APPRAISAL OF DRAINAGE CONDITIONS AND FLOOD FREQUENCY IN CALABAR, NIGERIA

EMMANUEL EFOBE NDOMA[1], ADAM MODU ABASS[1], BIBI MUHAMMED[1], ALI ABDU[1] AND EDNA UWAYEME INEGBEDION[2]

[1]Federal University of Kashere, Gombe State.
[2]Department of Geography, Ahmadu Bello University, Zaria, Kaduna
Corresponding Author: semmamyx2@gmail.com

ABSTRACT

Flooding has been identified as one of the major factors that prevents Africa's growing population of city dwellers from escaping poverty and stands in the way of United Nations 2020 goal of achieving significant improvement in the lives of urban slum dwellers. The rapid increase in urbanization without corresponding infrastructures in Calabar metropolis has led to increased incidences of flood. The available drainage channels in the area cannot contend with the volume of storm water. The study is aimed at appraising the drainage conditions and flooding frequency in Calabar metropolis. This study therefore, establishes gauging stations for the measurement of drainage run off using stop-watch method (velocity of flow), measuring steel tape, and copies of questionnaires were administered to 400 households proportional to seven sample units. The time, volume of flooded water was measured using stop watch, measuring velocity of flow. The frequency of flood is compounded with its intensity as over 59% of the sampled population agreed that flooding is very high in Calabar. The study also revealed that as shown in frequent floods in the city. The incessant flood often leads to water inundating compounds (64.5%), preventing people from going out (11.25%), distortion of the scenic beauty of the environment (6.25%), landslide (4.75%). However, it was not waters from the Ocean that usually floods the city but the heavy rains, and the low nature of the topography and the poor drainage networks, increased paved surfaces, river channel encroachments, poor waste disposal techniques, physical development control problems, gaps in basic hydrological data and cultural problems as major causes of street flooding in Calabar metropolis. Based on these findings, the study recommended that since Calabar is located in a tropical zone characterized by heavy rainfall the government should take proactive measure to mitigate storm water. It is recommended that the present drainage systems in Calabar metropolis should be cleared on regular basis to allow for a free flow of storm water in the area.

Keywords, flooding, urbanization, storm, water, rainfall

INTRODUCTION

Flooding has been identified as one of the major factors that prevents Africa's growing population of city dwellers from achieving significant improvement in the lives of urban slum dwellers (Action Aid, 2006). This is because many African cities lack the infrastructures to withstand extreme weather conditions. Poor urban planning together with other urban governance challenges

contributes to making African urban slum dwellers most at risk (Eze 2008).

In Nigeria a study by Douglas *et al* (2014) report that many of the urban poor in Africa face growing problems of severe floods. They further buttressed the fact that increased storm frequency and intensity related to climate change are exacerbated by such local factors as the growing occupation of flood plains, increased runoff from hard surfaces, inadequate waste management. Askew (2015) reiterated that floods cause about one third of all deaths, one third of all injuries and one third of all damage from natural disasters globally. Generally, flood events are attributed to global warming, climate change, ocean swell/surge and torrential rains. flood hazards are natural phenomena, damage and lose from floods are mostly the consequences of urbanization without corresponding infrastructural restructuring (Brooks, 2013).

Other researches have been conducted to establish the relationship between urbanization and flooding. Some of these studies emphasized the implications of flooding on the environment and socio economic wellbeing of the affected cities, Offiong and Eni, (2007) in their study on the effects of urban floods on infrastructure in Calabar that rainfall duration was the major determinant of runoff volume which leads to drainage infrastructure destruction in the city. Ahern, *et al.*, (2004); Abaje and Giwa (2008); Ladan (2007); Offiong *et al.*, (2008); and Eze (2008) summarises that the twin factors of poor urban planning and increased paved surfaces are the main causal factors that increase the frequencies of floods in Nigeria. Eze (2008) using both questionnaire and secondary data in the analysis of the history and causes of flood incidence in the city of Calabar opined that no year passes without flooding in the city claiming lives and properties; on average, four lives were lost yearly to flooding. Eze (2008) attributed flood occurrence to expansion of residential areas and the multiplications of paved surfaces including roads and sidewalks. Offiong and Eni (2007) using both conventional questionnaire and secondary data corroborated these claim by observing that the damage to materials is quantified to be well over 115.76 million naira per year. The main factors of flooding in the city of Calabar in the view of Offiong and Eni, (2007) are increasing demand for concrete surfaces for buildings which has increased surface runoff, and waste waters that have increased the volume of water in rivers, streams and drainage channels.

