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Assessment of Flood Vulnerability in Katsina–Ala, Benue State, Nigeria

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ABSTRACT

Assessment of Flood Vulnerability in Katsina-Ala Local Government Area of Benue State was carried out using rainfall data for thirty-five (35) years and the perception of the floodplain dwellers. The rainfall variability and trend were analyzed using Simple Linear regression. However, the study reveals that the possibility of flooding is to some extent, influenced by the pattern of rainfall which shows general increase as the year progresses. About 300 questionnaires were administered to land owners in the selected settlements in the study area using systematic random sampling. The results of the analysis showed that it is statistically significant at 0.05α and population with regard to the settlement pattern are the most important causes of floods as well as heavy prolonged rainfall which leads to river overflow flooding. Nonetheless, they have the knowledge of the frequency of severe floods and flood alleviations schemes. Most flood victims do not get compensation or relief during flood disaster. The study recommends that flood control in the region needs the cooperation and efforts of both government and the community. An enlightenment programmes through environmental education and campaign awareness needs to be strengthened.

Keywords: Flooding, vulnerability, flood risk, classification of flood.

Aims Research Journal Reference Format:
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1. INTRODUCTION

Flood are known as the most common and destructive natural phenomenom (Yoon et al. 2014). They can cause severe physical, social and economic damages and losses in both rural and urban areas (Masood & Takeuchi, 2011; Balica et al. 2012; Balica et al. 2013; Zhang & You, 2013; Albano et al. 2014). Several studies (IPCC 2007; Tilmaz 2014) reported an increase in frequency and of extreme rainfalls which have aggravated the flood related concerns. Global warming is one of the main reasons for the increase in frequency and magnitude of the extreme rainfalls (therefore floods), since the warmer atmosphere with enhanced humidity leads to a more active hydrological cycle (Mailnot et al. 2007). Katz & Brown (1992) stated that even a small change in the mean rainfall due to global warming can cause significant changes in extreme rainfalls. Also, urbanization is another driver which increases intensity and frequency of floods. (Alaghmand et al. 2010) showed that there is a direct relationship between urbanization and hydrological characteristics such as infiltration, run-off frequency, flood depth and urban area.

Despite its importance, vulnerability assessment for floods and other natural disaster has received less attention than hazard assessment. For instance Changthon, (2003) reported that there have been few efforts to standardize vulnerability measure and estimation techniques particularly in developing countries and for none economic measures. Depending on the context however, non- economic consideration can be extremely important. Because of this, it is important to involve flood vulnerability expert, preferably with previous local or regional experiences.

Today many countries are trying to reduce property damages and loss of human lives to floods. Through flood prediction and creating data base of flood hazards it will substantially reduce flood disaster losses, activities need to be implemented that reduces flood risk and generate an effective preparedness for flood disaster. These activities are firmly grounded in their specific contexts. Assessing rise amidst task in any serious attempts to substantially reduce disaster losses without an understanding of the relevant risks, it is impossible to effectively prepare for or reduce them. This risk assessment process should involve different methods for analyzing risk evaluating their results. The human factors especially increases in paved area, refuse disposal habit and occupation of the flood plain were emphasized by Adefolalu (2002), while Trevor (2010) emphasized the role of rainfall amount and intensity. It is against this background that the paper is focused on the assessment of flood vulnerability in Katsina–Ala of Benue State Nigeria.

1.1 Study Area

Kastina–Ala Local Government Area is one of the 23 local Government Area of Benue state. It is comprised of several settlements within the study area, which are Hange, Gburuku and Kastina–Ala. These settlements are aligned and located along the river in linear form with a population of approximately 227718. (NPC 2007). The Local Government Area headquarters is the Katsina–Ala town and its administrative functions along with the availability of utilities, facilities and services which has attracted large number of population from the rural areas.

Kastina-Ala is located between longitude 14^{o} 10 to 15^{o} 16 E and Latitude 7^{o} 15' n to 11^{o} 30' W. The land surface is generally flat with elevation of between 103 – 189 metres. The flood plains are very shallow with several settlement located close to areas of high flood risk. The Kastina – Ala river Basin covers an area of 2402km^2 and drains portion of the Adamawa highlands. The town has five months of dry season and seven months of rainy season. The peak of the rain is in July, August, and October each year. The rain starts by April and ends in October each year. Kastina –Ala is within the southern guinea savannah vegetation belt Lyam, (2000)

