THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Assessment of Rainfall as an Element of Flooding in Makurdi, Benue State, Nigeria

Onyeke Ochu
Mathematics Programme (Applied) National Mathematical Centre, Sheda-Kwali, Abuja, Nigeria
Research Assistance, National Mathematical Centre, Abuja, Nigeria
Ph.D. Student, Department of Environmental Sciences,
University of Agriculture, Makurdi, Benue State, Nigeria

Abstract:
The study surveyed a 30 year rainfall data (1987- 2016) as an element of flood in Makurdi. The purpose of the study was to analyse the temporal variations in the annual and monthly amount of rainfall in Makurdi area of Benue State, Nigeria as well as attempt to predict the amount of rainfall expected in the future. The rainfall data had the following statistical value;Mean (1181.91),Median (1173.70), Range (856.50), Standard deviation (209.36), Coefficient of variation (0.18). The confidence interval at 95% confidence level was between 1102.28mm and 1261.55mm. Return periods of amount of rainfall for some of the periods that Makurdi area experienced floods were also analysed and includes; 1151mm- 2years, 1492.8mm- 12years, 1287.8mm- 4 years,1266mm - 3 years, 1000mm- 1 year and 1240.5mm – 2years. Therefore once in every 12years, Makurdi town will have 1492.8mm of rainfall. The model will help to predict the amount of rainfall expected in the coming years and assist the people in Makurdi to prepare adequately for it. The study also compared the rainfall data of past (1987-2001) and present (2002-2016) periodsusing figures and identified that apart from rainfall intensity, other factors like urbanization and land use play major roles in the flooding of the area.

Keywords: *Annual rainfall, Floods, Makurdi, Nigeria*

1. Introduction

Digby's study (1996, as cited in Abah, 2012) states that floods are of utmost prevalence amongst the natural disasters. Many countries around the world have experienced this common natural disaster especially in recent times. In 2017, some parts of the United States of America have been disrupted by catastrophic floods. Such areas include; Florida, Georgia and South Carolina (Richard, 2017). Also stated was the fact that Hurricane Irma which is one amongst the many hurricanes experienced in recent times, stills produces very heavy rain across the south eastern United States even though it was no longer a hurricane. The National Hurricane Centre in the United States also stated that "significant River flooding will persist over Florida peninsula in the wake of Irma and across Georgia, South Carolina and north-central Alabama where additional heavy rains are expected (NHC, 2017). Consequently, other countries like Nigeria, India and Romania etc. have also experienced flooding in some parts of the countries in the same year. However, the 2017 flood disaster in Nigeria is reported to be not as deadly and disastrous as its occurrence in 2012 and 2016 respectively (Falae, 2017). In 2012, Nigeria experienced disastrous floods across 30 of its 36 states which led to loss of lives, properties and leaving a large number of people homeless. It was also reported by Emmanuel (2016) that the News Agency of Nigeria (NAN) recalled that Benue state was one of the worst-hit in the flood disaster. It was also reported by Falae (2017) that Nigeria is currently among the 20 countries that will be negatively impacted by floods in the coming years.

In Benue state, Makurdi area has recorded floods concurrently in past years. From 2011 to date, flooding has become an annual event in Makurdi not including the later years(Joseph, 2011; Peter, 2012; 2013; 2015; Emmanuel, 2016).This study therefore attempts to analyse the temporal variations in the annual and monthly amount of rainfall in Makurdi area of Benue State, Nigeria as well as attempt to predict the amount of rainfall expected in the future so as to combat flood in the area.

