RAINFALL TREND ANALYSIS AND ITS IMPLICATION ON FLOOD IN SULEJA, NIGERIA

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Abstract

Rainfall distribution pattern has been a major concern to Climatologists, Penologists, Agriculturist hydrologist and even to the ordinary man in the street. Rainfall is a critical index of climatological investigation and has major impacts on flora and fauna, as well as ecological setting and water resources management of any area. The study is in this direction as it examines the trend in the rainfall over a period of 10years. Data obtained from 60 local dwellers with the aid of a well-structured questionnaire were analyzed using descriptive statistics. Linear Regression model was used to analyze the trend in rainfall. A Digital Elevation Model was used for terrain analysis while findings from the fieldwork were used to ground- truth the results from the analysis of the image. Result shows that there was an uneven distribution of rainfall throughout the period of years that was considered. The result shows that the study area experiences little changes in rainfall patterns and the occurrence of flood was so minimized but from year 2012 it rises to over 800mm and dropped down in the next two years (2013-2014). The year 2015 and 2016 sixteen experience the highest annual rainfall, it was the same year that the study area experienced the worst occurrence of flooding that claimed about 9 lives and destroyed several buildings and damaged several properties. From 2017 to 2018 there was a downslope experience which indicates low annual rainfall. The terrain analysis shows that the area is vulnerable to flood coupled with the poor drainage system in the vulnerable areas. Result also shows that the local dwellers adopted some cultural method in coping with the flood incidence before and after such as embankments, clearing of refuse and blockages and building with fortified materials.

Key Words: Rainfall, Vulnerability, Flooding, and Trend

Introduction

Rainfall is one of the parameters in climatic condition that contribute to the way people lives. Its useful in every area of the ecosystem, plant and animal as well. the study of rainfall is very important and cannot be neglected (Obot and Onyeukwu, 2010). Aside the beneficiary aspect of rainfall, it can also be dangerous in nature; natural disasters like floods are caused by downpour of rain.

Globally, many researches have been undertaken about rainfall. Climatic variations have been indicated to increase as a result of changing rainfall pattern, some locations have experienced a general decrease in rainfall patterns, Rainfall trends are often seen as one of the causes of problems in the environs like flood incidence in the state (Ekwe *et al.,* 2014).

Variation in rainfall is one of the features of climate variability that could affect the hydrologic characteristics of an area as the water availability can be impaired and could have cruel effects on the entire environment (UNFCCC, 2007). Studies on climate are becoming more pertinent because of its impacts in almost every aspects of human existence, (Ukhurebor *et al.*, 2017). Many researchers including Ogundebi (2004) and Ologun (2004) have alleged intense downpour of rain to be the main reason of flooding. The increase in flooding as a result of perceived increase in rainfall intensities within the Southern part of Nigeria, is posing enormous risk to lives and properties.

According to Ayansina *et al.*, (2009) the seasonal and annual rainfall variability in some parts of Nigeria is on the increase as a result of climate change. Regionally, it has been noted that changes are occurring in the amounts, intensities, frequencies and types of rainfall. In Nigeria, rainfall manifests high spatial variability. Mean annual rainfall trends from as low as 10 mm in the inner part of the Sahara region to more than 2000 mm in areas of the tropical region.

Flooding is one of the most common of all environmental hazards inspect of human and natural conditions. Flooding has shown to be one of the deadliest of most weather system in Nigeria, and has been hazardous in almost every parts of the globe at large, because of the large numbers of costly destruction to properties and lives (Ashley and Ashley 2008). In Nigeria flood incidence is not new. Over the years there have been occurrences of different types of flooding.

It has been noted that the researches are little in many liable areas of flooding and FRM in Nigeria. Some researchers noted that there is scarcity of information on the consequences of flood hazard on the values of people's belongings, in Nigeria.

In Nigeria, studies on rainfall and their implication on flood and it coping mechanism have been left to the southwest and south South parts of Nigeria, because of the frequency of flood occurrence in that area of the country, but little effort in researching the implications of changes in rainfall trends on flood incidence and it coping mechanism in north parts of Nigeria despite the increase of flood incidences in this region, and this is the point where this study derives its significance.

