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Developing Flood Resilient Buildings in Nigeria: A Guide

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Abstract
Recently, the damage caused by flood in Nigeria has become unbearable leading to series of economic losses. Several post flood measures taken has proved to be inadequate because they are temporary. Hence, the needful is the flood risk management. Managing the risk of flood can be achieved by enhancing the resilient of the buildings in Nigeria. This requires a pragmatic approach from the concerned stakeholders. In this paper, we observed and discussed some of the drawbacks in Nigeria buildings leading to its vulnerability to flood. Also, guide was developed for government and stakeholders to achieve the incorporation of resilience in Nigeria building and its environment. Expected resilience was proposed and a flowchart to assist the prospective builders was developed. This will assist in developing the necessary blueprint towards achieving this goal. Necessary suggestions made will aid in the actualization of a resilient buildings within Nigeria.
Keywords: Flood, resilience, Nigeria, flood risk management, building

1. Introduction

Overflow or retention of water in an area that is normally dry is referred to as flood. This inundation is harmful to habitants of the environment which may include man, plants and animals (Udosen, 2011). Flood hazards losses majorly affect buildings, lives and properties housed within the buildings. Flood often comes with different definitions which are attributed to their causes, type or the extent of the damage. West (1991) and Ating (2003) described flood as high flow that overtopped high stream and natural channels. Researchers have shown that there are different flood types caused by and aggravated by various factors within the environment. Some of the widely discussed floods include; pluvial flooding, ground water, tidal flooding, fluvial flooding, flooding from sewers and flooding from man – made infrastructure (Aderogba, 2012; Agbonkhese, 2014; Anthony & Edem, 2015). These flood types can occur differently in a location and can happen jointly at the same time depending on the terrain of the environment. Flood is one of the major challenges of the world today with Nigerians been affected recently seriously (Oladokun *et al.,* 2016). Flood incidents have contributed to more deaths, injuries and damage among other natural disasters (Askew, 1999; Etuonovbe, 2011). A major factor has been linked to the vulnerability of our Nigerian buildings and built environment. Flooding has displaced thousands from their farm lands, place of work and rendered many homeless. Emotional and social costs during flood experience are very significant in the flood affected houses and the nation as a whole. Such costs, which may include fear, insecurity, loss of home and personal belongings of the victims is insignificant when compared with the long term disruptive effects on the economy (Baiye, 1988; Akinyemi, 1990; Nwaubani, 1991; Edward-Adebiyi, 1997). The effect on utilities and infrastructures leading to disruption of industrial activities, destruction of farm lands has been shown to constitute huge economic losses.

Meanwhile these impacts could have been moderated if critical elements of built environment system such as buildings are engineered in a way to resist the havoc and or recover from havoc in good time. This ability of a system to recover is referred to as resilience. While flooding pattern across the world may be similar to what obtains in Nigeria the extent of the disruptions in recent times however suggest that Nigerian buildings are more vulnerable. While there is a global trend towards adopting the concept of blue-green cities encourages flood resilient infrastructures and systems (Everett *et al.,* 2014; Lawson *et al.,* 2014) the enhancing capacity of Nigerian urban systems to cope with increasing trend and intensity of flooding remains a major challenge (Oladokun *et al.,* 2016; Adelekan, 2011; Adewole *et al.,* 2014). The development of resilient buildings and community systems has been identified as a critical step towards a sustainable blue-green built-environment (Everett *et al.,* 2014; Lawson *et al.,* 2014). Therefore this paper describes a proposed guide for enhancing the resilience of buildings in Nigeria.

This study understands that the problem of frequent occurrence of inundation in Nigeria requires a sustainable approach involving developing resilience of those exposed to flood risks (Gallopin, 2006; Klein *et al.,* 2003). Flooding problem is a systems problem that has a lot of complexity because of the surrounded subsystems. The solution to such problem requires a holistic approach which will remove desegregation. To achieve this, the housing subsystem is identified as key component of the flood-environment interaction that must be considered in any integrated flood risk management (FRM) approach. FRM efforts in Nigeria have been characterized as mostly reactionary focusing on short term post hazard measures such as relieve materials

distributions, erection of internal displaced peoples' camps. However, the need to adopt as more sustainable approach that place emphasis on building resilient systems capable of coping with increased risks of flood hazards due to the interplay of extreme weather events, growing population and rapid urbanization (Kron, 2005; Gallopin, 2006).

