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Assessing Architects' Knowledge of flood Resilient and Adaptable Buildings in Yenagoa, Nigeria

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Abstract

Studies have shown that most parts of Yenagoa, the Bayelsa State capital fall within the high-risk flood zone of Nigeria and are susceptible to annual flooding. However, the 2012 flood was unusual in magnitude and led to the inundation of entire communities, the destruction of buildings and infrastructure. Over five years have elapsed since the floods and new building projects have resumed in some of the hardest hit areas of Yenagoa. This paper draws on data from a survey architects that reside and practice in Yenagoa, to investigate possible lessons learnt in design, material use and construction in the aftermath of flooding in the region. The results of the survey show the level of knowledgethese architectshave about floods and flood resilience in buildings, in the high-risk flood prone region in which they practice. Recommendations are also made on the way forward based on the results obtained from the survey.

Keywords: *Architectural Design, Flooding, Architects, Resilience, Adaptability*

Introduction

Bayelsa State is subject to perennial flooding as a result of low terrain levels, high rainfall intensities, high tidal levels, dam failures and overflow of the River Niger and its tributaries. In addition to the above factors, flooding in Yenagoa which is the capital city is accentuated by sedimentation and urbanisation activities such as construction of roads, erection of buildings and ineffective drainage and waste management systems. Like most flood prone areas it experiences frequent floods in various magnitudes, ranging from minor to extreme flood events.

The 2012 flood was one of such extreme flood event and it occurred as a result of a dam release. Pent up flood waters were released from the Lagdo dam in Cameroun and the resulting deluge affected most downstream communities along the River Niger, its main tributary which is the Benue River as well as its main discharge outlet the Niger Delta. High-risk flood zones in the Niger Delta like Yenagoa, the Bayelsa State capital was adversely affected with considerable damage to buildings and infrastructure.

After the 2012 floods, the Bayelsa state government set up an Infrastructure Advisory Committee (IAC) and a Post Flood Management Committee (PFMC). The aim was to assess the level of damage to buildings and infrastructure and advice on control and mitigation measures in the event of any future extreme floods. Part of the committees' report was that most of the existing buildings were ill-designed for flood resilience, hence the large extent of damage incurred.

Based on the official report by the Post Flood Management Committee PFMC (2013), some communities were either fully or partially inundated with flood heights ranging from 0.80m to 2.5m especially at the back swamps. It was also observed that most of the flooding resulted from overflow of nearby rivers, creeks, streams and other natural/artificial canals. The comprehensive Post Disaster Needs Assessment conducted from November 2012 to March 2013 on the flood induced damage in Nigeria's Niger Delta with the support of the World Bank, United Nations and other agencies estimated the total value of infrastructure, physical and durable assets loss at $9.6bn (Soriwei, 2013).

Studies have shown that buildings incur several levels of damage, often directly proportional to the length of time the flood waters are retained in the buildings (Blanco and Schanze, 2012; Nikolowski et al, 2013 and Naumann et al

2009). Some of the conclusions deduced by the PFMC were that the trend of building designsand construction within Yenagoa allowed for the possibility of several openings for ingress and retention of flood waters in buildings. The report revealed that the avenues for flood water ingress into buildings include;

- Backflow of sewage from overflooded septic tanks, soakaway pits and sewers bringing return discharge into buildings through sanitary appliances
- Ingress through cracks in the walls
- Doorways and windows
- Seepage through unrendered external walls
- Capillary action through hollow sandcrete blocks where no damp proof membrane was used.

