DEVELOPING SUSTAINABLE ADAPTIVE STRATEGIES OF AQUATECTURE IN COMBATING FLOODING IN COASTAL REGIONS IN NIGERIA

Alli F.C*
Department of Architecture, Federal University of Technology Minna, Nigeria
*Corresponding author's email: [illegible]

Isah, A. D
Department of Architecture, Federal University of Technology Minna, Nigeria

ABSTRACT

In Nigeria, cases of flood incidents have been on a steady rise in recent years. It is predicted that with climate change and increased global warming together with the melting of the polar ice caps of the world, the trend is expected to continue. It is therefore imperative to have an adaptive architecture that is able to mitigate the effects of such floods as they happen. Adequate knowledge on such adaptive strategies, been used in coastal areas is still limited. The paper is aimed at investigating the application of the adaptive strategies of aquatecture in coastal and flood prone areas of Nigeria. The research process adopts a descriptive survey method which employs the use of observation schedules, and an in-depth review of existing literature. Findings show a low level of implementation and use of adaptive strategies of existing buildings in these flood-prone regions of Nigeria to combat floods leading to these settlements being vulnerable to destruction and damage occurring from floods. It is however pertinent to know that adaptive strategies to combat floods can be employed to allow for a sustainable development in flood prone areas and coastal areas of Nigeria and their adoption is of utmost importance to combat the expected floods in these areas which is a recommendation this paper puts forward. This paper concludes by advocating for the use of adaptive strategies of aquatecture in the flood prone and coastal areas of Nigeria to combat floods.

Keywords: Adaptive strategies, Aquatecture, Coasts, Floods, Flooding

INTRODUCTION

The need to adapt to the environment has always been a necessity for man, from pre-historic times till modern times. From adapting to living in clusters as society to adapting to the various challenges and environmental situation around him man has always found a way to happily coexists with nature and make the most of it to survive.

The world as it is, is currently plagued with issues of climate change which has led to global warming and that has resulted in increased flooding in coastal cities and flood plains leading to the destruction of lives and properties including buildings (Williams, 2009). Coastal flooding already seen and regarded as one of the most dangerous, harmful and destructive natural disasters in the world (Douben, 2006). A huge percentage of the world's population

almost 21% currently live on adjacent shorelines, making these coastal cities large concentrations of growing settlements, human population and socio-economic activities (du Gommes, Guerny, Nachtergaele & Brinkman, 1997; Brooks, Nicholls, & Hall, 2006). The potential impact of the rising sea level on coastal communities would be quite significant (Kumar, 2006), on the coastline but also specifically on the buildings in these communities that inhabitants live and carry out their daily activities in.

Adaptive architecture is concerned with ensuring that buildings are designed to adapt or work cohesively with the environment in which that building is found. Therefore buildings in coastal areas need to be adapted to be able to combat these floods which are predicted to increase in future (Balica, Wright & Van der Meulen, 2012). The concept of aquatecture is an architectural adaptation typology that is used to manage and control floods. Here water and architecture are combined together to bring about dynamic and reliable solutions to flood related issues in the built environment.

This paper is aimed at investigating the application of the adaptive strategies of aquatecture in coastal and flood prone areas in some parts of Nigeria.

Coastal Systems

Coastal communities around the world are expected to be increasingly affected by floods due to climate change and it effects. As a matter of fact, some of these coastal communities are already considered vulnerable to the ongoing climate changes (IPCC 2007a, b; Mirza 2003). Accelerated sea level rise with elevated tidal inundation, increased flood frequency, erosion, water table rise, increased salt water intrusion, storm surges and cyclones are just some of expected results of climate change (Fenster and Dolan 1996). The coasts will be affected the most by these outcomes.

Coasts are dynamic systems which undergo changes to its form and process at varying times and space as a response to geo morphological and oceanographical factors (Cowell et al. 2003a, b). Pressure exerted by human activities on the coasts sometimes dominate and relegate the natural processes to the background.

It is sometimes difficult to identify the impacts of climate change on coasts due to its natural variability, for example erosion on beaches may not necessarily be caused by sea level rise but by other factors such as altered wind patterns, offshore bathymetric changes, reduced fluvial sediment input or hard structures built near the coast (Pirazzoli, Regnauld & Lemasson, 2004; Regnauld, Pirazzoli, Morvan, & Ruz, 2004; Cooper & Navas, 2004; Nicholls et al. 2007).

