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IMPACT ASSESSMENT OF SUBSTANTIVE HYDRO-CLIMATIC VARIABLES ON 2012 FLOOD EXTENT IN YOLA AND ENVIRONS

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ABSTRACT

Flood is a seasonal phenomenon which is natural in it hazardous implication and occurs when there is relative high flow over the banks of the streams as a combine consequence of high recorded data of hydro-climatic related variables in a given geographical area. Yola North LGA, of Adamawa state had experienced an unprecedented flood in the year 2012 over the past decade which might have been influenced by some hydro-climatic variables and caused devastating effects on lives, properties, farmland and buildings respectively. This study focused on the impact assessment of substantive hydro-climatic variables on 2012 flood event in Yola -North and its environs. The hydro-climatic variables data were obtained from Meteorological station at UBRBDA, Yola for a decade. The amount of rainfall experienced was found to be highest (1085.2mm) in the year 2012 than any other year under consideration (2008-2017) except that of 2016, number of rainy days was highest (81 days) in the year 2012. Similarly, in the month of August in the year 2012 evaporation rate was lowest with about 69 mm than any other month of August in the decade, the annual value of water discharge was highest in the year 2012 over the decade with about 6,340(m^3/s), the gauge height was found to be highest with about 7.33 m in the year 2012 and the water level was highest in the month of June, July and September with the corresponding values of 3.37 m, 3.49 m and 6.58 m compared to similar months in the years of the decade respectively. These increased changes in some hydro-climatic data analyzed might be the fundamental natural factor that causes the unique *flooding than any other factor in the year 2012 in the study area and over time posed negative impact on agricultural lands. Therefore, the study recommends the urgent need to carry out a comprehensive seasonal hydro-climatic data record simulation analysis and variations with a view of taking them as a recipe and strategies of forecasting and predicting the reoccurrence of such phenomenon. The additional meteorological station should be provided by the government agencies in all agricultural zones of the state for adequate and wide range of hydro-climatic data recording for appropriate prediction of weather indices in future.*

***Keywords**: Flood, Hydro-climatic variables, Extent, weather*

INTRODUCTION

In Nigeria, flooding is the most frequent and most widespread natural hazard accounting for about one-third of all disasters arising from geophysical hazards and adversely affecting more people than any other natural hazard (Adebayo and Oruonye, 2012).Floods are the most common environmental hazard in Nigeria (Etuonovbe, 2011), which are mostly caused as a consequence of some substantive changes in the climatic variables over the years. The usual causes of flood in Nigeria are high precipitation, topology (low/ flat slopes), geology, soil condition, poor drainage, rapid and high runoff occasioned by deforestation in hilly catchments also enhance flooding in such areas (NIHSA:AFO: 2016). Similarly, floods which are wholly or partly climatologically in Nature; intense and heavy rains account for the majority of the flood that occur in the tropical cyclones or may just be from a large thunderstorm while in the temperate region snowmelt in spring especially if sudden or rapid frequently cause floods in many part of the temperate region in spring. In Adamawa State the causes of seasonal flood in the region can be grouped into two main factors namely: Natural and Anthropogenic factors. The natural factors are weather-climate related which are relatively uncontrollable that leads to generation of river and flash flood in the state while anthropogenic factors are human related activities such as poor drainage system, buildings on water ways, poor waste disposal among others. The natural factors are hydro-climate inclined variables which play a vital role in causing devastating river flooding resulted to negative impact on human and material as well as the economics activities in the flood plains areas of the state over the years most especially that of 2012 flood scenarios which was conceived to be unprecedented in the past decade.

The most recent experienced flood which occurred in 2012, it was considered to be the worst ever to have hit the country in four decades (Integrated Regional Information Networks, 2012.).Similarly, NIHSA: AFO: (2013) that reported that the utmost floods of 2012 occurred within the flood plains of the rivers Niger, Benue and their tributaries. It was also reported by NIHSA: AFO: (2013) in 2012 between July and October rivers overflowed their banks than normal over the years, submerging thousands of hectares of farmland, settlements and infrastructure. About 7.7 million people were affected, 1.3 million people were displaced from their homes, 363 people died while 5, 851 persons sustained various degrees of injuries during the unprecedented floods. The 2012 flood disaster in Nigeria adversely affected more people in one year than the previously combined years, including soil erosion between 2005 and 2010 (Hassan and Tokula, 2013). In 2012 alone, Nigeria recorded a total estimated loss of properties worth N 2.29 Trillion (National Emergency Management Agency, NEMA: 2013 in NIHSA; AFO; 2016).

In Nigeria, Adamawa state is one of the most occurring flooded states over the decade with a large extent of vulnerability leading to devastating loss of lives, properties, farmlands, displacement and negatively affecting the socio-economic activities in the state. Similarly, over the decade, it was observed that in the year 2012 Adamawa state experienced an unprecedented flooding scenario as a consequence of natural weather and hydro-climatic variables that transpired above normal level if compared with the past data decade records (Sadiq and Hena, 2018).

