# Analysis of the Relationships of Urbanization dynamics and Incidences of Urban Flood Disaster in Gombe Metropolis

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**Abstract**
The purpose of this study is to critically analyze the relationships of urbanization dynamics and incidences of flood disaster in Gombe metropolis, Nigeria. Flood is a peculiar phenomenon to cities, urban centers and villages that lie along major rivers, delta regions and coastal areas. Generally, it is attributed to global warming, climate change, ocean swell/surge and torrential rains. Gombe is a landlocked town which lies within the savannah region of Nigeria. Ironically, there has been a phenomenal increase in the incidences of flood in Gombe over the years. In this research work, the survey research design was used to obtain data from the field. Stratified sampling technique was adopted in determining the study sample which consisted of 250 households (i.e. 13% of the population, consisting of 1,923 households in flood prone areas of the metropolis). 250 questionnaires were administered to household heads in the study area; however, only 237 questionnaires were retrieved and used for analysis. Spearman's rank correlation and multiple linear regressions were used in the analysis of the data collected. The study showed that urbanization dynamics is the major factor responsible for flood incidences in Gombe metropolis ($r = 0.805$, $P = 0.000$). It was recommended among others, that effective countermeasures to combat the issue of flood in the study area require the contribution of all stakeholders. The town planners and property developers, supported by the legislative and executive powers, should direct the urban development in Gombe and also intervene in the urbanization process with the aim of achieving ecological sustainability.
**Keywords:** Urbanization, flood, urbanization dynamics, disaster, sustainability

## 1. Introduction

Floods by nature are complex events caused by a range of human vulnerabilities, inappropriate development planning and climate variability. Generally, it is attributed to global warming, climate change, ocean swell/surge and torrential rains. Although flood hazards are natural phenomena, damage and lose from floods are mostly the consequences of urbanization without corresponding infrastructural restructuring (Brooks, 2003). Normal floods are expected and generally welcomed in many parts of the world as they provide rich soil, water and a means of transport, but flooding at an unexpected scale and with excessive frequency causes damage to life, livelihoods and the environment. Hence, a solution to curbing this menace, will mean saving of millions of lives and properties. Over the past decades, the pattern of floods across all continents has been changing, becoming more frequent, intense and unpredictable for local communities, particularly as issues of development and poverty have led more people to live in areas vulnerable to flooding. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change IPCC (2007) predicts that 'heavy precipitation events, which are very likely to increase in frequency, will augment flood risk'.

The problem of flood in Nigeria and particularly in Gombe has spanned over a long period, and is associated with many factors. Among these factors are the increase in population and rapid urbanization aggravated by urban sprawl, unplanned development, overgrazing, and excessive land cultivation. The town, which lies at the western side of Liji hills on the Akko escarpment, is facing threats from drainage problems. However, in spite of efforts made by Government, Individuals, Non- governmental organizations and International donor agencies, the problem of flood is increasing rapidly in Gombe.

The world Bank, in its effort to assist the state fight against the menace of flood in the year 2000 embark on the construction of drainages in GRA, Pantami, Madaki, Yelwan Bogo /BCGA, Sabon Layi and

Herwagana. In 2005/2006 SARPLAST was awarded the contract for the construction of drainages in: FMC road/Federal Lowcost/Checheniya and Buba Shongo/Jekadafari/Kumbiya-kumbiya. Despite all the effort stated above, the problem still persists. The major purpose of this study is to identify the major cause of flood in the study area, through a critical analysis of the relationships of urbanization dynamics and the incidences of flood in the study area. The paper is divided into six sections: The introduction, review of related literature, study area, methodology, results /discussion and lastly conclusion/recommendation.

