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Effectiveness of Drainage Networks on Floods in Calabar Metropolis, Nigeria

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Abstract

The study examined the effects of drainage networks on floods in Calabar metropolis. The rapid increase in urbanization without corresponding infrastructures in the city of Calabar has led to increased incidences of flood as the available drainage channels cannot contend with the volume of storm water. In view of this, the study established gauging stations for the measurement of drainage run off using measuring steel tape. The volume of flood water was determined using stop watch method (Velocity of flow) and copies of questionnaire were administered to 400 households proportionally to the seven sample units. Results from the work revealed that the frequency of flood is compounded with much intensity as over 59% of the sampled population agreed that flood is very high in Calabar. The study also revealed that the drainage were very narrow and shallow and contributed to the frequent floods in the city. The incessant flood often led to water inundating compounds (64.5%), preventing people from going out (11.25%), distortion of the scenic beauty of the environment (6.25%) and landslide (4.75%). 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. The present drainage systems should be cleared by the people on a regular basis to allow for a free flow of storm water.

Key words: *Drainage, network, urbanization, rainfall*

Introduction

Although urbanization is the driving force for modernization, economic growth and development, there is increasing concern about the effects of expanding cities, principally on human health, livelihoods and the environment. The implications of rapid urbanization and demographic trends for employment, food security, water supply, shelter and sanitation, especially the disposal of wastes (solid and liquid) that the cities produce are staggering (United Nations Conference on Environment and Development, 1992). The process of urbanization is believed to be connected with levels of development and some assert that, for a country to develop there is the need for an increased level of industrialization as it is generally accepted that there cannot be urbanization without rapid economic growth (Tettey, 2005).

Cities the world over are the dominating forces in the organization of human population. As the world most crowded places, cities continue to show increase in urban population. This increase leads to a growing urbanization trend. Duru and Nnaji (2008) defined urbanization as the increase in the population of cities in proportion to the region’s rural population. Urbanization is the outcome of social, economic and political developments that lead to the concentration and growth of large cities, changes in land use and transformation from rural to metropolitan pattern of organization and governance. Rapid growth of towns and cities has been a common feature of the developing world (Aderamo, 2008).

Like other developing countries, the rapid growth in urban areas in Nigeria is a ‘sword of two edges’ (Sule, 2009). While increasing human capital increased the economic status of the country, the growths of large centers had outpaced government capacity to meet the increasing demand for the provision of basic infrastructural facilities and services. These are manifested in poor investment in roads, housing, water supply, electricity, waste disposal mechanisms, adequate drainage systems etc. (Sule, 2007; Aderamo, 2008; Jimoh, 2008). These problems have continued to persist and made worst due to non-compliance to planning ordinances (Sule, 2010). Appropriate management of drainage systems requires knowledge relating to the system boundary, system resources, interactions between adjacent systems and allowable limits, or thresholds, for each resource. Each of these elements will be unique to the particular system under consideration, and each system must be assessed on its own merits.

Flooding has been identified as one of the major factors that prevent Nigeria growing population of city dwellers from escaping poverty and stands in the way of United Nations goal of achieving significant improvement in the lives of urban slum dwellers by 2020 (Action Aid, 2006).The problems of flood in Nigerian urban centers have been attributed to anthropogenic and natural factors. Olufemi (2008) observed that, it is evident from research, that residence contributes greatly to flood problems of their area and their act jeopardizes the environment which attracts many people for economic, social and recreational facilities.

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 the average four lives were lost yearly to flooding. Eze 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 Ofiong and Eni, 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, Ekpe and Offiong (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), which degenerated into the „ugly face of Canaan city‟ (Iquot, 1982). Today in spite of the fact that Calabar is acclaimed to be one of the cleanest cities in Nigeria, the menace of flooding has more than double.

The aim of the study is to assess the drainage network in relation to flood occurrences in Calabar. Specifically, the objectives of the study are to: examine the intensity and frequency of floods in

Calabar, determine the relationship between drainage width, depth and floods, as well as assess the drainage system in Calabar.

Much of the reviewed studies only mentioned poor drainage system as a factor of flood events in Nigeria with no emphasis or measurement of the dimensions of drainages and their role in flood events. This very important aspect is needful and will serve as the gap this research intends to fill.

Study area

Location and Size: The study is confined to Calabar Metropolis that lies between latitudes $4^0 46^1$- $4^0 58^1$Northand longitudes $8^0 15^1$ - 8^0 26^1 East with an approximate area of 1480 km^2. (Eze 2008). It covers Calabar Municipality and Calabar South Local Government Areas of Cross River State. 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 (Fig1).