Afangideh, *et al.,* (2012) examined the implication of changing rainfall pattern on building loss in Calabar. Rainfall data for the study were collected from the Nigerian Meteorological Agency (NIMET) and Margaret Ekpo International Airport, Calabar. While data on cost of building loss to flood for the previous 20 years were gotten from the inhabitants of the flood prone areas in Calabar. The result from their study revealed that annual rainfall intensity with beta coefficient of 0.437 has more implication on cost of building loss to rainfall in Calabar than annual rainfall duration, with beta coefficient of -0.063.

Flooding in urban areas is not just related to heavy rainfall and extreme climatic events; it is also related to changes in the built-up areas themselves. In the case of Calabar, the problems of street flooding began when some socio economic and anthropogenic activities gained momentum as a means of face lifting the city as State Capital. The influx of people from both rural and adjoining states led to increased demand for housing. Houses were hurriedly built to meet the burgeoning demand for shelter. This alters the aesthetic

image of the city as buildings were erected anyhow and anywhere (Sule, 2004),.
However, none of these studies measured the condition of drainage channels (gutters) and their role in flood events as majority of reviewed studies only mentioned poor drainage system as a factor of flood events in Nigeria. This is the gap the research intends to fill. It is against this background that this research to assess the condition of drainage channels in the study area and how they influence flooding incidence in Calabar metropolitan city of Calabar.

MATERIALS AND METHODS

The Study Area

The study is confined to Calabar Metropolis that lies between latitudes $4^{0}46^{1}$-$4^{0}58^{1}$Northof the equator and longitudes $8^{0}15^{1}$ - 8^{0} 26^{1} East of the Greenwich meridian with an approximate area of 1480 km^{2}. It covers Calabar Municipality and Calabar South Local Government Areas of Cross River State, Nigeria. The area is bordered in the North and West by Odukpani Local Government Area, in the east by Akpabuyo Local Government Area and in the South by the Atlantic Ocean (Fig.1).

Climate

Calabar is located in a coastal zone within the humid subtropical region and it is affected by weather systems originating from all sides. The city experiences the full influence of the over- head sun throughout the year which provides abundant and constant insolation. Consequently, the atmospheric temperature within the area as observed by Mannion (2002) are constantly high and changes slightly with the year and according to Udo (1975) the mean daily temperature remain around 37^{0}C all year round excepts during the raining season due to the cooling effects of rains and clouds cover that curtails the amount of insolation (incoming radiation).