## 2. Related Literature

Flood disaster is defined here in terms of risk to humans and human society, and is seen as a product of the severity and probability of occurrence of flood hazard and the vulnerability of the population/system (Brooks, 2003). Vulnerability is shaped by a combination of physical, social, economic and environmental factors. In the past, physical aspects of vulnerability - the spatial distribution of populations and infrastructure in relation to flood hazard - tend to receive more attention in hazards research (Hilhorst, and Bankof, 2004)). But there is now increasing recognition given to the social aspects of vulnerability. Flooding, as one of the most frequent and widespread of all environmental hazards and of various types and magnitudes, occur in most terrestrial portions of the globe, causing huge annual losses in terms of damage and disruption to economic livelihoods, businesses, infrastructure, services and public health. Long term data on natural disasters suggest that floods and wind storms have been by far the most common causes of natural disaster worldwide over the past 100 years (Few et al, 2004). According to the International Federation of Red Cross and Red Crescent Societies, in 10 years from 1993 to 2002 flood disasters affected more people across the globe (140 million per year on average) than all the other natural or technological disasters put together (IFRC, 2003).

A review of climate change impacts on urbanization by the international institute of environment and development (Huq et al, 2007) found that floods are already having severe impacts on cities, smaller urban centers and rural areas in many African Nations. Examples cited include floods in Mozambique in 2000, heavy rains in East Africa in 2002 that brought floods and mudslides and forced tens of thousands to leave their homes in Rwanda, Kenya, Burundi, Tanzania and Uganda (Huq et al, 2007).

Table 1: Types of floods

| Type | Duration | Characteristic impacts |
|---|---|---|
| Predictable, regular flooding . | Up to 3 months . | Blocks access. Damage and displacement of population often relatively low depending on levels of protection. |
| Increased size of regular flooding | Up to 6 months | Blocks access to many areas. Greater potential for infrastructure damage, livelihoods impacts, and large displacement of population |
| Flash flooding . | A few days to weeks | Rapid cresting often with little warning. High velocity flood flows can destroy infrastructure. Population displacement often localized. |
| Urban flooding . | A few days to weeks . | Can be rapid-onset, often coming from flash floods in urban rivers or from saturation or blockage of urban drainage systems. Potential for infrastructure damage affecting larger service area. Population displacement often localized. |
| Coastal flooding | A few days | Often combined with wind damage from storms. Damage and displacement along coastline with extent depending on storm size. |
| Slow-onset from | 3-6 months Blocks access. | Depending on season, damage to crops may be significant. Population displacement limited and may be dependent on food security |

Adopted from McCluskey, 2001

With an increasingly urbanizing world, flood disasters are reportedly increasing in urban areas and particularly negatively impacting on poor people and urban development in general (Alam et al, 2008). The magnitude of disaster is not determined by floodwater alone but also by the pattern of vulnerability in which people live. The lives and livelihoods of many poor people are hardest hit by floods. Henderson (2004) and Satterthwaite et al (2007), asserted that the level of risk and vulnerability in urban areas of developing countries is attributable to socio-economic stress, aging and inadequate physical infrastructure. Nigerian urban areas are typical examples of this high level of risk and vulnerability (Olorunfemi, 2008). Many risk problems sit at the interface of the natural and social environment, such as flooding, which occurs as the result of the inadequate provision and maintenance of drainage systems, the location of people on marginal sites, and the physical characteristics of an area (Olorunfemi, 2008).

Sultana, et al (2007) asserted that structural measures like embankments can provide protection against many types of flooding. In South and South-east Asia, flood-proofing measures includes raising the plinths or foundations for homesteads, flood shelters and schools (DEC, 2000; Kent et al, 20004). In Bangladesh, one measure that has proved effective is keeping space for livestock in flood shelters (DEC, 2000).

## 3. Study Area

The study area is Gombe metropolis, it is located on latitude $10^{0}$12'N and longitude $11^{0}$10'E. The LGA has an area of 52 km² and a population of 266,844 according to 2006 population census (NPC, 2006), today the population is projected to be 399,531 using 3.2% growth rate (National Population Commission Gombe State Office). Gombe state was created out of the then Bauchi state in 1st October 1991 with its headquarters situated in Gombe. The state is located between latitude 9°30' and 12°30'N and longitudes 8°45' and 11 °45'E of the Greenwich Meridian. It share common borders with Borno,Yobe, Taraba, Adamawa and Bauchi states. Gombe has two distinct seasons, the dry season (November-March) and the rainy season (April-October) with an average rainfall of 850mm. A large part of the existing town is at the foot of the Akko escarpment and on a shallow dish-like site. However, there is a westward expansion of the town up-hill the escarpment.

