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FLOOD HAZARDS, VULNERABILITY AND ADAPTATIONS IN UPPER IMO RIVER BASIN OF SOUTH EASTERN NIGERIA

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ABSTRACT: Imo River Basin has a fluvial erosion system dominated by powerful rivers coming down from steep slopes in the area. This research investigated various hazards associated with flood, the vulnerable areas, elements at risk of flood and various adaptation strategies to cope with the hazards. The study identified the role of elevation, and also elements at risk of flooding. It also examine the effectiveness or otherwise of the adaptation strategies for coping with the hazards. Both primary and secondary data were used for this study and they were generated from field measurement, questionnaire survey, library and websites searches. Other types of data were generated from topographical, geological, and Digital Elevation model (DEM) maps, while the hydro meteorological data was sourced from NIMET, and some higher institutions. Eight hundred copies of questionnaire were distributed using systematic sampling to eight locations used for a pilot survey. 96 percent of the questionnaire were retrieved and used for the study. Thirteen flood events were identified. Their causes, years and dates of events were documented, and the damages done were evaluated. The study established that for each flood event, there is over 200mm of rain observed on the day of the flood and the day before the flood. The study also revealed that the areas that situate at higher elevation are less prone to flood hazards than low elevations. Elements identified to be at risk of flood are agricultural land, residential dwellings, and retail trading and related services. The study thereby recommends non settlement at flood plains and flood prone areas and rearrangement of land use activities in the upper Imo River Basin among others

Keywords: Flood, Hazard, Flood plain, Imo River Basin, DEM

INTRODUCTION

Imo river basin is located in the Eastern Nigeria. The region is comprised of 11 states and 210 local government areas. Majority of the states are located within the coast of Atlantic Ocean, hence about 8 states of the region is classified as the Niger Delta region. The basin constitutes about 603 stream channels of 5 different orders. The basin has a fluvial erosion system dominated by some of the powerful rivers coming down from steep slopes in the area. The topography is plain generally in the south but consist of gentle to high undulating ridges in the north. The land use map of the basin showed that it is largely developed with 29 urban locations and 33 rural areas. The attributes of the basin makes the area vulnerable to environmental problems associated with water such as flooding and gully erosion. The dynamic geography of the location combined with the meteorological parameter of heavy rainfall during the rainy season period are the determining factors for occurrence of flooding in most parts of the basin. Flash floods occurring frequently within the flood plain region of the basin are caused by peak discharges of notable rivers in the area like Imo, Nworie, Otammiri, Ukwa Rivers etc and some stream channels with smaller water courses.

Another factor that can be attributed to the flooding of most parts of the basin is the uncontrolled urban expansion and land use activities within the basin. These activities have narrowed the rivers channels thereby reducing their discharge capacity. The consequence of this is that the amount of rainfall needed to cause flood has decreased and serious several floods has occurred within the basin recently causing severe damage presented in Table 4

From various literatures, hazards associated with flood can be divided into primary, secondary and tertiary (Nelson, 2015). Primary hazards are those that occur due to contact with water, secondary hazards occurs because of flooding, tertiary hazards are as a result of changes in the position of the channel. What this study sets out is to examine the kind of hazard due to flood in the upper Imo River basin. The distribution of flood water within the Imo river basin and consequently is determined by the nature of the development, the topography of the area and land use activities in the basin. Flooding along flood plains and some developments in the hinterlands within the basin consequently represents large loss in the economy in the forms of damages to the infrastructure, agricultural and residential areas.

In the light of the above problems, the research aim is to evaluate flood hazards, vulnerability and adaptations in the upper Imo river basin of south eastern Nigeria.