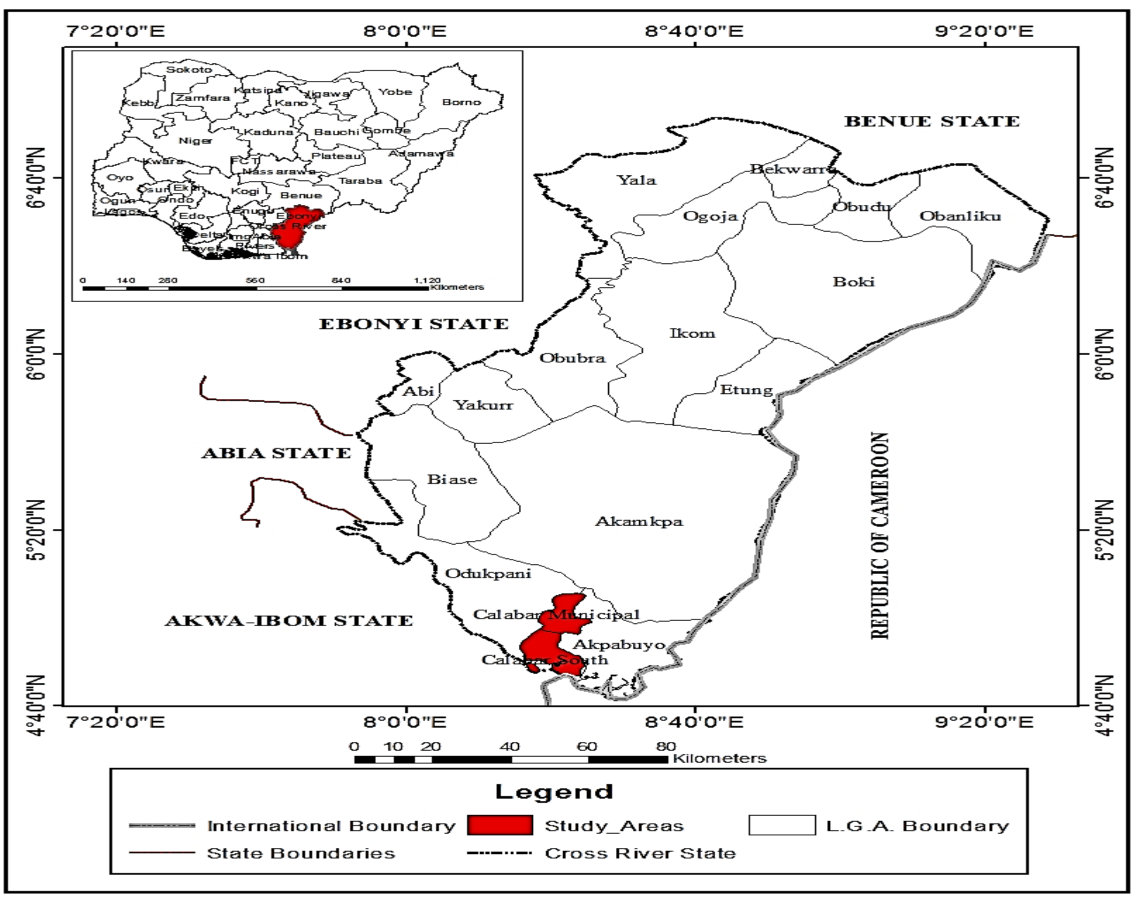

Fig 1: Cross River State showing the study Locations.

Sources: Modified from Map of Cross River State

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 37^0C all year round except during the raining season due to the cooling effects of rains and clouds cover that curtail the amount of insolation (incoming radiation).

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.

Topography 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 has a moderately undulating land that descend 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.

Vegetation and Geology

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.

Materials and Methods

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, analysis of topographic maps, 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

Data 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.

Data on flood volume (Direct field measurement)

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.