Fig. 1: Map of Nigeria showing Gombe State

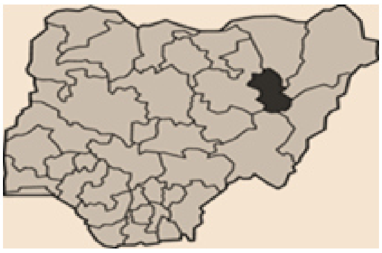


Fig. 2: Map of Gombe State showing the study area

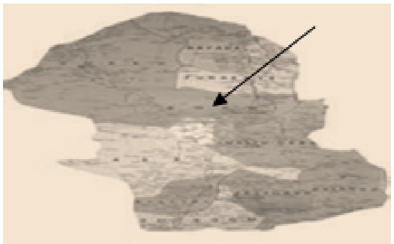


Fig. 3: Map data showing Gombe town


Fig. 4: Map showing overview of Gombe metropolis

## Method

In this study, the survey research design was used to collect data from the study area. The targeted population for this study consisted of 1,923 households in flood prone areas in Gombe metropolis. 13% of the population was used as sample size. The stakeholders involved cut across civil servants, business men/women, and farmers. The sampled areas included: GRA, Pantami, Burundi, Checheniya, Federal lowcost, Jekadafari, Herwagana, Jankai and Tudun Wada. The stratified sampling technique was adopted for sampling. Two sources of data i.e. (primary and secondary) were used to collect data from the study area. Primary Source; these data were sourced from the field through personal observations, structured and unstructured interviews, as well as a structured questionnaire (250 questionnaires were administered to family heads in the study area; however, only 237 questionnaires were retrieved). Secondary Source; these are data sourced from documented materials. The study involves two variables i.e. the criterion variable (flood) and the predictor variables (urbanization dynamics). Simple statistical tools such as tabulation, percentages and charts were used in the analysis of the collated data. Spearman's rank correlation and multiple linear regression analysis were also carried out to determine the relationship between the criterion and predictor variables.

**Results and Discussion**

Gombe is blessed with natural gullies that have presently metamorphosed into streams Fig. (5), the sizes of these gullies are wide enough to accommodate any storm water and runoff from drains down to the river outside the town. Besides, the nature of soil in the upper region of the escarpment is soft and sandy and can easily permeate or infiltration rainwater. Nevertheless, due to urban sprawl, that has encouraged residential development and hard surfaces; the vegetation cover is displaced, thereby reducing the chance by which rainwater could infiltrate into the soil. Furthermore, Individuals build rampantly without control even on drainage channels (see fig. 6). These aggravates flood problem in Gombe.

Fig. 5: Gullies in Gombe

Fig. 6: Buildings on drainage channels

Table 2: Annual/ Monthly Rainfall Figures of Gombe 2000-2011.

