Urban Development and the Increasing Trend of Flood Risk in Gombe Metropolis, Nigeria

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Abstract: ***The world's population is quickly becoming more urbanized as the world witnessed a rapid urban population growth. Gombe Metropolis being one of the urban areas of Nigeria suffers the consequences of frequent annual flooding causing an unpropitious effect on the populace in many parts of the metropolis. These urbanization dynamics has led to a rapid urban growth through conversion of vegetated cover, open spaces, farmlands and bare lands into the built-up environment. As a consequence flood risk in the city has been increasing in recent years and approaches and efforts by both public and government to control and mitigate the flood risk have not been fully successful. Thus, this paper strives to examine and estimate the urban development variables influencing the increasing flood risk and the frequency of floods in Gombe Metropolis. Basically, field survey such as questionnaire survey, correlation, and regression analysis was carried out to find answers to the research problem. The result obtained from the questionnaire survey was utilized to establish a statistically relationship between flood risk, and the set of independent variables including social vulnerability factors, geographical factors and urban development factors using Spearman's Correlation and Multi-Linear Regression model. The paper was able to reveal that urban development dynamics are responsible for the seasonal floods and the increasing flood risk in Gombe Metropolis. The most important variables influencing flood risk are poor flood control measures, inadequate and narrow drainage facilities, lack of obtaining building plan approval, poor housing type as well as poor management of solid waste.***

Keywords: Urban Development, Flood Risk, Gombe Metropolis, Vulnerability and Multiple Regression.

1. Introduction

The magnitude and frequency of occurrence of flood disasters and the impact on lives, properties, and the environment necessitate the need for sustainable flood risk management globally so as to mitigate the impact on the persistence of town and cities all over the world. It is estimated that on the average almost 200 million people in more than 90 countries are exposed to catastrophic eventualities of floods every year and it is expected to rise due to climate change effects and the steady impact on the population as well as of urbanization in the future (United Nations/ New Partnership for Africa's Development (UN/NEPAD), 2006). In recent years, there has been also an alarming rise in economic and social losses due to flooding in Nigeria.

Flood risk is defined as the probability of inundation of an area by unexpected rise of water due to dam failure or extreme precipitation with long duration and intensity in which life and properties in the affected area are under risk (Nyarko, 2000). Davidson (1997) and Wisner *et al.*, (2004) characterized disaster risk in terms of the following components or concepts; hazard, exposure, vulnerability and capacity measures. Since risk is a product of three major concepts, namely, 1) hazard, 2) exposure and the 3) vulnerability of element at risk, and all approaches must aim at measuring risk and vulnerability through selected comparative indicators in a quantitative way in order to be able to compare different areas or communities.

Therefore, flood risk hazards are generated by two systems, the natural environment (hazard and exposure) on the one hand and the nature of local human activities on the other (vulnerability). Some researchers argue that global warming and climate change are directly and or indirectly increasing the volume of precipitation (rain and ice melting) and as a consequence, the magnitude of the runoff increases. Apart from precipitation, several other natural factors influence the generation of surface runoff which eventually leads to floods and these includes: geological features, land use, topography, soil characteristics, vegetation, and hydrological aspects.

However, others argued that, human activity affects the nature of the physical environment and that the environment is only responding to these actions (Daniel, *et al.,* 2012). Man-induced factors includes human activities such as poor planning of the physical environment, poor management of wastes, inadequate drains, dumping of refuse, erecting of constructions on flood plains and other inappropriate actions that interfere with the free flow of water.

In recent time, empirical works have shown a significant link between urbanization and flooding. This is because the volume of runoff is governed primarily by infiltration characteristics and is directly related to the percentage of an area covered by roofs, streets, and other impervious surfaces at the time of hydrographic rising during storms (Derek, 1991). Mwape (2009) argue that the cumulative impact of human activities without regard for nature has turned floods of recent time from a natural phenomenon into a man-induced disaster. The problem is even more critical in developing cities where there is poor control over land use practices within floodplains and an inadequate institutional mechanism to enforce floodplain ordinances (Daniel, et al., 2012).

