Assessment of Adaptation Strategies to Flooding Impacts in Nigeria - A Review

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Abstract:
Flooding is one of the climate change natural disasters generated by human activities which constitute a threat to human life, property and the built environment. Although risks from such cannot be fully eliminated, however, adaptation to climate change can reduce the exposure and vulnerability to extreme climate and sustain the built environment. This work surveyed literature on climate change flooding and its effects on Nigerian built environment to find out that most developed nations with longer water bodies and greater exposure to flooding disaster have been able to curtail the negative effects of climate change induced flooding over the years than Nigeria were able to minimize the negative effects of climate change flooding on their built environment whereas, Nigeria with comparable minimum and manageable length of water bodies continuously have higher negative impacts from flooding. The application of adaptation theory will mitigate against the effect of climate change flooding and lead to the achievement of a sustainable built environment in Nigeria. The work eventually recommended concerted efforts of all stakeholders in the built environment to cooperate among themselves for the actualization of gains of adaptation approach to climate change flooding in Nigeria towards achieving sustainable built environment.

Keywords:
Adaptation, Built Environment, Climate Change, Flooding, Sustainable- Development

1. Introduction

Every human activity affects the environment directly or indirectly and that increasing population and urbanization are man's greatest activities that impact on the environment. Rapid urbanization and the growth of mega cities, especially in developing countries like Nigeria, have led to the emergence of highly vulnerable urban communities, particularly through informal settlements and inadequate land management. In the wake of this, as the concentration of urban populations is increasing coupled with growing occurrence of climate change induced disasters,

millions of naira in property are lost and its cost is increasing by day. According to United Nation Development Programme (UNDP) in 2010, Climate change is one of the major challenges of our time and adds considerable stress to our societies and the environment. From shifting weather patterns that threaten food production, to a rise in sea level that increases the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. Without drastic action today, adapting to these impacts in the future will be more difficult and costly. Flooding has been observed as one of the climate change causative natural disasters generated by human activities which consequently hinder sustainability of the built environment (Adeofun, 2011). It is a situation where the land is covered with water due to overflowing of river triggered by heavy rainfall, an aspect of negative response to climate change, and due to its destructive effects on the built environment. It is an impediment to sustainable development. Flooding is identified as threats to human life, property and the built environment worldwide, most frequent in the developed countries, but mostly the degree of its vulnerability is much felt by the developing countries (Ojo, 2011). Perhaps due to lack of proper adaptation, hundreds of millions of urban dwellers in developing nations are at risk from the direct and indirect impacts of climate change. The trend and occurrence of flood rise and flooding are a factor of increased frequency and incidents severity. According to Satterthwaite et al (2007) a third of the world's population are most at risk from sea-level rise and the heat waves, storms and floods (as recently experienced in India, Indonesia, United States of America and United Kingdom) and many of the urban centres will need to adapt fast to avoid serious impacts of climate change on flooding. The developing countries have large deficiencies of the preconditions for successful adaptation because they are ill-equipped due to inadequate provision for the infrastructure and services needed to reduce climate-change-related risks and vulnerabilities. There will be very serious consequences for the people, the environment and the national economies if there is no effective adaptation measure to climate change flooding. In the wake of unavoidable climate change, over exploited coastal resources posed a great threat to the built environment in Nigeria because of lack of proper development and effective flood management. In 2011, Ibadan experienced a flood disaster that washed away 2,105 properties and 25 bridges and culverts which, according to the Oyo state task force on flood prevention and management will require 100 billion Naira and 4.31 billion respectively to reconstruct (Ojo, 2011). Also in 2012, there was a general flood affecting over 80% of component states in Nigeria, although the total loss was not documented, but it had a huge loss and damages to people and the built environments. In preparation against negative effect of future flood, Olusina and Odumade (2012) used geographic information systems (GIS) to model future climate of Nigeria for 50 years (2000-2050) by comparing climate data from Nigerian Meteorological Services (NIMET) with World Clim model and application of their variation to obtain polynomial for predicting future temperature and rainfall change for Nigeria covering the period. The findings include; expected negative and positive variations in rainfall across Nigeria, increase in temperature, coastal regions to expect average increase of 100mm rainfall monthly during rainy season. This however is a pointer for all stakeholders in the built environment in Nigeria to adapt to climate change flooding. The questions agitating the mind of these researchers are; which aspect of climate disaster is mostly noted in Nigeria and what are its causes? What are the effects of flooding on the Nigerian built environment? To what extent can adaptation strategy be of use to flood disaster in Nigeria? And what are the adaptation strategies that can be applied for a reduction in flood disaster in Nigeria? The focus of this paper is