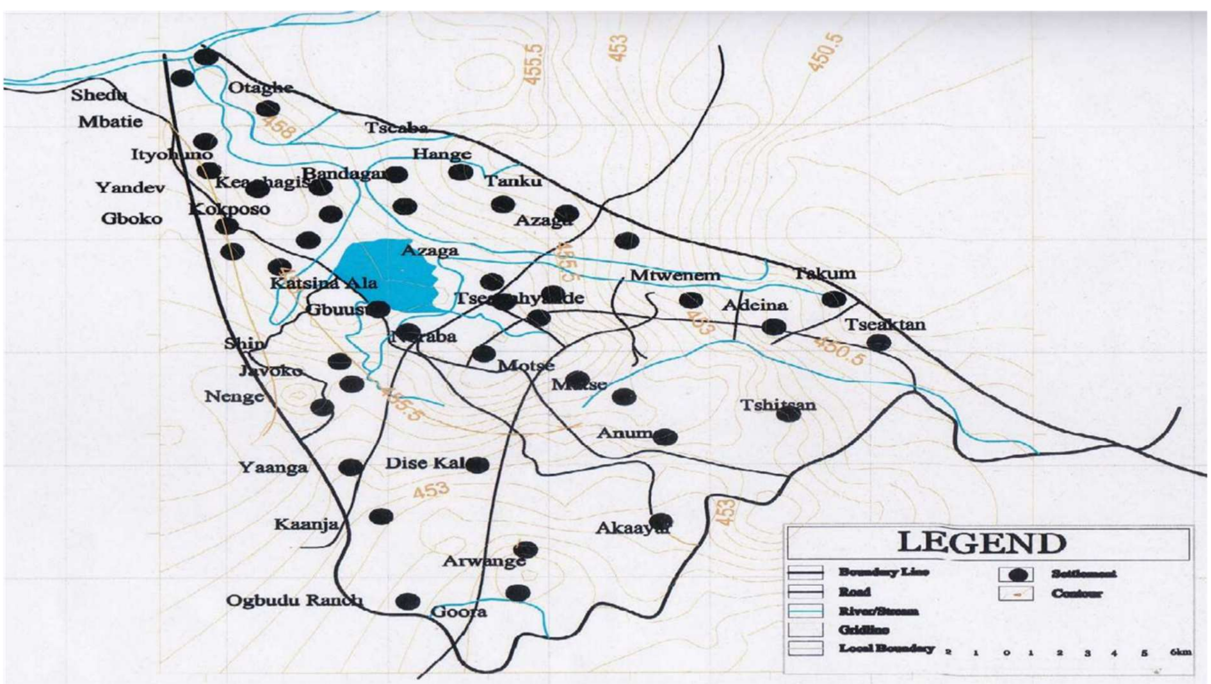

Fig 1: Showing Katsina – Ala L.G.A
Source Benue State UDPA

1.2 The Concept of Flood Management

The Comprehensive flood hazard management is the most effective way to address flood control issues. It incorporates a variety of engineering, environmental protection and planning measures. It includes flood plain management, flood control maintenance activities, storm-water management, shoreline management, protection of frequently flooded areas under Growth Management, watershed management, other flood hazard mitigation activities, and preparation for flood disasters where mitigation activities cannot prevent flooding.

1.2.1 Flood Hazard Management

The concept of flood hazard management includes flood control management and floodplain management. Traditional flood control measures have generally referred to various engineering type projects aimed at controlling flood waters, such as building of levies and traditional floodplain management which was aimed at controlling building in the floodplain. Current efforts are directed toward comprehensive flood hazard mitigation planning. In the federal regulations floodplain management means the operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works and floodplain management regulations (CFR 44 Part 59.1). Participation in the National Flood Insurance program requires the adoption of floodplain management regulations that comply with federal requirements. The state regulates flood control management projects on the state's streams and requires a comprehensive flood control management plan to qualify for flood assistance account funds. Natural hazard mitigation plans that include floods are required for certain NEMA funds. Hazard mitigation is the ongoing efforts to lessen the impact disasters have on people's lives and property through damage prevention and flood insurance (NEMA's and MRSC's).

1.3 Types of Floods

Flash Floods

These are usually defined as floods which occur within six hours of the beginning of heavy rainfall, and are usually associated with towering cumulus clouds, severe thunderstorms, tropical cyclones or the passage of cold water fronts. This type of flooding requires rapid localized warnings and immediate response by affected communities if damage is to be mitigated. Flash floods are normally a result of runoff from a torrential downpour, particularly if the catchment slope is able to absorb and hold a significant part of the water. Other causes of flash floods include dam failure or sudden breakup of ice jams or other river obstructions. Flash floods are potential threats particularly where the terrain is steep, surface runoff is high, water flows through narrow canyons and where severe rainstorms are likely.