To achieve the stated aim, the specific objectives are to,

i. Identify the role of elevation in the flooding Imo River Basin
ii. Identify and evaluate hazards associated with flood in upper Imo river basin
iii. Examine vulnerable locations to flood in the basin
iv. Investigate the relationship between flood events and daily precipitation
v. Examine and evaluate adaptations strategies by the local inhabitants to cope with

Study Area

Location and size: The study is conducted in the upper Imo River Basin of South Eastern Nigeria (Figs 1 -3). The Imo River basin is located within Latitude $4^0$38N to $6^0$01N and Longitude $6^0$40E to $8^0$00E of the Greenwich meridian and covers an area of about 9100km^2 The study area has a plain topography generally in the south but consist of gentle to high undulating ridges in the north. Imo River is the major river that drained the study area. The river rises from the cretaceous formation, flows though Imo clay before it flows on coastal plain sand. It transverses from North to South of Imo state with length of about 240km.The Imo River has its source from Nneochi in Umunneochi Local government area of Abia state. The estuary of the river is around 40 kilometres wide, and the river has an annual discharge of 4 cubic kilometres with 26,000 hectares of wetland.

For the climate of the study area, the area lies within the tropical monsoon (AM) based on Koppen's classification. In nearly all counts, the area is richly endowed with water resources from rainfall. Mean annual rainfall ranges from 2250mm to 2500mm in areas lying between 5^o40'N. This decreases to mean annual value of 2000mm to 2250mm between $5^0 49$'N to $5^o 55$'N and further inland $5^o 55$'N to $6^o 03$'N, mean annual value decreased to 1750mm – 2000mm. An important feature of the rainfall is its seasonal distribution, which is closely associated with movement of inter-tropical convergence zone (ITCZ) and precipitation resulting from conventional storm. Table 1, shows the rainfall data for the study area from 2004 to 2015