2. Material and Method

Makurdi town is positioned in the plains of the River Benue in the Benue Trough. It is located between latitude 7^0 38' N and 7^0 50'N, and longitude 8^0 24'E and 8^0 38'E. It has a population of 249,000 and a density of over 380 per Km2. It is also located in the Benue valley in the North Central region of Nigeria and is cut across by the River Benue, dividing the town into the North and South banks. The River Benue is the second largest river in the country and is the main drainage channel that traverses the town (Abah, 2012). The town has mostly a low-lying relief of 90 – 150m on the average, resulting in a considerable amount of the town being waterlogged and flooded during heavy rainfalls (Abah, 2012; Marcellinus & Joseph, 2015). Ayoade's study (1983 cited in Abah, 2012) states the

climate of the town as tropical wet and dry type. The dry season usually last for a period of five months (November- March) while the rainy seasons lasts for a period of six months (April – October). The vegetation of the town is characterized as guinea savannah.
Rainfall data obtained from the Nigerian Metrological Agency (NIMET) office in Makurdi was used for the study. The data collected was for a period of 30 years (1987 – 2016). Information relating to flood events were sourced from online National dallies and articles. Statistical analysis was implemented using Microsoft office Excel 2010. Descriptive statistics was used to determine the Mean, Median, Standard deviation, Confidence level (95%), Confidence interval, Skewness of the total annual rainfall (1987-2016) in Makurdi. Histograms and Graph were also created. Return period for the rainfall data was carried out using the excel 2010 software.

3. Result and Discussion

Return periods of rainfall in Makurdi

Table 1 shows the return periods of some of years between 2011 and 2012 characterized by floods in Makurdi. This indicates the number of years it will take for such amount of rainfall to reoccur. The return period is calculated as follows;

Return period (T) = 100/Fa, Where Fa is the Probability of occurrence.

Probability of Occurrence, $Fa(\%) = \frac{100\,(2n-1)}{2y}$

Where n = the rank of each event and y = the total number of events.

Therefore, Year 2016 was calculated as follows;

$Fa = \frac{100\,(2*13-1)}{2*30} = 41.6666667$ therefore $T = 100/41.6666667 = 2.40$

Year of flood	Rainfall depth (mm)	Return periods
2011	1151	1.71 ~ 2
2012	1492.8	12.00 ~ 12
2013	1287.8	3.53 ~ 4
2014	1266	2.86 ~ 3
2015	1000	1.28~ 1
2016	1240.5	2.40 ~ 2

Table 1: showing the return periods for some of the years affected by flood in Makurdi

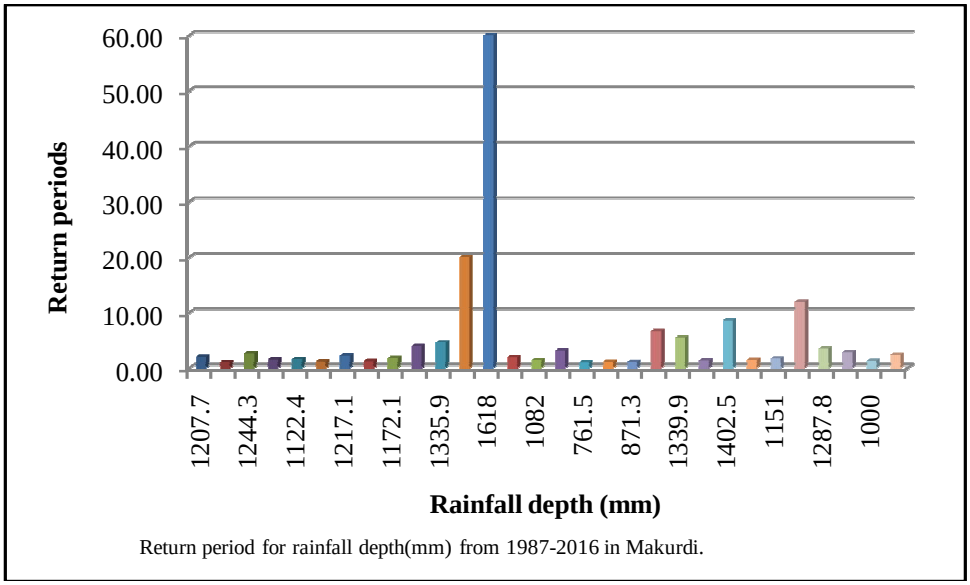

Figure 1: Showing the return periods for rainfall depth (mm) from 1987 -2016 in Makudi.