2. Resilience in Flood Risk Management

Resilience is the ability to contain or recover from disturbance in reasonable time. The resilience of a system can only be measured by the rate at which the system bounces back from any form of perturbation (Folke *et al.,* 2002; Adger *et al.,* 2005; Oladokun, *et al.,* 2017). Environment which is a system containing ecology, physical, human etc. is mostly affected during any natural disaster. The disturbance set the system into unrest because of sudden change and the extent at which it is affected will be determined by its vulnerability (Adger, 2006). A resilient environment is a system which comes alive or recovers easily after disturbance. Flood resilient environment will be a robust system that can contain and manage flood at any level of occurrence and still recovers in a reasonable time. This should be achieved with little to no loss or damage. Resilient environment will not be degraded by any of the sources or causes of flood but even be stronger after the occurrence.

Reducing the negative effect of flood requires the implementation of adequate prevention, preparation and protection of buildings. Applying integrated risk management cycle which is a concept with wide acceptability by both international and national organizations is key (DKKV, 2003; EEA, 2011).

Consecutive phases to follow by a society to improve its resilient against natural hazards have been described although; this talks in generality of resilience. Kienholz *et al.* (2004) and Thieken *et al.* (2007) noted the process to be starting after severe events. This is then succeeded by series of phases which includes the stage of preparatory, precautionary and preventive measures. The process by which the risk analysis of flood, assessment and its prevention are carried out can be regarded as the flood management.

Recent time describes flood a life-threatening issue leading to rethinking as a result of the magnitudes of the events. This has resulted to the fact that its complete prevention and absolute safety are impossible. Several ways of coping with the unexpected hazards and quick changes is the proffered solution (Berkes, 2007). The concept of resilience stresses the ability to cope and adjust to the unstoppable events. Other risk management, the analysis of resilience analysis can help the system in times of trouble (Park *et al.,* 2013).

Resilience concept has been applied in diverse area because of its usability in various fields of research. This could be traced back to psychology and psychiatry in the 1940s (Manyena, 2006) and later in system ecology in 70s (Holling, 1973). Gradually, it was extended to researches on risk, natural hazards and social sciences (Schwindt & Thieken, 2010). Thywissen, (2006) and Mayunga (2007) resilience revolves around three aspects of resistance, recovery and adaptive capacity. These three aspects form the basis of the concept of resilience (Fisher, 2015; Maguire & Hagan, 2007; Schwindt & Thieken, 2010).

Ability to repel a disorder or disturbance caused by any natural occurrence is referred to as resistance. The extent, at which a system resists, absorbed or can withstand perturbation before any alteration. The ability to remain functional in a troubled circumstance is a key in resilience. Recovering is another key basis of resilience. It refers to the time, rate, how quick a disturbed system get back to its former status. Füssel and Klein (2006) the faster the recovery process the more resilient the system under recovery. It also refers to how the system develops overtime against disturbance. The adaptation of the system from the previous events and the ability to adjust in such a way that will denote improvement is regarded as adaptive capacity.

3. Methods and Study Area Description

Nigeria is a country with population of more than 170 million and this has made the country to be considered as the seventh most populous country in the world (NPC, 2007; World Bank, 2013). A developing economy which is located between latitude 4^{o}N to 14^{o} N; and longitude 3^{o}E to 15^{o}E has a land extent of about 923,769 km^2. Towards the north-south are 1,450-km length and breadth of about 800 km to west-east. Figure 1 shows the map of the country and the states with major rivers within and surrounded lakes.

A search process of literature that is relevant to flood resilient of building in Nigeria was carried out. Guides towards achieving resilience in Nigeria building were proposed for government and relevant stakeholders. Some expected features of building to improve its resilience were suggested and well explained. A flowchart that can be followed by a prospective builder was developed.

The methods used for this study include majorly qualitative data. Observations were made through visitation to areas affected by flood and information was retrieved from relevant personnel.

Figure 1: Map of Nigeria showing the major and surrounding river that cut across the Nation
Source: Etuonovbe, 2011

4. Guide for Government and Stakeholders in Developing Resilient Buildings in Nigeria

The guide involves the practical steps to be taken by government and stakeholders to foster development of resilient buildings in Nigeria. Suggested guides to assist in achieving the aim and lessen the effect of flood are given with brief explanations.