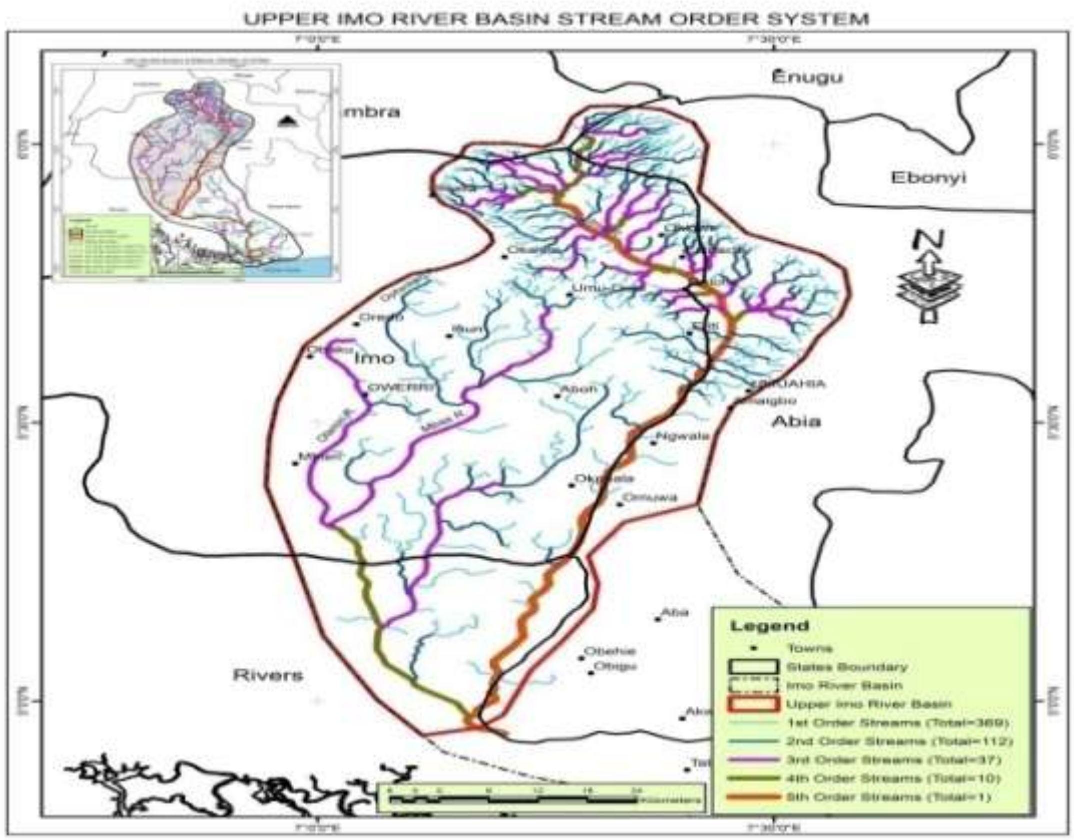

Fig1: Imo River Basin Showing Stream order

Source: Source: Digitized from Federal Survey Topographic Map, 1967 and www.earthexplorer

Table 1: Rainfall data for the study area in mm from 2004 to 2015

Month	2004*	2005*	2006*	2007*	2008**	2009**	2010**	2011**	2012***	2013***	2014***	2015 ***
January	8.2	2.0	5.6	8.2	36	38.6	47.3	0.0	0.0	59.3	2.5	20.7
February	0.0	12.7	1.5	10.0	0	71.4	51	21.3	90.0	56.5	0.0	208.9
March	102.7	75.1	2.24	6.8	55	71.2	35	28.6	55.3	83.2	157.0	26.1
April	238.8	28.7	1.82	139.3	62	242.8	198.8	56.1	187.4	198.7	102.7	108.9
May	310.1	310.1	29.6	249.0	65	441.5	326.4	100.6	306.1	330.7	308.2	252.9
June	469.6	289.8	36.7	262.6	71	239	292	190.3	518.5	185.9	142.3	369.8
July	237.4	371.3	371.3	760.4	328.8	497.9	134.7	305.2	516.0	263.1	288.7	194.7
August	353.8	332.5	471.5	688.1	75	539.2	488.9	506.7	367.7	243.6	173.8	440.7
September	189.0	65.5	554.7	382.1	74	485.3	322.8	77	493.9	254.2	432.7	544.1
October	450.5	239.2	547.7	316.4	67	236.8	438.3	74	211.8	159.9	236.2	345.6
November	8.0	0.95	(0.0	79.9	59	115.4	36.6	60	86.2	56.5	163.1	37.2
December	28.0	0.0	0.0	34.8	53	0.0	0.0	24.8	0.0	84.1	17.7	0.0
Av. Ppt.	182.8	144.7	209.1	255.42	78.8	248.3	197.7	120.4	236.6	157.6	168.7	214.7
Tot. ppt.	2193.6	1736.4	2059.4	704.5	945.8	2979.1	2372.3	1444.6	2838.9	1891.6	2024.9	2576.6

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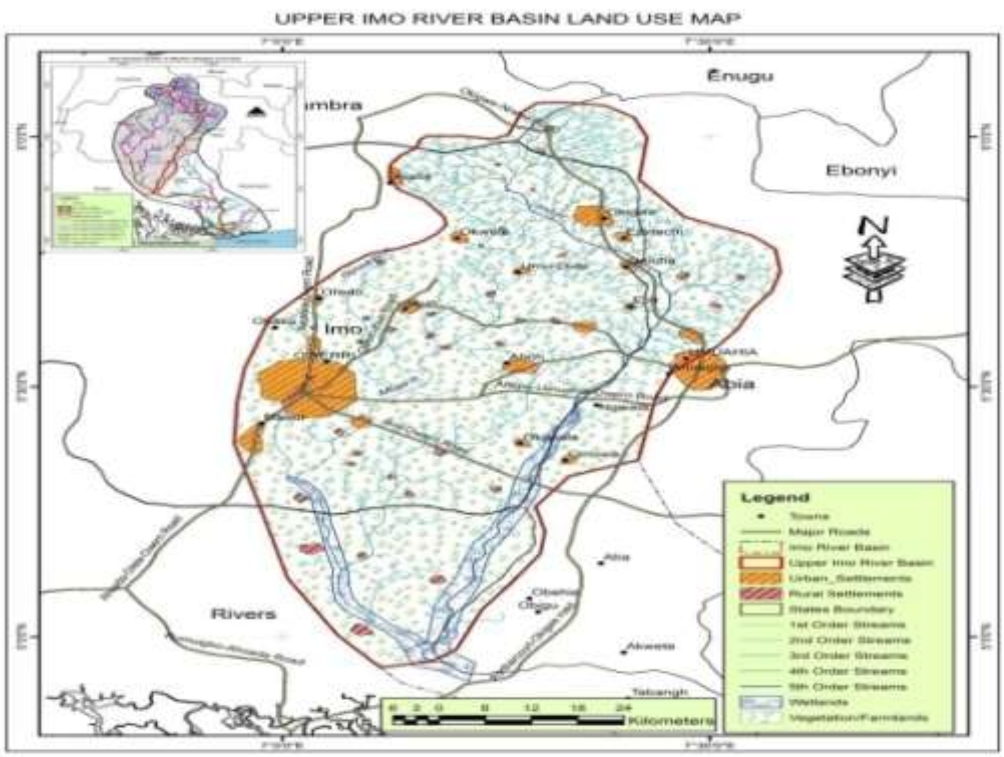