These avenues for flood water ingress allowed for different types of direct damage to buildings such as:

- Weakened or failed foundations
- Caving-in of ground floors due to erosion of filling material such as mud or sand from under the foundation
- Destruction of most timber based building products from doors to roof members depending on level of inundation or flood depth and duration of flood waters in contact with building
- Damaged wall render and paint due to prolonged contact with floodwater
- Damaged electrical wiring and fittings due to surface wiring technique widely used
- Contamination of property with sewage, drains and chemicals from garages

In effect, one of the crucial lessons learnt was that the conventional way buildings in this region have been designed by architects and built over the years makes them vulnerable to damage by flood waters in so many areas.As such, the aim of this study is to investigate if architects practicing in this region have learnt any lessons from these building failures experienced during the floods due to their conventional design methods. Following this aim, two research questions have been developed as follows:

- Have therebeen any lessons learnt by architects practicing in this region to make subsequent new buildings more flood resilient or adaptable?
- If so, what are these lessons learnt and how have they been reflected in the architectural designs and construction techniques in subsequent buildings?

Literature Review

This study examines the knowledge of floods, flood resilience, adaptability and mitigation of architects that reside and practice in Yenagoa, the Bayelsa State capital. Surveys that involve issuing questionnaires to architects to ascertain their knowledge levels on certain topicsor opinion about issues are few (Osmani et al 2008, Akintoye and Fitzgerald 1996). But even fewer are studies involving surveys of architects on issues relating to flood resilience and mitigation strategies. Some of the few existing studies include the work done by Bosher et al (2009) who investigated the level of stakeholder involvement in construction decision making on flood hazard mitigation strategies. The study required a survey involving a range of built environment professionals (architects, engineers and planners) amongst others to ascertain their level of awareness of flood as a threat. The study showed that the respondents' awareness of the flooding threat was high, indicating a healthy knowledge among professional in the UK about flooding and resilience. An earlier study had examined professional involvement in disaster risk management in the construction industry based on lessons learnt from past floods (Bosher et al 2007).

Haigh and Amaratunga (2010) also examined the role of the building professionals in the development of society's resilience to floods. But unlike Bosher's work their study adopted an integrative literature review method rather than a direct survey of built environment professionals. But Godschack (2003) strongly opined that in order to achieve flood resilient societies, it is imperative to increase knowledge and awareness on flood resilient planning and design among built environment professionals by imputing this goal into the everyday practice of planners, architects and engineers amongst others.

The focus on knowledge level of architects and other built environment professionals on floods and flood resilience, stems from the failure of conventional building designs in tackling flooding. Balmforth (2016) in his work on flood resilient cities, highlighted the fact that based on lessons learnt from past floods, the way conventional buildings are currently constructed makes them highly vulnerable to destruction by floods waters. Studies on the assessment of building resilience, vulnerability of buildings and resilience of different existing building types to floods have been conducted (Naumann et al 2010, Naumann et al 2009, Cutter et al 2010, Nikolowski et al 2013). Similarly, studies on how to make buildings more resilient to flooding in all aspects have also been undertaken. These include; improving the resilience of building materials and material technologies (Escarameia et al 2012, Golz et al 2015, Lawson 2011); innovations in architectural designs for enhanced flood resilience (Kolarevic and Parlac 2015, Watson and Adams 2011, Anh and Phong 2014, English 2009); and assessing and upgrading planning regulations and building codes to cover extreme flood events and climate change (Aerts and WouterBotzen 2011, Rogers et al 2015).

All these studies emphasized a need to rethink building designs and assess the knowledge levels of architects in flood prone areas towards a more resilient and adaptable approach. In the course of this study two terms were constantly resurfacing, the understanding of which is pivotal to this research and discussions in this field as a whole. These are 'Resilience' and 'Adaptability'. In this field of study, the possibility of interchangeably using these terms is a regular occurrence. As such, there is a need to clearly define these key terms to form the basis for discussion in this study.

Definition of Terms

Majority of the definitions used are those borrowed from reviews done by scholars that bear direct relevance to this study as well as a few which I have attempted to define based on the study context. The terms 'Resilience' and 'Adaptability' as used in this paper are discussed in relation to flooding and building design.

Walker et al (2004) rightly observed that there are different interpretations of what is meant by resilience. More so, it is sometimes used interchangeably with adaptability since these two form part of the related attributes of social ecological systems (SESs) yet they differ distinctively. This distinction is made evident in what constitutes flood resilient designs and flood adaptable designs. As such, it is has become necessary to assess these terms on their own right as well as in relation to flooding and buildings.