The Study Area

Suleja LGA is between latitude 9º6'14.7'' and 9º17'48.36'' north of the equator and longitude 7º6'59.5' and 7º12'17.42' east of Greenwich Meridians. It covers an area of 136.33 square kilometer. The LGA is only 111km south-east of the Capital city Minna, Niger state and bounded by FCT Abuja at the west in just about 64km away. Suleja lies on the physiographic unit known as central highland and is located on high elevations of over 1300 feet or 374m above sea level. The rapid development of Suleja's population can be explained by the large influx of people into the LGA its location near the FCT Abuja has had a serious effect on its Population. Suleja climate condition consists of two seasons: the dry and wet season. RH is 72% in rainy season and quite low in dry season. August and July always have the highest downpour of rain while the mean annual rainfall is about 1333 mm^2. The month of March always have the highest amount of temperature of about 31°C and lowest in August at about 26°C due to the frequency of rainfall (Akano, 2016). The study location enjoys sub-humid climatic condition and a raining period of over 6 months every year. There is a single maximum in the rainfall regime usually in august. Temperature is always high in the summer months, but reduces during the hamattan months which last from November to February (Aminu, *et al.*, 2013).

Soil in Suleja is very rich in humus and also favored crops such as groundnuts with yam guinea corn, maize, melon and rice which can all serve as both food crops and cash crops.

The population figure officially given for suleja Local Government Area as at 2006 census is estimated at 216,687 people (NPC, 2006).