River Floods

River floods are usually caused by precipitation over large catchment areas or by melting the winter's accumulation of snow or sometimes by both. The floods take place in river systems with tributaries that may drain large geographic areas and encompass many independent river basins. In contrast to flash floods, river floods normally built up slowly, are often seasonal and may continue for days or weeks. In some semi-arid countries, such as Australia, flooding of dry or stagnant rivers may occur many weeks after the onset of heavy rain, hundreds of kilometres away. Historical records of flooding of towns on the main river can be unrealizable for flood protection purposes due to the many contributing river tributaries.

Coastal Floods

Some flooding is associated with tropical cyclones. Catastrophic flooding from rainwater is often aggravated by wind-induced storm surges along the coast. Salt water may flood the land by one or a combination of effects from high tides, storm surges or tsunamis. As in river floods, intense rain falling over a large geographic area will produce extreme flooding in coastal river basins.

1.4 Urbanization

The that many towns and cities have developed without physical planning and coupled with the fact that development control have been very poor, has increased susceptibility of many towns and cities to flooding. In most of these ancients' cities, in what we may call pre-colonial cities roads were badly constructed without drainages, houses were and are still built on what should have rightly been waterways. Protective covers as trees were and are still destroyed (without replacement) to give way to new buildings. Those towns and cities that developed unplanned, still maintain their old design. What town planners have attempted to do today is articulate modern town planning on obsolete and unplanned design structures, a tedious and expensive exercise which makes the final result not exactly the same as could have been the case had the towns and cities had followed a planned design. In rural and urban areas, ignorance may have been mostly responsible for environmental degradation, but the biting effect of inflation in that last twenty years has combined with ignorance to facilitate the process that leads to flooding.

2. MATERIALS AND METHODS

Both primary and secondary data were used for this study. The primary data includes information on flood perception, adjustment and other socio–economic losses suffered during floods. This was collected directly from the field using questionnaire, sixteen flood vulnerable settlements were identified and used as sampling, and were used for the collection of primary data and flood risk zone classification. Iyogo, Ozever, Otaghe, Tseaba, Hange, Tanku, Azaga, Mtwenem, Shedu, Mbatle, Keaghagise, kokpaso, Katsin - Ala, Tsegahyande, Gbuusu, and Ishin. A total of 300 samples were taken from the sixteen settlement base on their population and vulnerability, questionnaires were administered on the settlements using systematic random sampling, using sample interval of 5 houses. The sample represent 9% of the study population of the area. Robert & Daryle (1970)