Population sample determination

Given the TaroYamene (1964) formula

$$n = \frac{N}{(1+N\,(e)^2} \quad (1)$$

Where

n = Sample Size

N = Sampled population

e = Level of precision or confidence level at 0.05 significance

Where $n = \frac{6553}{1+6553\ (0.05)^2} = 400$

Table1 Sample districts, sample size distribution according to proportionate population

	Sample locations	Estimated houses	Proportionate samples	Sample size %
A. 1	IkotAnsa	2204	86	21.5
B. 2	EsukEdiba	1326	52	13
C. 3	Henshaw Town	788	31	7.8
D. 4	Anantigha	2131	84	21
E. 5	CRUTECH	986	39	9.8
F. 6	MCC	2345	92	23
G. **7**	Satellite town	104	16	4.0
	Total	**9884**	**400**	**100**

Source: Researchers field survey (2018)

From the figure obtained, 400 copies of questionnaire were administered proportionately among the six districts in relation to their specific population figures as shown in Table 1 above with the following formula;

$$\frac{p}{P} \times 400$$

Where p = Proportionate population

P = Overall population

400 = the calculated (n)

Technique of Data Analysis

The data collected were analyzed using descriptive statistics of mean, Frequency, tables, and charts. The use of descriptive statistics to analyze the data and add value to the overall work

Result and Discussion

Socioeconomic Profile of Respondents

The socio-economic characteristics of the respondents are very important in determining the degree of urban growth. The channels which were essentially constructed or created by the storm water drains to let flood waters pass freely are being tress-passed by slum dwellers, small shopkeepers, motor garages, garbage dumping among others result in obstruction of water flow and thus contributed immensely to the fury of floods in the city of Calabar. Most of the drains in Calabar are characterized by such trespassing and garbage dumping. The socioeconomic characteristics of the people could possibly be linked to their disposition to environmental management.

Information gathered on educational background reveal that more than half of the inhabitants in the area have acquired one form of education or another as 48.84% of the respondents in Ikot Ansa have acquired a tertiary education certificate. The respondents in Henshaw town have the least distribution in terms of tertiary education. As shown on Table 1, out of 400 respondents interviewed, 147 of them said they have obtained senior secondary certificate. The distribution in the table further shows that majority of those with secondary education certificate were found in Henshaw town. The highest number of those who claimed to have no formal education was found in Esuk Ediba (15.38%), while the least was found in Satellite town with 0.00% which also has the highest recipient of tertiary education.

Table 2: Educational level of respondents

Educational level	Ikot Ansa		Esuk Ediba		Henshaw		Anangtigha		MCC		CRUTECH		Satellite	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
No formal education	13	15.12	8	15.38	2	6.45	9	10.71	4	10.26	3	3.26	0	0.00
Primary education	8	9.30	6	11.54	4	12.90	13	15.48	3	7.69	12`	13.04	2	12.5
Secondary education	23	26.74	14	26.92	17	54.84	28	33.33	17	43.59	45	48.91	3	18.75

Tertiary education	42	48.84	24	46.15	8	25.81	34	40.48	15	38.46	32	34.78	11	68.75
Total	**86**	**100**	**52**	**100**	**31**	**100**	**84**	**100**	**39**	**100**	**92**	**100**	**16**	**100**

(Source: Field survey, 2018)

The occupation of the respondents determines their level of income and possible areas to live as clearly stated above 32.56%, 29. 92%, 25.81%, 33.33%, 15.38%, 17.39%, and 12.5% (Figure 2) engage in trading activities in Ikot Ansa, Esuk Ediba, Henshaw town, Anangtigha, CRUTECH, MCC and Satellite town respectively. Majority of the respondents claimed to be civil servants (133 out of 400) with the highest number observed in MCC (62.5%). The least number of people claiming to be civil servants were recorded in Esuk Ediba (19.77%).

On household size, majority of the households were made up of between 3 to 6 people. This accounts for about 49.0% in the entire sampled zones, while 29.5% of the sampled population had household size of 1 to 3. Specifically, 39.5% of the sampled respondent in Ikot Ansa accepted to have household size of 1 to 3, 32.6% in Eusk Ediba. Majority of the sampled population in Satellite town (81.25%) have occupancy ratio of 1 to 3 (Table 2). The general observation in the seven sampled district is that the control (Satellite Town) have the least occupancy ratio compared with the other six zones. This could be due to the fact that the zone is occupied mostly by people with advanced degrees and good paying jobs like lecturers, medical doctors and nurses.