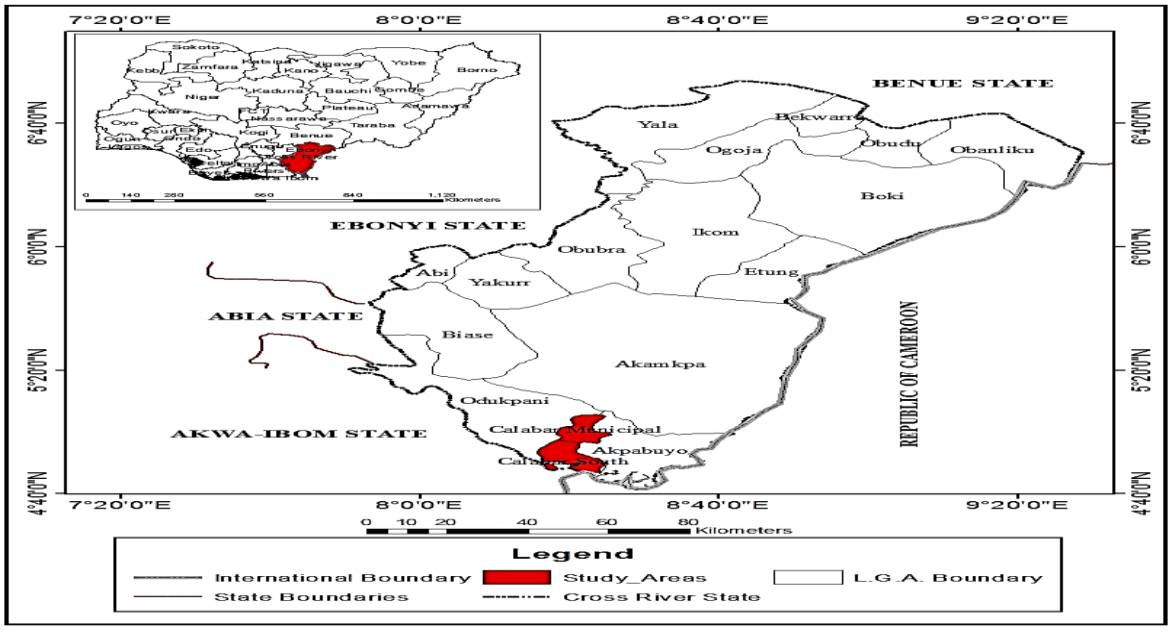

Figure 1: Cross River State Showing the Study Locations (Source: Modified from Map of Cross River State 2018

Rainfall in Calabar is however influenced by the interaction between two air-masses blowing over the area. the warm moist (rain bearing) tropical maritime (mT) air mass, which originate from the Atlantic Ocean and the dry dusty tropical continental (cT) air mass which originated over the Sahara Desert. These two air masses alternate seasonally with each other, but the tropical maritime (Tm) has domineering influence over the area because of the nearness of the area to the sea which has resulted in rain falling throughout the year.

Rainfall is therefore very high in Calabar. With an annual rainfall average of 2000mm to 3000mm (NAAR, 1995), Calabar ranks very high among stations receiving heavy precipitation in the coastal zone of Nigerian and West African sub-region (Inyang, 1980). The rainfall distribution shows that it is characterized by double maxima rainfall regime which starts from the month of April to October, reaching its climax in the months of July and September.

The area has a relative humidity that is high throughout the year except during the short dry harmattan spell. Calabar has an average of eighty (80 %) percent relative humidity that is sometimes one hundred (100 %) percent much higher in the morning and with an average vapour pressure in the air of 29 millibars throughout the year (NAAR, 1995). Udo (1975) reported that Calabar has the highest amount of relative humidity in Nigeria. Generally, the major air masses which are separated by the Inter-Tropical Convergence Zone (ITCZ) or Discontinuity (ITD) oscillate north and south to give the two distinct seasons of the area.

Relief and Drainage

The area is an inter-fluvial settlement, built on a high land between two rivers adjacent valleys of the Great Qua River on the east which flows into the Cross River State estuary and the Calabar River on the west. Calabar is moderately undulating with land descending rather abruptly to the Calabar River at the western boundary of the town while the slope is towards the Qua River to the west (Inyang, 1980). The crest of the coastal range of hills rising from the coastal plains about 40km to the Atlantic sea shores, with height of 60 to 70m above sea level in some places. The coastal plains is linked with undulating hinterland on which the rest of the town is built by a number of channels and gaps, open primarily by head ward erosion of formal streamlets.

Reconnaissance Survey

A Reconnaissance survey of Calabar was undertaken to identify flood prone areas. Using information obtained from literature on flood in the city of Calabar, couple with verbal discussion of residents of the city, the researcher identified areas that are often flooded whenever it rains. The reconnaissance assisted in the determination of suitable location for the establishment of the measurement points. At the end, a distinct area with well-defined boundaries was identified. Thus, flood volume data were collected from the following locations; IkotAnsa, EsukEdiba, Henshaw Town, Anangtigha, CRUTECH, MCC and a control was established at Satellite Town. Questionnaires were administered to residents of the selected streets in accordance with the guide outline in the procedure for data collection.

Types of Data

Poor drainage system is exhibited in the structural degradation of the form and pattern of already existing urban social facilities. Therefore, the following physical and social

facilities which form the main component of the urban facilities were considered as data required for this study.

Four types of data were collected in the study:

i. Data on flood frequency and intensity
ii. Data on drainage characteristic (drainage width and depth)
iii. Data on runoff volume (Direct field measurements)
iv. Data on effects of poor drainage systems on the urban environment.

