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ANALYSIS OF RAINFALL PATTERN AND FLOOD INCIDENCES IN WARRI METROPOLIS, NIGERIA

ABSTRACT. Climate change has led to changes in the known patterns of rainfall and other climatic variables as well as increase in the frequency and magnitude of natural disasters including floods in different parts of the world; and flood is indeed a global environmental issue that had destroyed lives and property amidst other untold hardships. The study examined rainfall characteristics in Warri metropolis for the past 30 years (1986-2015) vis-à-vis the flood situation in the metropolis; as well as the factors responsible and adaptation strategies to flood in the area. Dividing the study area into four zones after Sada (1977), the researchers collected rainfall data from the archives of Nigerian Meteorological Agency; 268 copies of questionnaire and oral interview were used. The result of the correlation analysis performed showed a negative relationship of -0.156 between rainfall and time (years), this implies that rainfall is decreasing over time. The trend line regression equation Y=243.75-0.4572X, confirms that rainfall in Warri Metropolis is decreasing at the rate of -0.45 per year. However, the p-value 0.412 is greater than 0.05, hence, the trend is not statistically significant at 95% level of confidence. It was discovered that rainfall, absence of drainage and poor urban planning practices (as factor 1) contributed 51.09% while overflowing of rivers, blocked/poor drainage and untarred roads (as factor 2) contributed 44.10% variance to flood occurrence in the metropolis. Recommendations given included continual monitoring and study of rainfall characteristics and other climatic data and dissemination of such information for planning purposes; construction of integrated drainage system and river rechannelisation, legislation against dumping of refuse on roads and drainages; proper urban planning including implementation of the metropolitan urban drainage master plan.

KEY WORDS: Rainfall, flood, climate change, disaster and metropolis

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INTRODUCTION

The earth's climate has not been static since inception but the rapidity, frequency and severity of the consequences of climate change in the last few decades are however, alarming (NRC, 2010). According to Afangideh, et al. (2013), the current and projected manifestations of climate change include global warming (increase in temperature), rise in sea level, shifting of global climate zones, changes in the intensity, quality, duration and general pattern of rainfall leading to drought, desertification, and flooding; melting of glaciers/polar ice and increased incidences and severity of extreme weather events, among other effects.

As different parts of the world experience different types of extreme weather events and disasters, the one that cut across all continents is flood. The term flood as defined by Sada and Odemerh (1988) represents high rate of water discharge which often lead to inundation of land adjacent to stream often caused by intense or prolong rainfall. Zbigniew et al (2013), however went further to describe flooding as overflowing of the normal confines of a stream or other body of water or accumulation of water over areas that are not normally submerged. It could then mean a flow of water over areas which are habitually dry which can be resulted from storm surge, melting of glacier, snow melt or heavy rainfall. Increasing flood risk is now being recognized as the most important threat from climate change in most parts of the world (Afangideh, et al., 2013). This view was equally supported by Bhanumurthy and Behera (2008) which asserted that flood is the most common and widespread of all natural disaster, accounting for about 46% of fatalities.

On the global scale flood is said to regularly claim over 20,000 lives per day and adversely affected about 75 million people (Smith and Ward, 1998). The United Nations Disaster Relief Coordination (UNDRC, 1976) stated that flood accounted for second only to typhoon and tidal waves as causes of mortality. To corroborate this, the study of Efe and Mogborukor, (2010), showed that over 173,000 deaths occurred from various flood occurrences between 1947 and 1970. The European space agency (ESA, 2004) reported further that flood incidences accounted for almost 55% of all disasters in the year 2004, adding that flood incidences have increased by 10-folds in the last 5 decades from only 206 cases in 1990 to about 1,900 incidences in 2005, with each incident having different levels of severity among continents and Asia being the worst hit (Raji, Adeniyi and Odunuga, 2014).

Flooding is a major problem in African cities. According to Action Aid (2006) projection, by 2030 majority of Africa's population will live in urban areas. Climate change will increase the vulnerability level of the urban poor throughout Africa because urbanization aggravates flooding by its paved surfaces which hinder water percolation and hence increase surface runoff.