The result from the return periods shows the frequency of a reoccurrence of a rainfall event in another year. The highest amount of annual rainfall depth is 1618mm which was experienced in 1999. From figure1, it could be predicted that once in every 60 years, Makurdi area may have 1618mm amount of annual rainfall. Observation form table 1 shows that once in every 12 years, 1492.8mm amount of rainfall has a chance to reoccur in Makurdi and once in every 4years, 1287.8 mm of rainfall has a chance to reoccur in Makurdi. Also, analysing the 2011-2012 floods in Makurdi, the expected rainfall amount was predicted from previous years such as the 1998 rainfall amount of 1556.9mm was predicted to reoccur once in every 20years (2011 -2012 falls here), the 2006 rainfall amount of 1343mm predicted to reoccur once in every 7 years, reoccurred in 2007 with rainfall amount of 1339.9mm . The 2009 rainfall amount of 1402.5mm was predicted to reoccur once in every 9years can be said to have reoccurred in 2012 with rainfall amount of 1492.8. It could also be attributed with the 1998 rainfall amount of 1556.9 predicted to reoccur every 20 years. In 2012, disastrous floods were recorded in Nigeria where 30 of its 36 states were hit by flood. This led to loss of lives and rendered a large

number of people homeless (Al Jazeera, 2017).It was also reported by Emmanuel (2016) that the News Agency of Nigeria (NAN) recalled that Benue state was one of the worst-hit in the 2012 major flood disaster. The 2013 rainfall amount of 1287.8mm was predicted to reoccur once in every 4 years can be said to have reoccurred in 2016 with rainfall amount of 1240.5mm.

3.1. Descriptive Statistics

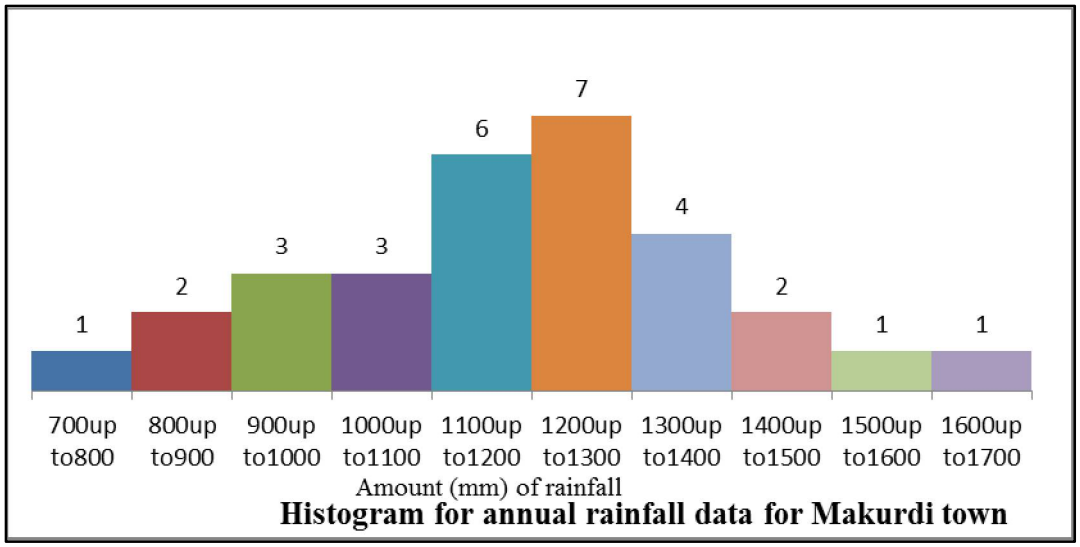

Figure 2: A histogram chart showing the frequency of the amount of annual rainfall for Makurdi from 1987 -2016