Urbanization is a major factor in the growth of vulnerability, especially among the lower income families living in floodplains and areas liable to flooding (Daniel et al., 2012). Urban development in terms of population increase through natural increase and immigration, infrastructural development, socioeconomic, inherently creates the probability of flood risk especially among the urban poor. Due to the fact that floodplains encroach and vegetation covers are dislodged and where these changes are not met with complementing spatial planning and management measures, other issues such as high risk of disaster such as flooding is unavoidable, particularly in the floodplain areas (Adewumi, 2013). Therefore, contrary to old assumptions that natural factor is the sole factor for flooding, recent research works have discovered that human activities is the most important causative factor for flood risk in many urban towns including Gombe Metropolis, where indiscriminate clearance of forest and vegetation, erecting buildings on the floodplains, poor infrastructural development and population explosion, have no doubt increased the problems of flooding in the metropolis.

Gombe Metropolis has experienced a demographic explosion that generates a high population pressure on land and the subsequent urban developmental processes, especially the increasing number of building structures on the floodplains areas and thereby exposing the urban poor to flood risk vulnerabilities (Daniel et al., 2012). These series of infrastructural growth and urban development in Gombe significantly brought changes in the population, land use/ land cover and the urban development as a whole leading to a massive transformation of forest and the savannah vegetation areas into the built-up environment to accommodate the increasing population. This brings urban poor closer to a vicious circle of poverty and suffering of all sorts of woe and misery due to frequent occurrences of floods and its consequences on the metropolitan communities.

Finally, one has to agree, that the aspects of urban development processes in terms of economic development and population pressure, the changes in a society, the growing imbalance between nature and man and the structural problems of the urban administration in Gombe Metropolis result in the reduction of the overall carrying capacity of nature and leading towards unsustainable development. Approaches and efforts by both the public and the government to control and mitigate the flood risk have not been fully successful. Therefore, it is based on this background that this paper aims at assessing the flood risk and to query whether these seasonal flood events that affect areas of Gombe metropolis and the damage they caused originated from the typical natural savanna climate or are the product of an ecologically un-adapted urbanization process in Gombe metropolis.

2. Study Area

Gombe Metropolis was designated as the Gombe State Capital City in 1996 and is relatively located at the heart of Gombe state and it shares a boundary with Akko, Yamaltu Deba and Kwadam Local Government Areas. It is absolutely located at Latitude 10^0 8^1 and 11^0 23^1 N and Longitude 11^0 20^1 and 10^0 24^1 E (Gombe State Ministry of Land and Survey, 2003). Virtually all the rivers and streams flow from the Akko escarpment in the west and truncated at the mid-streams sections of the metropolis towards eastwards. Increasing rate of erosion and floods has led to a creation of gully erosion and active gully heads within the central part of the metropolis where seasonal floods are common. Gombe Metropolis is basically a tropical continental wet and dry climate. The wet season occurs from April to October with average annual rainfall of 650-1000mm. The relative humidity can reach up to 94 percent in August but declined to 10 percent during the harmattan period (Daniel, et al., 2012).

3. Methodology

The scope of the study is the entire Gombe Metropolis, with a total population of 312,467 people. However, the target population consists of a total of 1929 households within the flood-prone areas in each residential areas of Gombe metropolis. Thus, to select the sample, multi-stage, random and systematic sampling procedure was adopted to collect data from the subjects of the study. The metropolis was clustered into eleven residential areas (strata) of Pantami/Madaki, Barunde, Checheniya, Malam Inna /Unguwa Uku/Arawa/Kagarawal (MUAK) Dawaki, Jekadafari, Herwagana, Jankai, Tudun Wada, Bolari and New Planned Area (Federal Low cost). Thereafter, thirteen percent of the total households are used as a sample size and subsequently, 23 households were selected from each of the eleven residential areas making a total of 251 respondents. Applying a systematic random sampling, the sampling fraction is K=N/n (1929/23=5).