| **Month** | **Year** | | | | | | | | | | | | **Mean** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | |
| JAN. | | | | | | | | | | | | | |
| FEB. | | | | | | | | | | | | | |
| MARCH | | | | | | | | | | | | | |
| APRIL | 20.7 | 19.6 | 20.15 | 40.3 | 14 | 66.7 | | 19.5 | 14.7 | | 18.9 | | 26.06111 |
| MAY | 7.5 | 80.7 | 44.1 | 31.6 | 63 | 0.3 | 70.1 | 54.9 | 125 | 147.3 | 122.5 | 73.7 | 68.39167 |
| JUNE | 157.8 | 92 | 124.7 | 107.4 | 66.3 | 148.6 | 144.5 | 118.4 | 109.9 | 136.0 | 144.2 | 117.4 | 122.2667 |
| JULY | 236.5 | 235.2 | 235.8 | 203.9 | 268.5 | 139.3 | 221.3 | 259.4 | 107.3 | 159.6 | 187.4 | 130.2 | 198.7 |
| AUG. | 238.7 | 272.4 | 255.5 | 387.6 | 435.4 | 339.9 | 175.6 | 271.8 | 347.6 | 220.1 | 182.0 | 237.2 | 280.3167 |
| SEPT. | 131.7 | 181.6 | 156.6 | 159.1 | 136.4 | 181.7 | 264.7 | 141.9 | 194.3 | 159.0 | 122.3 | 120.8 | 162.5083 |
| OCT. | 11.3 | 28.9 | 20.1 | 52.8 | 22.0 | 83.6 | 28.9 | | 72 | 67.3 | 64.8 | 76.0 | 47.97273 |
| NOV. | | | | | | 8.2 | | | | | | | 8.2 |
| DEC. | | | | | | | | | | | | | |
| **MEAN ANNUAL RAINFALL (cm)** | **114.88** | **130.06** | **122.42** | **140.38** | **143.65** | **121.04** | **150.85** | **144.3** | **124.83** | **148.21** | **120.3** | **125.88** | **114.3021** |

Source: Federal Ministry of Aviation, Meteorology Unit, Gombe.

Gombe is located within the Sub-Sudan climate zone. It is characterized by two distinct seasons: dry season (November to March) and wet season (April to October). The highest rainfall is recorded in August as shown in table 2 above.

Table 3: Urbanization dynamics

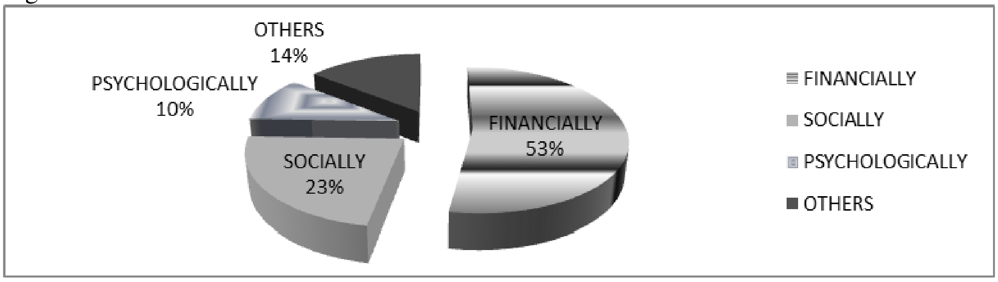
| **Urbanization dynamics** | **Frequency** | **Percent** | **Cumulative Percent** |
|---|---|---|---|
| Lack Of Drainage | 103 | 43.5 | 43.5 |
| Indiscriminate Dumping Of Refuse | 39 | 16.5 | 59.9 |
| Lack Of Good Layout Plan | 44 | 18.6 | 78.5 |
| Lack Of Development Control Measures | 42 | 17.7 | 96.2 |
| Slope/Gradient Of The Area | 9 | 3.8 | 100.0 |
| Total | 237 | 100.0 | |

Source: Field Survey 2011

From the urbanization dynamics in the study area, lack of drainage facilities constitutes the major factor that is causing flood in Gombe (42.5%). Slope and gradient does not seem to cause any significant problem rather, it serves as an advantage to channel flood/storm water away easily down to the river.