Figure 2: Settlement Map of the Study AREA

Source: Digitized from Federal Survey Topographic Map, 1967 and www.earthexplorer

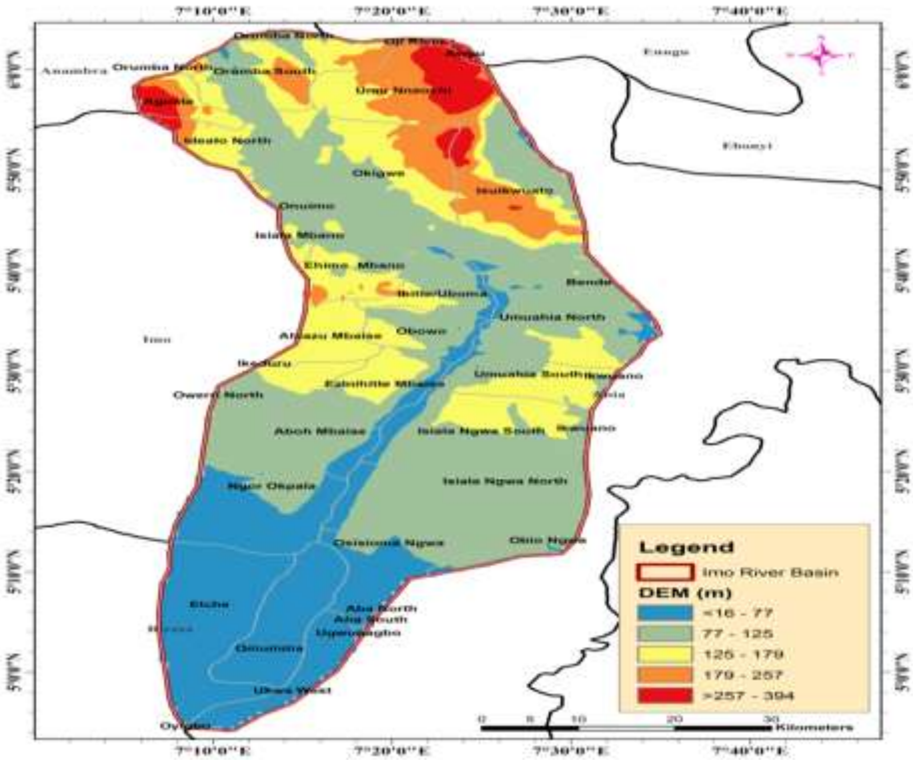

Figure 3. Digital Elevation Model of the Study Area

Source: Digitized from Federal Survey Topographic Map, 1967 and www.earthexplorer