The hydrology of Nigeria is dominated by the two major river system viz; the Niger-Benue system and the Chad system (NIHSA: AFO:2016). Adamawa State falls under Hydrological Area three (HAs III) as described in figure 1, which is made up of about 70 % sedimentary and 30 % Basement. The major rivers in the (HAs III) are Benue, Gongola, Taraba, Donga, Kastina-

Ala, Faro and Mayo-Kebbi and 75 % of the rivers found in Adamawa State. (NIHSA: AFO: 2016).

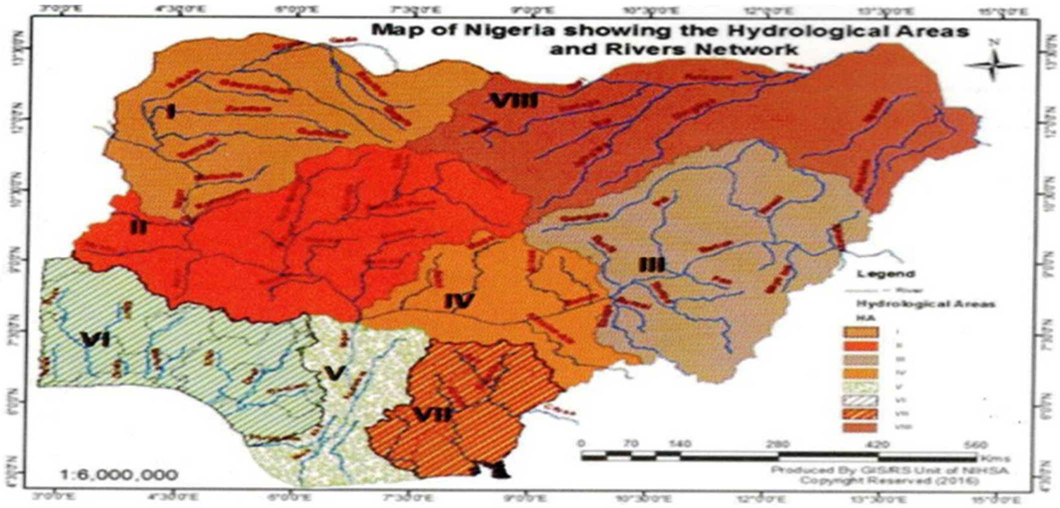

Figure 1: Hydrological Areas and Rivers Network (Adopted from NIHSA:AFO: 2016 pp. 12)

According to Annual Flood Outlook report of NIHSA, (2013) in the year 2012, Adamawa State experienced the highest peak flow of about 3, 362.40m3/s compared with other gauging stations in the Northern part of the country. Similarly, NIHSA: AFO: (2013) reported that the peak of the major floods of 2012 occurred within the flood plains of the rivers Niger, Benue and their tributaries. Hence, the study area is the most ultimate flood plains of such rivers which eventually put the area prone to flood zone of the state. In Adamawa State, the study area are precariously placed in terms of flood vulnerability as a consequence of nature, pattern and extent of the catchment rivers around the study area. Thus, slope of catchments also affect run off and run off rates in well drained catchments move surplus water away more quickly than poor drained catchment. Outstanding to the nature and seasonal trellised and annular pattern of the Catchment Rivers along the River Benue Plains received very high amount of rainfall to the extent that the tributaries Rivers cannot carry the entire runoff, they overflow and submerged the neighboring fields silted there by mapped the area flooded in the 2012 hydrological year.

In Adamawa State, Yola North is one of the flood prone areas in the past decade looking at the its proximity to river Benue, low land undulating nature of the topography and above all, the hydro-climatic variables that tends to fluctuate above anticipated or predicted level. It is imperative to study the hydro-climatic data which conceived to be most contributed factor of unprecedented flood scenario in the year 2012 in the study area with the specific objective of analyzing the extent and quantifying the amount of hydro-climatic data recorded that caused 2012 unprecedented flood in the recent decade. Therefore, this study aims to assess the impact of substantive hydro-climatic variables that influenced 2012 flooding in Yola - North and its environs.

STUDY AREA

Yola North is also called "**Jimeta**" which is located in the north eastern part of Nigeria, (Mohammed, 1999). It lies on latitude 09^{0} 14'N and 09^{0} 20'N of the equator and longitude 12^{0} 25'E and 12^{0} 28'E of the Greenwich meridian. Population of the Yola North through which the study segment traverses is about 198,314 (NBS; NPC, 2006). It is also characterized by high population progression of 3.6% and rapid urbanization of about 7%. (Census, 2006).The annual precipitation value received within the last 30 years period of the study shows that the mean value for the period is 938.4mm with the lowest value of 679mm recorded in 1987. The rainy season runs from May through October (with insignificant rains in March, April and November). The dry seasons commence in November and ends in April/May. The average annual rainfall in the study area ranges between 850mm-1000mm with over 41% of rain falling in August and September. Temperature also has a significant temporal variation in the study area; April is the hottest month with an average maximum temperature of 42 ^{0}C. January and February are the coldest months with an average mean minimum temperature of about 20 ^{0}C. The driest months are January and February with an average relative humidity of about 29%. (UBRBDA,2018).