Nigeria the giant of Africa has witnessed several flood disasters in different parts of the country, both in coastal, inland, rural and urban areas; they include those of Ibadan, Yobe, Akure, Kafachan, Markudi, Lagos, etc. However, the Niger Delta has been recognized by far the largest single area subject to annual flooding in Nigeria (see Fig. 1). This is because of its disposition as flat, low-lying swampy area of alluvial deposition across which the tributaries of the Niger meander, (Agbonkhese et al. 2014).

Flood is arguably the most common and severe natural disaster in the Warri Metropolis like most coastal cities in the Niger Delta, it has become an annual environmental problem during every rainy season. Umuteme and Orusi (2012) reported that in July 2012 over 300 people were render homeless in Warri due to an early morning rain that lasted for several hours (Fig. 1). According to Efe and Mogborukor (2010), the 4th – 6th August 2002 flood in Warri which resulted from rainfall submerged several houses, workshops in the metropolis. It reoccurred in the following years leading to the destruction of properties worth over 3.6 million of naira and rendering over 3,250 people homeless. Other notable incidences of floods recorded in the metropolis included those of 1999, 2000, 2002, 2003, 2005, 2006 and 2007.

Fig. 1. Flood incident in Warri (Information Nigeria 2012)

Since the major causal factor of Warri flood is heavy rainfall as observed above, this study aimed at analyzing the pattern of rainfall characteristics and flood incidences in Warri metropolis with the view to providing lasting solution to flood menace in the city through various adaptive and mitigation strategies that can be adopted to cope with flood challenges in the study area.

THE STUDY AREA

Warri Metropolis is geographically located between 5°30′ N to 5°35′ N and 5°29′ E to 5°48′ E. The study area is bounded to the north by Okpe and Sapele Local Government Areas; to the southern axis by Warri South West and the Atlantic Ocean; to the east, the metropolis is bounded by Ughelli South Local Government Area while it shares its western boundary with Warri North Local Government Area (Fig. 2).

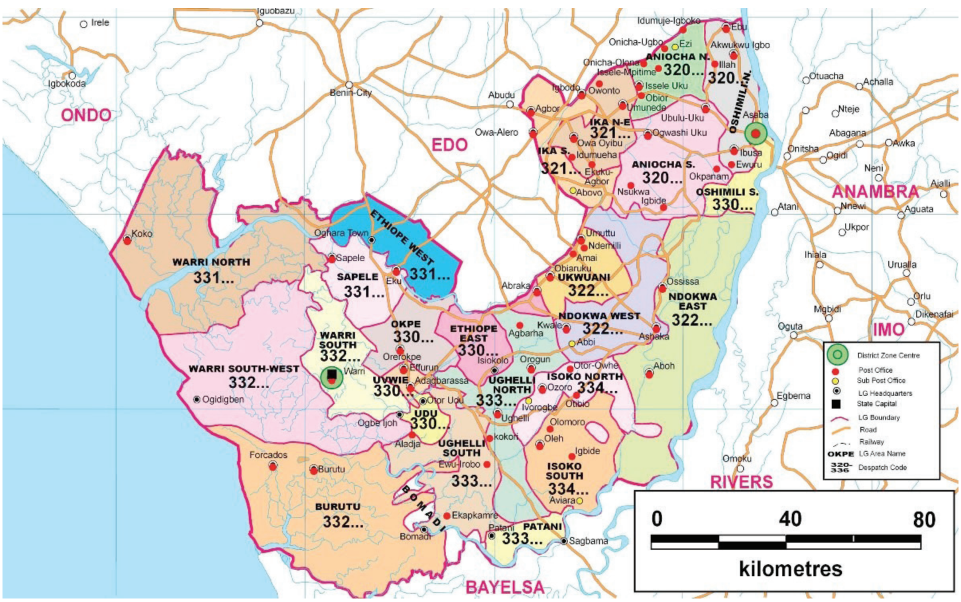

Fig. 2. Study Area (Ministry of Land and Survey, Delta State/Google)

Warri is directly underlained by a quaternary formation, the Somebreiro-Warri Deltaic Plan Sand consisting of fine and coarse-grained unconsolidated sediments – sands, peats, gravel, etc. The rock types that formed the geology of this area are the sedimentary rocks with silty clay and sand on the top (4-6m), followed by a thick layer of about 17m, the silt then become coarse and pebbly at that depth below. Having a flat terrain devoid of hills and mountains, with average height of about 6m above sea level (Olabaniyi and Efe, 2007); the area is traversed by networks of many creeks, rivers and streams all draining water into the Atlantic Ocean.