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3. DATA ANALYSIS

Table 1: Rainfall Data from 1980 - 2014

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	0	0	59.8	115.9	183.3	162.5	227.1	351.1	222.7	63.1	0	0	1385.5
1981	17.6	0	0	80.1	161.5	119.3	316.3	287.6	195.7	45.8	3.2	0	1227.1
1982	0	0	18.5	31.5	57.6	196.9	313.2	85.9	163.7	84.2	0	0	951.5
1983	0	0	1.2	2.6	193.2	213.8	232.4	158.2	128.1	0.8	0	0	930.3
1984	0	0	51.8	116.3	222.4	126	314.4	453.2	175.2	111.4	0	1.3	1572
1985	18.5	0	60.5	14.1	119.2	148.3	289.6	124.8	185.3	34.8	0	0	995.1
1986	0	3.7	32.2	60.7	169.5	172.2	183.6	174.9	31.3	113.2	31.4	0	972.7
1987	0	3.3	23.9	12.4	161.8	81	198.1	449.7	179.2	98.5	0	0	1207.9
1988	9	0	1	61	100.4	68.8	158.2	197.5	144.9	91.5	0	7.2	839.5
1989	0	0	1	58.9	191.8	203.2	237.3	170.6	249	131.9	0	0	1243.7
1990	0	0	0	109.9	79.7	142.3	158.5	219.5	310.8	81.2	1.6	17.4	1120.9
1991	0	0	45.6	103.8	183.2	82.7	96.4	264.3	185	161.2	0	0	1122.2
1992	4.4	3.1	5.2	65.3	75	84.2	154.8	154.5	312.6	80.9	32.7	0	972.7
1993	0	0	9.2	46.9	52.9	268.1	341.3	174.6	137.2	186.9	0	0	1217.1
1994	27.1	0	0	58.7	150.5	108.4	82	213.4	12.2	149	0	0	801.3
1995	0	4.4	15.4	35.1	85	353.9	108.4	284.4	32.3	154.1	12.1	0	1085.1
1996	0	0.1	0	109.2	135.4	24.1	204.8	287.7	247	98.7	0	0	1107
1997	0	0	1.5	212.5	99.1	161.5	87.4	146.2	377.2	213.3	27	0	1325.7
1998	0	0	0	134.8	156.2	338.8	241.7	273.8	318	93.6	0	0	1556.9
1999	0	0	42.2	112.3	154.6	304.6	132.3	348.6	367.3	155.1	0	0	1617
2000	0	0	0	96.4	114.2	227.6	172.7	334.6	149.2	79	0	0	1173.7
2001	0	0	0	98.5	136.7	240.5	96.1	257	216.3	36.9	0	0	1082
2002	0	0	42.4	79	109.9	171.1	187.9	215.6	353	108.5	20.1	0	1287.5
2003	0	0	0	56.4	30.7	300	119.2	145.3	136.4	39.8	33.7	0	861.5
2004	0	0	7.8	61	72.1	164.5	169.8	185.1	162.9	147.5	0	0	970.7
2005	0	0	22	42.9	90.5	209.8	142.4	112.7	159.4	91.6	0	0	871.3
2006	46.9	0	13.3	261	276.1	109.9	322.7	215.1	229.3	103.6	0	0	1577.9
2007	0	0	8.7	124.8	170.5	210	114.5	272.7	217.9	219.2	1.6	0	1339.9
2008	3	0	0	148.1	145.9	186.1	81.6	280.2	83	84.5	1	0	1013.4
2009	2.3	0	3	180.1	190.3	239.6	86.1	275.3	140.5	284.1	1.2	0	1402.5
2010	0	0	126	314	134.7	119.4	192.7	178.1	305.6	116.88	24	0	1511.3
2011	0	0	0	78	142.8	60.4	87	217.4	272	293.4	0	0	1151
2012	0	0.5	0	143.2	145.2	160.6	351.9	174.3	290.7	199.1	27.3	0	1492.8
2013	0	0	44.2	122.9	183.4	141.8	243.6	131	285.3	125.5	0	10.1	1287.8
2014	4	4	33.7	56.4	160.5	165	129.3	274.6	306.9	100.6	26.4	4.7	1266.1

Source: NIMET – Makurdi Benue State, Nigeria

Relevant flood data on depth of flood, flood duration and level of damage were obtained by field observation and measurements. Flood depth were measured using ranging poles while duration at level of damage were obtained using questionnaires on flood plain dwellers. The analytical tools employed include simple linear regression analysis for determining rainfall trend while SSPS version 20 statistical packages for rainfall and the question data. Rainfall trend analysis is shown below in Figure 2, 3, 4&5 Figure 6 graph.

The above figures shows that Kastina–Ala has a positive correlation which indicates upwards annual rainfall trends and consequently, the possibility of flooding. The result of the upward trends of Kastina–Ala is statistically significant since $p < 0.5$ (alpha level) an indication that the upward trend could be random. The flood vulnerability map was done base on the flood vulnerability assessment of the environmental parameters of 16 flood prone area used in the study areas. These indices are depth of flooding (Metres) duration of flood hours / weeks perceived frequency of flood occurrence, perceived extent of damage arising from flood , percentage deviation of seasonal rainfall (mm) from the mean area or location / relief, proximity to hazard source (e.g. to source of river), land use of dominant economic activity and adequacy of flood alleviation measures. The scale used for scoring of the parameters are shown in table 2 while Table 3 shows flood risk classes while table 4 show the indices