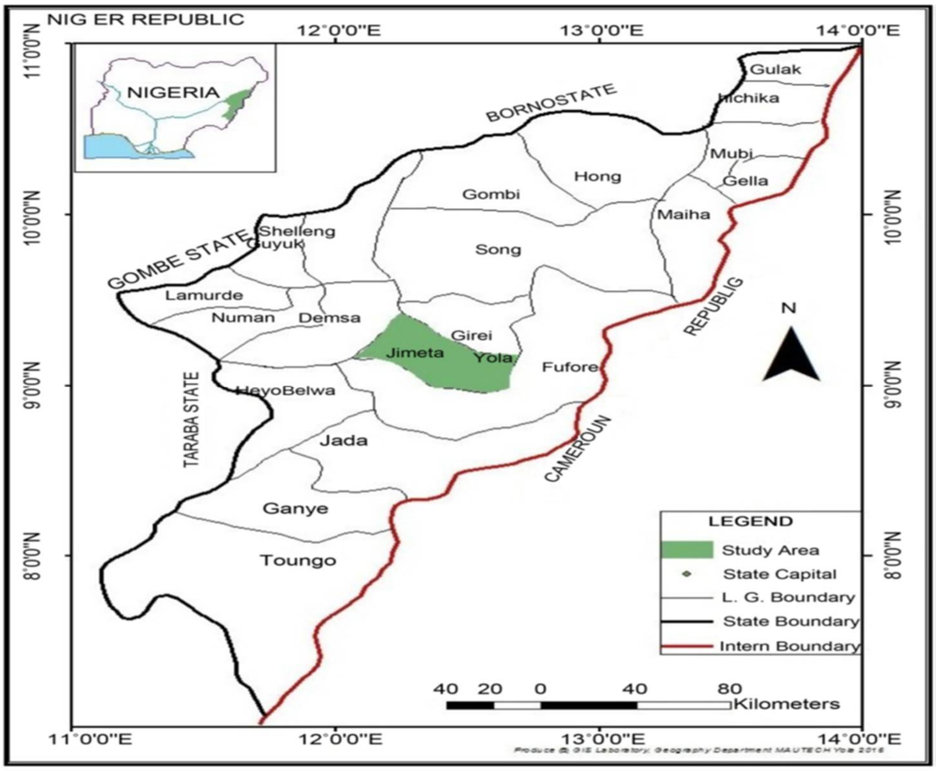

Figure 2: The Study Area

Source: Alkasim, *et al.,* (2018)

RESEARCH METHODOLOGY

The data used for this research were obtain from Meteorological station, Upper Benue River Basin Development Authority (UBRBDA) Yola, Nigeria Hydrological Services Agency(NIHSA) annual reports and other related scientific literatures were also overviewed from Journals, textbooks, internet, unpublished theses and maps obtained from library and institutions as secondary sources. The data were analyzed using simple descriptive statistical tools where means, tables and charts were presented respectively.

THE HYDRO-CLIMATIC VARIABLES

High Amount of Rainfall/ Precipitation

From 2008-2017 record has shown that the year 2012 was the year with prolong duration of rainfall from the onset to cessation period which was from April-November (8 Months) above normal duration of rainy season period which is 5 to 6 months as shown in table 1. These prolong duration of rainfall in the study area might be attributed to 2012 flood which occurred in the study area. This finding is in conformity with the verdict of Ward and Robinson, (1990) which explained that quick flood are those usually caused by intense or prolonged rainfall or snow melt or combination of these two in a given area. Similarly, it was noted also by Oyegun, 2001 and. Angillieri, (2007) that flood may be induced by a variety of factors, most notably heavy precipitation (intensity, duration, amount, or snow). Hence, this scenario was apparently unusual over the decade with the exception of 2013 and 2014 which experienced a seeming onset of rainfall late March but ceased early October. Thus, changes in precipitation events will affect flow rates and timing (Constantine, 2009), also Knapp (1979) explained that time to time heavy rainfall also resulted in flood occurrence over a particular geographical area. Moreover, the seasonal flood expected month in the region ranges from late July-September where in September 2012 (seasonal flood expected month) the amount of the rainfall was highest (214.1 mm) than any other month of September in the decade except that of 2009, 2011 and 2015 with slight differences. This finding agrees with the report of Mazumder (1983) who conceived that when there a heavy downpour in short period of time with poor drainage system in the area will lead to stagnation of surface run off for some period consequently leading to flooding. Thus, this might also be an accredited factor that impaired overwhelmed exceptional flooding in the state during the year 2012.Similarly, the total amount of rainfall experienced in 2012 was highest with about 1085.2 mm apart from 2016 season having 1260.1 mm in the decade as shown in table 1. The high total amount of rainfall experienced in the year 2012 had led to the excessive run-off which subsequently resulted to river flooding of the year 2012 in the study area. Thus, excess water is expressed in form of floods and poor drainage (Ayoade, 1988). Moreover, the recorded rainy days were highest in 2012 with 81days (Table 1) than any other days in the decade with an average range of 17 days accordingly. Thus, Hydrologically, “The more the intensive rainy days the more the tendency or susceptibility of flood scenario in the geographical area”. Conclusively, due to high intensity and long duration of precipitation recorded in 2012 might be the impetus recipe of that significantly stemmed and extraordinary flooding in the decade around the flood plain areas damaging farmlands, properties and loss of human lives.