Warri is characterized with the tropical equatorial type of climate and just like most cities of the Niger Delta is influenced by two air masses namely the southwest monsoon wind and the northeast trade wind. The former is responsible for the long rainy season experienced in the metropolis lasting from March to October. The latter ushers in short dry season in the city which lasts from November to February. The city has an annual total rainfall of about 3000mm and temperature of 280C Mean monthly rainfall value is as low as 20.4mm in January and as high as over 499.1mm in September. Warri city enjoys two rainfall peaks every year. The first is observed in the month of July and the second occurs in September with a short period of dry spell in between termed August break. The metropolis mostly experiences the convectional type of rainfall, with a relative humidity that oscillates between 80%-90% as well as dense cloud cover (Obafemi, et al, 2012; Abotutu and Ojeh, 2013; Aderoju, et al. 2014).

MATERIALS AND METHODS

Rainfall data from 1986-2015 were collected from the Nigeria Meteorology Agency (NIMET), Warri station. Rainfall characteristics used include daily, monthly and yearly amount of rainfall, intensity, frequency, variability, trends, return period and fluctuation of rainfall. Data on frequency of flood incidences was sourced from available literature while questionnaire and oral interview were employed to collect data on residents' perception and understanding of causes of flood in the area and their mitigation strategies.

In order to ensure widest coverage of questionnaire administration, the Warri Metropolis was zoned into four areas. This is taken after Sada's (1977) four physical divisions in most developing cities in Nigeria. Consequently, the four zones-designates Warri Metropolis is divided into for this study were; (a) Government Reserved Areas (GRA)/ Bendel Estate; (b) Warri Core; (c) Effurun; and (d) Udu.

Equal number of respondents (67) was selected from each zone; residents in the 1st street and every 3rd street was systematically picked in this consecutive order in all the zones until the required sample size was derived.

Coefficient of variation was used to determine the percentage deviations in rainfall values for the study period; it showed the degree of variability in the monthly and yearly means of rainfall. To calculate the intensity of rainfall, both yearly and a monthly run of 30 years, the formula below (1) was adopted after Afangideh, et al (2013);

$$\text{Intensity of rainfall}=\frac{\text{annual rainfall amount (mm)}}{\text{annual rainfall duration (days)}} \quad (1)$$

The Simple Linear Regression analysis method was used to determine the patterns/trends of rainfall in the study area. Igweze et al. (2014) and Ologunorisa (2006) had adopted this tool in similar studies. While factor analysis was employed to assess the dominant factors responsible for flooding in the area.

RESULTS AND DISCUSSION

Monthly and Annual Rainfall Intensity in Warri Metropolis

Table 1 shows the monthly rainfall intensity for the period of study, and the results show that the month of July recorded the highest rainfall intensity (21.10mm/d, i.e. per day) in the study area. This result indicates that the month with the highest total monthly rainfall is also the month with the highest rainfall intensity in the study area. The followings were the next highest monthly intensities, the months of September, August and April with 18.95mm/d, 18.18mm/d and 17.02mm/d respectively. On the other hand, the month of December recorded the lowest rainfall intensity (9.61mm/d), followed by the months of November and January with 10.23mm/d and 11.44mm/d respectively (Fig. 3).

Trend/Pattern of Rainfall in Warri Metropolis

The trend in rainfall amount over time was determined using regression analysis (table 3). The p-value for the rainfall slope of 0.412 obtained is greater than 0.05, hence, there is no statistically significant relationship between rainfall and year at 95% confidence level for the 30 years period of study. The R-squared statistic shows that the model, as

Table 1. Case studies and used methods

Months	Rainfall Intensity (mm/d)
January	11.44
February	13.59
March	13.82
April	17.02
May	16.33
June	16.57
July	21.10
August	18.18
September	18.95
October	16.60
November	10.23
December	9.61