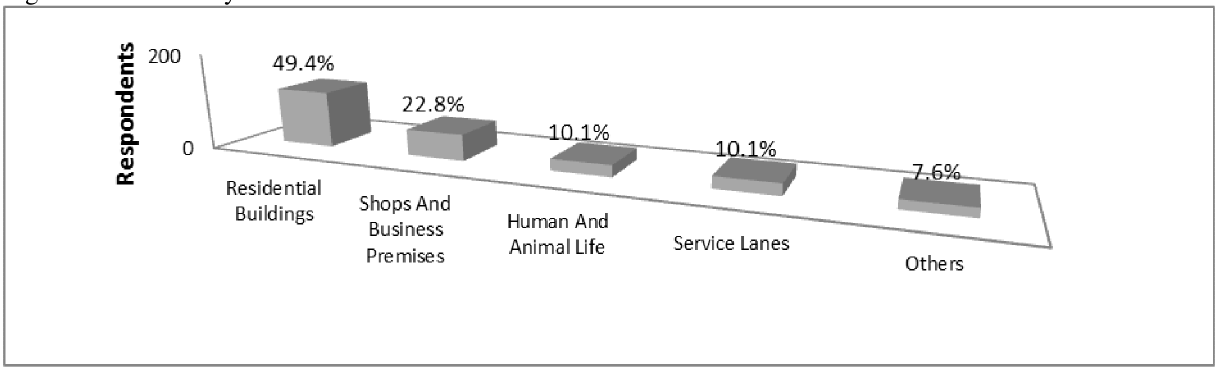
Fig. 7: Effects of flood disaster.




Field survey, 2011

The effects of flood in Gombe metropolis is becoming more worrisome to residents living within the town. Looking at Figure 7 above, the issue does not only affect residents financially, but also socially and psychologically.

Fig. 8: Destruction by flood




Source: Field survey 2011.

Many lives and property worth millions of naira is lost to flood almost every year in Gombe. The August 20th 2004 flood was the worst flood disasters experienced in Gombe. State Emergency Management Agency (SEMA) reports that over 120 people were reported dead, while many houses were swept away completely and several others collapsed. As a result, several thousands of families were rendered homeless. Many shops were destroyed and roadside drainages were blocked by silt and sand. Some roads were rendered impassable as heavy deposits of sand covered everywhere. Vehicular traffic was disrupted for few days. Service lines such as PHCN poles, NITEL lines and Water pipes were badly affected.

Table 4: Flood Frequency

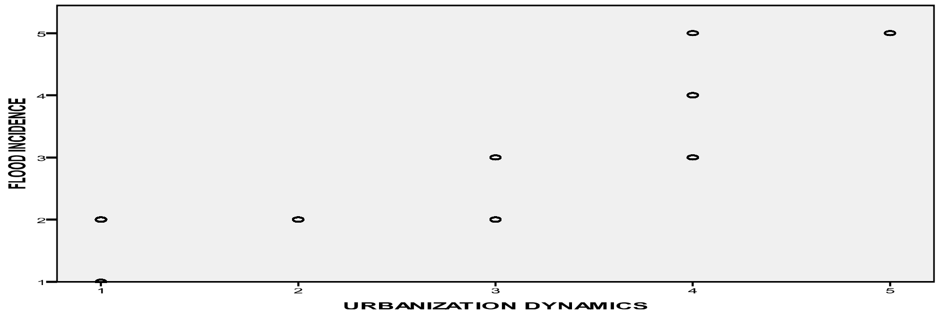
| **Frequency of flood** | **Frequency** | **Percent** | **Cumulative Percent** |
|---|---|---|---|
| Every Month Of The Season | 24 | 10.1 | 10.1 |
| Every Year | 145 | 61.2 | 71.3 |
| Once In Two Years | 34 | 14.3 | 85.7 |
| None At All | 19 | 8.0 | 93.7 |
| Others | 15 | 6.3 | 100.0 |
| Total | 237 | 100.0 | |

Source: Field survey 2011.

Flood incidences have become a perennial problem in Gombe metropolis. Table 5 above shows that every year residents in Gombe metropolis experience flood during the wet seasons. Even though the average annual rainfall figure (850mm) is low, yet every year there is a record of flood incidence. This is a clear indication that, it is not high amount of rainfall that is causing flood in Gombe; rather it is the direct result of negative influence of urbanization dynamics.

Fig. 9 Relationship between Flood Incidence and Urbanization dynamics




The scarttergram above reveals that there is a positive linear relationship between flood incidence in the study area and urbanization dynamics.