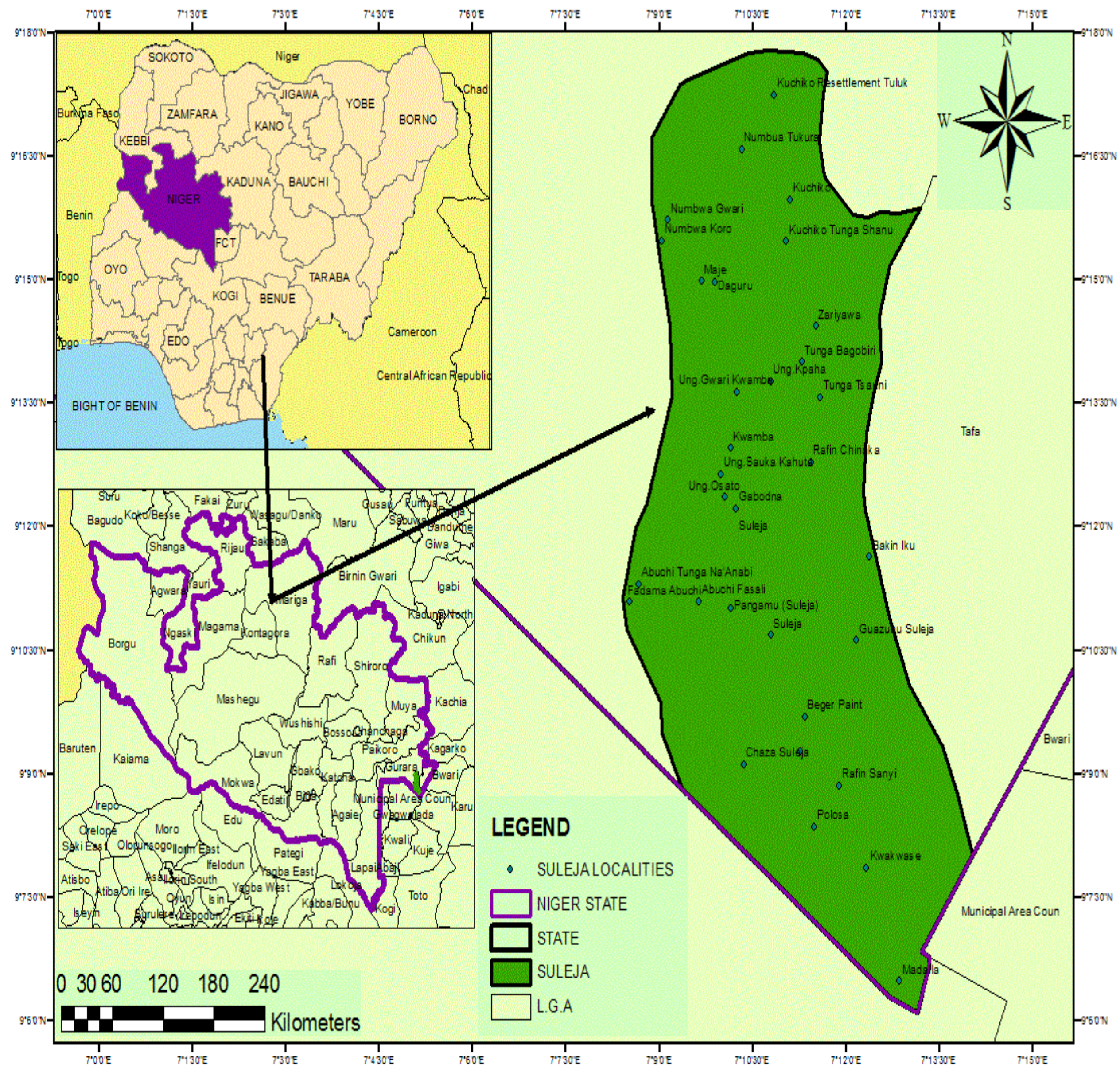

Figure 1.1 (Suleja, Niger State, Nigeria) The Study Area

Source: OSGOf, 2018

Material and Methods

Data Analysis and Data Collection

Both primary and secondary sources of data acquisitions were used in this research. The primary data include: A total of (60) structure Questionnaire were administered, it was provided to household heads in the areas vulnerable to flood focusing on socio-economic characteristics, impacts of flood risk disaster, perception and coping strategies adopted. It also focuses on the history, experience, impact and the institution during and after flood disaster. Questionnaire usage permitted the evaluation of the different opinions of the villagers on the causes of flood as well as the consequences.

A Digital Elevation Model DEM was generated using zonal statistics in the spatial analysis tool of ArcGIS 10.3 used for terrain analysis; it was used to check the vulnerability of the study area to flooding activities with the streams flows and settlements. The secondary data sources Monthly Rainfall data from the period of ten years (2009-2018) was collected for analysis from (NIMET), Abuja.

Data was analyzed descriptively and inferentially from information gathered from rainfall data, observation and questionnaires. In terms of analysis, statistical techniques like means and totals were used for basic treatment of the data.

Arithmetic Mean Method

The mean or arithmetic mean of a set of numbers (n), x^1, x^2, x^3 ….. xn denoted by x is the

sum of all these variables divided by the numbers (n) The trend in annual rainfall was analyzed using linear regression model. The linear regression is a method use to model a relationship between two set of variables. The results gotten from this model was used to predict the data.

Results and Discussions

Table 1: 10 YEARS RAINFALL DATA FOR SULEJA

(2009-2018)

Jan	0	0	0	0	24.62	3.48	0	0	0	0.64
Feb	0	0	0.39	0	2.75	0	0	0	0	6.11
Mar	0	0	0.44	0	17.95	18.67	1.96	47.76	0	0
Apr	20.51	8.79	80.85	61.81	64.97	0	13.57	108.12	9.36	101.82
May	85.99	53.32	123.33	30.04	11.49	99.14	87.4	68.72	84.9	38.46
Jun	85.51	63.02	63.05	81.01	101.34	49.82	42.58	173.39	108.96	107.01
Jul	194.76	424.78	197.05	190.31	90.76	88.57	64.64	164.31	32.35	103
Aug	334.09	164.03	90.04	130.28	93.47	104.27	72.54	148.24	227.77	72.91
Sept	31.38	360.7	285.61	186.5	51.3	54.08	157.83	78.79	64.62	181.72
Oct	66.47	57.55	63.98	159.47	100.12	25.83	52.88	78.82	10.55	78.23
Nov	10.21	0.9	0.13	1.56	0	4.47	10.54	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0
Total	**828.92**	**1133.09**	**904.87**	**840.98**	**558.77**	**448.33**	**503.94**	**868.15**	**538.51**	**689.9**
Mean	69.07667	94.42417	75.40583	70.08167	46.56417	37.36083	41.995	72.34583	44.87583	57.49167

Trend in rainfall in the study area

Over the period, the rainfall has not been evenly distributed. Figure 2 displayed the variations in annual rainfall distribution in the study area over 10 years (2009-2018).