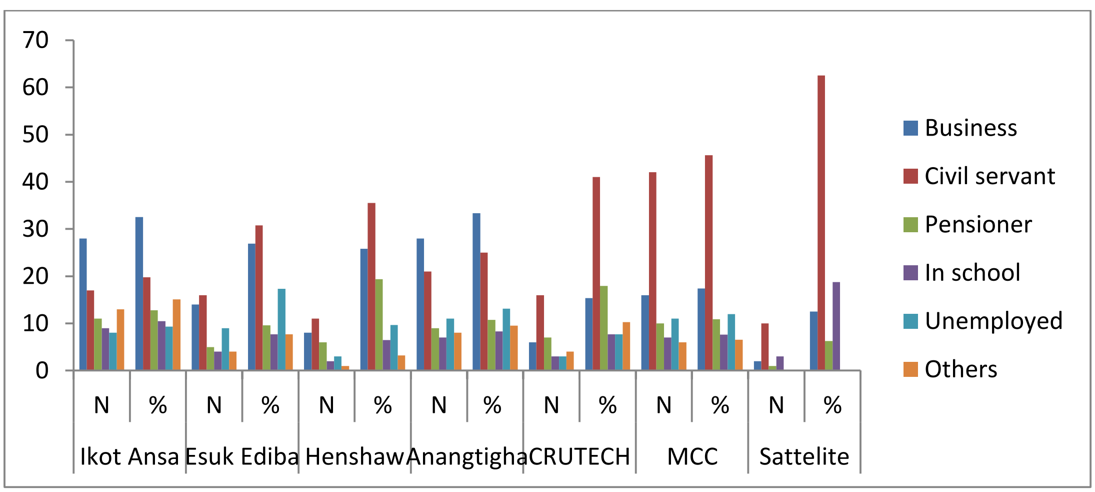

Fig 2: Occupation of respondents (Source: Analysis, 2018)

Table 3: Household size in the study area

Houseshold size	Ikot Ansa		Esuk Ediba		Henshaw		Anangtigha		CRUTECH		MCC		Satellite	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
1-3	34	39.53	17	32.69	4	12.90	21	25	13	33.33	16	17.39	13	81
3-6	36	41.86	24	46.15	19	61.29	46	54.76	16	41.03	53	57.61	2	12.5
6-9	12	13.95	8	15.38	5	16.13	10	11.90	4	10.26	13	14.13	1	6.25
9 & above	04	4.65	3	5.77	3	9.68	7	8.33	6	15.38	10	10.87	0	0.00
Total	**86**	**100**	**52**	**100**	**31**	**100**	**84**	**100**	**39**	**100**	**92**	**100**	**16**	**100**

(Source: Field survey, 2018)

This study have buttressed the fact that flood occurrence in the city of Calabar is linked to both physical and socioeconomic variables particularly, inadequate drainage network and building housing and other infrastructures without recourse to planning ordinances in the area. From the sampled households, different opinions were expressed on the frequency of flood. About 47.25% of the sampled population said flood occurs in the zone every year. Similarly, some of the respondents (41.75%) agreed that they experience flood most parts of the year while 1.75% of the interviewed people were of the view that flood has never occurred in their zone. It was also observed that 6.25% of the sampled population agreed that they experience flood in their area every month of the season.

Ogba and Utang (2008) reviewed the problems of flood in the Niger Delta, it was reported that increasing built-up areas without proper recourse to urban planning rules, and additional concretion, could have accelerated infiltration excess over-land flow. This could still have been lower than some other years prior to the present urbanizing phase of development that is being experienced.

Table 4: Drainage Length, width and Length to width ratio and flood volume

Sampled zones	Mean Width of drainage (cm)	Mean depth of drainage (cm)	W/D ratio	Number of drainage channels in the clusters	Mean value of runoff (m^3/s)
Ikot Ansa	64	58	1.10	7	38.12
Esuk Ediba	84.8	63	1.34	4	42.10
Henshaw	75.3	45	1.67	6	36.0
Anangtigha	61.3	38	1.61	8	38.01
CRUTECH	107.6	69	1.55	13	49.8
MCC	82	56	1.46	3	32.2
Satellite	55.5	36	1.54	4	09
Total	530.5	365	1.45	45	245.23
Mean	75.8	52.2	1.45	6.4	35.03

(Source: Authors survey, 2018)

The data collected were analysed using descriptive statistics of mean, frequency and tables. As it concerns the relationship among the three variables, drainage width, depth and runoff volume, it was clear that drainages that are wide tend to contain larger volume of runoff; though this was not consistent across the sampled drainages. Little variations were recorded in some zones. In the case of CRUTECH, the mean width of the drainage is 107.6cm with 49.8 ^{S}/cm runoff volumes was recorded. It was also observed that the same situation was replicated in Esuk Ediba where the mean width of the drainage channel is 84.8cm with runoff volume of 42.10^{S}/cm. However, the different pattern was observed in the remaining drainages. For instance, in Satellite Town, the width of the drainage is 55.5cm while runoff recorded was 09^{S}/cm

In the study sites, it was evidenced that the drainages were not wide and deep enough to contend with the high volume of water that pass through them hence the regular incidences of floods. This was particularly observed in areas like CRUTECH where even after days of heavy rainfall stagnant water can still be seen on the area.