Table 1. Monthly Total Rainfall Data (mm) for a recent Decade (2008-2017)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (mm)	Rainy Days
2008	-	-	-	19.7	115.3	115.1	152.9	194	174.8	37.1	-	-	808.9	64
2009	-	-	-	15.1	128.9	200.2	193.4	246.5	238.1	41	-	-	1063.6	72
2010	-	-	-	32.2	76.9	211.1	213.2	199.3	199	130.7	-	-	1063.4	72
2011	-	-	-	33.1	90.8	116.9	93.4	161.9	228.5	98.6	-	-	823.2	71
2012	-	-	-	32.8	160.7	240.3	156.4	171.4	214.1	94.6	14.9	-	1085.2	81
2013	-	-	22.4	1.70	144.4	119.1	147.4	144.3	204.4	44.0	-	-	827.7	67
2014	-	-	9.8	89.7	137.6	216.6	121.2	157.8	189.0	93.6	-	-	1015.3	71
2015	-	-	-	6.5	47.8	1886.4	204.1	253.7	221.3	58.6	0.6	-	979.0	69
2016	-	-	-	22.3	226	320.6	133.6	269.9	208.6	79.1	-	-	1260.1	68
2017	-	-	-	76.2	143.3	177.1	143.4	166.4	231.8	0.4	-	-	920.6	65

Source: UBRBDA, Agromet, Station Yola (2018).

Table 2. Monthly Total Evaporation (mm) and the mean annual Evaporation (mm) in a Recent Decade

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (mm)
2007	209.44	242.08	299.48	279.56	187.02	180.24	255.8	100.75	120.23	125.29	192.77	210.98	2403.64
2008	210.67	247.45	339.41	280.21	211.27	158.12	151.07	108.12	113.69	158.64	205.92	205.06	2389.63
2009	156.55	167.9	220.32	181.92	146.43	122.07	106.54	92.37	100.28	108.84	125.36	147.33	1675.91
2010	160.22	170.0	224.56	227.03	159.52	107.44	86.14	79.42	97.01	107.8	126.4	146.45	1691.99
2011	151.7	166.32	226.29	211.98	162.54	229.53	142.96	90.28	80.94	112.34	611.57	501.61	2688.06
2012	587.16	167.4	213.22	208.5	131.83	121.18	89.34	69.9	103.48	101.49	105.57	112.47	2011.54
2013	133.72	156.75	171.23	191.79	166.69	127.9	92.88	87.19	99.24	107.78	112.05	137.78	1585
2014	148.78	156.48	195.13	187.52	117.55	153.31	101.34	83.43	95.45	166.33	126.79	131.16	1663.27
2015	150.2	172.76	208.54	225.27	210.87	149.30	114.34	90.18	83.5	108.67	130.35	130.0	1773.98
2016	153.19	170.84	200.66	209.75	161.65	112.15	99.69	96.29	1015.5	107.75	128.8	143.93	1470.65

Source: UBRBDA, Agromet, Station Yola (2018)

Evaporation Rate

From table 2 below, it can be noted that the month of August in the year 2012 evaporation rate was lowest with about 69 mm lower than any other month of August in the decade (2007-2016) .This finding might also be a recipe to unprecedented precarious flooding experienced during the 2012 in the study area. This is because if the rate of precipitation is higher than the evaporation rate with low temperature (July-September) the soil macro and micro-pores spaces will filled up with water leading to water logging effects and consequently rejuvenating to leading to devastating floods as it was feasible in the study area. Conversely, if the rate of evaporation is higher than the precipitation the ground water or soil moisture will eventually be depleted which might lead to hydrological drought leading to drying of reservoirs, lakes, streams, rivers and cessation of spring flows and fall in the groundwater table.