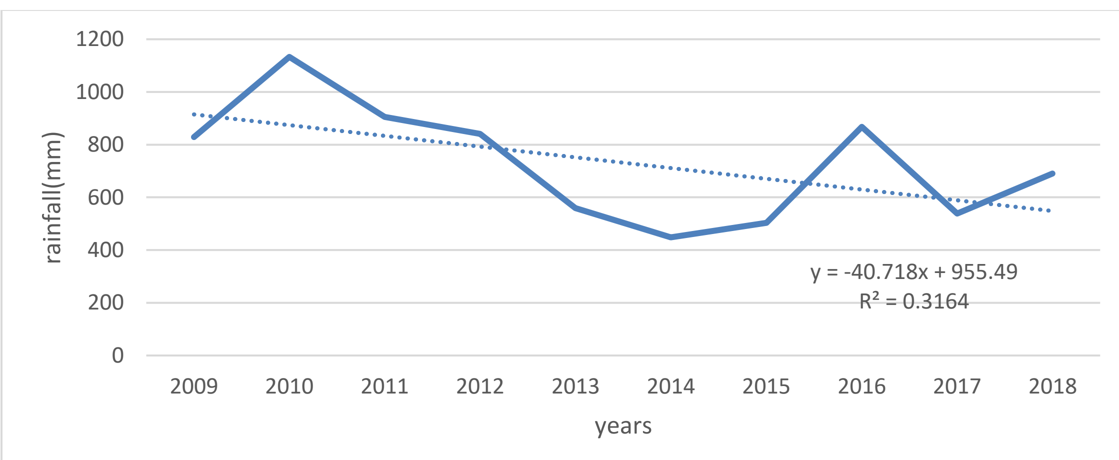

Figure 1: Annual Rainfall Trend in Suleja (2009 – 2018)

The highest rainfall was recorded in 2010 as displayed in Figure 2 with a total of 1133.09mm, while in 2014 the lowest rainfall was recorded with a total of 448.33mm; other high values were recorded in 2011, 2012 and 2016 at 904.87mm, 840.98mm and 868.15mm respectively. In 2013, 2015, 2017, low rainfall is recorded which are 558.77mm, 503.94mm, 538.51mm respectively. This an indication of low rainfall when compare to others years.

The result shows that the year the study area experiences little changes in rainfall patterns the occurrence of flood was so minimized but from year 2012 it rises to over 800mm and dropped down in the next two years (2013-2014). The year 2015 and 2016 sixteen experience the highest annual rainfall, it was the same year that the study area experienced the worst occurrence of flooding that claimed about 9 lives and destroyed several buildings and damaged several properties. From 2017 to 2018 there was a downslope experience which indicates low annual rainfall and no major flooding as recorded in these years.

The result of the trend analysis shows clear fluctuations in the pattern of rainfall for the period under study. Based on this study, the month of March and April was seen as the period of onset of rainfall while the month of September and October was observed as the period of retreat. Considering the period under study, current years from 2013, 2014 and 2015 shows decline in the pattern rainfall as against the previous years; from 2011 downwards. Since the result shows inconsistency in the pattern of rainfall, it’s an indication that the increasing rainfall in the study may be partly responsible for the increase in flood events.

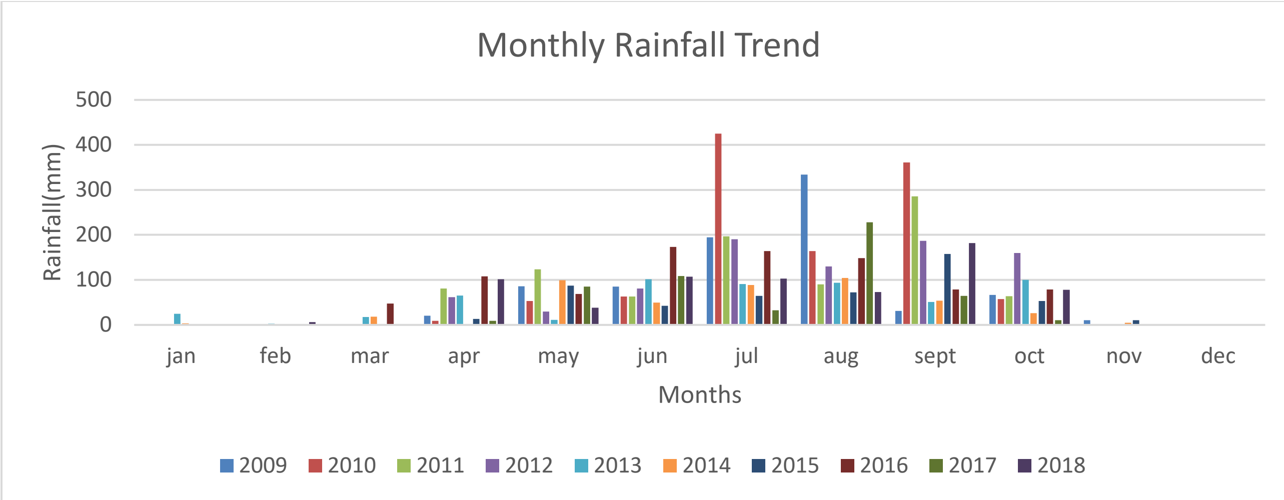

Figure 3: Mean Monthly Rainfall Distribution in Suleja (2009-2018)

The mean monthly rainfall patterns in the location are presented in Figure 3, rainfall begins between March and April with a scanty downpour once or twice a month. In January and February there little or no rainfall, but by May the area begins to experience a continuous increase in downpour of rainfall.