To ensure the validity of inferences as well as avoiding bias, the starting point for the selection of units was random. Hence, from the sampling frame, the sampling began by randomly selecting one household among five households from the start and subsequently fifth household is selected in a continual manner until a total of 23 households were selected from each of the eleven respective residential areas in the study areas making a total of 251 cases for the entire study area. Fundamentally, the research instrument adopted in this research is the field survey method such as questionnaire survey method. However, the research used both ordinal and ratio measurement scales. For that reason, the research used the structured weighted close ended questionnaire method, because response can be coded easily and enters into a database such as the Statistical Package for Social Sciences (SPSS). The questions were presented to the households and with alternatives to select according to their own individual views and opinions in a convinced relevant matter and later coded and weighted accordingly. Other ratio scale variables we obtained using GIS analysis. Furthermore, Spearman's Correlation coefficient is employed to measure the relationship between the variables and finally, the Multiple Regression Model was used to estimate the significant variables influencing flood risk in Gombe Metropolis.

4. Result and Discussion of the Analysis

Inferential statistics was fundamentally conducted in order to make a prediction, estimate and to examine whether the relationships exist between flood risk and a set of independent variables and whether it is statistically significant. The analytical method employed includes

Spearman's Correlation and multi-linear regression analysis. The correlation analysis is conducted to show whether the relationship between the dependent and the independent variables exist. The coefficient obtained gives the direction and the strength of the relationship, the scale ranges from plus 1 (positive relationship) to minus 1(negative relationship). Spearman's Rank Correlation measures a correlation where at least one of the variables is an ordinal scale variable and this research adopts the Spearman's Rank Correlation because the variables were measured using both ratio and ordinal scale.

4.1. Urban Development Dynamics

The Spearman's Rank Correlation was run in SPSS software to determine the relationship between flood risk and the independent variables. The correlation matrix Table 1 gives the Spearman's Correlation Coefficients of the variables under study.

Table 1: Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
F_R	1.00												
R	-.034	1.00											
E_l	-.108	-.101	1.00										
P_{fa}	-.012	-.121	.145*	1.00									
P_f	.121	-.247**	-.680**	-.031	1.00								
B_d	-.007	.668**	-.269**	- .130*	-.359**	1.00							
R_{dm}	623**	.198**	.138 *	-.045	-.169**	.127*	1.00						
D_f	-.763**	.248 **	-.002	.007	-.095	.148	-.611**	1.00					
B_{pa}	-.637**	-.188**	.174**	.003	-.042	-.226**	-.467**	.547	1.00				
R_w	.098	.097	-.385**	-.132*	.355**	.083	.007	.010	-.070	1.00			
H_t	.673**	-.345**	.071	.034	.125*	-.284**	.504**	-.846**	-.393**	-.026	1.00		
I_n	056	.006	.200**	.009	-.008	-.114	.021	.016	.020	-.092	-.013	1.00	
Fcm	.758	-.014	- .098	-.061	.948	.086	.640	-.785	-.718	.102	.635	.016	1.00

p>.10 Correlation is insignificant at .10
*P< .05. Correlation is significant at .05
**p< .01 Correlation is significant at .01
Source: Compiled by the Author, 2016

The dependent variable, Flood Risk (F_R) was measured as flood frequency in the various residential areas of Gombe Metropolis once in a year ranked as 3, once in two years ranked 2 and flood frequency once in more than two years ranked 1. The independent variables includes, average annual rainfall (R), elevation(E_l), proximity to flood plains (P_f), percent floodable area (P_{fa}), building density (B_d), refuses disposal methods (R_{dm}), drainage facility (D_f), building plan approval (B_{pa}), housing type (H_t), monthly income (I_n), adaptive capacity (A_{dc}) and road right of way (R_w).