Floods in Nigeria

In Nigeria, floods have become a major cause of concern particularly in recent times. With a rapidly growing population and urbanization coupled with climate change, floods have become a menace and hazard in the country. In 2012 alone it was estimated that $16.9 billion was lost in damaged properties, oil production and agricultural produce owing to floods (Amangabra & Obenade, 2015; Egbenta, Udo & Otegbade, 2015). Prior to recent flood events in Nigeria, floods rarely occurred in Nigeria. Some recorded flood events in Nigeria dates back to the 60s when Ibadan was flooded

by the Ogunpa River leading to loss of life and properties with reoccurrence in the 70s, 80s and in 2011 (Adegbola & Jolayemi, 2012; Agbola, Ajayi, Taiwo, & Wahab, 2012). However in recent times devastating levels of floods have been witness in various regions of the country from Lokoja, Idah, Benue and Lagos. These floods are predicted to become a staple feature in Nigeria as an impact of global warming and climate change that is being experienced in the world.

According to the Assessment Capacities Project (ACAPS) flood briefing note of 2018, floods occurring across Nigeria in 2018 has left devastating effects in its wake, it is estimated that 141,500 people across 12 states in Nigeria have been displaced. Over 108 deaths have been recorded this year alone with the estimated number of 13,000 houses damaged and around 80,000 people estimated to be living friends and family and in IDP camps already set up.

Flood Prone Areas in Nigeria

Oladokun & Proverbs (2016), described the varying regions and sources of major flooding in Nigeria as seen in Figure 3 below and categorized them as follows.

1. Coastal cities and southwestern Nigeria has over 853 km of coastline with extensive low lying areas that is heavily industrialized and prone to flooding.

   Lagos, Port Harcourt and Bayelsa are prone to urban flooding.
2. Communities and settlements along the two major rivers in Nigeria: As seen in Figure 3 below the entire area along the coast of both the River Benue and River Niger have been seen to be prone to floods but most especially communities and urban settlement along the river Niger have been affected more by recent floods as witnessed in Lokoja (Amadi & Ogunsoi, 2015).
3. Communities downstream of dammed Rivers or on the bank of other major rivers are also prone to floods from these rivers or dams.

