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Development of built environment and its implication on flood risk in Gombe Metropolis, Nigeria

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The increasing frequency of flood events in urban areas and its devastating impact on lives, properties, resources and the environment as a whole has posed a serious concern to environmental scientist the world over. There are many different perspectives regarding factors responsible for flood risk in urban areas, which range from hydrological extremes to man-induced factors. This paper examines the impact of built environment on the increasing flood occurrences in Gombe Metropolis in Nigeria. Data was essentially collected through questionnaire survey and analyzed using statistical model so as to discover the main factors causing flood in the metropolis. A multi-stage sampling technique was applied for data collection, where Gombe Metropolis was categorized into eleven residential quarters and a total of two hundred and fifty one questionnaires were administered to chief householders in the respective residential quarters in the metropolis, and finally multi- linear regression analysis was conducted, where flood risk is conveyed as a function of some selected urban development variables and used to examine the relationships and impact of these variables on causing flooding and the increasing flood risk via a statistical model. The result shows that rapid growth of built-up environment with poor implementation of building control measures is the main factor for flood risk in Gombe Metropolis. However, construction of built-up areas on floodplains as well as inadequate space between building structures as recommended by the town planning laws, has also contributed immensely to the increasing flood risk in Gombe Metropolis.

Key words: Flood risk, built environment, Gombe Metropolis, hydrological extremes, vulnerability.

INTRODUCTION

It is estimated that more than half of African population may probably live in urban areas by the year 2030, and Nigerian urban population is already rapidly proliferating at a rate of six percent annually (Balzerek, 2001). As a result, urban centers especially in Nigeria have witnessed an intensive physical development in terms of building constructions to accommodate the increasing urban population (Falade, 2003). Furthermore, the recent rise of flood occurrences in cities across Nigeria has been a great source of concern and challenge to people and

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governments especially Gombe Metropolis. Gombe Metropolis is typically one of the fast growing cities in Nigeria. Gombe metropolis has witnessed a significant growth immediately after its inception as the capital city of Gombe State in 1996. The city grew in total population from 169,894 in 1996 to 219,946 in 2000 and reaching 321.467, 400,000 in 2006 and 2010, respectively (National Population Commission, 2006; Mbaya, 2013). This demographic mobility triggered a rapid development of built-up and the increasing building density in the old settlement and the outward expansion of the marginal lands in virtually all directions of the metropolis. Since then, flood occurrence has become a seasonal event impacting lives, properties and the environment as a whole. Therefore, urban growth and the increasing development of built environment without adequate spatial planning has become a major concern worldwide especially with the rising trend in flood risk in urban areas.

Flood risk is one of the most recent environmental hazards affecting human settlements and causing a lot of mayhem to lives, properties, resources and the environment as a whole, and the world over. A risk is a probability of a loss that depends on two basics elements: hazard exposure and vulnerability. Indeed, if any of these elements increase or decrease, the risks also increase or decrease accordingly (World Meteorological Organization and Global Water Partnership, 2008). Hence, risk is a cross-cutting combination of vulnerability and hazard and a disaster cannot occur if only hazard exists with no vulnerability, or if there are vulnerable people but no hazard. In short, risk is the probability of hazard and the related consequence on the elements at risk. That is why, flood risk is defined as a probability of flood occurrence and the potential adverse consequences (Barredo and Engeleng, 2010).

There is a probability that flood events may increase in the future as a result of climate change, steady increase of human population, as well as increasing growth of built-up environment (United Nations International Strategy for Disaster Reduction, 2004). However, there are many different perspectives that can be proffered as reasons for the increasing flood events globally. For instance, floods occur as a result of extreme hydro-meteorological events causing inundation of usually dry places. Nevertheless, Pielke (2000) argued that the there is weak correlation between hydrological factors and the damaging floods in urban areas. Hooijer et al. (2004) asserts that urban flood risks increase not only due to climate change but also as a result of continued encroachment of people and their cultural built environment in areas of risk of flooding. Moreover, the damaging flood occurs from a combined force of both the physical and the social processes. This is because, the variable related to exposure normally include proximity to source of threat. Hence, the progressive land use change and growth of built environment on unsuitable urban places or areas liable to flood may play a significant role in the increasing flood frequency in urban areas. For this reasons, urban growth is one of the determinants of urban flood risk especially where developments of buildings are not accompanied by complementary spatial planning and poor development control measures, flooding became inevitable (Adewumi, 2013).

In addition, urban growth is by far the most forceful cultural change that causes peak flow discharge, changes in total run-off and capable of reducing infiltration capacity (Leopold, 1968). Thus, it is related to the percentage of an area overlaid with built-up structures on the earlier pervious surfaces. Thus, the increasing impervious surface has the potential of increasing flood risk in urban areas (Leopold, 1968). Therefore, urbanization increases the volume and rate of surface run-off by attenuation of the natural drainage system and the modification of runoff leading to quick creation of high volume of runoff in a short period of time and potentially leading to a dramatic increase in food peaks (Pielke, 2000).