LITERATURE REVIEW

Flood is a body of water which rises to overflow land not normally covered with water. This environmental problem is as a result of numerous causes of which the most important results from climatic effect of rainfall (Okorie, 2010). Flooding is one of the most environmental hazards ravaging different parts of Imo state, Nigeria (Duru and Chibo, 2014). Barry (1997) said that floods produce damage through the immense power of moving water and through the deposition of dirt and debris when flood waters finally recede. He further explained that people who have not experienced a flood may have little or no appreciation for the dangers of moving water. In most cases, the damage potential of the flood is magnified by the debris that the waters carry: trees, vehicles, boulders, buildings, etc. According to Agnone (1995), the effect of water itself can be devastating on structures and on the objects within them: books, furniture, photographs, electronic equipment and so on can be damaged simply by being immersed in water, even if they are not directly damaged by the water movement. Moreover, floodwaters typically contain suspended silt and potentially toxic micro organisms and dissolved chemicals. This means that floods usually compromise drinking water supplies, resulting in short-term shortages of potable water, with the additional long-term costs in restoring drinking water service to the residents of a flooded area.

Adelekan (2010) stressed that the creation of flash floods has been identified as the worst effect of rainstorms hazard and the construction of infrastructures such as highway, road and bridges in the flood plain frequency increase the magnitude of flash flood which consequently increases the damage to the properties and life. Large, impermeable surfaces and concentrations of buildings disrupt natural drainage channels and accelerate runoff. According to Jeyaseelan (2006), flash floods cause more property damage and economic activity distortion than any other natural phenomena. Using the remote sensing to identify areas liable to flash flood as he explained, will have to contribute by mapping topography (generation of DEMs) and in defining surface roughness and land cover. In this case, remote sensing is used to updating cartography for land use and DEM

For instance in China, major floods killed about 2 million people in 1887, about 4 million people were killed in 1931, and over 1 million lives were lost in 1938. The 1993 flood event on the upper Mississippi River and Midwest lead to the death of 47 people, though the U.S. Army Corps of Engineers put the estimated total economic loss at between 15 and 20 billion dollars (Nelson, 2015). Floods can be such devastating disasters that it can impact negatively almost to anyone, any time. As demonstrated in the water cycle, when water falls on the surface of the earth, a lot of things happen to it and the water must find its route through somewhere. Three main approaches can be taken to predict flood, thereby reducing the risk associated with flood. They are, statistical studies which can be undertaken to determine the probability and frequency of high discharges of water that cause flooding. Second approach involves flood modeling and mapping to determine the extent of possible flooding when it occurs in the future. Since it has been determined that the main causes of flooding are abnormal amounts of rainfall and sudden thawing of snow or ice, storms and snow levels can be monitored to provide short-term flood prediction.

METHODOLOGY

Survey method was carried out in this research. Both primary and secondary date utilized in this study. Secondary data include the digital elevation modem (DEM) derived from the topographic map of the study area, the soil data and rainfall data obtained from NIMET, Meteorological stations of Imo State University Owerri and Alvan IkokuCollege of Education in Owerri. For each of the 13 flood events reported in this research since 1947, the amount of precipitation of the day of flood and the day that preceded the flood was determined and then the mean of the two days was computed. The reason for taking the 2 days is to extend analysis range to be able to cover precipitation of 24 hours. Primary for this study were generated through 768 copies of questionnaire distributed to the systematically sampled locations for the study.

DISCUSSION OF FINDINGS

Role of Elevation in Flooding of Upper Imo River Basin

Information available on previous researches in various literatures on the causes of flooding in the study area can be categorized into four groups: morphological, geomorphological, meteorological and anthropogenic. Data obtained through questionnaire and fieldwork indicated that areas in the basin that lie at low elevation are more vulnerable to flooding than areas with higher elevations. The data on the role of morphology to flood vulnerability in upper Imo River Basin is presented in Table 2

Table 2: Role of Morphology on Flooding of Upper Imo River Basin

Location (Elevation) (m)	No. of Respondents	% Respondent
Between 66 – 77	329	42.5
,, 77 - 125	224	29.2
,, 125 - 179	101	13.2
,, 179 – 257	74	9.6
,, 257 – 394	40	5.2
Total	**768**	**100**