1. Identification of flood prone areas: there are areas associated with serious flood events. Affected states, local governments and areas with flood in the past are to be identified across the country. This can be achieved through past occurrence of flood, predictions for future repetitions in the highlighted areas and new areas. Areas located along flood prone areas include swampy area, along river bank, valley land, along canal, close to ocean etc. The government and relevant stakeholders should take pragmatic steps in getting all the concerned areas of the country documented and well published for state physical planning unit, town planners and prospective builders.
2. Determination of the severity of the flood Events in Flood Prone areas: this succeeds the identification process. The flood prone areas identified must be evaluated for the extent or degree at which flood is experienced or may be experienced in the future. Models that can predict such should be developed to manage such issue and find practical solutions. Areas are different and the extents at which they will experience the flood damages are also different. High severity areas should be well highlighted and marked as such while the low ones as predicted or measured rather than generalization of the severity.
3. Identification of the Major sources and causes of flood in the identified areas: flood has been linked to various sources and causes in different areas. This could be different and or jointly occur in an area at a time. Flood has a pattern which could be studied for preventative actions. Such should be noted and documented as against these areas for easy future control. Also, this will prepare the mind of individual of possible danger and its extent to avoid sudden shock. The actions to be taken by anyone would be easier if such information is available.
4. Development of map for such areas: the document should be developed into visual representation for easy reading and interpretation. The map should be developed for the country as a whole, each state and local government. If it is breakdown from the top echelon to the least which could be made available for citizens and occupants in different areas. This map should include representations for the previous steps and any other relevant information.
5. Development of relevant building policies for each of the areas: there should be a working principle for achieving the goal. The same way there are codes for building; blueprint must hence exist for incorporating resilient into building in certain areas. Buildings should not just be developed haphazardly any longer, there should be types of building with incorporated resilient allow for various locations to avoid vulnerability. Resilient features that are required in each location should be indicated and well explained in the blue print.
6. Development of laws and enforcement to discontinue flood vulnerability increasing activities: after fulfilling the previous steps to be taken, there should be a statutory law to guide all the involved personnel. Builders should be encouraged to follow the developed policies and ways to enforce it must be developed. The building law should include resilient and must be enforced for strict adherence. This

will assist in achieving the goal rather than making it a mere propaganda.

5. Proposed/Expected Features in a Resilient Nigeria Building

Achieving the goal of this study includes the suggestion of various expected features in the Nigerian building. Many buildings in Nigeria have been discovered to be lacking in some of this features because of many reasons (Oladokun *et al.,* 2016). Buildings have been designed with a lot of aesthetic values without considerations for resilience. In our survey of some flood affected areas in different local government area in Ibadan, we discovered that over 98% of houses were designed and built with little to no element of resilient within. Some of the observed drawbacks are described in table 1 and the proposed/expected resilient features in Nigeria buildings are shown and described in table 2. Table 1 has described the noticed defects in Nigeria buildings. Table 2 suggests some resilient features which can help improve the Nigeria building resistance against flood.

Table 1: Observed/Suspected Drawbacks in some of the Nigerian Buildings towards Resilience

S/No	Drawbacks	Category	Observations	Consequences
1	Building Type	Structural	Larger percentage of Nigeria buildings are bungalows. Many are built without a raised foundation.	This makes the house to be almost at ground level and easily opened to flood.
2	Low Entrance height	Structural	The level of the main entrance to the buildings is very low. Generally many are almost at ground level.	This makes it easier for the flood water to enter the building even at low flood events through the entrance.
3	Unsealed Windows	Structural	Many of the window types in Nigeria easily give way to flood because they are without seals to resist water.	Gives way easily to flood water when it reaches window height.
4	Unsuitable Floor Type	Structural	Some floors are found not plastered and are not with tiles. Some that are plastered are with rugs and underlays.	During flooding they get damage easily and require longer time to recover. To dry the rug may request good sunny period which may not be available during the period of inundation.
5	Wall type	Structural	Uncovered wall, walls with poor finishing, unpainted walls, and walls covered with decorative papers. Many of the walls in Nigeria building are not flood repellent.	It gets the wall of the house easily defaced. When affected by flood it increases the damage of the flood.
6	Roofing Style	Structural	Majorly our roofing style does not give consideration on how to gather the water gotten from rain water and conserve it. i.e. using of water harvester and gathering it safely in a reservoir for human use.	This can contribute to run offs and can lead to flash flood under excess rainfalls.
7	Electrical Installation	Structural	Electrical sockets are fixed below 3 feet in the house and the sockets are not water proofed.	Electrical faults can be experienced when water overflows the electrical area and this can cause electrical shock during and after flood.
8	Drainage System	Structural	Lack of drainage system and poor drainage system around Nigeria system is a serious problem.	Lack of channel for water flows built around the building to take water away will lead to overflow of water within the environment.
9	Waste Disposal	Environmental	Poor waste disposal and management systems of many houses in Nigeria.	Problems of waste disposal and nonchalant attitude of many has led to blockage of water ways with refuse. Refuse have created local flood through illegal and unreasonable refuse dump.
10	Building Location	Environmental	Buildings constructed along the canal, dam, river, swampy area etc. are plenty in Nigeria. Building to block water ways, sand filling of river banks before building, wrong and local channelization of water.	Location determines the source and cause of flood to a reasonable extent. It also determines the severity and the extent at which it can be curtailed. Buildings located in extreme area are in for serious damages during flood occurrence.
11	Supportive Facilities	Flood Aid Materials	Many buildings are not with facilities that can sustain or give assistance during flood events. Facilities such as water pump, scooping bowl, life jacket, boat or flood warning systems facilities.	Lack of supporting facilities can render house occupants helpless during flood events. This could lead to high damages.