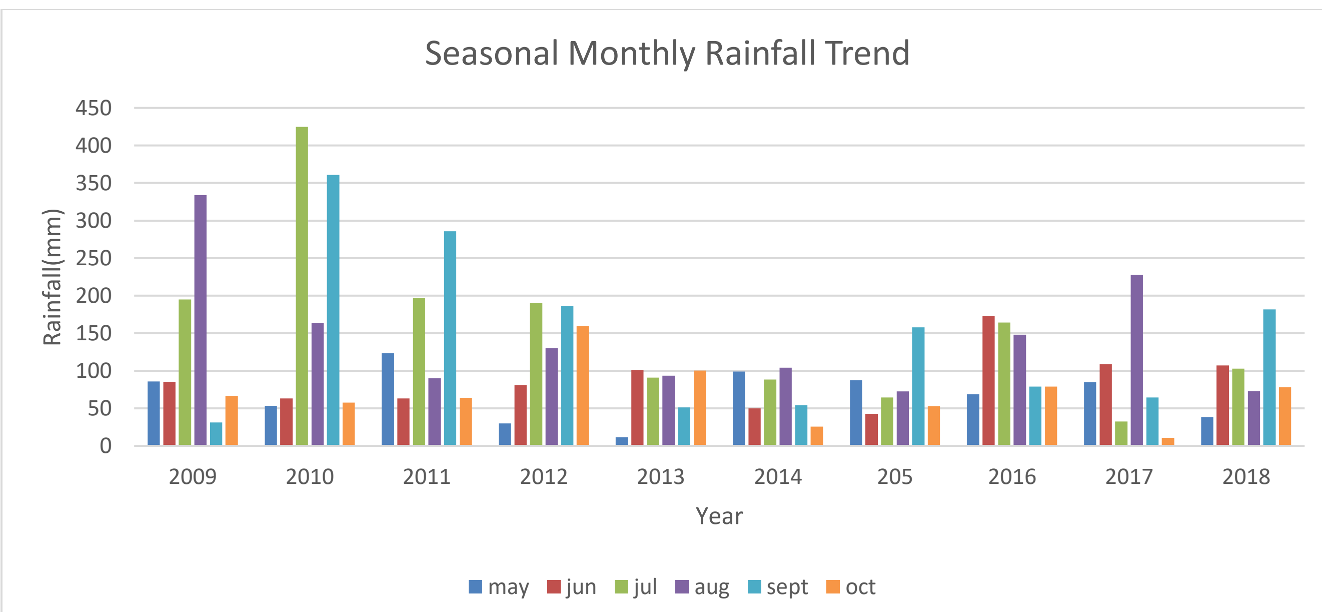

Figure 4: Month with the highest rainfall in Suleja (2009-2018)

However, in Figure 4 the month with highest rainfall are September, August and July by November the study area begins to experience reduction and stoppage of rainfall and in December, the location hardly witnessed any rainfall. The implication of this is that flood may likely occur in July, August and September and the study area may not experience any flooding during the later parts of the year.