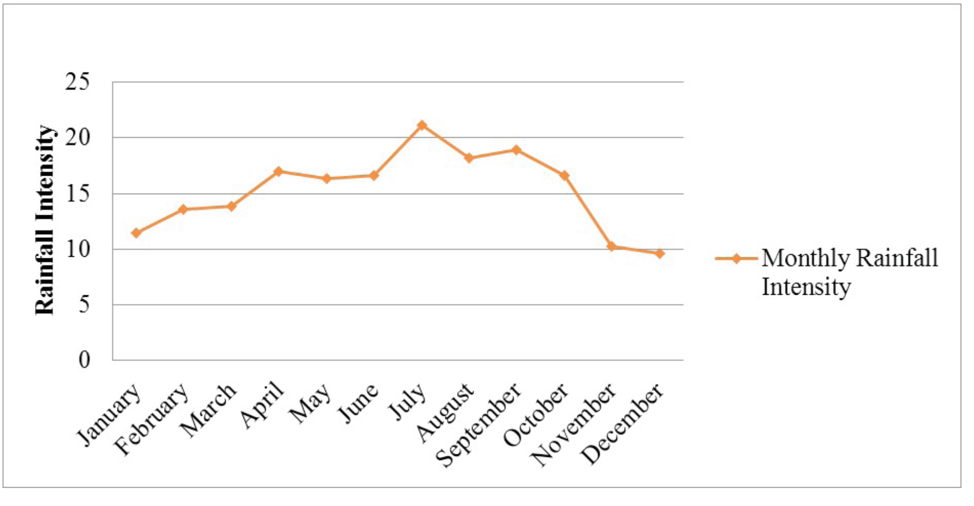

Fig. 3. Mean Monthly Rainfall Intensity in Warri Metropolis from 1986-2015 (Authors' Computation 2017)

Table 2. Mean Annual Rainfall Intensity for the Period 1986-2015 (Authors' Computation 2017)

Years	Rainfall Intensity (mm/d)
1986	19.84
1987	19.28
1988	15.44
1989	15.22
1990	18.82
1991	16.54
1992	18.86
1993	18.09
1994	17.53
1995	20.34
1996	16.13
1997	18.84
1998	16.84
1999	18.81
2000	15.86
2001	15.52
2002	20.74
2003	14.83
2004	18.05
2005	14.10
2006	14.26
2007	16.40
2008	19.19
2009	13.67
2010	15.22
2011	16.36
2012	16.04
2013	12.42
2014	16.84
2015	17.59

fitted, explains 2.40 % variability in rainfall in the study area. The correlation coefficient of -0.156 reveals a negative relationship between the rainfall and time (year). This suggests that rainfall is decreasing over time in the study area. Since the decreasing trend observed is not statistically significant (that is, the trend is random), decrease in the future cannot be categorically predicted or ascertained and the trend cannot be attributed to a particular causative factor in the study area.

Fig. 4 is obtained from the plotting of the mean annual rainfall amount against time. The graph reflects fluctuation in mean annual rainfall pattern of the study area however,

Table 3. Trend/Pattern of Rainfall Derived from Regression Analysis (Authors' Computation 2017)

Variables	Regression Equation	P-value	Statistically Significant	Sample Correlation	R^2
Warri	Y=243.75-0.4572X	0.412	No	-0.156	2.4%

the trend is on the decline since the last three decades. This is further corroborated by a negative trend line obtained. From the trend line equation, it can be concluded that the rainfall amount is decreasing at a rate of -0.45mm per year during the 30 years period under consideration. This method of analysis, according to Ologunorisa (2006) has been used by Sharon (1979, 1981); Adelekan, (1998) and several others in the study of rainfall trends.

Standardize Rainfall Anomalies Index (SAI) was used to establish the dry and wet episodes in the study area for the period of study (table 4). For critical analysis the thirty years under consideration were divided into three periods of ten years (decade) and the number of dry and wet episodes (years) within these ten years period were identified. The results revealed great insight into the nature of rainfall vis-à-vis the seasons (rain and dry) in Warri Metropolis for the past three decades.