These data sets are considered relevant given that flood episodes are often linked to the poor state of drainage system as exhibited in the structural degradation of the form and pattern of already existing urban social facilities.

Sources of Data

Two data sources were relied upon; primary and secondary data sources. The primary sources of data involved data obtained through questionnaire administration, measurement of the attributes of interest, direct observation to extract the necessary information in the field. Secondary Sources basically included, residential map, population trend data obtained from the National Population Commission (NPC), existing literature on the research topic from journal articles, textbook, magazines and gazettes.

Methods and procedure of data collection on drainage width and depth:

The dimensions of the drainage were measured directly from the field with a measuring steel tape and the volume of flood water was measured using stop watch method (Velocity of flow). Seven streets were purposively sampled. Along a given street, a number of measured points were established along the drainage paths. The values obtained were further subjected to statistical manipulation to determine depth to width ratio.

Data on flood volume (direct field measurement)

To determine flood volume in the sampled streets, a gauging station was established at predetermined points (Ayoade, 1988). The velocities were estimated and together with the cross-sectional area at each runoff gauge level they were used to estimate the runoff from the urban drainage catchment. The assumption is that the area where runoff was sampled is taken to be representative of the entire urban catchment of the city of Calabar.

Questionnaire administration and Sampling techniques

The construction of questionnaire focused on the factors of poor drainage systems, the effects of poor drainage systems on the urban environment, inadequacy of drainage systems, causes of flooding, frequency and intensity of flood events in Calabar, and the socio-economic implications of flooding. Systematic random sampling technique was used in the administration of questionnaire

RESULTS AND DISCUSSION

Drainage Characteristics

The incidence of floods in Calabar was attributed to diverse causes. Calabar like other cities in Nigeria lack adequate storm water way. This is evident in the recurrent waves of flood events in the study area. Table 1 revealed that heavy rainfall was claimed to be the main factor of flood occurrence in

Calabar (26.3%). Statistical evidence from the Nigerian Meteorological Agency. (NIMET), Calabar shows that the mean annual rainfall for the city based on 1912-2011 rainfall data of the area is 245.78mm. These will mean volumes of water running off roofs and paved surfaces from such storms are enormous. All too often, drains and culverts cannot cope and localized flash flooding occurs. These flash floods happen suddenly, with little lead time for warning; they are fast-moving and generally violent, resulting in threat to life and severe damage to property and infrastructure; and they are generally small in scale with regard to area of impact

Plate 1: Showing drainage characteristics of Waste strewed in gutters and road junctions in CRUTECH Source: Field Survey (2018).

In fact, drainage characteristics of waste management among most residents is rather too poor. Refuse and other wastes are usually dumped into available open spaces, including drainage channels and river plains and valleys. This practice has led to the blockage of the drainage channels at various points which could account for 14% of the households interviewed agreeing that flooding is usually a product of such blockages.

Table 1: Causes of Flooding In Calabar Metropolis

Causes of flooding	Number of responses Frequency	Percentage distribution
Building on water channels	21	5.3
Poor Physical Planning	63	15.7
Inadequate Drainage Channel	88	22
Heavy rainfall	105	26.3
Nature of Terrain	34	8.5
Dumping of wastes on channels	56	14
All of the above	19	4.7
Others	14	3.5
Total	400	100

Source: Field survey (2018)

Table 1 further indicates that 22% (88) of the sampled population attribute causes of flooding in the city to inadequate drainage channels. In a similar vein, poor physical planning was also identified as another factor of flood occurrence with a response intensity of 15.7 percent. Despite the efforts of the Cross-River State government to keep the city of Calabar clean, waste can still been seen strewed in gutters and road junctions (Plate 1).

The state of the drainage with regard to the prevalence of flood incidence cannot be over emphasized because of the poor observance of frequent flooding in the area (Plate 1). The respective views on the quality of the drainages across the sampled areas clearly points to the fact that the drainages are in poor state. Plate 1 is an evidence of what one

can easily find in most of the streets in the sampled area. As the plate indicates, the persistent rain couple with the poor materials and engineering works has made these gutters to look like rabbit holes.