Mean	1181.913793	Mean	1181.914
Standard Error	38.87783592	Standard Error	38.87784
Median	1173.7	Median	1173.7
Mode	#N/A	Mode	#N/A
Standard Deviation	209.3635538	Standard Deviation	209.3636
Sample Variance	43833.09766	Sample Variance	43833.1
Kurtosis	-0.252436018	Kurtosis	-0.25244
Skewness	0.015576209	Skewness	0.015576
Range	856.5	Range	856.5
Minimum	761.5	Minimum	761.5
Maximum	1618	Maximum	1618
Sum	34275.5	Sum	34275.5
Count	29	Count	29
		Confidence Level (95.0%)	79.63764
Coefficient of Variation	0.177139445		

Table 2: Table from excel showing the descriptive statistics of the total annual rainfall from 1987-2016

A pivot table in excel spread sheet was used to create a frequency distribution table with a range of 700 – 1700mm and a class size of 100 as shown in the chart in Figure 2.The histogram showed that out of the 30 year rainfall data, 1200mm-1300mm depth of rainfall had the highest frequency of occurrence while 700mm – 800mm, 1500mm – 1600mm and 1600mm – 1700mm had the lowest frequencies in the distribution. The histogram is also bell shaped indicating that it is a normal distribution. The skewness (0.02) of the distribution also indicates that it is a normal distribution. The confidence interval was calculated as follows;

Confidence interval = Mean value $\pm$ Confidence level (95%)

Where the calculated mean value = 1181.91 and the calculated confidence level (95%) = 79.62

Confidence interval = 1181.91 $\pm$ 79.62 = 1102.28 $\pm$ 1261.55

Therefore, the result shows that it is 95% confident that the average rainfall depth is between 1102.28mm and 1261.55mm.

The following conclusions can be reached about the standard deviation since the distribution of the rainfall data is normal or bell shaped.

Approximately 68% of the amount of total annual rainfall falls within one standard deviation of the mean.

Approximately 95% of the amount of total annual rainfall falls within one standard deviation of the mean.

Approximately 99% of the amount of total annual rainfall falls within one standard deviation of the mean.

Considering the mean value to be 1181.91 and the standard deviation to be 209.36 as seen in table 2, therefore it is estimated that approximately 95% of the total annual rainfall will fall in the range of 1181.91 – (2*209.36) to 1181.91 + (2*209.36) which results to

763.19 and 1600.63. This corresponds with the maximum (1618) and minimum (761.5) amount of total annual rainfall shown in table 2.

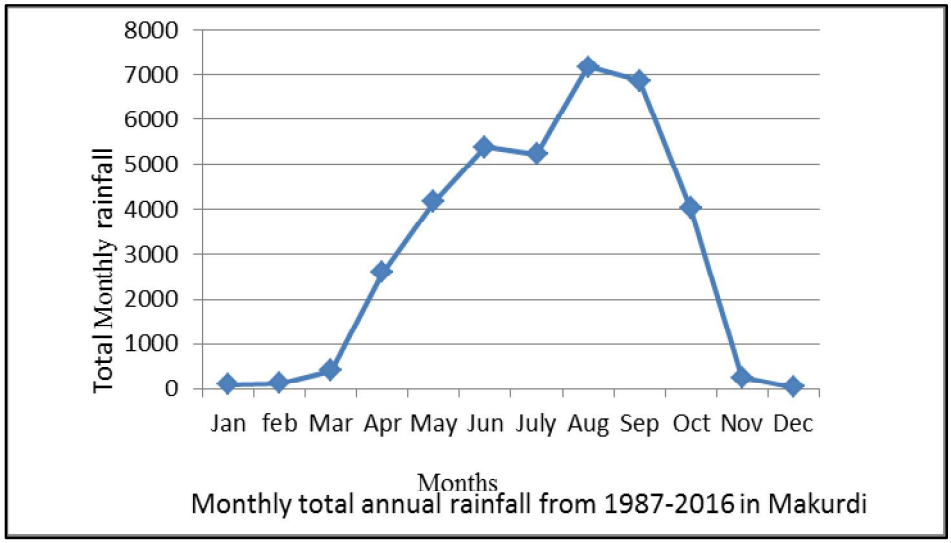

Figure 3: A line chart showing the total monthly annual rainfall from 1987 – 2016