Resilience

Resilience as defined by Walker et al (2004) is the "capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks". In relation to disaster, the International Strategy for Disaster Reduction (ISDR) defines resilience as;

The capacity of a system, community, or society potentially exposed to hazards to adapt by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures. (ISDR 2009)

With regards to design, resilience involves creating buildings, communities and regions that mitigate threats of extreme weather and climate change by engineering buildings for severe wind and wave impacts and using materials that are waterproof or otherwise impermeable to water damage (Watson and Adams 2011).

For the purpose of this study, resilience will be examined in relation to design against floods. As such, the data collected on resilient design measures would include; the use of waterproofing materials, waterproofing building products and flood protection methods such as barriers and defenses. This does not include the use of Damp Proof Membranes (DPM) which is a regular building feature that serves as a barrier for rising damp and other capillary actions. But it includes the use of waterproof cement admixtures, chemicals, asphalt or bitumen based linings, rubber or plastic sheet layers and other applications that increase resilience. Escarameia et al (2012) suggest that flood resilience of properties can be achieved by the use of adequate building materials, construction techniques and flood protection products amongst other measures.

Adaptability

Walker et al (2004) defines adaptability as the capacity of actors in a system to influence resilience. This can be done by altering how the threshold affects the system and vice versa. Where adaptability differs from resilience is that it may not require measures that resist or stop flood waters but allows buildings function in spite of the floods. In terms of design, it requires designs to be more adjustable to users and functions in the event of floods. Kronenburg

(2015) analyzed adaptable designs in the discussion on flexible architecture. He suggests that for a building to adapt or be adaptable it ought to adjust to different functions, users and climates or even change in climate.

For this study, the data collected on design adaptability include; adaptable floor levels including buildings that float with increased flood levels, fortified foundations, adaptable building services and components including emergency escape hatches amongst others.

Study Location

Bayelsa State is located in the Niger Delta area which lies in the southern part of Nigeria and is a mixture of tropical rain forests and mangrove swamps. It has a total land area of 9,059 sq. km and the capital city Yenagoa, is one of eight Local government areas that make up its administrative structure. The climatic disposition of this region is tropical. It lies just above the Equator with an annual mean temperature range of 23.9°C – 29.5°C. The mean maximum temperature rarely exceeds 35°C. Relative humidity is high and it increases as progression is made towards the coast.

The terrain is scarred by a network of tributaries, creeks and rivers, depositing their load into the Atlantic Ocean. There are 10 channels from which the waters of the River Niger are emptied into the Atlantic Ocean and 8 of these rivers run through Bayelsa State. The average rainfall experienced in this region is between 2000-2500mm per annum or between 290-360 days of rainfall annually, culminating in floods

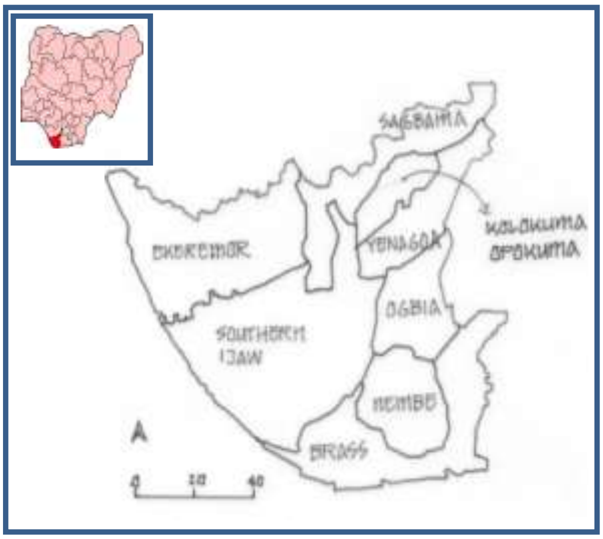

Figure 1: *Map of Bayelsa State showing the eight Local Government Areas (LGAs) and the capital Yenagoa*