Thus, this paper aimed to examine the process of urban growth and its implication on flood frequency in Gombe Metropolis and the objective of the study was to examine how urban growth increases flood frequency and also determined whether constructions of built-up on downstream areas increases flood risk in Gombe Metropolis.

Study area

The study area is Gombe Metropolis, a commercial, administrative town and the capital of Gombe State. The metropolis is approximately located at latitude $10° 0^{l}$ and $10° 20^{l}$ and $11° 1^{l}$ and $10° 19^{l}$ (Gombe State Ministry of Land and Survey, 2003).

Gombe Metropolis is located within the sub-Sudan wet and dry climate zone where the raining season is from November to March and the dry season is from April to October.It shares common boundaries with Kwami Local Government on the north and Akko Local Government Area to the south east and south west. The total population of Gombe Metropolis was 266,844 in 2006 and increased to almost double (400,000) in 2010 (National Population Commission, 2006, Mbaya, 2013).

The metropolis is a diverse multi-religious and multi-cultural consisting of mainly Muslims and Christians with different ethnic groups of Fulani, Hausa, Tera, Tangale, Bolawa, Waja, Igbo, Yoruba, and Kanuri tribes. Overall, the literacy level is considerable good with virtually all residents having at least the basic education but majority earning less than eighteen thousand minimum wage in a month.

The oldest core part of the metropolis is the most densely populated area with 260 persons per square hectare and coincidentally the most densely part of the

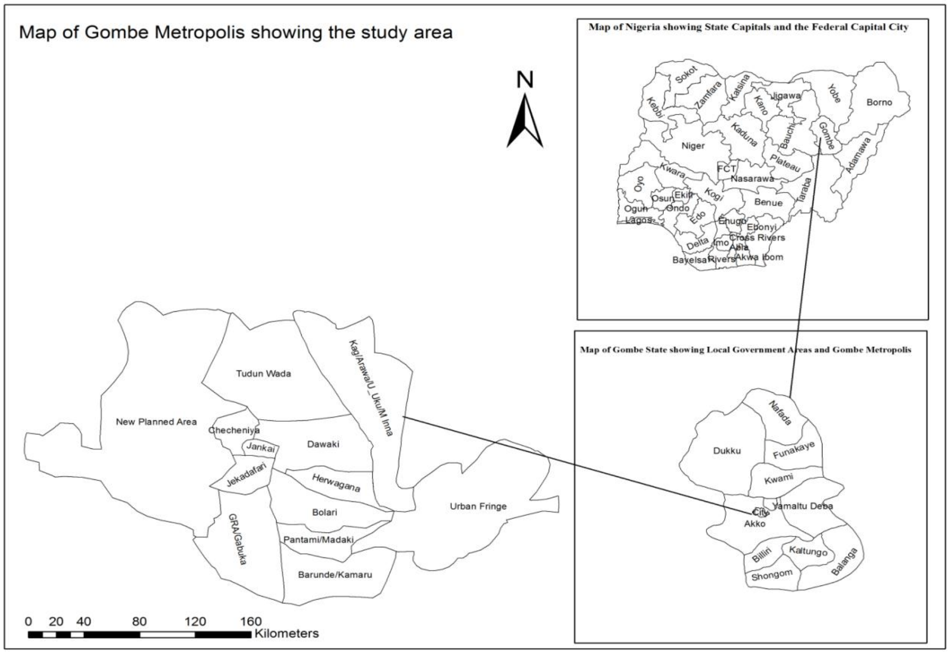

Figure 1. Map of Nigeria, Gombe State and the study area (Gombe Metropolis) (Source: Gombe State Ministry of Land and Survey, 2003).

metropolis in terms of buildings. Topographically, the highest part of the metropolis can be found on the west with an elevation of 489 m (Federal Low cost Quarters), while the lowest can be found in the extreme east with an elevation of 423 meters (Barunde) above sea level. Many gullies, rivers and streams in the metropolis have their sources from the foot of Akko escarpment and virtually all flow to the east (Figure 1).