3.2. Rainfall and Flooding in Makurdi

The U.S. Geological Survey study in 2017, states that the two major elements assigned to flooding is rainfall intensity and duration. Makurdi area in Benue state is cited in the floodplains of Nigeria Floods commonly take place in floodplains after a prolong period of rainfall usually for several days as well as heavy rainfall over a short period of time (U.S. Geological Survey, 2017). This can be observed in the 2011 floods in Makurdi where Joseph (2011), reported that the flood in Makurdi area had occurred as an aftermath of two days of heavy down pour of rain. It can also be observed in 2013 and 2015 as well where it was reported that a four hours and six hours torrential rain respectively, in Makurdi had left the area flooded (Peter, 2013; 2015).These findings also buttress the work done by Ayoade (1988, as cited in Marcellinus & Joseph, 2015) where he stated that rainfall intensity, duration and amount are generally the principal factors in most flood events in the tropics which are partly or wholly climatological in nature. Figure 2 which shows the frequency of the amount of annual rainfall for Makurdi from 1987 – 2016 indicates that 1200mm – 1300mm of rainfall had the highest occurrence, followed by 1100mm – 1200mm of rainfall. Some of the flood periods from table 1 fall under the rainfall amount with the highest frequency i.e. 2013, 2014 and 2016 respectively. Figure 3 shows the total monthly annual rainfall from 1987 – 2016. It was observed here that the months of June (5390mm), August (7191.6mm) and September (6867.5mm) had higher amount of rainfall with August ranking first. This agrees with the flood periods witnessed in the state which occurs mostly in the month of September as seen in the reports from the news dailies and articles (Joseph, 2011; Peter, 2012; 2013; 2015; Emmanuel, 2016).The result also agrees with a study by Marcellinus & Joseph(2015) that shows floods occurring in the town at the peak of rainy season between September and October respectively with 2012 having the highest water level.

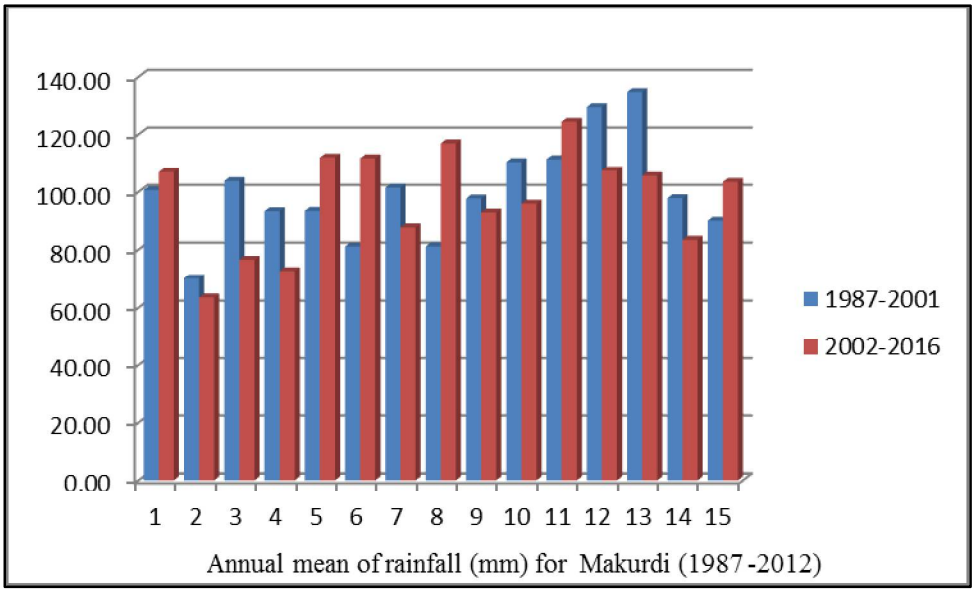

Figure 4: A bar chart comparing the mean of the Past (1987-2001) and present (2002-2016) annual rainfall in Makurdi.