On drainage dimension, the study, it was shown that the drainage dimensions vary from one study zone to another. However, the general observation is that the width and depth of the gutters in most of the sampled zones are narrow as exemplified by frequency flood episodes. Jimoh (2008) made a similar observation in a study of drainage dimension in Ilorin Nigeria. In the study it was reported about 31.5% of the respondents were of the view that one of the effects of drainage channel problem is the incidence of temporary street flooding. In addition, in a study by Daniel *et' al.,*(2012) in Gombe also observed that 42.5% of the respondents agreed that lack of drainage facilities constitutes the major factor that is causing flood in Gombe.

Plate 1 also revealed that government do not often prioritize the provisions of drainage channels as about 18.2% of the respondents claimed government neglects this segment of urban infrastructure development. Even when provisions are made for drainage channels in road construction contracts, the contractors often construct the roads without recourse to drainage provisions (Offiong *et al.,* 2008). This has persisted because governments pay little or no attention to contract specification. This is compounded by the weak institutions in the state.

Condition of the Drainage Channels in the Study Area

Table 2 presents data on the condition of drainage channels (gutters) in Calabar metropolis. From the table, it can be observed that there was an overwhelming agreement across the sampled flood prone areas that the dimensions of the drainages is well below the volume of storm water that is often experienced in the area. Specifically, in IkotAnsa, 65.11 %of the respondents believed the gutters are very narrow just like 75% were of similar view in Esuk Ediba. In Henshaw Town, Anangtigha, CRUTECH and MCC, 54.83% (17), 64.28% (54), 79.49% (31) and 77.17% (71) respectively of the sampled households accepted that the drainage channels in their area were very narrow

Table 2: Condition of drainage channels in the study area

	Respondents' Responses													
Conditions of	IkotAnsa		EsukEdiba		Henshaw		Anangtigha		CRUTECT		MCC		Satellite	
Drainage channels	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Very narrow	56	65.11	39	75.00	17	54.83	54	64.28	31	79.49	71	77.17	4	25.00
Not well plastered	9	10.46	4	7.69	7	22.58	16	19.04	02	5.12	14	15.21	9	56.25
Not well designed	18	20.93	6	11.53	5	16.12	9	10.71	5	12.82	6	6.52	2	12.5
Highly fractured	3	3.48	1	1.92	2	6.45	1	1.19	01	2.57	01	1.08	1	6.25
Not present at all	0	0.0	2	3.84	0	0.00	4	4.76	0	0.00	0	0.00	0	0.00
Total	86	100	52	100	31	100	84	100	39	100	92	100	16	100

Source: Field Survey (2018)

Table 2 further revealed that some of the respondents were of the view that the drainages were not well plastered. These views were unevenly distributed in the sampled zones. For instance, in IkotAnsa, 10.46% (9) of the respondents said the gutters

were not plastered properly, while in EsukEdiba, 7.69% of the sampled population held similar views. In the same vein, 22.58% of those sampled in Henshaw Town said the drainages were not well plastered. While in Anangtigha, 16 of those interviewed agreed that drainages around their neighborhood were not done properly. It was observed also that in CRUTECH axis, only 5.12% of those interviewed held the view that the drainage channels were not well plastered. Surprisingly, Satellite town which is purported to be a high brow area have very high responses in favour of the fact that drainages within their zone were not well plastered too. Specifically, out of the 16 people sampled, 9 representing 56.25% gave such responses. Relating it to the present dimension of the drainage, it was observed that the channels are without concrete at the base and walls. Over time, the force of the torrential rain will cut off the road as is the case in IkotAnsa (Plate 2).

Plate 2: Torrential rain in yellow duke Road

Effects of Poor Drainage Network on the Environment/Infrastructure

In figure 1, 64.5 % of the respondents have their houses flooded, 11.25 % of the respondents said they are prevented from moving out, while 6.25 % of the sampled population accepted that flooding distort the beauty of the environment. More so, 3% said houses often collapsed during flooding, 11 people out of the 400 interviewed said flooding of houses, landslide/erosion, collapsing of buildings, prevention from going out, pollution of water sources, silting of streams and compounds, and distortion in the beauty of the environment are agoning effects of poor drainage channels in the city.