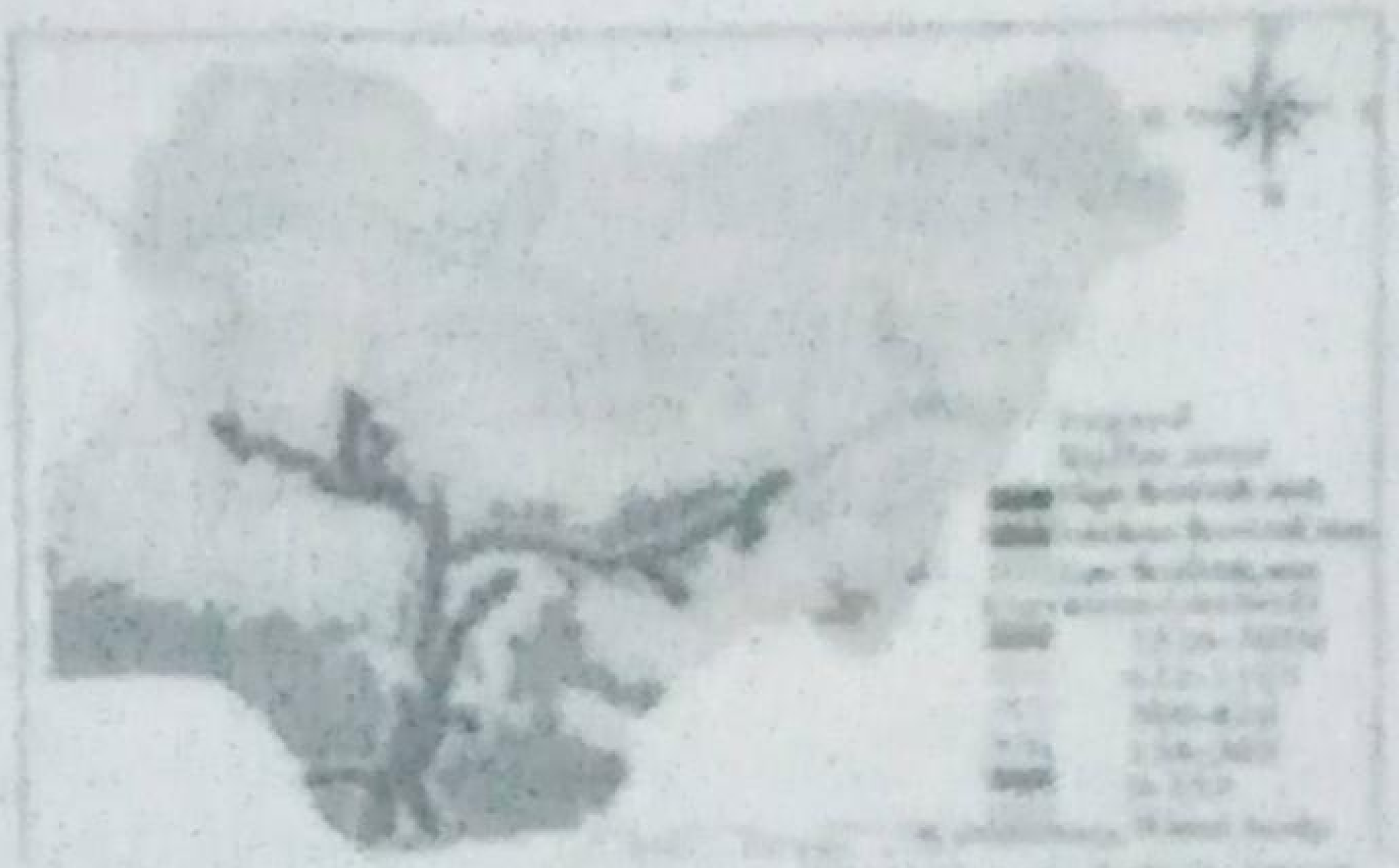

Fig. 3: A Map of Nigerian Flood plains; (Ibrahim, Ikenyin & Orem, 2013)

Strategies of Aquatecture

Aquatecture aims to harness the inherent potential of water and combine it with the building design to create a dynamic architecture that helps solve critical problems being faced in coastal and flood prone areas. Numerous strategies have been employed all over the world to adapt buildings to flood and all of these strategies all fall under aquatecture. Anderson (2014), and Williams (2009), both highlighted various strategies prominent of which include:

1- Terp dwellings: These are artificial mounds of earth made to safe guard against rising water levels (Figure 2). Terps of up to 05 metres in height have been built in times past to prevent floods and it has eventually led to the creation of permanent dyke systems used to protect large portions of land from flood. Terps are no more popular in modern times due to the advent of other strategies used in combating floods.

Fig 4: Terp Dwelling

2. Static elevation of the building to a specific height – This is a common means of combating floods and retrofitting buildings to prevent floods by elevating the building to a required height or to a distance from flood elevation. This causes the living area of the building to be above the floods (Figure 5). Static elevation can be achieved by either lifting the building or adding elevated floors and upper stories to the building.

Fig 5: Static Elevation.

3- Pile dwelling- These houses are often built on concrete, steel or wooden poles in places where it is easy to determine fluctuations in water level. Pile dwellings with different names are used all over the world as a means of protection from floods. (Figure 4).

Fig 6: Pile Dwelling

4- Housebouts- This strategy involves the conversion of ships and other water vessels into living spaces. These buildings look a lot like a normal building on land but are buoyant enough to withstand floods. (Figure 5).