therefore to review the literature on changes in the floods that might be related to changes in climate (referred to as 'climate-driven flooding'), rather than changes in engineering developments or land use and how such changes can be reduced and prevented for the purpose of having a sustainability in Nigerian built environment. To achieve the aim of the paper, it has been structured into 8 sections. Following this introductory section, the second section is devoted to climate change concept followed by section 3 which identify flooding as major visible natural disaster from climate change while section 4 discussed the climate change flooding effects on the built environment. Section 5 is on climate change flooding adaptation to built environment, section 6 observed flooding as a visible climate change induced disaster in Nigeria, the way out of climate change-flooding negative impacts on the Nigerian built environment was the focus of the seventh section before the work was concluded at the eighth section.

2. Climate Change

Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. This definition differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change is defined as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. According to Barros et al (2011) climate change indicate any long term and significant change in weather (temperature, precipitation and wind patterns) experienced by a given region. Climate events have increased in frequency or magnitude, but populations and assets at risk have also increased, with consequences for disaster risk (IPCC, 2012). Adverse impacts are considered as disasters when they produce widespread damage and cause severe alterations in the normal functioning of communities or societies. However, climate change may pose short term changes (e.g. flooding, storms, heat waves and drought) and long-term changes (e.g. increasing average temperatures and sea level rise). Within the built environment sector, climate change may be for adaptation or for mitigation purpose. Mitigation means efforts to limit the man-made causes of climate change, it has to do with taking actions aimed at reducing the extent of climate change factors, but adaptation is often used simply to mean changes that can be made to the design or construction (less often the operation or use) of buildings and landscaping in order to cope with the consequences of one or more of the impacts of climate change. Both terms therefore mean reduction of natural cause and prevention of human cause of climate change impact on the built environment. Currently, many existing buildings are wrongly adapted, indicating that the way they have been built increases their potential vulnerability to the effects of climate change. Moreover, in some cases it is not considered cost-effective to modify existing buildings to cope with a changing climate. Adaptation therefore includes any actions taking to minimize the negative effects and taking advantage of the opportunities, of climate change (both current and those yet to come). It may also be an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities. (UKCIP, 2009). Climate-change has both positive and negative current and potential effects on people and their livelihoods/investments

(e.g. buildings, neighbourhood and city). These effects can be direct, as in larger and/or more frequent floods, or more intense and/or frequent storms, or heat waves, or less direct as climate change negatively affects livelihoods or food supplies (and prices) or access to water needed for domestic consumption or livelihoods.