Source: Author’s Fieldwork, 2016

Analysis of the data in Table 1 shows that the locations with lower elevations are more vulnerable to flooding than locations with higher elevations. This response from the respondents showed that about 42 percent of flooding in the study area occurs within areas with elevation lying between 17 – 77 meters above sea level. By implication, it shows that majority of locations in the upper Imo river basins are not flooded. The few flooded locations from the higher areas come with very serious negative effect. The reason might be attributed to the high gradient and long steep slope of the area. The locations that are frequently flooded are areas around Ihitte Uboma, Obowo, Ezinihitte Mbaise, Ngor Okpala, Umuahia North and south and some locations in Bende and Isukwuato local government areas. It was deduced that majority of these locations are located within the floodplain of the principal river (Imo River). Locations within Okigwe, Aguata, Umunnochi etc are rarely flooded. This can be attributed to their elevation and non existence of major rivers in the area. Other elevations and their degrees of flooding in the study area can be seen in Table 2.

Identification of Hazards Associated With Flooding in Upper Imo River Drainage Basin

Natural hazard is the probability the probability of occurrence within a specified period of a time within an area of potential damaging location (Alexander, 1993). It is a physical event that can have an impact both on the natural physical and cultural environment including human lives and properties (Coto, 2002). To identify hazards associated with flooding in the study area, the respondents responses was as presented in Table 3

Table 3: Flooding Hazards in the Upper Imo River Basin

Hazards	No. of Respondents	Percentage Respondents
Destruction of farmlands/properties	426	55.5
Damages to roads and other infrastructures	124	16.1
Displacement of the people	91	11.9
Loss of life	49	6.4
Traffic congestion	29	3.8
Pollution of the environment	18	2.3
Health deterioration	17	2.2
Damage to automobiles	17	1.8
Total	768	100

Source: Author's Fieldwork, 2016

Evaluation of flood hazards in the upper Imo River Basin showed that destruction of farmland and other properties ranked first with 426 respondents or 55.5 percent of the sample population. This indicates that the major hazard of flooding suffered in the study area is the destruction of farmland and other properties. This is followed distantly by damage of road and other infrastructures. This hazard takes 16.1 percent of the sample size. Other hazards associated with flooding as seen in Table 3 are displacement of people (11.9%), loss of life (6.4%), traffic congestion (3.8%), and pollution of the environment (2.3%), health deterioration (2.2%) and damage to automobiles (1.8%).

Causes and Damages done by Flooding on Some Vulnerable Locations of the Study Area

Information obtained through fieldwork and questionnaire on the years of flooding, vulnerable locations, causes and damages done by flooding in the study area is presented in Table 4

Table 4: Causes and Damages done by Flooding on some Vulnerable Locations

Location	Year(s) of Flood	Settlements	Causes and Damages
*Isiala Mbano	2009	Rural	Result of overflow of Mbaa river. Affected mostly Ugiri and other five communities. Farmlands were inundated and roads covered and destroyed
*Onuimo	2012	Rural	Resulted from overflow of Okweregere River and obstruction of water flow by heaps of sand. Affected residential buildings leading to destruction of properties and farmlands. Link roads to villages were destroyed. Reptiles and snakes invaded the area