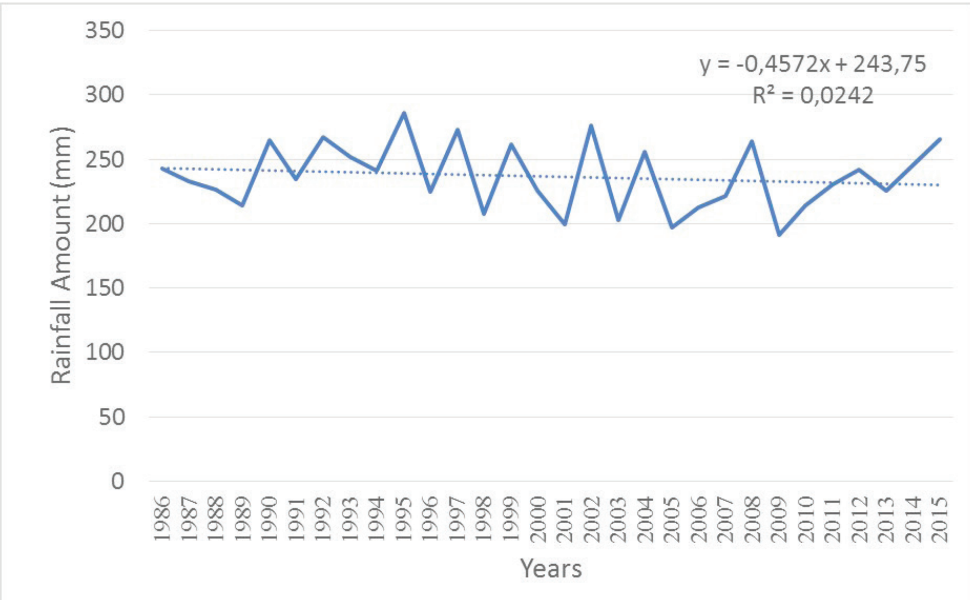

Fig. 4. Mean Rainfall Trend in Warri (1986-2015) (Authors' Computation 2017)

On the whole, there were 16 dry years out of the thirty years period considered in this study. Table 4 further revealed an average of six dry years in every ten years in the last twenty years in the study area. Fig. 5 reveals the pattern of rainfall anomalies in the study area for the thirty years period with the sixteen dry years and fourteen wet years on the negative and positive sides of the graph, respectively.

Implications of the Rainfall Characteristics on Flood Occurrence in the Metropolis

The information on table 5 was used to crosscheck the analyzed rainfall characteristics in the study area to see if there is any relationship between rainfall pattern and flood incidents in the study area. According to Ologunorisa and Tersoo (2006) this method has been used by Babatolu (1996) and they too equally adopted it in similar studies

Table 4. Dry and Wet Episodes in Warri in the last Three Decades (1986–2015) (Authors' Computation 2017)

Periods (Decades)	Dry Years	Wet Years
1986-1995	1987 (-0.14), 1988 (-0.39), 1989 (-0.86), 1991 (-0.09)	1986 (0.24), 1990 (1.10), 1992 (1.18), 1993 (0.58), 1994 (0.17), 1995 (1.93)
1996-2005	1996 (-0.47), 1998 (-1.12), 2000 (-0.41), 2001 (-1.45), 2003 (-1.31), 2005 (-1.52)	1997 (1.41), 1999 (0.97), 2002 (1.54), 2004 (0.73)
2006-2015	2006 (-0.92), 2007 (-0.59), 2009 (-1.75), 2010 (-0.86), 2011 (-0.24), 2013 (-0.43)	2008 (1.05), 2012 (0.20), 2014 (0.35), 2015 (1.10)

**Standard Rainfall Anomalies Indices are italicized in parentheses.

Available flood records (table 5 below) indicate that flood occurs in Warri and surrounding environments only in the months of April, May, June, July, August, September and October. This corresponded with the analyzed monthly rainfall intensity for the study (see tables 1, 2, and Fig. 3) which showed that these months marked the limit of wet season in Warri metropolis. No available flood showed that flood occurred in any of the months with least rainfall intensities, that is, December, November and January; these months with the addition of February equally represented the dry season in the study area.

