Flooding in the Anambra East Local Government area and Adaptation Strategies in Building Designs

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Abstract
Designing for flood risk focuses on preparation of buildings to withstand the threat of flooding, while ensuring that they support everyday livability and quality of life. The devastation in the riverine communities brought by flooding has brought a new level of urgency to rebuild and retrofit buildings within the areas. To meet these challenges, Case study methodology was employed to assess residential buildings in similar locations both locally and internationally for increased knowledge on methods of flood proofing strategies, materials of construction, use of recycled materials and techniques used for design and construction of flood proof buildings which must be shaped on tested principles. Results show that flooding is hazard specific that could be solved through building adaptive strategies. Together, this work presents a road map for supporting existing communities and providing for a sustainable future in our waterfront neighbourhoods.

Keywords: Flood adaptation Strategies, Hazard, Residential buildings, Zoning, Sustainability, Re-use of materials, Cost effectiveness

different decisions in the design,

Introduction

Environmental and natural phenomenon play very significant roles in laying any region's inter-related cultural, economic and social infrastructures. Thus, the buildings in the desert regions are designed and constructed according to the specific climatic conditions and differ from those built in riverine areas. In the past, without modern facilities, it was only intelligent architecture of the buildings that enabled people to live in in-tolerable and extreme climatic adversities. Ejikeme et al, (2015) believe that these climatic adversities can be determined by various climatic elements which can be mapped and kept in check. With this possibility of knowing adverse flooding condition, building Professionals will urgently need to integrate mitigation and adaptations strategies that consider future climate change within their region.

Over the years, the behavior of these climatic elements were used to inform construction, and operation of the built environment. In the study area, climate-related decisions are based on historic climate data and past trends, with the inherent assumption that the climate will remain relatively stable in the future but this is not so as can be observed by the extreme changes in the behavior of the climatic conditions of, excessive heating and melting of the arctic regions, increased rainfall and flooding. This led Christopherson, (1997), Oyegbile, (2008) to suggest that the world may be getting close to extinction unless immediate actions are taken. Hence, the perspective is starting to change. Enete, et al, (2012) therefore suggest that an important way for a city to help reduce the ecological impacts of climate change is by initiating conditions that make it easier for species and humans to adapt.

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Watson and Adams (2011) report, that flooding has been an integral part of human history. From the Brisbane flood of 1893 to present times, flooding has at different times, affected the environments and human lives, and their economy. This is true because on a global scale, floods have caused damage worth billions of dollars. Media reports had it that the flooding caused by Hurricane Katrina for instance, which hit parts of the United States in 2005 caused damages worth about 40 billion dollars and claimed 1570 lives.

Tracing a timeline of floods in Nigeria up to 2001, Etuonovbe (2011) says: "Flood has become a major problem in Nigerian cities. The first flood hit Ibadan, the headquarters of old western region, Nigeria (now the capital of Oyo State) in 1948. Subsequently, serious flood disasters have occurred in Ibadan in 1963, 1978, 1980, 1985, 1987 and 1990. Lagos recorded the first flood in early 1970s and till date, floods have become perennial event in the state." He added that flood events in Nigeria have caused the displacement of over 2 million individuals and devastation of about 597,476 houses worth millions of Naira in different parts of the country.

In 2012 alone, the National Emergency Management Authority (NEMA) reported that between July and October about 1.3 million Nigerians were displaced and 431 died in what it termed the worst flooding in over 40 years, with 30 of the country's 36 states were affected. In the same vein, the United Nations Office for the Coordination of Humanitarian Affairs in their publication in November 2012, reported that more than 7.7 million people were affected, with infrastructure worth many millions of Naira were damaged. It reports that 76000 persons were displaced in Anambra state alone.