Methodology

Over the last 5 years there has been an increase in new residential developments for the middle and upper middle classes in Yenagoa. Some of these new developments have engaged the services of architects in the city who are aware of the past extreme floods as well as the perennial flooding issues in the area and a survey was conducted among them. The study adopted a phone interview technique with the names and phone numbers of architects drawn from a directory obtained from the Bayelsa State chapter of the Nigerian Institute of Architects (NIA). From a list of about 30 architects in the Bayelsa branch of the institute, 20 semi-structured interviews were conducted over the phone with each lasting an average of 15mins, during which some fundamental questions were asked in addition to other follow up questions depending on the responses obtained. The questions include:

- If the architects had previous experiences of the flood whether personal or otherwise?
- If they had designed and supervised building projects anywhere within flood prone areas in Yenagoa after the 2012 floods?
- If yes, did they include any design features in the building(s) to make it more resilient or adaptable to flood waters in the event of future extreme floods?
- If so, what specifically was done to make the buildings more resilient or adaptable in the area of design, specification of waterproof materials for construction, specification of flood adaptable fittings, as well as flood adapted building services and components?

These questions were designed to ascertain the level of knowledge architects practicing in these flood prone areas have about flood behaviour, mitigation methods, adaptable designs and resilience. The survey also helps to determine the level of professional guidance architects in these flood prone regions give to their clients when consulted on building developments based on knowledge and lessons learned.

However, there were some limitations identified in the course of this study especially during data collection. Firstly, there was paucity of data on architects' advice on precautionary measures due to the limited engagement of professional architects for the design of buildings by private developers in Yenagoa. Secondly, the scope and robustness of the data on architects' awareness of floods was limited due to the small number of architects practicing in Yenagoa.

Data Analysis

From the data shown in table II below over 50% of architects interviewed had designed or supervised to completion at least one building in a flood prone area in Yenagoa since 2012. 10% of the architects interviewed had designed/ supervised at least six buildings from that period till date and just 0.5% had not designed or supervised any building in a flood prone area during this time.

When asked about their level of knowledge regarding flood resilient or adaptation measures, the data revealed that all 20 of them were conversant with raising the ground floor level as an effective precautionary measure. However, only two architects making up just 10% of the number interviewed had any knowledge about water proofing techniques in addition to raised floor levels. Water proofing techniques include the use of cement admixtures, chemicals, linings, wet and dry proofing techniques, sheet layers and other applications that increase resilience. When asked what architectural features each added as precautionary measures for escape or emergency evacuation in event of floods, no architect included escape routes or emergency exits in their design. However, six of them stated that they recommended structural reinforcements for foundation walls of bungalow structures built in flood prone areas that were raised above 1m height.

On the issue of raised floor levels, all 19 architects who had designed or supervised buildings in flood prone areas had recommended building floors to be raised to a minimum of 600mm above previous local standards. 50% of them designed ground floor levels between 1.0 to 1.5m in height, 10% had designed ground floor levels to be over 2.1m while 30% used between 1.6 to 2.0m as ground floor level height. However, one of the added data revealed by the study was how the architects determined the height of the raised ground floor levels on each of their projects. For this information, the data shows that no reference was taken from official datum points or established flood levels given by the Bayelsa State Geographical Information Services (BGIS) which is the government agency responsible for setting such standards and planning regulations. Rather, 60% determined their floor level heights from previous flood water marks on neighboring fences or buildings; a further 25% of the architects obtained their floor heights using the nearest major access roads as reference points; while about 15% did not use any reference point to determine their floor heights.

Finally, when asked how the raised ground floor levels were designed, 90% of the architects interviewed said the raised floor levels were designed as fully covered foundation walls and filled with earth before over site concrete was poured. None of the architects adopted the use of stilts, although just one created a pathway for water under a building using a concrete box culvert technique while another created a basement space under the raised floor level.