Atmospheric Temperature

The data of monthly mean maximum temperature of the study area from 2007-2016 were presented in table 3. From the table, the monthly mean maximum temperature of the months of May, June July and August were recorded as the lowest in 2012 compared to similar months from 2007-2016 respectively. The lowest monthly mean maximum temperature recorded in these months particularly in July and August (Flood Expected Months) might be attributed to the reason of low evaporation in the area, where low evaporation rate coupled with high intensity and rainy days give rise to exacerbated flooding in the region because water bodies might not be able to lose their water through evaporation process and the soil water holding capacity is filled thereby increasing the rate of water run-off. This agreed with the statement of Adewusi, (1990) who reported that flood is not caused by heavy rainfall but caused by the exposure of the soil to rain . Flood is indirectly depended on atmospheric temperature of a given geographical area, because temperature has a direct effect on evaporation rate of water bodies on the ground surface. Hence, rising temperature will lead to an intensification of the hydrological cycle, resulting in drier dry seasons and wetter rainy seasons, and subsequently heightened risks of more extreme and frequent floods and droughts (Holmes, 2007). High temperature facilitates evaporation rate while low temperature reduces the rate of water, moisture and vapour loss from the ground surface. As the earth's average temperature rises, the proportion of precipitation in the form of rain increases and there is also a decrease in precipitation proportion in the form of snow.(Adams and Peck, 2008).

Table 3. Monthly Mean Maximum Temperature (°C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (°C)
2007	31	37	38	38	35	32	31	29	30	32	33	32	398
2008	32	32	35	34	33	32	31	30	29	33	31	35	387
2009	36	38	40	38	35	33	32	31	30	32	34	35	414
2010	31	33	40	36	36	33	31	30	29	32	32	30	393
2011	33	38	40	39	35	34	32	30	30	35	35	33	414
2012	34	38	39	40	33	31	30	30	31	32	34	35	407
2013	34	37	42	39	37	35	31	31	32	34	35	35	422
2014	35	37	39	39	34	33	32	30	31	33	35	34	412
2015	33	39	39	39	37	32	31	31	29	33	35	31	409
2016	33	37	38	41	36	33	32	31	32	34	36	34	412

Source: UBRBDA, Agromet, Station Yola (2018).

Relive Humidity

In 2012, the mean monthly Relative Humidity (R.H %) was highest in the month of September (flood month predicted) with about 84 % than any other September in the years under consideration as it was shown in table 4.Similarly, the total mean annual relative humidity was highest in the year 2012 with about 56% followed by 55 % for the year 2013 while the least was in the year 2015 with R.H of 48 % respectively. This sensation also contributed to the unique scenario of flood in the area during the year 2012, because the extent of saturation depends on the quantity of water vapour present in the air which might give rise to condensation and later excessive precipitation. Thus, as the R.H ranges between 70-75 % there would be high possibility of intensive precipitation as recorded in the year 2012 in the study area.

Table 4. Monthly and Annual Mean Relative Humidity %

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (%)	Mean RH (%)
2007	22	21	28	47	68	70	74	82	79	72	51	26	645	53.75
2008	25	21	29	45	56	68	73	81	77	66	36	36	613	51.08
2009	27	22	26	47	62	71	75	79	80	74	46	26	635	52.9
2010	24	26	29	36	63	72	76	79	80	80	52	29	646	53.83
2011	30	36	31	38	61	66	73	77	82	72	41	31	638	53.17
2012	35	34	22	42	65	70	77	77	84	74	55	37	672	56.00
2013	30	23	38	46	60	76	77	77	78	69	50	40	664	55.33
2014	24	19	30	48	69	73	75	78	76	71	56	30	649	54.08
2015	25	23	29	28	47	65	71	77	74	71	39	27	576	48.00
2016	23	21	39	34	60	67	73	78	75	67	38	24	599	49.91

Source: UBRBDA, Agromet, Station Yola (2018)

Rate of River Flows

The River Benue Trough along Adamawa State flood plain areas experienced exceptional flows consistently and ultimately higher in 2012 than those in the previous years of the decade culminating the year as highest flooded year of the decade. Over five decades total flow was observed to be highest in 2012 at Wuroboki gauge station in the study area. There was high inflow during the month, before the arrival of monsoon flow (July September) from Upper Benue Basin. The high inflow in July, August and September in 2012 led to River Benue overflowing its banks and submerging farmlands and settlements into flood prone areas. Generally, river flows were observed to be very high in 2012 as shown in the flow hydrographs of figure 3, 4 and 5 below;