Ebuzoeme, (2015) in his study corroborated the report of the extent of devastation of properties, loss of lives and displacement of over seven hundred thousand people in 2012, that was caused by flooding in the Anambra East local Government area. As a result of the level of devastation, this led IPCC, (International Panel on Climate Change) (1998) to suggest that Nigeria, like the rest of Africa, is considered highly vulnerable to climate change-flooding.

This recurrent damage by floods, and the general acceptability that flooding is now a fact of modern life, made building designers across time or places to develop several methods of keeping the flood at bay and reducing its effects. The methods range from the creation of dams, levees, high building foundation, flood walls, among others, to ward off flood and to live with it. These strategies have served the residents almost perfectly then. However with the rapid growth of urbanization and climate change, the floods have become more severe, and even conquered the structures put in place to resist them.

Anambra East local Government area, the settlement pattern and Building typology reflects the physical environment as well as its history. Thus in the past, the building typology evolved out of their needs and in harmony with the environment as well as with optimal utilization of the available local building materials. This resulted in construction of mud residential buildings reinforced with bamboo strips on high foundation of 600-1200mm (An intuitive form of Static Elevation of flood resistance). A canoe is usually hung on roof eave, by the door entrance for ease of mobility during flooding. The patterns of development continued to change from mud building reinforced with bamboo strips to modern cement/sand block buildings with only flood resistant static elevation tenets. Recent observations suggest that this is not completely serving its purpose. This poses a challenge, because of the increased flooding due to climate change and devastation of properties which necessitated urgent need to improve the adaptation strategies of residential building's resilience to flooding. And so the search for sustainable and better approach of flood control. Instead of simply building

flood defenses, building designers are beginning to create structures and buildings that embrace water. Researches reveal that these structures are already created as suggested by Fenuta, (2010); Davidson, (2016); and ArchDaily.com; dezeen.com on the use of Buoyant foundation as a platform for the design of amphibious dwellings.

A cursory look at the building approach to flood defenses by the Royal Institute of British Architects, (2007) shows two main classes; Resistant and Resilient buildings. Resistant buildings totally resist the entry of flood waters by such means as raising them on stilts or piles, or by dry proofing the building using such building materials and components that make the building watertight. While resilient buildings are built to adapt to and accommodate floods, hence, these buildings are fitted with wet flood proofing materials as evidenced in amphibious buildings.

The Study Area; Anambra East Local Government Area.

Anambra state is one of the five states in the south-east geo-political zones in Nigeria. It lies between latitudes 6^0 20' N and 6.333^0 and longitudes $7^0$00'E and 7.05^0E. it has a hot-humid climate which is characterized by two main seasons (Dry and Rainy). It experiences constant high temperatures and relative humidity as well as its low wind speed throughout the year. The temperature ranges from 23-27^0C and maximum 30-34^0C, with a mean relative humidity value of 84%. The rainy season ranges from April to November, and dry season is from November to March.

This work focused on the residential building typologies within the study area; Anambra East local Government area of Anambra state and the residents there are predominantly farmers. The unique coastal geography is one of area's major assets but also that which poses flooding challenges for that environment.

Development in Sustainable Flood Housing

According to Fletche and Burchard (2005), the history of human beings living on water goes back to pre-historic times. Their floating or fixed habitations took one of three forms; Pile dwellings, rafts, or ships. Prosun, (2011) in her support for amphibious Architectures: the buoyant foundation project and alternative flood mitigation strategies in post-Katrina New Orleans, suggested that humans had been living on water- the Agusan marsh in Phillipines in chong Kneas, Cambodia, Iraqi marsh villages, amphibious dwellings on lake Titicaca. Fenuta, (2010) documentation of Dr. Vlach 's doctorate dissertation on the Louisana shotgun house, the construction of amphibious fishing camps at pointe Coupee parish in 1986 and Hertzberger floating house in 2002 contributed to the development of amphibious buildings. Prosun (2011) suggest the existence of the amphibious dwelling in Dhaka, Bangladesh which was based on the principle of LIFT (Low Income Flood-proof Technology). With these, amphibious architecture gradually began with newer cases coming up in the United Kingdom and Vietnam, (Fenuta, (2010); Prosun, (2011). Media report of Africa's largest lake village; City on a lake Nokue, Abomey-Calavi, near cotonu Republic of Benin with over 30000 people (www.sunnewsonline.com), The floating school Makoko-Lagos in 2013 by Arc. Adeyemi as reported in arcdaily.com signified the possibility of success of that type of architecture in Nigeria.