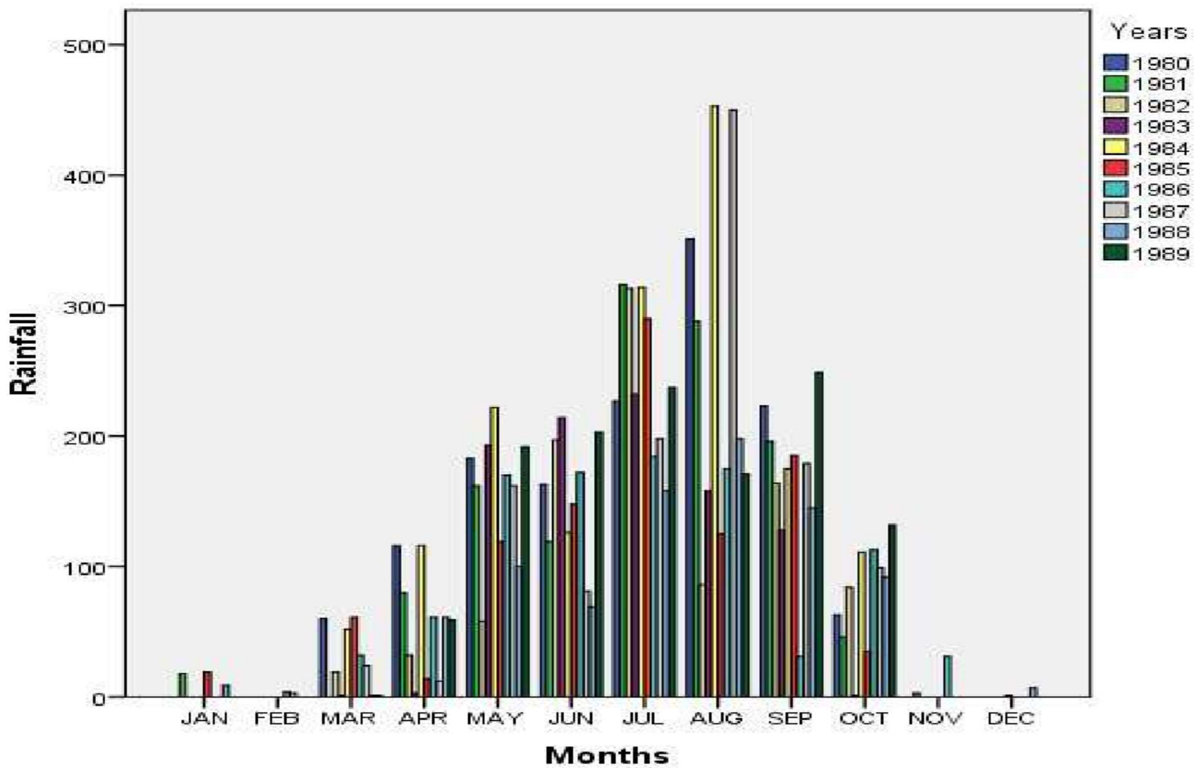

Fig 2: Showing Total Rainfall (mm) Trend for 1980 – 1989

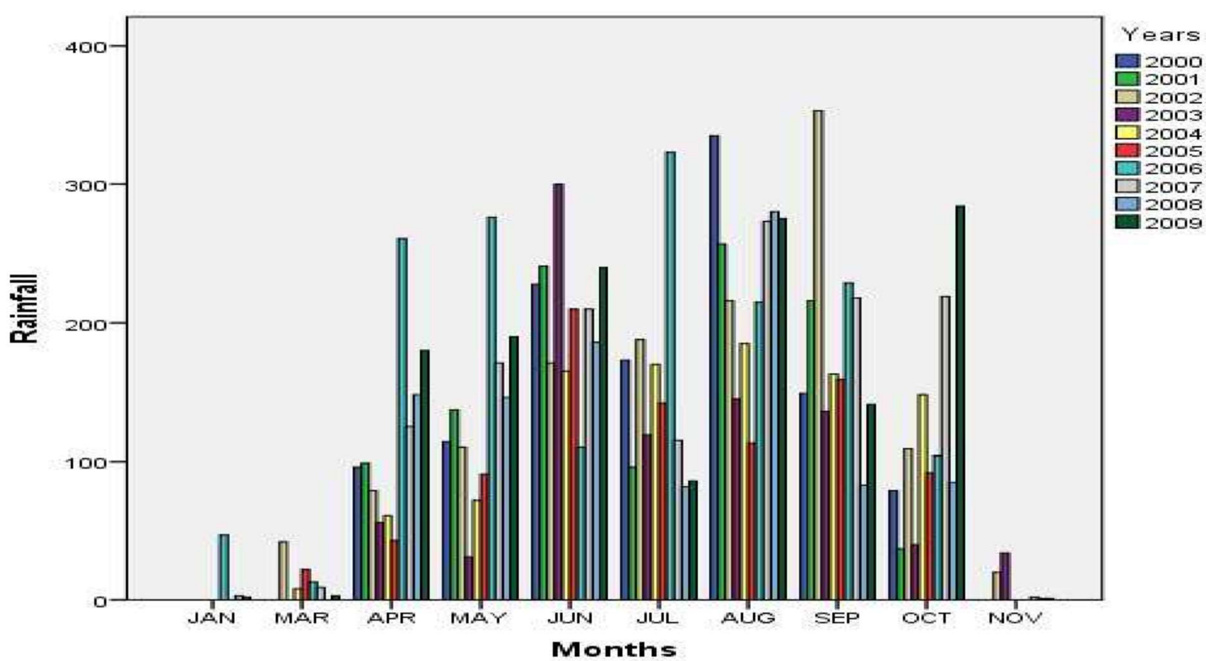

Fig 3: Showing Total Rainfall (mm) Trend for 2000 – 2009

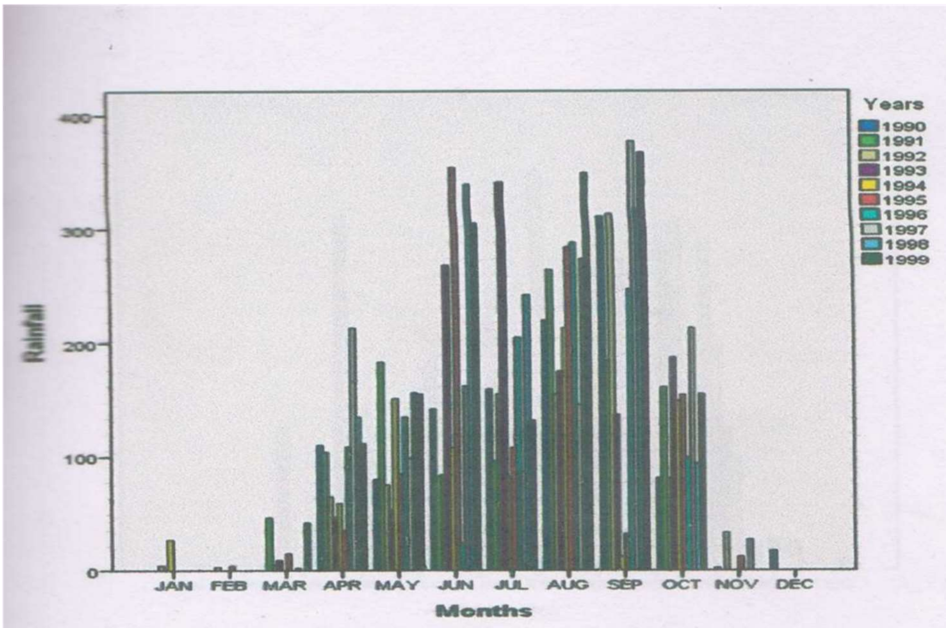

Fig 4 Showing Total Rainfall (mm) Trend for 1990 – 1999

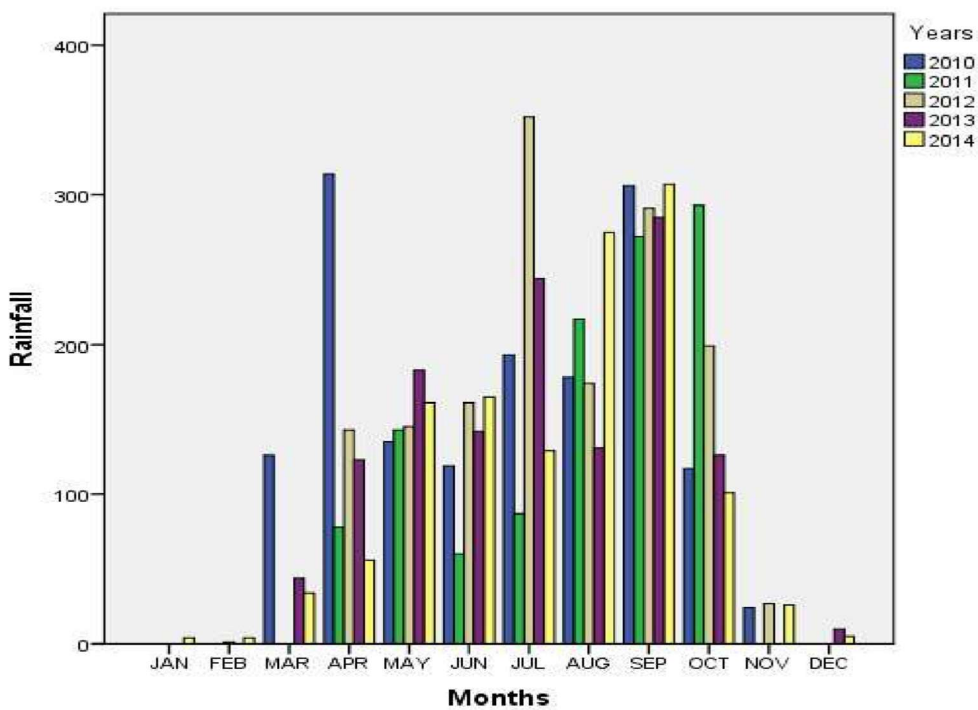

Fig 5 Showing Total Rainfall (mm) Trend for 2010 – 2014

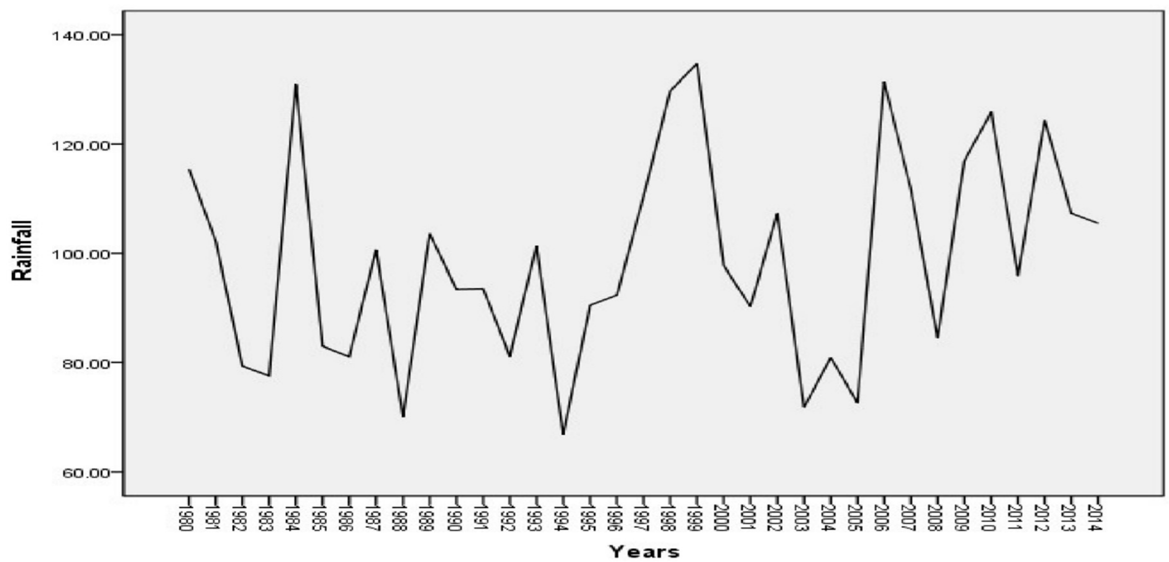

Fig 6: Graph showing Rainfall Trend Analysis 1980- 2014

Table 2: Graduated scale for scoring the parameters used flood risk

S/N	PARAMETERS	RANGE OF VALUES	SCORE
1	Depth of flood (M)	<1.0 metres 1-2.0 m >2 m	1 2 3
2	Duration of floods (Time)	< 12 hours 12 – 24 hours > 24 hour	1 2 3
3	Perceived frequency of the occurrence	Once in 5 years or more Once in 3 years Once in a year	1 2 3
4	Extent of damage in percentage	> 25 percent 26 – 50 percent 50 – percent	1 2 3
5	Percentage deviation of seasonal rainfall (mm) from the normal average	> 25 percent 26-50 percent > 50 percent	1 2 3
6	Location / relief in metres above sea level	>15 percent 1-15 percent < 5 metres	1 2 3