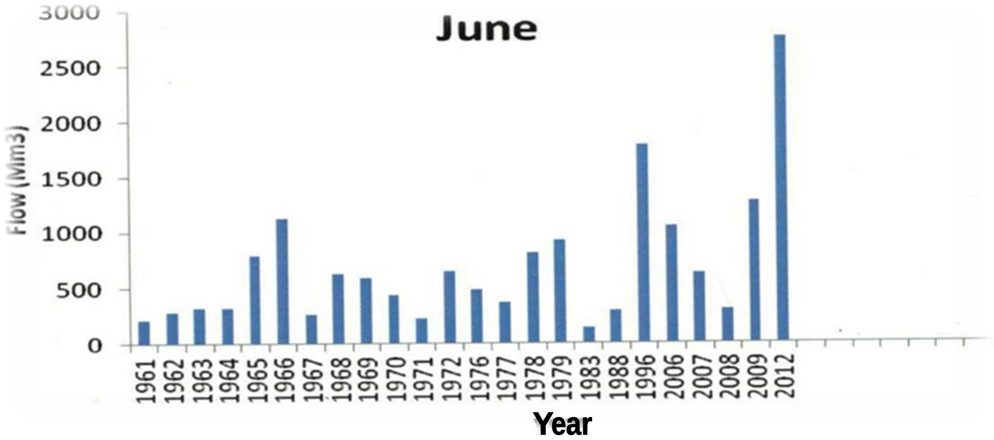

Figure: 3 Peak Flow Analyses at Wurobokki on River Benue (Adopted from NIHSA:AFO: 2013)

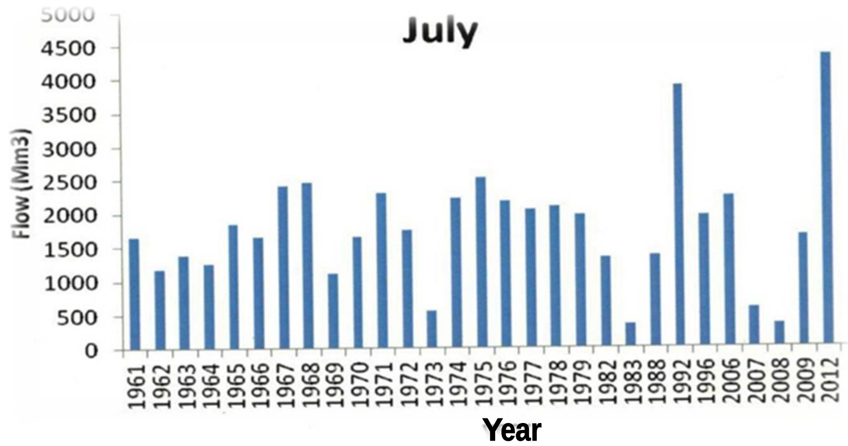

Figure: 4 Peak Flow Analysis at Wurobokki on River Benue (Adopted from NIHSA:AFO: 2013)

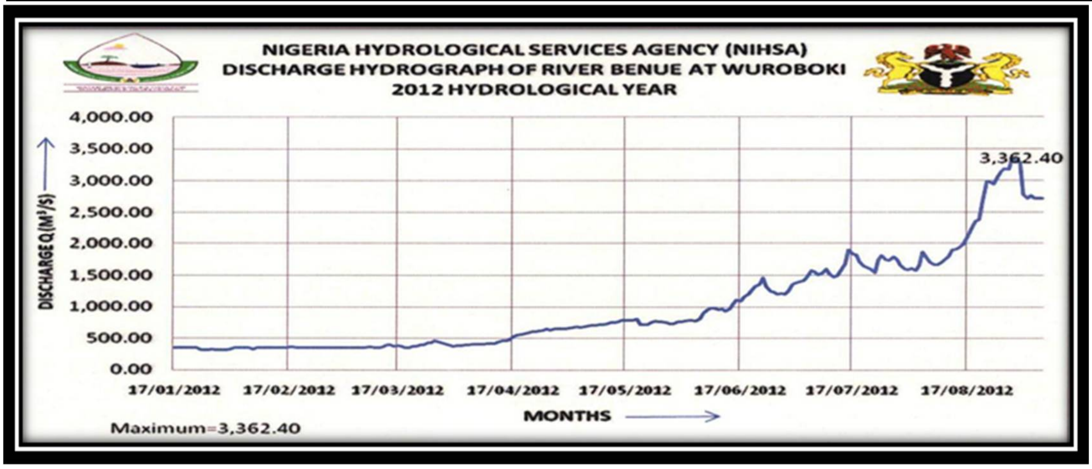

Figure: 5. Hydrograph at Wuroboki Hydrological Station Yola, Adamawa State (Adopted from NIHSA:AFO: 2013).

Water Discharge from Lagdo Dam

The data on water discharge obtained from Jimeta Bridge station of the study area were recorded on table 5. The annual value of water discharge was highest in the year 2012 over the decade with about 6,340 m^3 /s followed by 5, 460 m^3/s in the year 2007 respectively. This high amount of water discharge experienced might be due to the hydraulic factor that leads to high flood event in the year 2012. It was reported by Obeta, (2014) that, the flood was higher that the Lagdo dam which was constructed on the River Benue in the republic of Cameroon could not accommodate it, therefore the dam had to be opened to release the excess impoundment that is capable of collapsing the dam. The release of water from the Lagdo dam upstream of the River Benue led to the flooding of the entire length and breadth of the downstream catchment of the basin. (Obeta, 2014). Hence, all the settlements (both rural communities and townships) along the River Benue were flooded (Adebayo and Oruonye, 2012). Thus, the study area was situated on low undulating terrain at the south western bank of River Benue with some patches liable to flood when the discharge is high.