**Owerri	2014, 2016, 2015	Urban	Resulted from blockage of drainage channels, construction of roads during rainy seasons without adequate drainage channels. Road and electric powerlines were damaged, various automobiles were damaged, few motorcycles and tricycles were carried away by flood water. A tricycle operator lost his life
**Ikeduru	2009	Semi urban	Resulted after heavy down pores. Eke Atta market flooded destroying goods. House around the area including the Eze's palace inundated destroying properties worth over 10 million naira. Roads covered leading to damage to cars.lasted for 2 days
*Ahiazu mbaise	1993, 2005, 2010, 2011	Urban	Resulted after heavy rainfall. Communities affected include Ogbe, Ahiara, Obiohia,. Brought health hazard, destroyed residential building and markets. Two lives were lost including 8 months old baby and an 80 years old woman
*Orlu	1984, 1986, 2012	Urban	Caused by 18 hours non-stop torrential rainfall. About 5000 people affected. Properties worth millions of naira destroyed. Duruaku street mostly affected, also Ebenato road, Amaigbo road, Central School premises, and St. Joseph Catholic church. A 12 months old child lost its life
*Oguta	1947, 1969, 2012	Urban	Caused by overflow of rivers and Oguta lake. Two people drowned around Oguta axis. All houses around the riverine area inundated. Economic trees like cocoa plantations, destroyed. Ponds and farmland affected. Over 138 farm settlements destroyed. About 8000 people rendered homeless
**Umuahi a	2011, 2013, 2016	Urban	Resulted from blockage of drainage channels after heavy rainfall. Also caused by building along water courses and flood plains. Residential buildings, markets, stores electric powerlines and vehicles were damaged

Source: * Culled from Chibo and Duru, 2014, ** Authors fieldwork, 2016

Relationship between Flood Event and Daily Precipitations

The information on the relationship between flood event and daily precipitation as obtained is presented in Table 5

Table 5: Average precipitation for 2 days for flood events for the period 1947 - 2016

Year of Flood	Months Fof flood	Dates of Flood	Precipitation (mm) *	Average Precipitation for the 2 days
1947	May	26 and 27	181.2 and 166.6	173.9
1969	August	17 and 18	130.7 and 161.1	145.9
1984	September	10 and 11	164.8 and 170.6	167.7
1986	July	25 and 26	183.8 and 190.4	187.1
2005	July	14 and 15	271.3 and 262..1	266.7
2009	June	28 and 29	230.1 and 232.7	231.4
2010	October	1 and 2	288 and 291.3	289.7
2011	September	18 and 19	176.4 and 181.2	178.8
2012	September	20 and 21	271.1 and 291.6	281.4
2013	August	2 and 3	272.3 and 284.1	278.2
2014	June	25 and 26	244.6 and 250	247.3
2015	July	11 and 12	211.1 and 212.3	211.7
2016	August	28 and 29	251.8 and 221.1	236.5

Source: Author's fieldwork, 2016, * NIMET; Alvan Ikoku Federal College of Education, Meteorological Station; and Imo state University, Owerri, Department of Geography and Environmental Management Meteorological Station

It was established from the information in Table 5 that flood events in upper Imo River basin occur between the months of May and September. It was also established that the average rainfall for the day before and the day of flood event were 221.3 and 242.9mm respectively. The average rainfall for flood for the 13 events was 204.1mm. Therefore, the general tendency is that it rains at least 200mm of rainfall during the days of flood and the day before the flood.

Evaluation of Adaptations and Prevention Strategies to Flood Hazards in Upper Imo River Basin

Adaptation strategies are various human interventions, and an attempt to modify landscape and drainage systems to prevent or minimize hazards. Some of these interventions sometimes have adverse effects and may in many cases help to cause flooding in other areas. This is because landscape modification has potential to cause some changes in a river system.

To identify and evaluate adaptation strategies to flooding in upper Imo River basin, information obtained are presented in Table 6.

Table 6: Adaptation and Prevention Strategies to Flood Hazards

Adaptation Strategies	No. of Respondents	Percentage Respondent	Preventive strategies	No. of Respondent	Percentage Respondent
Engineering Approach			Regulatory Approach		
Channel modification	42	5.5	Floodplain zoning	77	10.0
Dams	41	10.5	Floodplain building code	46	6.0
Retention ponds	277	36.1	Floodplain buyout program	21	2.7
Levees	163	21.2	Mortgage limitation	12	1.6
Flood ways	49	6.4			
Total	612	79.7	Total	156	20.3