3.3. Factors Responsible for Floods in Makurdi Town

The bar chart in figure 4 shows a comparison between the means of two periods slated as past (1987-2001) and Present (2002 – 2016) of annual rainfall in Makurdi. This shows no significant difference in the amount of rainfall witnessed in the two periods. This further indicates that urbanization and population growth has played major roles in the increase of flood events in Makurdi in recent times. The U.S. Geological Survey, 2017 shows that the aftermath of urbanization which led to land conversion from farmlands or fields to roads and parking lots, makes the land to loses its ability to absorb rainfall. Marellinus & Joseph's study (2015) identifies some factors that have contributed to flood events in Makurdi town as dumping of dirt in drainages and water channels; rainfall intensity, duration and amount; lack of and poor drainage networks/connectivity; building on water channels and overflowing of river banks. The least contributing factors are said to be climatic variability and poor infiltration/topographic characteristics. The study also identifies overflowing of river banks most especially south bank as a factor responsible for flooding in parts of Makurdi town.

Emmanuel (2016) reported that the government had issued vacation notices to the households to be affected of which many refused to comply. This could be attributed to the fact that the individual had built their homes in such areas and were unwillingly to become homeless. Makurdi town is located in the flood plains of the River Benue. A study by Abah (2012) reveals that Makurdi town has witnessed constant and continuous changes brought about by urbanisation since it became the capital of Benue State in 1976. With the migration of individuals into the town, more building are constructed to house them as well as more road networks. A lot of pressure is built up on the land with activities such as placing impermeable concrete over the soil as well as removal of the vegetation cover, which provides little soil for water to penetrate and minimal vegetation cover to absorb water. This leads to an increase in surface run off which flows into nearby marshy areas and the river Benue that also increases the risk of a flood. Locations in Makurdi which suffer from seasonal flooding include Wadata, Wurukum, Logo, Demekpe, behind Benue State University, Idye and low-level areas as shown in figure 5.