What is evident in the area is only a minute number of residential buildings owned by a few wealthy individuals with minimal features of resistant architecture and static elevation building tenets.

Flood Adaptive Architecture

With the critical situation of the Anambra East local Government, two types of flood adaptive architecture could provide solution to the Problem: the Resistant and Resilient Architecture (Royal institute of British

Architects, 2007). An in-depth study of the adaptive strategies by RIBA, clearly shows that resistant buildings main strategy is to attempt to keep any water from entering it. It is normally viable if the potential flood water is less than 600mm above ground. The building strategies include static elevation buildings, buildings with dry flood proofing elements. Resilient buildings are adapted to flow with the rise and fall of flooding and designed in such a way as to reduce the cost and time required to re-instate the property should it be flooded. Robust materials and finishes are used, including hard floor surfaces that can be prevention, protection and mitigation to include the following;

a.) Elevated configuration: Elevated configuration buildings also known as static elevation buildings are buildings elevated to a required or desired base flood elevation (BFE). Anderson,(2014) insist that when a house is properly elevated, the living area will be above all but the most severe floods. In general, they involve:

washed down, and solid wood rather than particle or medium density fibre boards for doors and fitted furniture and bathrooms. Alternatively, finishes can be designed to be removable or sacrificial and easily replaced in the zone affected by flooding (RIBA, 2009). Resilient building typologies include buildings with wet flood proofing materials. They admit flood water but ensure that there is minimal or no damage to the property. The Royal Institute of British Architects (RIBA) in her document; Climate Change ToolKit 07: Designing for flood risk suggest strategies regarding flood

i. Lifting the house and building a new, or extending the existing, foundation below it,
ii. Leaving the house in place and either building an elevated floor within the house or adding a new upper story

Watson and Adams, (2011) suggest that elevation to desired Base flood Elevation (BFE) may be accomplished by raising and supporting a building structure on Piles, Posts, Piers, or Columns, Compacted fill, Walls or a crawl space. This is observed in the Elevated Building in the study area.



Plate 1: Photo showing the rear view of the late Igwe's Palace. (Source: Authors' field work, 2016)

a. Wet flood proofing: RIBA, (2007) during their work on flood Risk suggest that wet flood proofed buildings let flood waters into a part of the building that has been designed with materials which can withstand long exposure to water. Thus, as the flood recedes, the area is cleaned up and a few cosmetic repairs are done to make the space habitable again.

proofing is not recommended in areas threatened by flash floods (little warning time). Additional RIBA observations show that wet proofing should be accompanied by pressure sewerage (backflow

In addition, Wet proofing minimizes damage to building and its contents although flood water is allowed to enter the building. Utilities are installed at a higher level and people relocate vulnerable items permanently or temporarily (if sufficient flood warning time was given). This is observed in the Turnaround House designed by Nissen and reported by RIBA in their climate change Toolkit 2007. Equally, it was stated that wet flood prevention) and adequate drainage systems. Wet proofing entails health risks, risk of contamination, impact of debris and the risk of electrical shortcuts.