3. Flooding Effect and Climate Change Natural Disaster

A flood is the overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged, this include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (Satterthwaite, 2008). The main causes of floods generally are intense and/or long-lasting precipitation, dam break (e.g., glacial lakes), reduced conveyance due to landslides, or by an intense local storm (Smith & Ward, 1998). Usman and Tunde (2009) observed that the restriction of the flow of precipitation and water bodies as a result of human actions majorly caused flood in most urban centres thereby causing damages and losses to build and ecological environments. Distinguishing between primary and secondary causes of flooding, the primary causes of flooding with natural tendency have been traced to combination of; heavy or torrential rains or rainstorm, ocean storms and tidal waves along coastal area while the secondary cause of flooding with human influence have been traced to blockage of river drainage through indiscriminate waste disposal and development of structures along river setbacks. Urban flooding; Overbank, dam spills or dam burst levee failures, Flash, Coastal, Overland and Infiltration occurs in urban areas, where the impacts of extreme rainfall are exacerbated by high concentrations of impervious surface, infrastructure, buildings, and property and people (Omisore, 2011). Most of the associated climate-related threats could have major impacts on the built environment. The built environment sector may therefore need to consider suitable approaches for adaptation to a changed climate because of the associated direct threats it posed on the built environment and the people dwelling in it. However, those people and buildings close to the coast are particularly at risk when storm surges are combined with sea level rise. The major adaptation strategy to flooding involved the use of constructed defenses to prevent and reduce the effect of flooding on built environment, raising of river banks and flood walls, creating sufficient storage reservoirs and canalization or channelization of flood passage and establishment of standard drainage system on roads. Most of the effects of climate change flooding are negative; for instance, Oladokun (2016) identified joint failure as a major defect of climate change and observed health hazard as its consequent major effect. In addition, increased quantity of water may at the same time decrease its quality, calling for concern from government and the built environmental professionals. However, climate change effects are not all negative. Some are beneficial in nature, and for instance it may reduce energy bills and cold related deaths and hospital admissions. It may also reduce energy consumption and increase water supply. In some cases, overheating may lead to illness or death. Without taking the necessary actions, likely consequences of the projected climate variables will be wide ranging from increasing flood risk and coastal erosion, potential water shortages, ground instability issues to associate health impacts of increased temperatures and detrimental effects on the current and future infrastructure. Warmer summers, on the other hand, may increase the risk of buildings becoming too hot and uncomfortable for human habitation. Climate change with its consequential effect on the built environment may increase the risk of subsidence affecting the properties which subsequently, may increase the risk of flooding for both residential and non-residential properties, thereby reducing

their value, for instance, Ogbonna and Otegbulu (2014) observed the reduction of between 4-12% in housing prices in Nigeria due to flooding effect. Changes in water availability, particularly reductions in the summer, may lead to less reliable supplies, more frequent restrictions and potential water shortages in the longer term, unless more measures are taken to reduce demands and develop supplies. Climate change flooding effect on the built environment can be identified as: events of drier summers and drought; reduced water availability/shortages, reduced water quality, reduced soil moisture content/ increased subsidence, changes in biodiversity, sea temperature rise; sea level rise, increase in sea surge height, increase in precipitation or more rainfall in heavier form, increased river flooding, increased urban drainage flooding, higher wind speeds; increased storm damage, outage of emergency, infrastructure and transportation services, reduction in property value.

4. Climate Change Adaptations to the Built Environment

Adaptation in human systems is defined as the process of adjustment to actual or expected weather and its effects. In natural systems, it is defined as the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (ERC, 2010). Adaptation to climate change according to Tilahun et al (2014) involves two stages: perceiving the change and deciding whether or not to adapt by taking particular measures. Within the built environment sector, climate change adaptation is often used simply to mean changes that can be made to the design or construction (less often the operation or use) of buildings and landscaping in order to cope with the consequences of one or more of the impacts of climate change. Adaptation involves taking actions to minimize the effects of inevitable climate change, and take advantage of its opportunities, both current and those yet to come (ERC, 2010). These definitions modify the IPCC (2007) definition that generically mean the "adjustment in natural and human systems in response to actual and expected climatic stimuli, such as to moderate harm or exploit beneficial opportunities." The essence of adaptation to climate change induced flooding is to ensure reduction in risks for inhabitants and built environment and have environmental, economic and social political sustainability of built environment. Actions that range from incremental steps to transformational changes are essential for reducing the risk from climate extremes. Incremental steps aim to improve efficiency within existing technology, governance, and value systems, whereas transformation may involve alterations of fundamental attributes of those systems (IPCC, 2012).

5. Flooding As a Visible Climate Change Induced Disaster in Nigeria

Most noted flooding the world over are those of coastal, river and urban categories caused by natural causes and aggravated by human causes. According to IPCC (2012), where vulnerability is high and adaptive capacity is low, changes in climate extremes can make it difficult for systems to adapt sustainable without transformational changes. In the ranking of countries with water bodies liable to floods, Nigeria was the least of 15 countries ranked having, 8,600km length of water bodies, while China was ranked the first with 110,000km length of water bodies (see Table 1). This was corroborated by the fact that the coastal region of Nigeria (Delta, Edo, Lagos, Ondo, Ogun, Akwa-Ibom, Bayelsa, Cross River and River state) covered about 70,000km2 representing only 7.5% of total land mass of Nigeria indicating that Nigerian flooding problem should be manageable compared with other countries. In Nigeria, coastal