7	Proximity to hazard source in metres	>200 metres 100 -200 metres < 100 metres	1 2 3
8	Perceived adequacy of flood control measures in % percentage	> 50 percent 25 – 50 percent > 25 percent	1 2 3
9	Dominant land use or economic activity	Agricultural / residential Planned/ unplanned Industrial / Commercial	1 2 3

Source: adapted from Ologunorisa, 2006

Table 3: Flood Risk Classes for Land Use Planning

S/N	Flood Risk indices	Flood Risk Classes	Remarks
1	< 100	I	Low flood Risk
2	100 – 600	II	Moderate Flood risk
3	<600	III	High flood Risk

Source: Adapted from Ologunorisa, 2006

The Nine indices were selected because of the fact that they are capable of truly measuring flood risk. They are believed to be capable of doing this because Ologunorisa and Abawua, (2016) have shown that they have strong positive bearing in flood generating and vulnerable components of flood hazard. Also parameters selected are easy to measure and quantify. Also is believed that after thorough work it will bring clear internal variation within the area of study. In devising the scale for measuring, the nine environmental parameters, and emphasis was placed on the range of values obtained in the field work. The rating procedure adopted was based on Clark's principle (Clark, 1951). This entails multiplying the scores, the flood risk index in each settlement to give the settlements fold risk index for land use planning. By multiplying the scores, the flood risk index in each settlement will be limited to least favourable parameters influencing flood (That is the law of minimum). This is preferred to additive method of computing indices which assumed the different parameters add together without interference Gbedegesin, and Nwagwu (1990). In this method, the higher the value of the risk index, the higher the degree of risk. Based on the scales rating in table I three flood risk classes were obtained and shown in table 2 while table 3 shows the computation of the flood from areas used in the study. The flood risk classes obtained in table 2 were used to divide into flood risk zones for land use planning and property values