Results and Discussions

The study reveals that majority of architects interviewed are acquainted with the effects of flood waters on buildings and have been opportune to design or supervise the construction of buildings in flood prone areas. However, for most, the extent of their professional knowledge is still limited to the basic precautionary measure of raised floor levels and even at that there are little or no innovative, efficient and adaptable designs being employed to these raised floors. Some scholars have recommended raising buildings unto stilts or platforms as well as designing smart buildings that respond to varying levels of rising water (Balmforth 2016, Kolarevic and Parlac 2015, English 2009). Also the studies show the architects have little or no knowledge of current flood resilient technologies (FReT) as proposed by Lawson (2011) and discussed by Golz et al (2013) in reducing flood damage.

In addition, the level of paucity of knowledge by architects in the area on designing flood resilient buildings was also revealed in the inclusion of a basement floor as indicated in row 5 of table 2. Building designs with cellars or basements are not recommended in flood prone areas (Kreibich et al 2005). This supports the ICPR (2002) study in Germany which states that buildings without cellars can help reduce flood loss in the residential sector by 3000-6000 EUR.

The data also showed that none of the architects interviewed included emergency exits or escape hatches in their designs as a means by which survivors can escape to elevated positions and await rescue. This issue was discussed in detail as a design feature in buildings in flood prone areas that has been known to contribute to the rescue of lives in several flood events in the world. Its absence is also seen as a major design flaw in building designs in Bayelsa State (Brisibe and Pepple 2016).

Furthermore, the study revealed that the paucity of knowledge by architects about flooding and the reason why some developers did not take precautionary measures was, based on the fact that the building codes/ planning regulations contained no information on flood resilience and adaptation measures to act as guidelines in professional practice. Escamareia et al (2012) observed that for an effective uptake of resilience, there should be regulations to that effect backed up by legislation to make them enforceable. Only few countries in Europe namely; UK, Czech, Poland and Germany have current building regulations covering the use of flood resilient building materials. Although Norway has no specifications with regards to resilient materials, yet there are recommendations on building layout or adaptable designs such as elevation of buildings above certain levels (Escarameia et al 2012).

Table2. *Data From Interview Of 20 Architects Practicing In Yenagoa Since 2012*

1	No. of buildings designed/ supervised after 2012 floods	1 – 2	3 – 5	6 – 10	11 – 15	Over 15
	Out of 20 persons	11 (55%)	6 (30%)	2 (10%)	Nil	Nil
2	Extent of Architect/ professionals' knowledge of flood resilience, mitigation and adaptation	Raised floor levels and reinforced foundations	Use of water proofing techniques	Use of waterproof building materials	Use of adaptable spaces and services	Others
	Out of 20 persons	20 (100%)	2 (10%)	Nil	Nil	Nil
3	Architectural features added as precautionary measures against floods	Raised floor levels	Use of water proofing techniques	Use of waterproof building materials	Creation of emergency exits and escape routes	Others
	Out of 20 persons	20 (100%)	2 (10%)	Nil	Nil	6 (30%)
4	Height to which ground floor levels were raised above previous levels	0 – 0.6m	0.6 – 0.9m	1.0 – 1.5m	1.6 – 2.0m	Over 2.1m
	Out of 20 persons	1 (5%)	1 (5%)	10 (50%)	6 (30%)	2 (10%)
5	Design type for raised ground floor levels	Use of stilts	Creating water pathway under building	Complete filling of raised floor	Introduction of basement under raised floor	Others
	Out of 20 persons	Nil	1 (5%)	18 (90%)	1 (5%)	Nil
6	How height of raised ground floor levels were determined	Reference from official datum point	Reference from nearest main access road	From previous flood water mark on neighboring fence or building	No reference point used to determine floor height	Others
	Out of 20 persons	Nil	5 (25%)	12 (60%)	3 (15%)	Nil

But it is the US and Australia that currently leads in this study of resilient building materials. The US has standardized building codes updated every 3years that specifically covers the use of flood-damage resistant materials for all structures in flood hazard areas. They have also provided documentation identifying some such materials based on ability to withstand direct and prolonged contact with water, without sustaining damage that requires more than cosmetic repairs. The US has also gone further to propose future standards that use certain methods to determine flood damage resistance ratings of materials, as well as materials that can withstand contaminants carried by flood waters (Escarameia et al 2012).