Gombe Metropolis has evinced a rapid growth of built-up environment in progress on undeveloped ground in almost all parts of the metropolis, causing excessive building densities. The core town is becoming more compacted by spontaneous construction works more especially in the central metropolis that include: Jekadafari, Jankai, Dawaki, TudunWada, Pantami, Bolari/Madaki and Herwagana. These areas have increased in building densities, while in the urban fringes, there is a wide spread of development of new areas, such as in NPA, MUAK, Barunde. The urban growth around the urban fringe with poor development planning is causing a spontaneous development and poor spatial order. The shortage of housing and the desperate efforts of private developers have led to the emergence of the unplanned residential sectors, especially on places considered unsuitable for development (Gombe State Ministry of Land and Survey, 2003). These places are mostly common in the oldest part of the town and the urban fringes

METHODOLOGY

The scope of the research is the entire Gombe Metropolis with a total population of 312,467 (Mbaya, 2013). The research was conducted in stages where the metropolis was categorized into eleven residential areas comprising of Government Residential Areas (GRA), Pantami, Barunde, Checheniya, federal low cost quarters, Arawa, Kagarawal/Unguwa Uku, Dawaki, Madaki, Jekadafari, Herwagana, Jankai and Tudun Wada. The target population consists of a total of 1,929 chief householders within these residential section affected by the previous floods in Gombe Metropolis. Hence, thirteen percent (253) were randomly selected, where a total number of twenty three questionnaires were administered to each residential quarter to acquire necessary information relevant to the research. A Likert scale of three point scales and linear measurement were constructed to measure the variables, where structured close ended questions were coded and administered to the respondents with alternatives to choose based on their subjective views on a certain matter and a total of 251 questionnaires were returned and analyzed. Finally, standard regression method (multiple regression) was conducted using a computer and Statistical Package for Social Science (SPSS) to estimate flood risk from a set of urban development variables comprising of rapid development of built-up, proximity to floodplains and space between building.

RESULTS AND DISCUSSION

The Gombe State Urban Planning and Development Board (GSUPDB) are responsible for development control and implementation of physical development plans. Land use planning involves establishment of specific regulatory constraints to avoid or limit development of housing structures as key tool for planning strategy in urban management especially flood risk in urban areas (Wheat et al., 2009). The rapid urban growth in Gombe Metropolis ought to be guided towards

Table 1. Responses for space building of the households.

Residential quarters	Responses on space between buildings	
	1.7 m and below	Above1.7 m
Jekadafari	35	65
Jankai	78	22
Dawaki	65	35
Barunde	56	44
Tudun Wada	52	48
Pantami	74	26
Bolari/Madaki	69	36
NPA	83	17
MUAK	78	22
Checheniya	83	17
Herwagana	50	50
Total	66	43

Source: Field Survey, 2015.

a spatial order and development; this is due to reasons that the development control code stipulated that building should be constructed in conformity with the approved building plans. But unfortunately, the rapid increasing numbers of built-up areas in Gombe metropolis are not constructed in accordance with the town planning laws and regulations, which causes a serious setback for urban development in the metropolis and the consequential seasonal flooding.

The reason for such a spontaneous development of urban structures in the metropolis may also not be unrelated to erection of buildings by individuals without getting the approval of building plan by the appropriate authority. The building code stipulated that no building or construction of any structure shall commence except with building plan approval accompanied by the relevant building plan or construction plan (Gombe State Ministry of Land and Survey, 2003). However, this is contrary to what is seen where close to sixty percent of the metropolitan inhabitants have constructed their building structures without getting the building plan approval by Gombe State Planning and Urban Development Board.

Further sign for poor implementation of building codes is the constructions of built-up areas without leaving the stipulated space between buildings. The functional purpose to keep distance or space between buildings is essentially meant to allow passage of water in the event of heavy rainfall and lack of such provision for un-obstruction flow can lead to creation of a quick swirl and sudden high surge of runoff situation that can cause flooding. The recommended standard space between buildings in Gombe Metropolis is at least 1.7 m (5 ft) and maximum of 3 m (10 ft) (Gombe State Urban Planning and Development Board Law, 2012). The space between buildings in Gombe Metropolis is inadequate because a substantial part of the built-up areas (66%) have less than 1.7 m space between their buildings and the next opposite buildings, while only 34% leave a space of 1.7 m and above as depicted in Table 1. This could serve as one of the factors for accumulation of run- off water within a short period of time inundating the metropolis.

Further, the disadvantage of poor spatial planning is the construction of buildings in unsuitable location like floodplains, because, elevation is one of the most important factors in determining flood liability of areas, such as close to a rivers, streams or gullies. Variables related to exposure, normally include proximity to hazardous areas because people encroach urban floodplains reducing floodplain's capacity to attenuate the impact of flood, such an encroachment expose urban built-up areas to flood vulnerability and rapid increase of the flood risk potential (Wheat, 209).