The correlation coefficient in table 1 for rainfall, elevation, proximity to flood plains, building density and monthly income shows a marginal negative correlation with flood risk. It means an increase in one of the above variables, the flood risk decreases on average. Furthermore, the values of Spearman's Correlation Coefficients for all the above variables are statistically insignificant, because their p. values are greater than 0.05 significant levels. By implication, these variables cannot make a meaningful contribution in the regression model. For this reason, they are excluded from the regression model analysis. However, refuse disposal methods, drainage facilities, building plan approval, housing type and adaptive capacity (flood control measures) are statistically significant and are included in the regression model.

A further analysis using standard multiple regression was carried out using the statistically significant variables disclosed by the Spearman's Correlation Analysis, so as to estimate (predict) flood risk (dependent variable) and to determine the important factors (Independent Variables) responsible for flood risk in Gombe Metropolis statistically. Regression analysis is essential and necessary for cause-effect studies.

Table 2: Flood Risk Models Summary

Flood Risk			
Variables	β	SE	βeta
Constant	2.086	.297	
Refuse Disposal Method	.106**	.037	.134**
Drainage Facilities	-.169**	.064	-.206**
Building Plan Approval	-.359**	.094	.201**
Housing Type	.139**	-.054	.172**
Adaptive Capacity	.141**	.036	.274**
R	.829		
R^2	.688		
Adjusted R^2	.681		

Standardized regression coefficients are displayed in the table.
*p<.05
**<p.01
Source: Compiled by the Author, 2016

Table 2 accounts for the overall model and it shows that the model has successfully predicted flood risk. The 'R' represents the multiple correlation coefficients and is a measure of the quality of the prediction of the dependent variable and a value of 0.829 in this research indicates a good level of prediction. In the model summary, there is a total of five independent variables. On the whole, the r-square (R^2), which is the proportion of variance in the dependent variable that can be explained by the variation in the independent variable. Table 2 shows that the r-square

(R^2) is 0.688, explained that the five variables account for 69 percent of the variation of flood risk in Gombe Metropolis, and the remaining 31 percent can be explained by other variables which this research did not study.

The unstandardized values labeled (β slope) make it possible to predict flood risk by the independent variables. Table 2 further shows that an increase in refuse disposal method, the flood risk goes up on average by 0.106 in Gombe Metropolis. This is statistically significant at 0.05 levels. By implication, an increase in the current disposal method increases flood risk on average. The reason behind it is that the waterways such as the drains, gullies, rivers and stream are heavily used by many residents in Gombe Metropolis for disposal of household refuse and solid waste. In effect, waterways are clogged with solid material and this reduces the capacity of waterways in discharging runoff in rain season causing floods in the metropolis. Therefore, since these disposal methods continue, the more the flood risk persists in Gombe Metropolis.

Also, the table 2 shows that increase in availability of drainage facilities, the flood risk goes up on average by 0.169 and statistically significant at 0.05 significant level. In addition, the basic flood control measures in Gombe Metropolis is primarily a construction of structural drainage concrete lining along the natural drainage alleys and most of them are very narrow to hold the volume of water is discharged from the upstream areas of the metropolis as seen above. This led to the subsequent overflow the bank site of the constructed drainage channels and this causes an increase of the impact of floods, hence, the positive correlation coefficient.

The model estimation of the unstandardized coefficient (β slope) for Building Plan Approval shows a negative value of -.357 and is significant at 0.05 P. value. The result means that as each additional unit of one person acquires building plan approval before building constructions; the flood risk reduces by 0. 357 on the average.

The model also found a positive value for housing type (β slope), showing that, an increase in the number of type of housing increases the flood risk on the average by 0.139 and is statistically significant at .05 level (two-tailed). By implication an increase in the current type of material used for building construction increases the probability of flood risk in Gombe Metropolis. Basically, the type of housing built is with earth/mud, hence, it increases flood risk.

Finally, an increase in adaptive capacity (flood control measures) increases the flood risk on the average by 0.141. The current flood control measures in Gombe Metropolis are fundamentally temporary planting of protective plants, constructions of wall stones and sandbag embankments on a micro level. This result shows a need for macro-flood control measures such as the construction of retention basin, infiltration trenches and unstructural measures like land use planning through the removal of building on flood plains.