Rate of Run-off / Infiltration Rate

Rainfall of high intensity seals soil spores resulting to surface runoff. Runoff starts if the intensity of rainfall is more than the infiltration capacity of soil. When the rainfall continuous for longer periods, the runoff increases and subsequent leading to flooding. Correspondingly, due to the high intensity of rainfall observed in 2012 which is than the rate of soil infiltration in the region which led to the occurrences of flooding in the study area. Thus, increased rainfall events results into more rainfall on the hardened ground, and if not absorbed will cause flash floods instead of of soil moisture (Constantine, 2009).

Table 5. Annual Maximum Gauge heights and Water Discharge in meters on River Benue at Jimeta Bridge Station

	Zero Level of Gauge: Datum 151.166m	
Year	Gauge Height (m)	Water Discharge m^3/s
2006	6.80	5,360
2007	6.88	5,460
2008	6.11	4,000
2009	6.52	5,000
2010	6.85	5,390
2011	5.18	2,320
2012	7.33	6,340
2013	5.13	2,260
2014	5.55	2,710
2015	5.82	3,165
2016	5.98	3,500
2017	5.48	2,640

Source: UBRBDA, Jimeta Bridge, Gauge Station (2018)

Gauge Height

Annual gauge height obtained from Jimeta Bridge station on River Benue shows that the gauge height was found to be higher with about 7.33 m in the year 2012 than the other years under consideration followed by 2007 with about 6.88 m (table 6).The level of gauge experienced might be among the impetus that qualified the year 2012 as the highest rainfall event year of the decade. Hydrologically, as the level of gauge reach 7 m on river Benue there will be a high probability of flood occurrence along the river areas. The gauge station is shown on plate 1 below.

Plate 1: Gauge station at Yola on River Benue, Adamawa State

Table 6. Monthly Mean Gauge Heights-Meters at Jimeta Bridge Gauge station

River : Benue   Station: Jimeta Bridge   GaugeZero- Level : DATUM 151.166-m

Year	Gauge Height's (m)	Discharge m^3/s
2006	6.80	5,360
2007	6.88	5,460
2008	6.11	4,000
2009	6.52	5,000
2010	6.85	5,390
2011	5.18	2,320
2012	7.33	6,340
2013	5.13	2,260
2014	5.55	2710
2015	5.82	3165
2016	5.98	3500
2017	5.48	2640

Source: UBRBDA, Jimeta Gauge Station.(2018).

Water Level

The monthly water level in meters from 2006-2016 of Jimeta Bridge station on River Benue were presented on table 7. The result shows that in the year 2012, the water level was highest in the month of June, July and September compared to similar months in the years (2006-2017). Thus, the higher the water level of a given river, the more vulnerable the area is to flooding.

IMPACT OF FLOOD ON AGRICULTURAL LANDS IN YOLA AND ENVIRONS

Agriculture still remains the major important sector of economy in Nigeria most especially in the current political dispensation as it is also remain the major primary functions of people along river Benue of Yola north LGA and environs. However, the farming system in the area has been associated with different problems of which flooding is the most destructive factor (Sadiq *et al.*, 2019a). Flooding of agricultural land that occurs after seeding can be as costly as flooding before seeding, and possibly more costly to the individual who has incurred production expenditures (Jay and Donald, 1977). The ability for plant roots to tolerate long period of being submerged in flood water depends on the period of year the flood event occurred, duration of the flood event, species sensitivity to flooding and type of soil the plants grow (dormant growing plants are more tolerant to flooding than actively growing plants). Flood pragmatic frequencies rejuvenate erosion indices of soil in most places where it occurs and the consequences on farmland productivity can be measured in situ. According to Sadiq and Tekwa, (2018) reported that soil erosion by water or wind agents selectively damages the soil by removing organic matter (OM) soil particles, plant nutrients, pedon thickness, and reducing soil chemical capacity to retain added nutrients. It is a known fact that erosion is a two-way problem; loss of soil fertility and thickness of the eroding soil (on-site problems) and the addition of unwanted sediments in the depositional sites (off-site problem). Thus, the removal of topsoil is always a loss to agricultural productivity as topsoil is the part of the soil horizon with higher level of organic matter and nutrients and generally better structure (United State Department of Agriculture, USDA; 1993).