Table 2: Proposed/Expected Resilient Features in Nigeria Buildings

S/No	Proposed Resilient Features	Description	Expected Effect
1	Invulnerable Site	Buildings should be located in areas that are not prone to flood. Structures developers should avoid water ways, swampy areas, valley lands, close to canal etc.	This will make the house and the properties there in to be free from any attack or damage from flood. The house that is totally free from such area will require little or no additional features for resilience.
2	Storey Buildings, High foundation level, high building entrance level and Column raised buildings.	Storey buildings with opened ground floor or column raised building. The ground floor will not be for accommodation but just column to raise the building.	This will raise the height of house against the level of flood at its peak thereby water will not be able to enter the main building.
3	Tiled floors and tiled walls	The floors of the house and the walls should be covered by ceramic tiles. The floor and walls of the building must be well plastered with cement.	This will hasten the recovery of the building during flood. It will reduce the extent of damage during flood events and bouncing back will never be a problem.
4	Harvesting of the rain water into a storage tank or dam, adequate channelization and drainage system.	Rather than allowing the rain water to increase the run-off when falling directly from the roof the water should be collected through a harvester and gathered into storage or dam in a community. The water can be recycled for domestic use or hydro energy generation.	This will reduce the run-off water in the community and the environment at large will not be disturbed by the excess water. Since most flood events are associated with the period of heavy downpour.
5	Excellent Waste Disposal Method (Waste Recycling Plant, Engineered Landfill).	Waste should not be thrown anyhow in the environment. Recycling the solid waste is the best. In situations where it is not recyclable an engineered landfill should be used rather than throwing waste in drainages, roadside, inside the rain etc.	Reduction or total elimination of blockages in the water ways and drainages will be achieved through this. This will allow the water to have free flow through the right channel.
6	Boat, Life Jackets, Tube, Snow Boards, Flood Warning Systems, scooping bowls, water pumping machine, shovel etc.	These are materials that can assist during flood. Escaping from sudden flood events requires some of these facilities while staying alive among other things remain important; these materials can assist to certain level.	Boat can be used to transport the occupants of the house and valuable properties during flood while the floating tube, life jacket will help safe life of the occupants especially kids who are at more risk.

6. Flow Chart to Guide Individual or Prospective Builder

Achieving this goal has a lot of economic implications which requires many resources for good success. The government and stakeholders' part may seem to be easy to achieve and may easily get the required resources for its success. Individual or prospective builders' cases are different because of the varying financial strength. This made the work to consider an easy to use flow chart to guide the idea of individual or prospective builders. The flow chart considers some of the related steps to be follow and the decisions to be taken by non-corporate body. This is described in figure 2.

7. Discussion

Our survey has shown that there is need for proper planning of our towns and urban area and these has been suggested as a key way in achieving the goal of this study. Many who are considered been seriously affected with flood could have been saved from some of the associated losses. This would be made possible if the necessary blueprint to assist developments in vulnerable areas is put to use.