Source: Author's fieldwork, 2016

From the information gathered in Table 6, it was observed that two major strategies were used to adapt to flood hazards in Upper Imo River Basin. They are engineering approach and non structural/regulatory approaches. While engineering approaches were used for individuals, organizations and institutions already affected by flood, non structural approaches are basically preventive mechanisms in the form of laws that helps to avoid or minimize occurrence of hazards. The data in Table 6, reveals that engineering approaches to flood hazard adaptations constitutes 79.9 percent while structural approaches takes about 20.3 percent of flood adaptation strategies. It was established that more attention is given to flood hazard management while less attention was given to flood hazard occurrence and prevention. Analyzing Table 5 shows that retention pond is the major technique employed by inhabitants of Upper Imo River basin to adapt to hazards caused due to flood. This represents 36.1 percent of adaptation mechanisms employed. This method traps water in the retention pond and then releases same at a controlled discharge to prevent flood down slope. This method is basically employed in the rural areas and around areas with rivers and streams. This is closely followed by construction of levees or structures built along the channel to increase the stage at which flood water moves. This method constitutes about 21.2 percent of flood hazard adaptation strategies in the study area. The third strategy is the construction of dams, which are used to hold water back so that discharge down slope can be regulated. This method was the opinion 81 respondents or 10.5 percent of the sample size. Other strategies include construction of outlets (flood way) to a flood water and allowing it to flood into the area being designated for it, so as to reduce hazards due to flood. This takes about 49 respondents or 6.4 percent of the sample population

The regulatory or non-structural approaches basically strategies to prevent flood occurrence, and where they occur, the resulting hazard will be minimal. In Upper Imo River Basin, the major regulatory approaches as indicated by the respondents are: floodplain zoning, which are laws passed by the government of the day to restrict construction and habitation of floodplains. This strategy comprise of 10 percent of the sample population. Others include floodplain building codes, in which structures that are allowed within the floodplain could be restricted to those that can withstand high velocity of flood waters and these structures are high enough off the ground to minimize the risk of contact with water. This practice takes 6 percent of the sample population. Table 6 provides other information on adaptation strategies to combat flood hazards in upper Imo river basin.

CONCLUSION

Floods can be such devastating disasters to anyone affected anytime. As seen in the hydrologic cycle, when water falls on the surface of the earth, it must go somewhere. Some of them infiltrate into the soil, others are trapped by vegetation, and some followed the drainage channel as overland flow and joins nearby streams. Those without defined routes especially during the period of high rainfall flood the environment, causing serious damages. Upper Imo river basin of south Eastern Nigeria has been suffering from this environmental hazard over the years and the negative effects on the area has been so enormous. Flooding in upper Imo River basin constitutes a great economic loss because of damages it cause on farm lands, residential areas and infrastructures. The role of elevation in flooding was investigated and the result shows that lower elevations are more vulnerable than their higher counterparts. Based on the findings, it was ascertained that flooding is a serious threat to individuals, communities, organizations and institution in the study area.. Though no one prays for flood, it is paramount that one be vigilant and careful about the activities that can cause flood with its attendant hazards. Anything that will encourage or facilitates flooding should be avoided to be free from hazards associated with its occurrence. Since it is something that no one can categorically tell when it can occur, efforts should be geared to prevent it taking unawares in order to reduce the risk associated with it.

Finally, the research makes the following recommendations

1. Efforts should be directed at flood prevention rather than at adaption strategies. This is because when flood occurrence are prevented, what is spent in adaptation and hazards associated with it will be minimal
2. There should be proper channelization of flood water out of the residential areas and cities. Adequate measures should be taken to make provision of channels that can store and carry water during intensive rainstorm.
3. Areas designated as floodplains should not be inhabited or even be farmed. This will reduce hazards encountered during flood event.
4. Warning alerts should be given by government agencies from time to time when rivers and lakes are expected to overflow their banks. This will avoid flooding them the people unawares.
5. There should be proper construction of drainage channels during road construction.

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