Table 7 shows the Monthly Mean Water Level (m) from Jimeta Bridge on River Benue

Monthly Mean Water Level (m)

River: Benue **Station:** Jimetabridge**. STATE:** Adamawa**. Gauge Zero Reference Level:**151.166m

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2006	#	#	#	#	2.58	2.58	3.42	4.57	6.57	5.22	2.51	2.22
2007	2.09	2.09	2.09	2.07	2.27	2.46	3.33	5.60	6.04	3.91	2.36	2.24
2008	2.09	2.03	2.04	2.05	2.09	2.51	3.00	4.66	5.69	4.54	2.49	2.17
2009	2.06	2.02	2.03	2.05	2.17	2.61	3.33	4.88	5.44	#	3.30	2.41
2010	#	#	#	#	#	#	3.47	4.33	5.99	4.69	#	#
2011	#	#	#	#	#	#	#	3.72	4.54	3.81	#	#
2012	#	#	#	#	1.64	3.37	3.49	4.76	6.58	4.74	2.38	#
2013	1.36	1.32	1.36	1.45	1.6	1.95	2.83	3.74	4.88	3.89	1.85	1.52
2014	1.39	1.39	1.39	1.40	1.86	2.10	2.78	3.75	4.63	4.40	2.06	1.63
2015	1.46	1.47	1.51	1.53	1.63	1.97	2.65	3.56	5.24	3.44	2.17	1.61
2016	1.50	1.50	1.52	1.53	1.67	2.37	3.29	4.20	5.24	3.66	2.07	#
2017	1.52	1.39	1.46	1.49	1.68	2.48	3.45	4.33	4.54	#	#	#

Source: UBRBDA, Jimeta Bridge, Gauge Station (2018) **#:** Missing data

In Adamawa state, Yola is among the probable flood prone area which might be associated with some natural climatic phenomenon such as high rainfall or precipitation, River flow, Run-off, coupled with anthropogenic activities and their proximity to the River Benue Plains (Sadiq, 2018). The extent and degree of flooding varies from farm to farm and from year to year resulting in a large number of losses of farmlands and farm produce respectively. Sadiq *et al.* (2019a) explained that farming activities is high along river Benue flood plains of Yola north LGA where small scale farmers utilizes the available fertile farmlands cultivating food crops such as maize, rice seasonally with an average profitable yield. However, the study area had experienced flooding annually which destroyed hundreds hectares of farmlands and damaged crops as a result of different heavy downpour, river overflows among others, while some parts of the farmlands were deposited with sediment damaged crops as shown in plate 2 and 3 respectively.

(a)

(b)

Plate 2a & b: Apparent effects of off-site erosion caused by river flooding damaging crops in the study area (Adopted from Sadiq *et al*.,2019a)

(a)

(b)

Plate 3a & b: Apparent effects of on-site erosion caused by river flooding on farmlands in the study area (Adopted from Sadiq *et al.,*2019a)

The results also revealed that the hundreds hectares of farmlands had been affected by flood and this led to negative impacts on the farming community members who engaged primarily in farming activities with low monthly average income. In terms of farm output, majority of the farmer interviewed in the area suffered individual loss of more than 61-80 % as a result of flooding annually. Thus, farm-yield was to have reduced with more 70 % due to flood damaged. Similar result was reported by Sadiq *et al*., (2019b). Many farmlands both arable and agro-foresting were detached by soil creeping, solifluction and covered by effects of siltation where hundreds hectares of farmlands were been lost seasonally/ annually.

CONCLUSION

Floods is a natural phenomenon which may be inevitable, it is directly related and depended on some physical hydro-climatic variables which influenced peculiarity of flood in a given geographical area. Over a decade, Yola North LGA is among the areas in Adamawa state that experienced excess unprecedented 2012 flood scenario in the recent decade. These hydro-climatic variables are high amount of rainfall, low temperature, low relative humidity water discharge recorded in 2012 than the recorded value in the past years. Therefore, it can be said that these hydro-climatic data assessed with distinct values compared with the other values in the decade, might be a fundamental factor that positively influenced the high flood extent in the year 2012 in Yola North LGA, of Adamawa State and in consequence having negative impact on agricultural production through its on-site and off-site effects on arable lands, damaging crops and depositing unwanted soil sediments which led to low food productivity most especially in the recent years respectively.

RECOMMENDATION

From this research,

i. It is recommended that, the State government should intensify effort towards creating awareness on the flood-prone areas to the General Public and particularly the immediate LGAs around river Benue areas with the aim of relocating them to the safer terrain.
ii. There is need to develop flood modeling and early warning systems with current trends in hydro-climate change in the area which influenced by temporal fluctuations in the recent decade. Similarly, there is also need to carry out a comprehensive seasonal hydro-climatic data record with a view of taking them as recipe and strategies of forecasting and predicting the reoccurrence of such phenomenon from the past historical data recorded with the aim of turning it in to an opportunity in transforming society into a higher level of sustainability.
iii. The high extent of flood scenarios in the area can be reduced also through structural measures such as rejuvenating the river-Benue, routing of river courses, and channelization of river tributaries and drainage, and construction of artificial lakes as a source of water for irrigation farming in the floodplain of the study area.
iv. Additional meteorological station should be provided by the government agencies and other related national and international organization in all the agricultural zones of the state for adequate and wide range of hydro-climatic data for appropriate prediction of weather indices in future.

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