Plate 2: Turnaround House designed Nissen Adams. Source: Climate Change Toolkit 07: Designing for Flood Risk by RIBA, 2007)

b. Dry flood proofing: The City of Hoboken in her publication of 2015 on Resilient Building Design suggest that Dry flood proofing is a combination of design modifications that result in a building or structure, including the attendant utility and sanitary facilities, being water tight with walls substantially impermeable to
c. The building. Note that dry proofing above 0.9m would be very expensive and make the house considerably less user friendly. RIBA, (2007) recommended that Dry proofing is best recommended in frequently flooded areas with low flood water depth. Dry the passage of water and with structural components having the capacity to resist floods loads. Further on, it said that Dry flood proofing involves covering and protecting openings, making them water tight up to a height of 0.9m to withstand flood forces and avoid entrance of water in proofing normally includes the backflow prevention by pressure sewerage systems (valves) to prevent backflow of floodwater, closure system for ventilation grids, etc. additionally adequate drainage systems can reduce flood duration and thus damage.

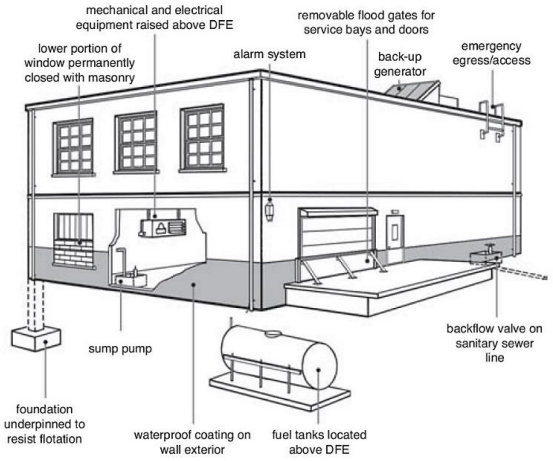


Plate 3: Design for flooding
Donald and Michele, 2011)

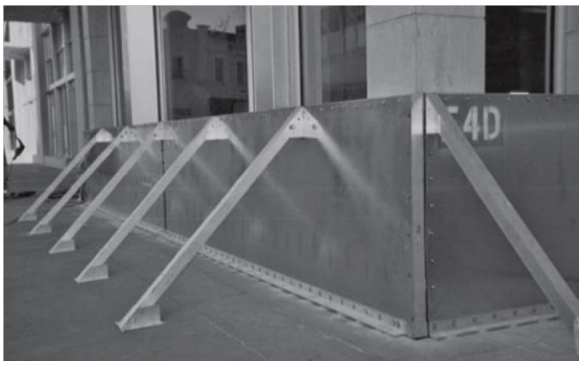


Plate 4: Design for flooding. Source: Donald by and Michele, 2011)

d. Floating or Amphibious buildings: RIBA, (2007) refers to this flood mitigation strategy that allows an otherwise-ordinary structure to adapt to inundation. An amphibious foundation retains a building connection to the ground by resting firmly on the earth under usual circumstances, yet it allows a building to float as high as necessary when flooding occurs. A buoyancy system of light weight recycled materials beneath the house displaces water to provide floatation as needed, and a vertical guidance system allows the rising and falling of building to return to exactly the same place on descent. The idea of amphibious buildings was taken from the Archimedes Principle. It states that, “any mass completely or partially submerged in a fluid (gas or liquid) at rest is acted upon by an upward, or buoyant, force the magnitude of which is equal to the weight of the fluid displaced by the body. Amphibious construction is a flood mitigation strategy that works in synchrony with a flood prone region’s natural cycles of flooding, rather than attempting to obstruct it. Fenuta, (2010) assert that specially, amphibious foundations allow a house to remain on land during normal, non-flood conditions, but enable the house to rise and float on the water’s surface flood during a flood.