Table 4: Flood Risk Zones

S/N	Settlement	Depth of the flood	Duration from hours/ weeks	Perceived frequency of flood occurence	Extent damaged in percentage	% Deviation of seasonal rainfall From the mean	Location or relief	Proximity to hazard source	Adequacy of Alleviation level	Dominant economic activity	Flood risk index	Flood risk class
1	Iyogo	3	3	2	1	2	2	1	3	3	648	III
2	Ozever	3	3	3	1	2	1	3	2	3	972	III
3	Otaghe	2	1	3	3	1	2	2	3	2	432	II
4	Tseaba	3	3	1	3	1	2	2	3	1	324	II
5	Hange	1	1	2	1	2	2	1	2	2	384	II
6	Tanki	1	1	2	1	2	2	1	2	2	32	I
7	Azaga	3	3	3	2	2	2	3	1	2	1296	III
8	Mtwenem	3	3	3	1	2	1	2	3	1	972	III
9	Shedu	3	3	3	2	3	1	2	1	3	648	III
10	Mbatte	3	2	2	2	3	2	1	2	2	192	II
11	Keaghagis	2	3	2	1	2	1	3	2	1	432	II
12	Kokposo	1	3	3	2	2	2	2	3	3	1944	III
13	Katsina – Ala	3	3	3	3	2	3	3	2	3	5832	III
14	Tsegahyande	2	2	3	2	1	2	3	2	2	576	II
15	Gbuosu	3	2	3	3	2	3	3	1	2	1944	III
16	Ishin	1	2	3	2	1	3	1	2	1	72	I

Field Survey

The three flood prone zones are based on flood mechanisms. The flood control and abatement management strategies in zone I and II according to the findings which are high and moderate flooding areas while zone three is low. I and II are likely to scare investors from coming to invest and human occupation through land use regulation.

4. RESULT AND DISCUSSION

Following the findings, the foregoing results are obvious from the study. First, analysis of the total annual rainfall indicates that there is positive correlation in the analysis which is statistically significant at $p< 0.5$, indicating that the upward trends could be random. Secondly, based on the behavioural responses of the study, the results has shown that the population have idea of the causes of flooding which is the heavy rainfall of long durations and river overflow are the most prominent causes especially river Kastina-Ala. Thirdly, it shows consistent increase in rainfall amount towards the later parts of 1990's. Fourthly, the result also shows that the frequency of heavy rainfall equal or greater than 25.00 (mm) from July to October which constitute heavy downpour and flood season. Fifthly analysis of the flood plain dwellers shows that there is stability in most population of the dwellers has stayed in the area for considerable period of twenty one years and above.

The respondents are aware that the areas where they live are close to the riverine, which are subject to flooding. result also revealed that flood occur after 5 years and occasionally moreover, results of the seasonal risk also indicate that there is no flood at all during the dry season months of November to April. Also the months of May marks the beginning of flood risk in the entire study area. Also during the month of June "moderate flood risk" is experience in the study area, while the months of July to October is period where the entire area experience high flood risk. In terms of spatial variations in the level of high floods Ishin, and Tanku and followed by Kastina–Ala are the critical zones of high flood risk where settlements are displaced as a results of flood.

5. CONCLUSION

Based on the research, the study has revealed that the populace have idea of the flood occurrence and none or little knowledge of the flood risk insurance and prevention by the government to ensure high sustainability of the flood management. In view of that recommendation were made base on the findings such as Introduction of embankment, flood wall, river channels and other engineering controls. There are also policies on the proper land use management which provide protection to individual buildings on the flood plain especially to the settlement along riverine which are being ravaged by threat of flooding. Also there is non-structural management options ranges from public relief funds to victims of the flood hazards, introduction of the flood insurance schemes to flood plain residence and flood plain zoning of the entire study area and setting up of flood protection acts and education on flood risk management to handle flood and other disaster related management. And also flood insurance as a flood adjustment strategy should be adopted in order to curtail further disaster of displaced homes. Finally government should formulate detail plans on evacuation, so that people may be moved in a good term smoothly and efficiently to avoid such occurrences.

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