The observations pointed out in the existing buildings are to correct some of the suspected drawbacks in the resilient of our building in Nigeria against flood. The suspected drawbacks can be corrected but there is a limit to what can be corrected in most of the already existing buildings. However, there are ways to contain the existing

buildings through integration. Achieving new ones should be of paramount importance especially in areas where new settlements are been developed. This will help to achieve the goal at a long term and also contributes its own quota to the resilience of the community.

Expected and/or suggested resilient features are to assist for proper guidance in developing the blue prints. This will enhance the resilient of the Nigerian building against flood and will make a unique environment where everyone has fairly the same features of design. Improvements on other resilient features would be easy to achieve. Creating a roadmap for monitoring and evaluating the achievements becomes easier when a common ground is established. Further index development on flood resilience of buildings could be developed with the guide.

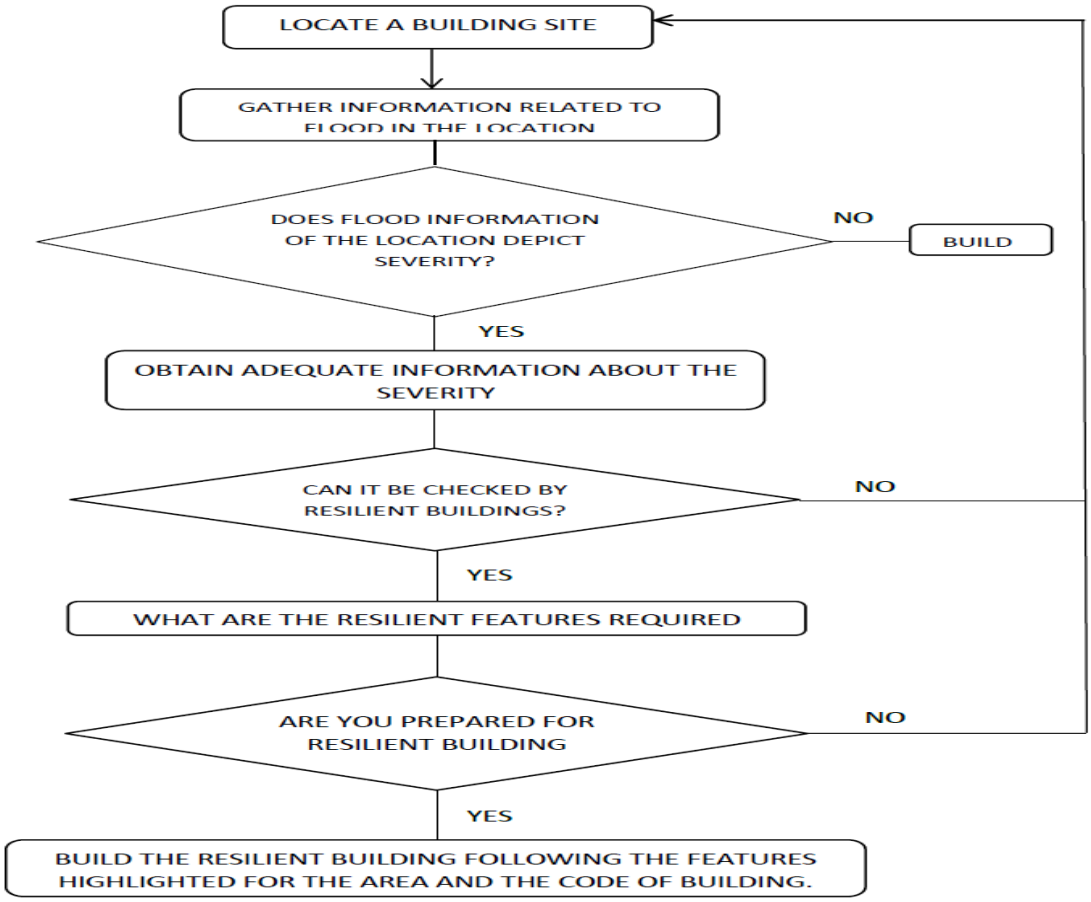

Figure 2: Flowchart to Guide Prospective Builder

9. Conclusion

In developing flood resilient buildings in Nigeria a guide is needed to achieve the goal. The guide that covers the government, stakeholders and the prospective house builders is necessary for achieving. The road map for the success of the resilient buildings in Nigeria has shown that it is a joint task and should be braced with policies that can uphold it. Values of resilience can only be appreciated if there is proper guidance and is well followed as laid without bias. It is involving in terms of resources but the benefit will pay off for the cost if it is properly done.

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