flooding coupled with beach erosion is the most common climate change disaster applicable to the build environment and their widespread is due to the higher waves generated by on shore storm winds (Patunola-Ajayi, 2014). While Halley (2001) identifies the major cause of flood in Africa to be inadequacy of drainage, but study of cause of flood in Nigeria has been identified to be excessive rainfall (Akanin & Bilesanmi, 2011; Ojo, 2011, and Aderogba, 2012) and the ones caused by increase in rainfall. Chukwu and Okeke (2015) therefore assess the effects of climate change on solar radiation, relative humidity and temperature in Southwestern Nigeria. Orunonye (2015) therefore attributed the causes of flooding in Nigeria to lack of drainage network, if available it will be in small size or in some situations the drainage channel is blocked. While some of the flooding could be due to natural occurrence or closeness to coastal areas, the case of urban flooding in Ibadan, a non-coastal city in Nigeria is a typical example of man-made flood disaster. United States of America have about 35% of its population living within shore-adjacent coastal counties representing about 17% of its total land area (Hindsley et al 2012) and the likely effect of flooding was not allowed to overshoot. Despite the fact that Nigeria has a manageable length of water bodies, it still lacks the required materials and resources for flooding adaptation approach when compared with other countries with a longer length of water bodies as indicated in Table 1. The resultant effect is that Nigeria has manageable flooding risk but magnificent negative flooding impact.

Table 1: *Ranking of Length of Global Navigable Rivers, Canal and Other Inland's Bodies of Water*

S/N	Country	Length in Ki Kilometres	Rank
1	China	110,000	1st
2	Russia	102,000	2nd
3	Brazil	50,000	3rd
4	United States	41,109	4th
5	Colombia	24,725	5th
6	Indonesia	21,579	6th
7	Vietnam	17,702	7th
8	Congo	15,000	8th
9	India	14,500	9th
10	Burma	12,800	10th
11	Argentina	11,000	11th
12	Papua New Guinea	11,000	11th
13	Bolivia	10,000	13th
14	Peru	8,800	14th
15	Nigeria	8,600	15th

Source: Patunola-Ajayi (2014) adapted from the world fact book (2014)

Past flooding occurrences have been noted in some states in Nigeria; Oyo (1980 &1990), Lagos (1970-2015), Kano (2001), Delta (2001), Edo (2015), Adamawa (2001-2015) and Kogi (2012) with negative effects on the built environment; destruction, submerging or washing away of buildings and structures, water pollution, bridge collapses and road wash away (NEMA, 2012). The worst flooding occurrence in the history of Nigeria has been that of June/July 2012 when Benue and Niger rivers overflowed their banks. Although this was predicted early by the Nigerian Meteorological Agency, but governments at all tiers took no adaptation or mitigation

actions. This singular incidence affected 30 of the 36 states in Nigeria, about 250 local government areas (representing 32% of 774 total local governments in Nigeria). About 30% of Nigerian land mass was submerged by flood affecting 7.7million people, 300 were dead, and over 2million people were displaced. Kogi state was the mostly affected state, but it was only in Plateau state that 200 homes were documented to have been destroyed. From the report of NEMA (2012), between June and September 2012, over 363 lives were lost and about 1.2 million Nigerians were displaced. Adapting buildings to the impact of climate change requires an integrated approach to environmental design and the performance of buildings in use. The Environmental Agency (2007) was of the view that if the environmental issues are taken into account, building in the right places and in the right way can be an adaptation for mitigation of effect of climate change induced flooding for the benefit of both current and future generations.

6. Way Out of Climate Change-flooding Negative Impacts on Nigerian Built Environment

The major problem of flooding effect on the Nigerian built environment is that many existing buildings are mal-adapted and lacked defined adaptation strategy. In other words, the way they have been built increases their potential vulnerability to the flooding effects of climate change especially the ones close to coasts. The following general strategies can therefore be adopted to increase the ability of the built environment to adapt to climate change flooding:

A strong need and emphasis on climate adaptation in planning policy, including action on coastal change and water resources are required. This must ensure that building design is done to be climate sensitive and conscious of high-risk areas through more stringent development control, building regulations must not only be set but must be enforced.

