shows two (2) location where flood almost annually occur in Suleja L.G.A, this area are Ranfi-Sanyi and Bakin-Iku, this areas falls in the low vulnerability region in figure 5. The 2017 flood occurrence in Bakin-Iku communities is said to be the worst flood occurrence so far in its history as property worth millions of Naira were destroyed while some houses were submerged (NEMA, 2017), it was reported that the flood occurrence is as a result of heavy

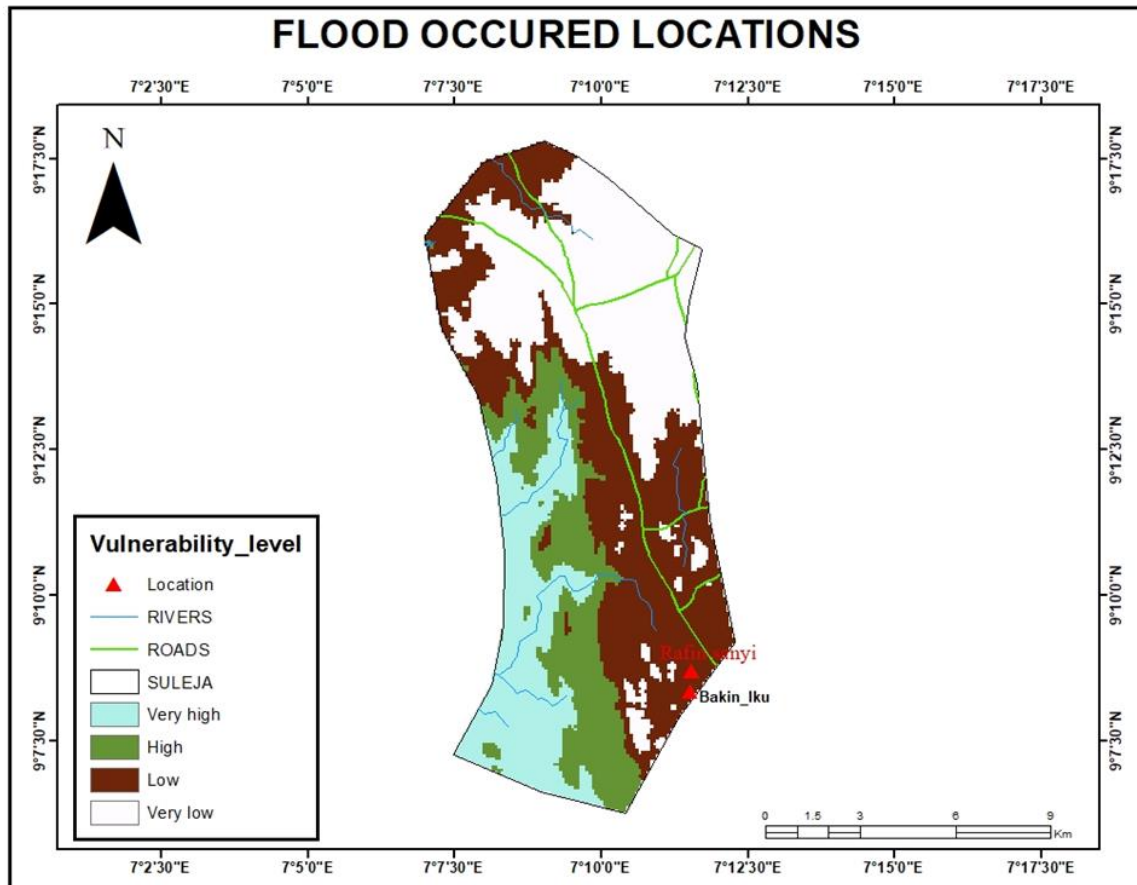


Figure 6: Flood Occurrence Location in Suleja L.G.A

rainfall which lasted for 6-8 hours leaving more than 100 houses flooded in the area (NEMA, 2017). The 2018 flood occurrence in Ranfi-Sanyi which is cause by six (6) hours of heavy rainfall caused the death of 15 people with several others displaced while more than 200 houses were submerge (NEMA, 2018). This means that flood occurrence is not only associated with natural causes (elevation and long hours of rain) but also human factors such as building along the water ways and blockage of drainages by dumping of refuse in the drainage ways. However, the anthropogenic (human) factors are the major or primary causes of flood in the built-up areas while natural factors are the secondary causes of flood in Suleja L.G.A.

#### 5. Conclusion

This study established that human settlement is on the increase in the eastern, south-eastern, north-central and toward the northern part of Suleja as a result of the influx of people, majorly because of the proximity of Suleja town to F.C.T, the presence of commercial activities and presence of transportation

route linking most of the state across the country. Most of the areas that are located in the lowest of elevation are the most vulnerable however they have fewer settlements and are mostly dispersed farmland and open spaces thereby having less implication in terms of life lost. In addition, most of the places that witness flooding each year such as Ranfi-Sanyi and Bakin-Iku are as a result of anthropogenic factors such as building along waterways and dumping of refuse in drainages leading to loss of life, submerging of farmlands, destruction of culverts, destruction of houses, health care facilities, schools, roads among others. The natural factors such as elevation and heavy rainfall mostly play secondary role in terms of flood occurrence in these places. The study therefore recommends that government should relocate and resettle the people that are discovered to be in areas that are highly vulnerable to flood and stiffer measures should be put in place by relevance law enforcement agencies to discourage future settlements along flood prone areas. Public enlightenments, awareness on flood, early warning signs should be disseminated to the public in their own languages and through the media that the people can have access to listen. The flood plain maps should also be used by the relevant stakeholders in the structural design of drainages and other flood preventive measures in Suleja town.

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