According to Gombe Urban Development Laws, approval for building construction can only be granted where the sites and buildings are not in close proximity to any natural features like streams, rivers, gullies, that may render or expose the location to unsafe and vulnerable to flood risk (Gombe State Urban Planning and Development Board Law, 2012). A significant number of buildings in the metropolis are located in proximity to natural water channels (streams, rivers and gullies). For instance, these places include: Jankai, Barunde, Tudun Wada, Pantami, Bolari/Madaki, Checheniya, and Herwagana. On the whole on average, about 70% of the built-up areas in Gombe Metropolis are located on one way or the other within floodplains.

Factors predicting flood risk in Gombe Metropolis

The model conveyed flood risk (dependent variable) as a function of rapid built-up development, proximity to

Table 2. Flood risk: Model summary.

Variable	Flood risk		
	B (Slope)	Std. Error	βeta
Constant	-0.006	010	
Space between buildings	-0.079*	0.059	-102
Rapid built up development	0.384*	0.066	0.443
Proximity to floodplains	0.303*	0.048	0.380

N=251, β=unstandardized regression coefficient in parentheses, Beta =standardized regression coefficient, R =0 .710
R^2 = 0.504, Adjusted R^2 = 0.483, *P. value is statistically significant at 0.5 level (Source: Field Survey, 2015).

floodplains and the space between buildings (predictive variables).

The estimated regression coefficient for rapid development of building structures is 0.420 as indicated in Table 2. The implication of the coefficient can be interpreted as: each additional increase in constructing buildings causes flood risk increment on an average by 0.420 and this is statistically significant at 0.05 level of importance. The proximity to flood plains variable is also statistically significant at o.05 and by implication increasing the closeness of built-up environment to gully, river and stream, increases flood risk on an average of 0.322.

The coefficient for space between building variable also has a negative coefficient (-0.074) in the model and is also significant at 0.05 level. This explains each additional increase of distance between individual building structures which reduces flood risk on the average by 0.074 point.

The 'β' (unstandardized) coefficient relies heavily on the units of measurement for the dependent and the independent variables. However, it is rather difficult to compare coefficient of the two different variables measured in two different ways. Hence, 'βeta' (standardized) coefficient is used to bring all into a single common unit. The standardized coefficients explain how many standard deviations affect the changes in the dependent variable due to an increase in the standard deviation of the independent variables (Cramer, 1994). Therefore, an increase of one standard deviation in rapid development of built up structures gives an increase of 0.488 standard deviations in flood risk. By comparison of the standardized coefficients among different variables, we can have an idea of those variables that are more or less important in predicting the dependent variable (flood risk). The model in Table 2 shows that rapid development of built-up structures has the highest coefficient (0.488). Hence, it is the most important variable causing flooding and flood risk in Gombe Metropolis, followed by proximity to floodplains (.405). The least important variable causing flooding is space between building structures with the least coefficient of -0.096.

The R^2 measured how well the model predicts the dependent variable by the independent variable (Singh, 2007). The R^2 is 0.480 in the model, this means that rapid development of built up structures, proximity to floodplains and space between building, altogether, explained 48% of variation in flood risk and flood occurrences in Gombe Metropolis.

Conclusion

According to the result, it is vividly clear that generally in Gombe Metropolis, there is rapid growth of built environment in progress and this rapid urban growth has affected town planning and has posed problem to urban development board to properly discharge building control measures. Hence, spontaneous developments have taken place, where a significant number of buildings were constructed without considering the stipulated space limit or no space between buildings (as required for easy passage of run-off water). Furthermore, buildings were constructed on unsuitable locations such as in a close proximity to gullies, rivers and streams. The flood risk model estimated rapid development of built-up environment with poor implementation of building control measures as the most important factor for flood risk in Gombe Metropolis. However, construction of buildings on areas predisposed to flood as well as leaving inadequate space between buildings has significantly contributed to the increasing flood risk in Gombe Metropolis.

Policy implication

Based on the findings of the research, the following are applicable to policy makers in the state for sustainable flood mitigation in the metropolis:

The current building control measure is not effectively implemented to the expected level of controlling the rapid building development activities in the metropolis. Therefore, the results of the research indicate that there is a general lack of commitment from the acting urban planning and development agencies in ensuring a strict enforcement of the implementation of the building regulations such as inadequate space between buildings, and erecting buildings on floodplains. Hence, spatial zoning can be proposed for flood risk vulnerable areas to regulate, prevent and restrict future building development.

The rapid development of built up environment with poor implementation of town and urban planning laws and regulations, the increasing flood frequency and its prevailing impacts necessitate the need for a comprehensive sustainable flood risk management measures for Gombe Metropolis. And finally, some sections of the residential areas that are very dense in terms of built-up should convert part of the built environment into open spaces in order to reduce the sealing effect of the built environment. These residential quarters include: Jekadafari, Barunde, Pantami, Bolari/Madaki, Herwagana, mostly located at the central town with the exception of Barunde.

Conflict of interests

The author has not declared any conflict of interests.

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