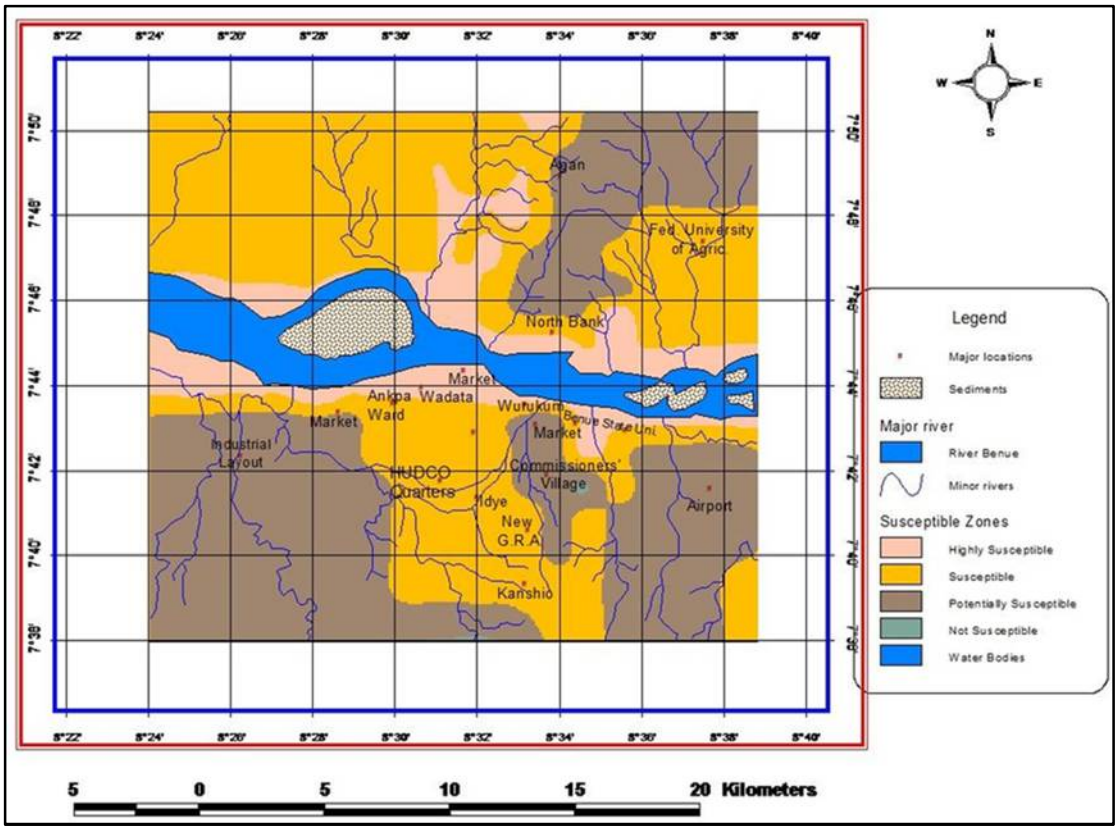

Figure 5: Map of flood risk zones in Makurdi town, Benue State
Source: Abah R.C. (2013)

4. Conclusion

Results of the study reveals that the flooding of Makurdi town can be minimal or avoided with knowledge of the return periods of heavy rainfalls. It also reveals urbanisation and population increase has accelerated the degree and frequency of floods in Makurdi not excluding the town's low relief and other human activities along the River banks that causes it to overflow its banks. Recommendations include the following;

Government relocation of individuals living in flood prone areas as well as prohibiting some areas for land use such as residency and road in order to avoid loss of lives and properties.

Good depth as well as width of drainage channels should be built and left unblocked by dirt in different areas of the town especially in areas prone to flood.

Human activities such as farming, along the river banks should be minimized or discouraged.
Public enlightenment should be strongly driven to educate the people living in the town especially in areas prone to flood.

5. References

i. Abah, R.C. (2012). Causes of seasonal flooding in flood plains: a case of Makurdi, Northern Nigeria, International Journal of Environmental Studies, 1–9, iFirst Article.
ii. Abah, R.C. (2013). An application of Geographic Information System in mapping flood risk zones in a north central city in Nigeria. African Journal of Environmental Science and Technology, 7(6), 365-371.
iii. Emmanuel, A. (2016, September 6). 500 households to be affected by flood in Benue state. Sundiata post news
iv. Falae, V.(2017, July). Flood in Nigeria: why did the latest disaster happen? Naija.com
v. Joseph, W. (2011, October 8). Flood wreaks havoc in Makurdi. NBF News
vi. Marcellinus, A.H., & Joseph ,C.U. (2015). An assessment of the impact of flood events in Makurdi, Nigeria. Civil and Environmental Research, 7(10)
vii. Nigeria floods displace more than 100,000 people (2017, September 1). Al Jazeera and News agencies.
viii. Peter, D. (2012, October 5). Benue State: Makurdi flood victims recount their experience and pain. Vanguard
ix. Peter, D. (2013, September 2). Flood wreaks havoc in Makurdi, Submerges 180 houses. Vanguard
x. Peter, D. (2015, August8). Flood submerges over 150 houses in Makurdi. Vanguard
xi. Richard, D. (2017, September 12). USA – Hurricane Irma Causes Major Flooding in Northern Florida. Floodlist.
xii. The Hydrology of Floods (2017, January 18). U.S Geological Survey
xiii. The unending Makurdi flood disaster. (2015, September 28). Environ News Nigeria. 247Newsnaijaadmin (2014, October 8). Flood takes over Makurdi, 2000 houses submerged.247Newsnaija