Drainage Width, Depth and Flood (Runoff) in Calabar Metropolis

Table 4 presents the geometry of the drainage channels and runoff estimation in the study area as observed and measured. The drains consist majorly of channels with open trenches, which are rectangular in shape with concrete lining and covering; however, most of the drainage channels in the interior of the city are left open. It is important to note that drainage channels along important routes like IBB way, around the Transcorp Hotels, Government House (Diamond), and those around Bank clusters (Post Office axis) were observed to be covered and maintained regularly (Plate 1).

Plate 1: Drainage been covered on top (Source: Field Survey, 2018)

From Table 4, it can be seen that the drainages are characterized by different dimensions. For example, the width of drainage channels ranges from 61.3cm to107.6cmand the total mean width of the drainage channels is 75.8cm.For the depth of the drainage channels, it ranged from 38cm to 69cm with a total mean depth of the measured drainage channels being 52.2cm. Similarly, the range of the runoff is 9m^3/s to 49.8 with mean values of 35.03m^3/s.

On a zone by zone basis, the mean width in Ikot Ansa was 64cm while the mean depth in the area was 58cm. However, the width to depth ratio was 1.10. In all, 7 drainage channels were surveyed. The total mean value of runoff measured during rainstorm in three months (March to May 2014) in Ikot Ansa was 38.12m^3/s. In Esuk Ediba, the mean value of the drainage width is 84.8cm; depth was 63cm while the width to depth ratio is calculated to be 1.34 with the total of 4 gutters measured and runoff 42.10m^3/s.

In Henshaw town, one of the traditional settlements of the Efik Kingdom, the average width was 75.3cm; depth of drainages in the zone had mean values of 45cm and total of 6 gutters were measured with runoff of 36.0m^3/s. Similarly, in Anangtigha, mean values of the drainages width was 61.3cm, the depth was 38cm with a width to depth ratio of 1.6 and runoff of 38.01m^3/s was recorded in the area during the specified period. The total numbers of channels measured were 8. Table 4 also revealed that CRUTECH have the highest number of drainage channels as about 13 drainage channels were counted and measured. The mean values of the width and depth of the drainages was calculated to be 107.6cm and 69.0cm, while the width to depth ratio is given as 1.55 and runoff was about 49m^3/s.

The Table 4 further indicates that the zone with the least number of drainage channels is MCC. The mean width and depth of the drainage channels was 82cm and 56 cm respectively. The width to depth ratio was 1.46 and a total of 3 channels were observed and measured and 32.2m^3/s volume of runoff was recorded. In the satellite town, the average value of the width was 55.5 cm while the depth was 36 cm and the width to depth ratio is 1.54 and runoff was 09m^3/s.

Table 5: Frequency and Intensity of Flood in Calabar

Frequency of flood	Number in sample	Percentage distribution
Every year	189	47.25
Every month of the season	25	6.25
Most parts of the year	167	41.75
Once in two years	0	0
None at all	7	1.75
Others	12	3.0
Total	400	100

Source; Author's Survey (2018)

On the frequency of flood in the city of Calabar, result from table 5 showed that about 47.25 (189) of the respondents in the sampled zones claimed that they experience flood events every year. The Table 4a also revealed that over 40 percent of the sampled population in the study were of the view that flood do occur in most parts of the year. On further probing it was discovered that the months that usually record flood disasters over the last ten years are between March and November. The table also indicates that 41.75% of those interviewed said flood occur most part of the year while 1.75% of the sampled population said they have never experience flood in their area. These are mostly people who live in the Satellite axis, as this zone has plan layout with most of the needed drainage facilities.

Conclusion

Many factors were identified as being responsible for flood occurrence. Some of them include inadequate drainage channels, poor physical planning, building on storm water drainages, heavy rainfall, dumping of waste on drainage networks and nature of the terrain. This flood causing factors have created series of environmental and socioeconomic problems in Calabar. Some of which include flooding of streets, loss of life, pollution of domestic water sources, distortion of the beauty of the environment, prevented from going out among others.

Recommendation

Giving that Calabar is located in a tropical zone characterized heavy rainfall;

I. The government should take proactive measure to mitigating the storm waters by clearing the drainage channel on regular basis.

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. Building without plan approval in every part of Calabar should be unacceptable. In fact, all structures built on drainage right of way should be demolished to reduce the carnage caused by flood.

IV. All roads constructed in Calabar should be provided with adequate drainages to avoid constant flooding especially during the rainy season.

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