Identification of flood vulnerability in the study area

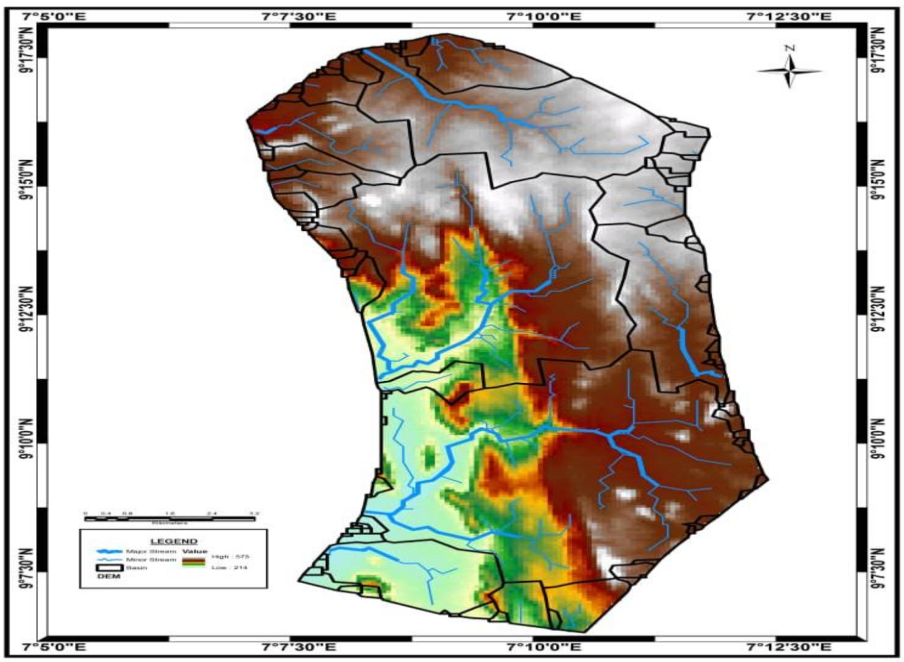

Figure 5: Flood risk map of Suleja depicting streams flow

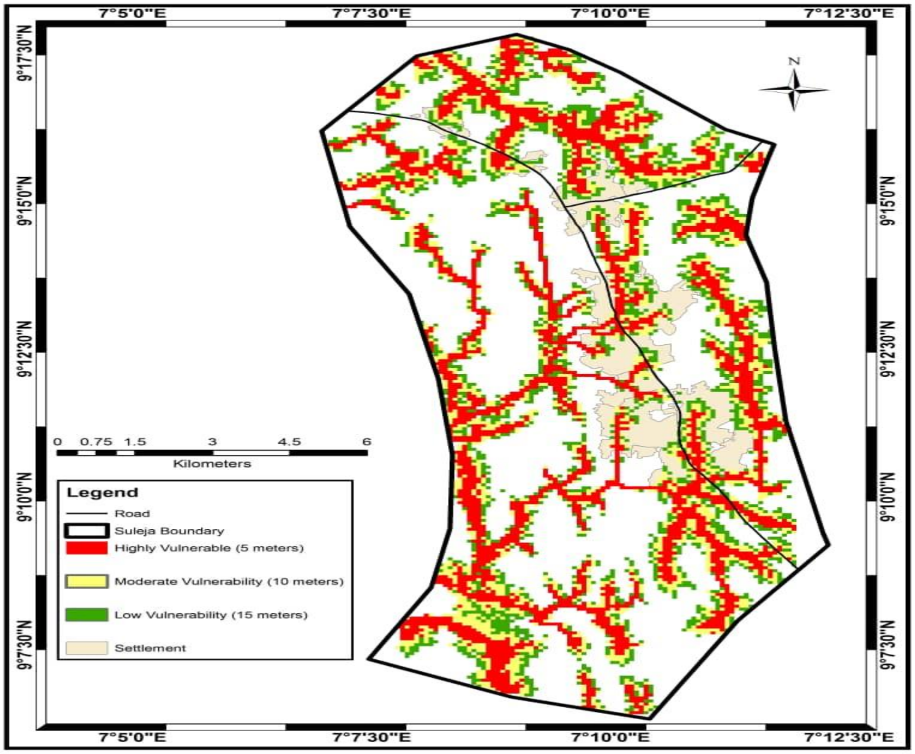

Figure 6: Flood risk map of Suleja represent settlement of the area

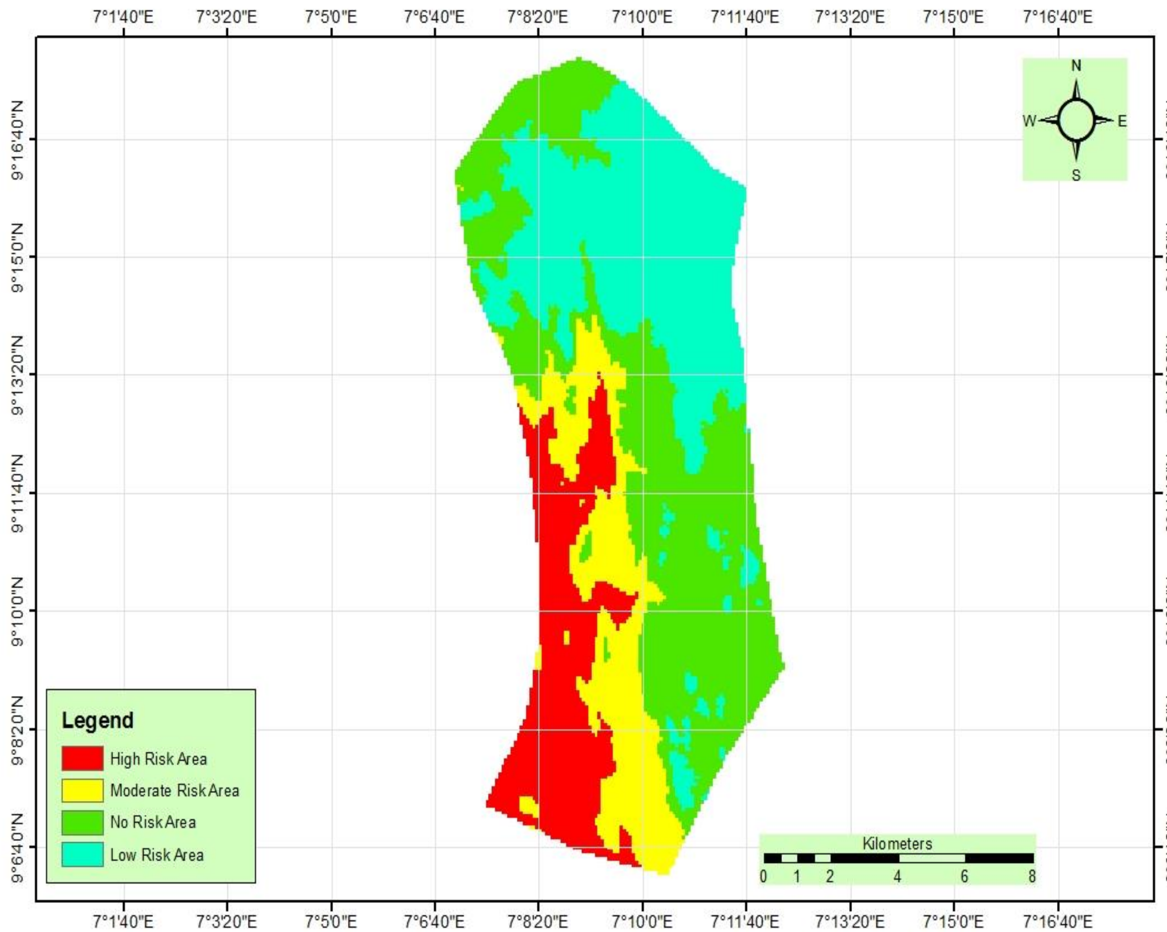

Figure 7: Flood risk map of Suleja

Flood Risk Zones

Figures 5 – 7 were DEM classified map of the study location which depict the slope in percentage and elevation of the area, generated using zonal statistics in the spatial analysis tool of ArcGIS 10.3.

In Figure 7, the areas mapped out as highly liable are mostly the areas closet to the River Muye. Flooding occurs in most areas in these mapped areas yearly. These places are known with low elevations and water-logged soils. The result from the classified DEM in Figure 7 represent that about 76.1335 square kilometer (71.35%) of the location is on a lower elevation which indicate a recurrent flooding, located at places like Barkin Iku, Then about 12.30389 square kilometer

(11.53%) are intermediate risk areas located at places like Berger Plant and 8.299563 square kilometer (7.78%) are low risk areas located at places like Zariyawa and finally 9.96803 square kilometer (9.34%) located at places like Nabwa Gwari It can be concluded therefore that the study location is a flood inclined area.

Figure 5 represent the DEM of the study locations with streams flow, there are with major streams flow and areas with minor stream flows, most of the streams flow are located in the floodable areas. Figure 6 represent the DEM of the study location showing the settlement along the floodable areas, people that lives in these regions are likely to be affected by flood incidence.

Table 2: Floodable Classes

Areas(km^2)	**Percentage (%)**	**Floodable class**	**Location**
76.11335	71.35%	High risk area	Barkin Iku
12.30389	11.53%	Moderate risk area	Berger plant
8.299563	7.78%	Low risk area	Zariyawa
9.96803	9.34%	Low risk area	Nambwa Gawri