The flood incidence of August 4th-6th, 2002 (table 5) corresponded with both the annual rainfall intensity and annual mean rainfall in table 2 as the highest rainfall recorded in that year. The year 2002 recorded the highest annual intensity (20.74mm/d) in the study period, and among other causes floods are equally induced by high rainfall intensity and consistent long duration of rains. A look at the daily rainfall amount for the days 4th-6th of August 2002 shows that each day had 144.2mm, 119.8mm and 7.3m respectively, and this individual amount especially the last two have the capacity to generate floods, and Olaniran (1983) confirmed that heavy rains have the capacity to induce

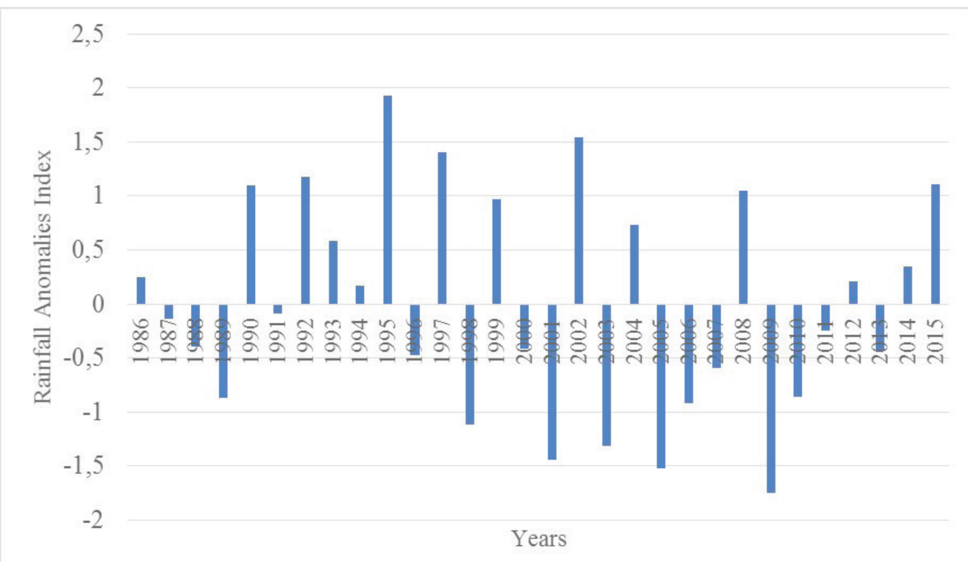

Fig. 4. Pattern of Rainfall Anomalies in Warri, 1986-2015 (Authors' Computation 2017)

Table 5. Chronology of past flood events in Warri metropolis (Authors' Compilation 2017)

SS/N	Date/Year	Location/Area	Cause(s)	Impacts/Effects	Source(s)
1	1999	Warri metropolis	Long and continuous rains	Over 5,000 houses affected	Efe and Mogborukor, (2010)
2	2000	Warri metropolis	Long and continuous rainfall	Property worth millions destroyed, several people displaced	Efe and Mogborukor, (2010)
3	August 4th-6th, 2002	Warri metropolis	Heavy rains	Several houses, shops worth millions of naira were submerged under 1meter floodwater	Efe and Mogborukor, (2010)
4	June, 2003	Warri and its environs	Rains	Property worth over 3.6millions destroyed; over 5,250 people rendered homeless	Efe and Mogborukor, (2010)
5	July, 2005	Warri metropolis	Heavy rains	Unspecified level of destruction	Vanguard, July 2005
6	August, 2006	Warri metropolis	Rains	Several houses, shops, worth millions destroyed	Efe and Mogborukor, (2010)
7	September, 2007	Warri metropolis	Rains	Several houses, shops, worth millions destroyed	Efe and Mogborukor, (2010)
8	July 10th -13th, 2011	GRA Effurun, Orhuwhorun	Heavy torrential rains	Unspecified levels of destruction (affected all southern states including Lagos, where 10 deaths were recorded)	Aderobga (2012)
9	July-October, 2012	Warri (and several other parts of Nigeria)	Heavy rains; Release of Lagdo dam in Cameroun due to excess water from rains there	People were killed and several displaced in the metropolis	Udo, et al (2015); Wikipedia (2016)
	July 12, 2012;	Asheshe layout, Jakpa, Igbudu axis, Mowoe	Heavy rains	Over 300 people displaced	Umuteme and Orusi (2012)
	September 20th, 2012	Several parts of the metropolis	Torrential rains	Property worth millions of naira swept away	Ogoigbe, et al, (2012)
10	May 21st-22nd, 2013	Several parts of the metropolis	Burst of water supplying reservoir/pipe	Unspecified levels of damage	Urhobo Today (Thursday 23rd May, 2013)
11	October, 14th, 2014	3rd Marine Gate, Warri	Heavy midnight rains	Residents trapped for several days; vehicular movements halted	Urhobo Today Newspapers (October, 2014)
12	April 26th; May 10th, 2015	Cemetery road, Warri Stadium	3hours heavy downpour	Submerged many parts of the road, including the Warri City Stadium in which an NNF league match between Warri wolves and Nassarawa Utd were delayed	The Guardian Newspapers (May 11th, 2015)