The standardized coefficient (βeta) measures how many standard deviations, the dependent variable varied with an increase of one standard deviation of the independent variable. According to the coefficient (table 2), the most important variable influencing flood risk in Gombe Metropolis is adaptive capacity (flood control measures) with a coefficient of .274, followed by Drainage facilities efficiency, building plan approval, housing type and refuse disposal method with -0.206, -0.201, 0.172 and 0.134 coefficients respectively.

4.2. Climatic Factor Dynamics

Rainfall and temperature are the most important variables for flood studies because precipitation is one of the components for rainfall-run-off relationships. To determine the long-term trend in annual rainfall and the increasing flood frequency in Gombe Metropolis, variations in the annual rainfall time series data for at least 31 years was obtained to study the past floods events in Gombe Metropolis. Gombe Metropolis mean annual precipitation for 1985 to 2015 ranges from a minimum of 34.9 millimeters (mm) to a maximum of 114mm with a mean overall average of 81.

Furthermore, figure 1 illustrates the rainfall time series data from 1985 to 2015 and the trend basically shows a decrease in rainfall in the overall data. The highest amount of rainfall was recorded in 1994 and the lowest was in 2012.

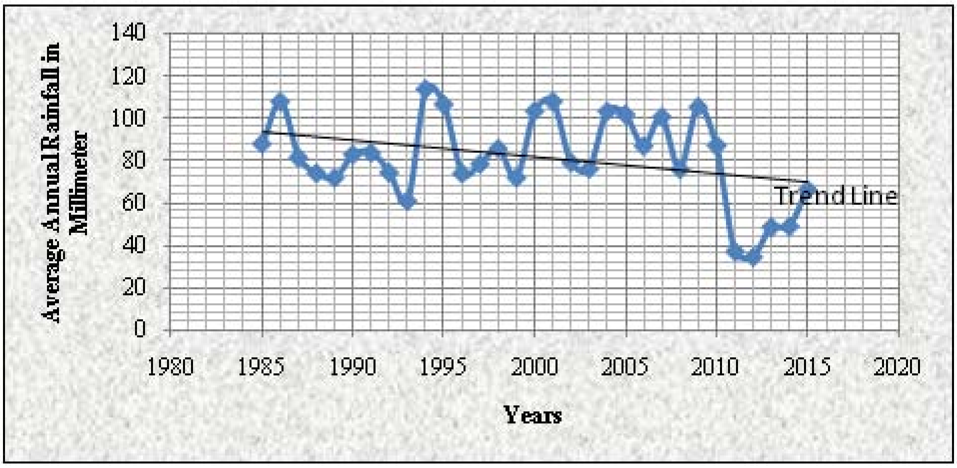

Figure 1: Gombe Metropolis Mean Annual Rainfall in 1985-2015
Source: Compiled by the Author, 2016 and Federal Ministry of Aviation, 2015

Fundamentally, the climate shows a general decrease in rainfall variation during these periods. However, flood frequency remains steady annually as experienced and asserted by the residents. In fact, the frequency of flooding in Gombe Metropolis does not seem to be as a result of climate change, because the trend of the mean annual rainfall in most of the years is below the average and flood frequency and extent in the metropolis keep on increasing as shown in figure 1.

5. Conclusion

The paper was able to reveal that urban development dynamics are responsible for the seasonal floods and the increasing flood risk in Gombe Metropolis. The most important variables influencing flood risk are poor flood control measures, inadequate and narrow drainage facilities, lack of obtaining building plan approval, poor housing type and poor management of solid waste.

Therefore, to move towards a sustainable flood risk management in the metropolis, there is need for a macro flood control measures such as retention basin, a comprehensive drainage channel that can cover the entire metropolis, strict implementation of building plan codes, improve the livelihood of the vulnerable flood communities and a comprehensive working refuse disposal methods.

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