Generally, beside the personal effects of flooding, all the respondents noted that flooding has affected public infrastructures such as roads been submerged, electric and telephones pulled down, markets, schools and churches flooded and drainage channels blocked with wastes. It was also observed that majority of the buildings do not obey established meters setback to the drainage channels and from one building to another.

The observation has been corroborated elsewhere in Nigeria. According to Etuonovbe (2011), floods are the most devastating natural disasters, claiming more lives and causing damage to properties than any other natural phenomena. In Nigeria, though not leading in terms of claiming lives, flood affects and displaces more people than any other disaster. It also causes more damage to properties and at least 20% of the population of Nigeria is at risk of one form of flooding or the other (Ochere and Okeke, 2012). The observation has also been corroborated in Calabar. According to Eze (2008), poor drainage network is often associated with street flooding and this has

become critical environmental problem in coastal cities of Nigeria especially in Calabar metropolis. However, it is not water from the ocean that usually floods these cities but the heavy rains, and the poor drainage network (Aderamo, 2008).

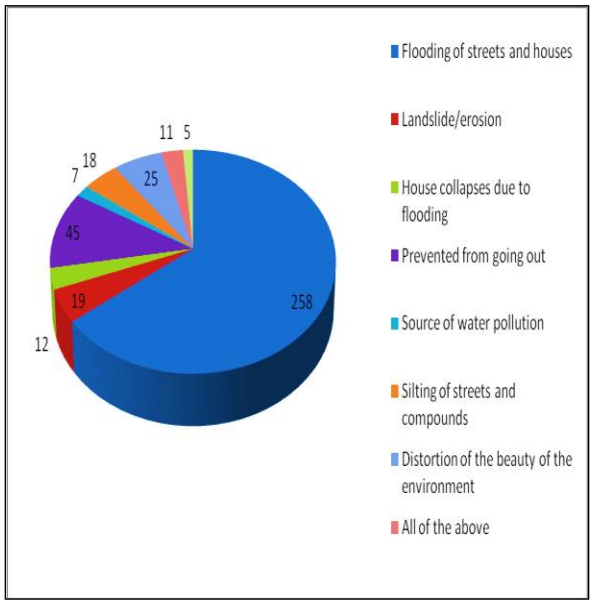

Figure 2: Effects of poor drainage network (2018), (Source: Field Survey, 2018)

The study also revealed that the effects of flood in Calabar include streets inundation by flood waters, landslide/erosion, distortion of the beauty of the environment, silting of streams, prevented from going out among others. The finding of this study is line with the studies of Offiong *et al*., (2008), Offiong and Imoke (2008), Eze (2008), Jimoh (2008), Adedeji *et al*., (2012), Aderogba (2012a, 2012b), Olajuyigbe *et al.*, (2012), Ocheri and Okeke (2012), Bariweni *et al.*, (2012).

DISCUSSION

These studies listed the effects of flood in most southern and northern parts of Nigerian to include both not limited to death of people especially children and the aged, damage to properties, displaces people prevented from moving out, houses collapsed, pollution of sources of water especially hand dug wells, flooding also affects public infrastructures such as roads been submerged, electric and telephones pulled down, markets, schools and churches flooded and drainage channels blocked with wastes.

CONCLUSION

Flood remains a very serious environmental problem in Calabar. Recurrent flood events in the city of Calabar have been traced to in inadequate drainage channels. Many properties have been destroyed, lives lost and this has subjected the people to unquantifiable trauma. More so, the menaces of flood have been on the increase as a result of incipient and prolong weather conditions.

In view of these, the study put forward some recommendations which when implemented will help in mitigating flood incidence in Calabar.;

i. The government should award contract to a competent company for the construction of underground drainages covering the entire city of Calabar, as surface drainages have created many problems to the resident including the loss of lives, the present drainage systems should be cleared with shovel on regular basis to allow for the free flow of storm water.

ii. The government and NGOs should carry out massive awareness campaigns on the need for the people to stop dumping waste in the drainage channels.

iii. In addition, government should put in place flood early warning signal system with the capability to deliver reliable timely and effective flood information at an appropriate

response time. This will help to reduce the loss of lives and properties in the city.

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