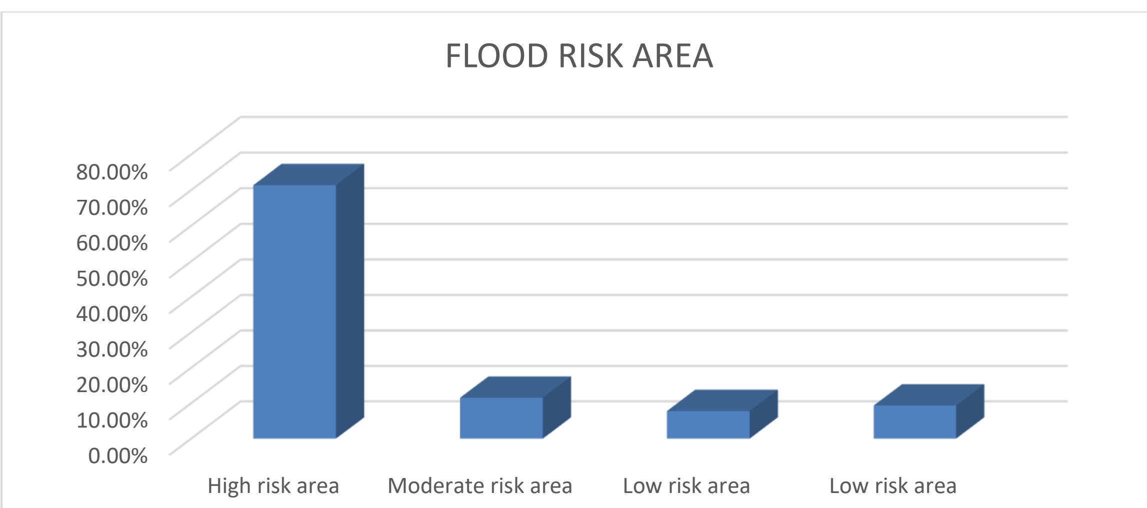

Figure 8: Flood Risk Area in Suleja

Non-floodable and Floodable areas in the study area

Tables 2 depict the spatial extent of the high, moderate and low risk area. The figure 4 shows the high, moderate and low risk area in the study location. It shows that the lower the elevation of a particular area and its proximity to a drainage network, the more vulnerable the area is to flooding.

In figure 7 The red colour represent floodable areas with 71.35% (76.11335) are incline to flooding due to the high elevation and water level and the green colour represent represent the non-floodable areas with 7.78% (8.299563).

Delineation of floodable and non-floodable area is particularly important in disaster risk reduction because it helped to identify hotspot areas where floods will occur; it consequences and final solution and provide effective flood warning system.

Inhabitant coping strategies

Method of Adaptation

Table 3 shows the types of method utilized by the people at different stages

Table 3: Method utilized by the people at different stages for flood

Stages	Strategies
Before flood	i. Clearing the waste covering the house as a method for dealing with flood stress ii. Constructing embankments before house using sand packs iii. Building of house with rigid materials.
During flood	i. Relocating the family especially younger ones and the old to a more secured and safer place ii. Relocating important household materials to the new place. iii. Closing the entryways and other opening
After flood	i. Repairing harms to structures ii. Cleaning the imparted environs iii. Fixing damaged things iv. Rebuilding structures

As shown in Table 3, the method for dealing with the impact used by the occupant living in Barikin Iku and Hi village in Suleja were grouped by Blaikie *et al.* (1994) into three stages as Before flood, During flood and After flooding.

We interacted with the villagers personally and they were able to make us believe that they are aware of the changes in rainfall patterns, even though their coping strategies are still their primitive practices which are employed during flooding to sustain their normal life. Their methods for coping with flooding are categories into different stages in the table above.

Conclusion

This research focuses on changing rainfall patterns and its implications on the flooding in Minna and its environs, Niger State. The line graph Showing the annual rainfall trend and the histogram showing the monthly rainfall trend depicts that there are changes in the rainfall patterns; from the year 2009-2011, the study area experiences little changes in rainfall patterns and the occurrence of flood was so minimized but from year 2012 it rises to over 800mm and dropped down in the next two years (2103-2014). The year 2015 and 2016 sixteen experience the highest annual rainfall, it was the same year that the study area experienced the worst occurrence of flooding that claimed about 9 lives and destroyed several buildings and damaged several properties. From 2017 to 2018 there was a downslope experience which indicates low annual rainfall.

The month of May to October experience rainfall, the month of July and August always experience the highest rainfall although their maybe variations experience in some years. The study has shown that the rainfalls tend to increase in certain years and decrease in certain years, but the years with highest rainfall caused the study area to experience flood. This shows that increase in rainfall is a major cause of flooding in the study location with the vulnerability of the location, poor drainage system and other environmental factor inclusive. The finding from this study brings to fore the need for a proactive approach that embraces an integrative risk management to flood disaster mitigation and its impact reduction on the residence of floodable areas in the study location. This study therefore concluded that the incidence of flood over the years is a result of climatic changes which eventually resulted into increase in monthly and annual rainfall that causes an overflow of water beyond its boundaries, also the poor drainage system situated around flood prone areas are not sufficient enough to curtail flooding, some has been damaged and neglected as well which has added to the cause of flooding. The use of poor building materials used for construction and also the building of houses along water passages has formed a cumulative cause of flood.

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