Table 5: Correlation analysis

| | | | Urbanization Dynamics | Flood Incidence |
|---|---|---|---|---|
| Spearman's rho | Urbanization Dynamics | Correlation Coefficient | 1.000 | .805** |
| | | Sig. (2-tailed) | . | .000 |
| | | N | 237 | 237 |
| | Flood Incidence | Correlation Coefficient | .805** | 1.000 |
| | | Sig. (2-tailed) | .000 | . |
| | | N | 237 | 237 |

Analysis of survey data, 2011

The correlation coefficient between flood incidence and urbanization dynamics is 0.805 indicating a strong positive correlation. This correlation is significant at the 0.01 level (2-tailed) of significance as indicated by a p value of 0.000.

Table 6: Regression Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .929[a] | .863 | .858 | .374 | .211 |

Analysis of survey data, 2011

Table 6 shows the regression model summary result, which indicates a high positive correlation of 0.929 between the variables. The Durbin – Watson statistic (d) of 0.211 indicates the presence of some degree of positive auto correlation between the variables.

Table 7: ANOVA (Analysis of Variance)

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | 200.557 | 7 | 28.651 | 205.356 | .000[a] |
| Residual | 31.950 | 229 | .140 | | |
| Total | 232.506 | 236 | | | |

Analysis of survey data, 2011

Table 7 tests the overall significance of the coefficients (β's). The results indicated that the overall model is statistically significant, [F (7,229) = 205.356, P = 0.000].

Table 8: Coefficients

| Model | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| (Constant) | .424 | .128 | | 3.315 | .001 |
| Distance Of Property To Drainage | .329 | .062 | .391 | 5.331 | .000 |
| Location Of Residents | -.226 | .078 | -.339 | -2.903 | .004 |
| Availability Of Layout | .014 | .106 | .007 | .133 | .895 |
| Plot Size | .358 | .101 | .410 | 3.555 | .000 |
| Urbanization Dynamics | -.349 | .084 | -.449 | -4.162 | .000 |

Analysis of survey data, 2011

In table 8, the result reveals that, of all the predictors, only availability of layout (t =0.895, p = 0.133) does not significantly predicts flood incidence in the study area. While all the other predictors are statistically significant. The regression equation therefore is:

$Y = 0.424 + 0.329X_1 + (-0.226)\ X2 + 0.014X_3 + 0.358X_4 + (-0.349)\ X5$. *Which can be presented as* $Y = 0.424 + 0.329(DPD) - 0.226\ (LOR) + 0.014(AOL) + 0.358(PS) - 0.349(UD)$.

Where: X1 = Distance of Property to Drainage (DPD), X2 = Location of Residents (LOR)
X3 = Availability of Layout (AOV), X4 = Plot Size (PS), X5 = Urbanization Dynamics (UD)

## Conclusion and Recommendation

Contrary to the general assumption that heavy rainfall is the major cause of urban flooding, the study revealed that urbanization dynamics such as: increasing informal settlements, lack of good drainage facilities, lack of a proper layout plan, indiscriminate dumping of refuse on drainage channels, indiscriminate building on water ways and lack of development control measures are among the major factors responsible for flood in Gombe metropolis.

It was recommended that effective countermeasures to combat the issue of flood in the study area require the contribution of all stakeholders. The town planners and property developers, supported by the legislative and executive powers, should direct the urban development and, if necessary, intervene in the urbanization process towards an ecological sustainability. A drainage system for sewage and surface run-off in the entire metropolis is absolutely necessary. Along the Akko slope of the Gombe catchment area a cascade system, consisting of an arrangement of retention basins and integrated small terraces bound by fast growing hedges, could effectively reduce the surface run-off and the causal flush erosion during a strong rainfall event. The meteorological agencies in the state should ensure that information on seasonal forecast and climate prediction data are made available, this is to ensure that strategies to reduce vulnerability are implemented. It is evident that resources earmarked for preventing and mitigating the impact of natural phenomena such as flood, are a very high-yield investment, both in economic, social and political terms in line with long-term growth. Hence government at all tiers should intervene by making available funds for such intervention. A paradigm shift of the behavioral pattern of the urban community, most especially with respect to urbanization is very crucial to the mitigation of flood disasters in the study area as well as ecological sustainability.

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