Continuing investment in community-wide and property-level flood protection, and steps to improve management of local flood risk. Planning policy should focus on directing most new development away from locations where it might flood especially in the coastal region or make them to be safe and resilient to flooding.

Encouragement of planting of trees to support cooling, drought resilience and drainage. To improve homeowner knowledge and risk-reducing behavior through education and enlightenment. For instance, they should make them aware of future and potential risks posed by surface water flooding to buildings, neighborhood and the city as a whole. Individual homeowners can have a significant role in reducing risk through protecting their own homes and reducing their contributions of storm water to municipal sanitary sewers and storm water management systems.

Drainage should be designed in an environmentally friendly way of dealing with surface water run-off that avoids the problems associated with existing drainage practice aiming at reducing the potential impact of surface water drainage discharges in new and existing developments. There is a need to maximize the density of development in non-flood risk areas and minimize density of coastal and flood risk areas.

Buildings, neighborhoods and cities may be vulnerable to an increasing frequency of heavy precipitation events. What are required to be done to adapt to the climate

change flooding occurrence in Nigeria built environment can also be segregated to 3 levels: building, neighborhood and city:

Building-there is a need to open water courses across the site for amenity and flood absorption on the site and provision of emergency access points. It is required to provide temporary/permanent flooding defenses for properties that are at risk to flooding and a need to fit (removable) flood defense products to properties. Electrical services should be located above flood levels if it is discovered that the building is wet proof un-protectable buildings. Also, mechanical or UV light systems need to be installed to prevent damp and mould growth, peak run-off and annual surface water run-off rates need to minimized, sustainable urban drainage systems (permeable paving attenuation systems, filter drains, ponds, wetlands) should be used, people should avoid development in flood risk locations and where already built, provide temporary/permanent flooding defenses for at risk properties. Building design and building materials that can withstand flooding threats should be used and back up of drains into the building should be prevented.

Neighborhood- soft defenses should be used as the buffer as part of green infrastructure and water courses should be opened across neighborhood for amenity and flood absorption. The development should be appropriately set back from flooding and flood defenses and vulnerable users should be located away from areas of high risk. Sustainable urban drainage systems (permeable paving attenuation systems, filter drains, ponds, wetlands) should be used and landscaping including tree canopies should be encouraged to intercept and soak up rain. Lastly, impermeable surfaces should be avoided, especially where soils have high infiltration capacities.

City- provision of flood plans for up and down stream flooding is highly desired in cities and emergency access routes and points should be provided alongside with city-wide safety retreat facilities against failure of flood defenses. Consideration of river restoration for storing water temporarily in green spaces alongside rivers at identified vulnerable areas across the city (e.g. where known incidence of surface water flooding is detected with low drain capacity and soils with high infiltration rates). In vulnerable areas of the city the use of permeable paving attenuation systems, filter drains, culverts, ponds, and wetlands should be used appropriately and permitting development in flood risk locations should be avoided entirely.

7. Conclusions

As most buildings and infrastructure have long lives; what is built now needs to be able to cope with the climate change-induced risks over the next few decades, the epitome of sustainability. There is a need for promoting a strategy for catalyzing support for sustainable building design and construction and the key challenge is to plan, design and construct cities, neighborhoods and buildings, in accordance with the principles of sustainable development that perform effectively not just in terms of today's climate but in the future as well. To achieve resilience of the existing built environment in Nigeria, there is a need to adapt the new buildings and ensuring modifications of existing buildings in the communities by joint actions of public and private sectors. All big urban centers and cities have had to make very extensive "adaptations" to environmental conditions, site characteristics, natural-resource availabilities and environmental hazards to be able to function as urban centers. Climate change's multiple impacts should be taken into account when planning and designing new developments and when refurbishing and regenerating the existing stock of

buildings. The importance of public awareness through effective hazard education is desired towards changing people's attitude to the climate change challenge. By and large, there is a need for concerted efforts of all stakeholders in the built environment (land surveyors, urban and regional planners, quantity surveyors, estate surveyors, architect, engineers, planning authorities and other statutory authorities, urban dwellers and urban building owners and governments)to cooperate with themselves for the actualization of adaptation approach to climate change flooding in Nigeria.

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