flood in a place when they occur several times in one month. This also confirms the findings of Ologunorisa and Tersoo (2006) which suggest that extreme daily rainfall events especially heavy rains can result in overland flow. Hence, the ability of these extreme daily rains to have caused flood in the reported days in the area cannot be doubted.

The flood incidences of October 14th 2014; April 26th, 2015 and May 10th, 2015 as shown in table 5 first corresponded with the period high annual rainfall intensities of both years. Secondly the individual daily rainfall amount for the three respective days, that is, October 14th, 2014 with 29.0mm, April 26 2015 with 66.0mm and May 10th 2015 with 62.6mm indicate their capacity to induce floods in the area especially when the accumulative effects of previous days of rainfall amount in the same area as well as other environmental conditions of the metropolis are considered.

In considering the results of decadal analysis (see table 4) available flood records show that flood incidences were reported in 4 of the 14 wet years of 1999, 2002, 2014 and 2015. However, many flood incidences were equally reported even in those years termed 'dry' such as the cases of 2000, 2003, 2005, 2007 and 2011 as shown in table 4. This suggests that dryness is relative, and Warri metropolis is one of the highest rainfall zones in Nigeria having rainy season that last for over 7-8 months. Though there are no available reported cases of flood in some of both the dry and wet years, however, individual daily rainfall events in some of the years have the capacity to induce flash floods.

The flood records in table 4 and 7 however, show that the May 21st-22nd, 2013 flood was caused by damage to water reservoir, water supplying scheme in the metropolis. The implication is that rain may not be the only cause of flood in the area, there are other contributory factors ranging from attitudes of inhabitants, nature of topography and the urban space among others.

Factors Responsible for Flood in Warri Metropolis

To identify the dominant factor responsible for flood occurrence in Warri, eight (8) flood causing variables were identified in the study area and were subjected to factor analysis statistical method. After vari-max rotation, only two (2) factors dominated the explanation of the variance in the flood occurrence experienced in Warri metropolis. **Factor I:** This factor has the highest loading on rainfall, absence of drainage and poor town planning. It is tagged nature of rainfall occurrence and urban design. This has the highest contribution to flood occurrence in Warri. This factor is an index of nature of rainfall incidences and poor urban planning which contributed 51.09% variance to flood occurrence in Warri metropolis. As seen in most cities of Nigeria, the nature of rainfall occurrence and poor urban planning are the major causes of flooding (leading factors). This is as a result of excess rainfall being disrupted from flowing directly to the river channels. In addition, the absence of artificial drainage which is part of poor urban planning play major role in flood incidence.

Factor II: This factor loaded highest on overflowing of rivers, blocked/poor drainage and untarred road, it is tagged river overflow and poor drainage. This factor is an index of poor natural/artificial drainage network management which contributed 44.10% variance to flood occurrence in Warri metropolis. Hence, poor natural (river) and artificial (gutters/culverts) drainage network management combined to form the second most dominant factor of flood occurrence in Warri metropolis. This is in terms of the drainage networks not properly linked, various waste items deposited in the drainage systems that leads to its blockage. Also, the topsoil washed from the untarred road during rain end up in river channel, increased the river sedimentation and caused the river to overflow its bank leading to flood.