Plate 4: Amphibious Architecture: Living with a Rising Bay by Anderson, 2014)

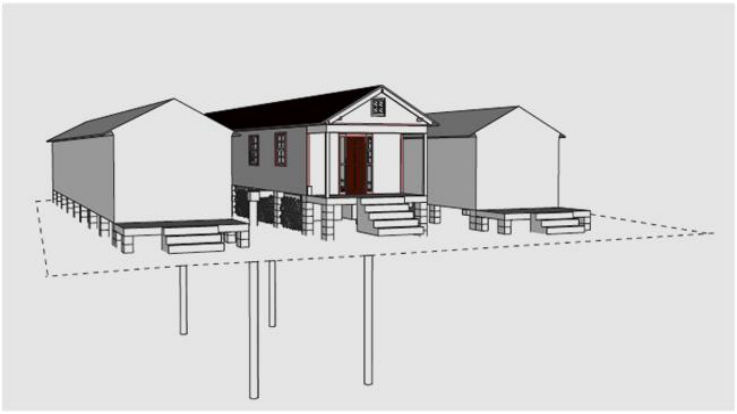


Plate 5: Showing the workings of Amphibious House at Normal and Extended positions



Plate 6: Buoyant Foundation Project in Post-Katrina New Orleans by Fenuta, 2010)

Static Elevation Versus Amphibious Buildings

A close look at the Static Elevation and Amphibious strategy reveals the advantages of Amphibious building strategy over Static elevation strategy are itemized here under;

Amphibious architecture has the following advantages over static elevation buildings:

i. The building is close to the ground under non-flood circumstances.

ii. It elevates the house to exactly what is required to stay above water even if the flood level is higher than the Base Flood Elevation (BFE).
iii. There is no need to clean the interior of the building after the waters recede
iv. The occupants of the building are not exposed to the risk of sickness from flood water.
v. In a high wind event with no flooding (e.g. windstorms), it stays close to the ground and is therefore less susceptible to wind damage.
vi. It alleviates loss of elevation due to soil subsidence and elevated sea level.
vii. The neighbourhood retains its original character.

Picture 5.0 Showing Static Elevation versus Amphibious building in flood conditions

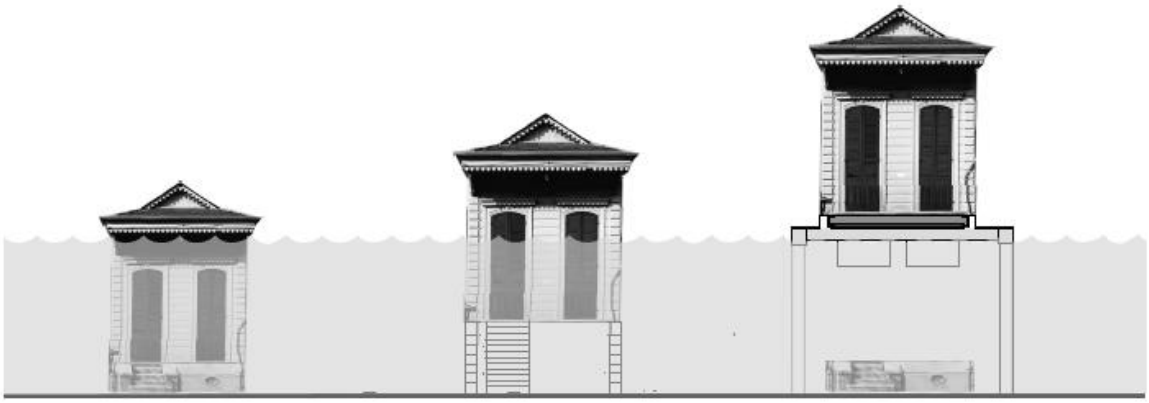


Plate 7: Amphibious Architectures: The Buoyant Foundation Project in Post-Katrina New Orleans by Fenuta, 2010)

Materials Selection

In the past, People in Nigeria built their houses according to their needs and in harmony with the environment as well as with optimal utilization of the available local building materials to achieve their abodes (Dmochowski, 1972). For any new design strategy to be accepted, it must consist of design solutions, materials and construction not alien to the users. These should not only meet building quality but also sustainable.