Lastly, an aspect of flood resilient technologies (FReT) is the building aperture technology which ensures temporary watertight closure of façade openings such as doors and windows, keeping flood waters out to a defined design level. This type of technology can be adopted to aid in reducing damage by flood water ingress through apertures and openings, which is one of the major sources of damage to buildings experienced during the 2012 floods as observed by the post flood management committee (PFMC) in Bayelsa State.

Conclusions And Recommendations

With extreme flood events occurring on an ever increasing scale due to the adverse effects of climate change, there is a need to re-evaluate and ultimately redefine the roles of professionals in the built environment. The redefining process puts the responsibility of offering sound advice on built environment professionals like architects, which can preserve huge financial investments in the built environment and potentially save lives. Such advice is based on current knowledge obtained through cutting-edge research and training on flood resiliency and adaptability in architectural designs.

For instance, following the increased rate of earthquakes in seismic regions like Japan and China and sweepers in tornado prone regions in the US over the last two decades, architects in those regions have invested in research into adaptive innovations in buildings for increased resilience to such natural disasters. Immense changes and innovations had to be made not only in material technology but also in design and this was achieved through an evaluation of the previous knowledge and skill set vis-à-vis the current technical know-how required to address such issues.

One of the observations from the study conducted by Anh&Phong (2014) on lessons learnt for disaster resilient shelters in Vietnam was the inadequate level of skills of local builders to construct resilient buildings to combat the enhanced threat of extreme flood events in that region. This study acts as an evaluation of the current knowledge level of architects in flood prone regions like Yenagoa and recommends the need for upgrade in their knowledge of flood resilient technologies (FReT) and flood resilient designs through enhanced training programmes. The study also reveals that part of the blame no matter how small, for developers not taking precautionary measures lies with the built environment professionals such as architects. With architects being the first point of call in designing flood resilient buildings, their invaluable expertise where it exits plays a key role in the development of society's resilience to disasters like floods. This supports Haigh and Amaratunga's (2010) review on the role of built environment professionals. However, there is a flip side to this issue which is a lack of consultation with professionals in the built environment in developing countries as majority of housing construction is still undertaking on owner-builder basis as observed by Anh and Phong (2014). As such, there is a need for legislation on the inclusion of a registered built environment professional when building in disaster prone areas both at the design and construction stage.

With regards to building codes, besides the countries in Europe listed above and some others in South-east Asia not listed, there seems to be a general lack of building codes and regulations related to disaster risk reduction (DRR) in developing countries. As such, a risk-based building regulation with legal backing to create resilient structures in flood prone areas where development is predominantly owner-built is highly recommended.

Another recommendation that cannot be overemphasized is the setting, implementation and use of code specified flood levels for Yenagoa. This has been used to great effect for cities like New York (Aerts and WouterBotzen 2011) and Christchurch, New Zealand where current buildings are required to have floor heights above the 200 year flood level including allowance for climate change and sea level rise (Rogers et al 2015). Similarly, after the Katrina floods, the state of Louisiana passed new building codes for floors to be raised to a minimum of 3ft above the highest existing adjacent grade or the local base flood elevation for new or substantially rebuilt houses (FEMA 2006).

In Yenagoa, the Bayelsa State Geographical Information Systems (BGIS) have carried out studies for code specified flood levels within and outside the municipality after the 2012 floods. In May 2017 a new Physical Planning and Development Authority (PPDA) was set up to oversee plan approval and development control. It is therefore part of my recommendation that this code specified flood levels should be adopted by the PPDA and made available to architects to ensure flood adaptable building developments in this region.

This study also recommends that this code specified flood level format be adopted to other flood prone regions in Nigeria, in addition to training programmes for architects in flood resilient designs, adaptability and flood resilient technologies.

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