The rotated component scores of spatial patterns of factors responsible for flooding in Warri using the two (2) identified factors as criteria is presented in table 6. The table

Table 6. Factors Responsible for Flood Occurrence in Warri Metropolis (Authors' Computation 2017)

SN	Parameters	Factor 1	Factor2
1	Rainfall	0.98	-0.65
2	Overflowing of Rivers	0.549	0.903
3	Nature of Topography	-0.76	0.02
4	Blocked/Poor Drainage	0.141	0.969
5	Absence of Drainage	0.782	0.389
6	Poor Town Planning	0. 902	0.475
7	Untarred Road	0.291	0. 817
8	Impervious Surfaces	-0.824	-0.553
Factor defining Variable		**Rainfall amount& urban design**	**River overflow & poor drainage**
Factor Description		Index of nature of rainfall incidence and urban planning	Poor natural/artificial drainage network management
Total Eigen value		4.087	3.528
% Variance		51.092	44.103
% Cumulative variance		51.092	95.20

revealed that factor I (Nature of rainfall incidence & urban planning) contributed highest to the flooding in Effurun with a factor score of 1.09 and lowest to flooding in GRA with a factor score of -1.23. Factor II (Poor natural/artificial drainage network management) contributed highest to flooding in Warri core with a factor score of 1.12 and lowest to flooding in GRA with a factor score of -0.82.

The study revealed that the month of July had the maximum monthly rainfall intensity of 21.10mm/d while the least monthly intensity was recorded in December (9.61mm/d). The yearly analysis shows that year 2002 observed the highest annual rainfall intensity of 20.74mm/d while the year 2013 was found to have the lowest annual rainfall intensity of 12.42mm/d for the study period.

Trend analysis revealed the R2 statistics of 02.4, and this is able to explain about 2.40% of rainfall variability in the metropolis. The correlation coefficient shows -0.156 which indicates a negative relationship between rainfall and time (years). This means that rainfall is decreasing over time in Warri metropolis. From the trend line regression equation Y=243.75-0.4572X, it can be concluded that rainfall in Warri Metropolis is decreasing at the rate of -0.45 per year. However, the p-value 0.412 is greater than 0.05, hence, the trend is not statistically significant at 95% level of confidence, that

Table 7. Rotated Component Scores of Factors Responsible for Flooding in Warri Metropolis (Authors' Computation 2017)

Zones	Factor I	Factor II
GRA	-1.2365	-0.8291
Warri Core	-0.2882	1.12426
Effurun	1.09826	-0.8565
Udu	0.42641	0.56132

is, the trend is random. By implication, future decrease in rainfall amount in subsequent years in the metropolis cannot be assured.

Factorial analysis of some identified factors responsible for flood in Warri showed that rainfall, absence of drainage and poor urban planning practices (as factor 1) contributed 51.09% while overflowing of rivers, blocked/poor drainage and untarred roads (as factor 2) contributed 44.10% variance to flood occurrence in the metropolis. By implication these two factors explained 95.19% of all flood occurrences while the 4.81% could be attributed to impervious/concreted surfaces, nature of topography and every other possible factor as causative agents of flood in Warri and its environs.

CONCLUSION AND RECOMMENDATIONS

The rainfall situation in the area as well as other climatic variables should be continually studied and monitored since they have major effects on flood occurrence and frequency, and such information should be made readily available to the urban planners, road engineers and other concerned professional and individual alike in the metropolis for effective planning purposes.

The management of flood starts with available of relevant data/information relating to its history, remote and immediate causes, impacts, frequencies, etc, therefore, it is recommended that concerned government agencies, ministries and parastatals both at the federal, state and local levels especially the Ministries of Environment and Works; National Emergency Management Agency (NEMA) and the Delta State Emergency Management Agency (DESEMA) should keep comprehensive record of flood incidences, and such records should be updated periodically.

The Delta State environmental laws should be reviewed and updated and check to see if there is a legislation against dumping of refuse on drainage channel and on roads. If there is none then it should be incorporated, modalities of its implementation and punishments for defaulters be clearly spelt out. Most importantly is the strict enforcement of such legislation because most several environmental laws do not go beyond the paper works.

Proper urban space planning and management is vital to controlling flood in any place, therefore, it is important that Delta State Ministry of Lands, Survey and Urban Development and any other relevant governmental body should rise up to the challenge of ensuring strict compliance with the original Master Plan of the Warri Metropolis. Ensuring enforcement of existing town planning laws and constant monitoring of the urban space is needed to prevent activities like unauthorized development, the practice of citizens changing residential structures to commercial and vice versa, erecting of structures on flood prone areas, among others. Furthermore, as matter of urgency, it is very imperative for relevant government authorities to implement the Urban Drainage Master Plan of Warri Metropolis immediately.

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