It is now generally accepted that building designs, choice of materials and construction should meet to the sustainability tenets. This condition led Kim, (1998) to suggest three concepts of sustainability in architecture that could be applied here. These are (a) **Economy of resources** which is concerned with the reduction, reuse and recycling of the natural resources that are input into a building, (b) **Life cycle design** which provides a methodology for analyzing the building process and its impact on the environment and (c) **Humane Design** which focuses on the interactions between humans and natural world.

The principles of sustainability as stated above, suggest that flood house should be a practical and cost effective response to the necessity of building on flood plains. It promotes waterside housing as a lifestyle choice.

The concept is simple. All major house builders invest heavily in ground works and substructure. Instead, the flood adaptive house will be composed of building fabric assembled on a relatively light weight and stable structural base to enhance the floatability of the structure. To that effect, the structural system will be an assemblage of prefabricated bamboo columns and beams, bolted, screwed or tied together. Other floatable materials include recycled

rubber containers, tubes and other light weight materials could be used to create buoyant homes that can float during flooding and return to normal conditions on recede of flooding. This, no doubt will be able to satisfy the needs of coastal dwellers in the face of anticipated increased flooding. For the effective functioning of the flood house, the choice of building materials becomes a very important aspect of the design. It is important that the materials chosen should serve to enhance the functionality of the structure and the comfort it offers to its users. This is in line with the suggestion of Damen, (1996); Honey and Buchanan, (1992) when they opined that the proposed project must be environment and community responsive. It must be green in its materials, energy planning, waste management, emissions to the air/water and designed for flexibility. In addition, choice of materials should also be based on the following:

- Durability and ease of maintenance
- Strength
- Water Resistance
- Weight (preferably light)
- Safety
- Fire resistance
- Acoustics
- Sustainability
- Cost effectiveness
- Aesthetics

Services

Water Supply: The flood house will harvest and filter its own water. This will be through a bore hole or well for the dry season and through rain water harvesting system and a bio-filter system for the rainy season. This ensures that the house has a steady supply of water all year round.

Power Supply: The flood house will exploit solar energy through the use of photovoltaic cells or solar panels or ' Lumos' mobile electricity power/solar supply strategy from MTN Nigeria. This removes the need to burn fossil fuels and also ensures a steady power supply all year round.

Waste Removal: Waste from the flood house as with any other structure is grouped into liquid and solid waste. Liquid waste is further grouped into grey and black water.

Grey water from the building will be filtered and re-used for flushing toilets. The system for filtration will be similar to that for filtering rainwater and will be composed of layers of fine and coarse aggregates.

Waste from the toilets however, will be collected in a 'GeePee Plastic' septic tank to settle and for ease of sludge disposal after the flooding period.

Conclusion

Many coastal communities in the Anambra East local Government Area have become accustomed to the form buildings must take in an area of coastal flood risk-buildings without basement or sometimes raised on columns. But these communities have not yet made this adjustment from their traditional building forms. Thus the repetitiveness of the level of destruction and economic loses every other time there is flooding. The paper therefore advocates that the inhabitants of these coastal settlements/flood Plains like Anam, Inoma, Miata and National and State flood emergency agencies should endeavour to understand the causes and consequences of flooding as well as strategies to deal with it, then work together to live with it and not fight it.

The residential buildings should be retrofitted to incorporate both resistant and cost-effective resilience strategies against flooding in accordance with socioeconomic factors and site conditions to enable the efficient operation of their buildings. Apart from the above, possible flooding zones should be mapped and graded for future design and construction of residential buildings with appropriate strategies to deal with flood.

The need to develop new building design approaches to create flood proof house in the study area. Flood resilience can be achieved through a range of solutions and at different scales of intervention by incorporating a combination of varied and tested strategies. Zoning is an important factor for shaping buildings, and can promote good design alongside increased flood protection. It can help determine where a building should have combined strategy, singly of resistant and singly resilient strategies respectively. So an amendment to the existing zoning pattern is expected to be more versatile and desirable design solutions to accommodate flood resistant and resilient building constructions.

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