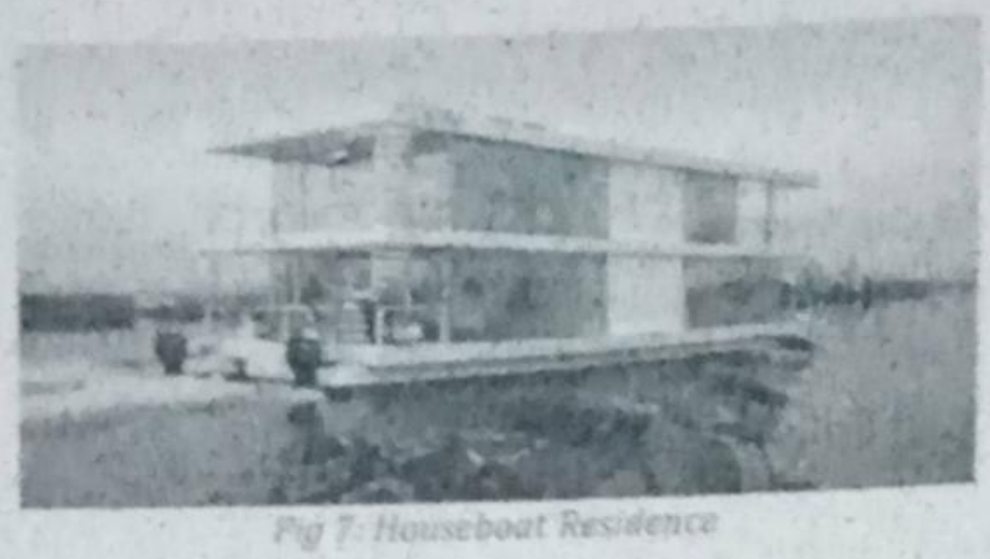

Fig 7: Houseboat Residence

5- Amphibious dwellings- This strategy involves the construction of a dwelling on land but is able to float in the occurrence of floods at the same time. (Figure 6). These buildings employ certain features like hollow basements or pontoons to ensure the building is lifted during floods. When the flood recedes the building then returns to its position on the ground.

Despite the numerous adaptive strategies available in combating floods amphibious dwellings are proven to be the most effective strategy of aquaculture as it enables coastal and flood prone areas mitigate and recover easily from floods without excess damage occurring (Anderson, 2014). It is paramount that designers and builders look to the opportunities presented by floods and water rather than to the limitations presented.

RESEARCH METHODOLOGY

The research method employed in conducting this study was the descriptive survey method which employed the use of purposefully structured observation schedule to obtain relevant data and for the study. A sample of some settlements in and around Lokoja which are known to have been affected by floods were selected and used for the study. The elements that were observed include the population of these settlements, building types predominant in the settlements, presence and nature of adaptive strategies employed in their buildings to combat floods.

The settlements observed are; Koton Karfe, Adankolo, Ganaja, Gadumo and Kpata

RESULTS AND DISCUSSION

The results obtained from the observation schedule were documented in tables using the following representations:

1 - Available

0 - Not available.

The result shown in Table 1.0 below shows that none of the settlements observed had any sort of embankments at the bank of the river to prevent flooding from occurring in the first place. Drainages to help control water flow in the case of floods was only found in Ganaja and Gadumo respectively. Of these two aforementioned settlements, only Ganaja had a planned drainage system to help control water in case of floods. However, it is important to note that despite the planned drainage in Ganaja, it proved ineffective in preventing floods due to blockage and excessive volume of water recorded during floods.

Table 1.0 Flood Features of Settlements

S/N	List of Towns	Embankments	Drainage	Planned Drainages
1	Koton Karfe	0	0	0
2	Adankolo	0	0	0
3	Ganaja	0	1	1
4	Gadumo	0	1	0
5	Kpata	0	0	0

Source: Authors

The results shown in Table 2.0 below also shows an apparent absence of adaptive features for floods in the buildings found in these settlements. The adaptive feature that Ganaja and Gadumo have is the raised floors which is present in lots of buildings in these areas. However, with flood levels expected to rise beyond two meters, these raised floors are rendered ineffective to help mitigate against floods when it occurs.

Table 2.0 Flood Adaptive features employed in Buildings in the Settlements

S/N	List of Towns	Raised Floors	Static Elevation	Terps	Boat Houses	Floating Houses	Amphibious Houses
1.	Koton Karfe	0	0	0	0	0	0
2.	Adankolo	0	0	0	0	0	0
3.	Ganaja	1	0	0	0	0	0
4.	Gadumo	1	0	0	0	0	0
5.	Kpata	0	0	0	0	0	0

Source: Author's

Figure 7 and Figure 8 below shows the situation in these settlements with buildings and roads completely covered in floods

Fig 7: Blocked drainage in Gurnah. Source: Authors

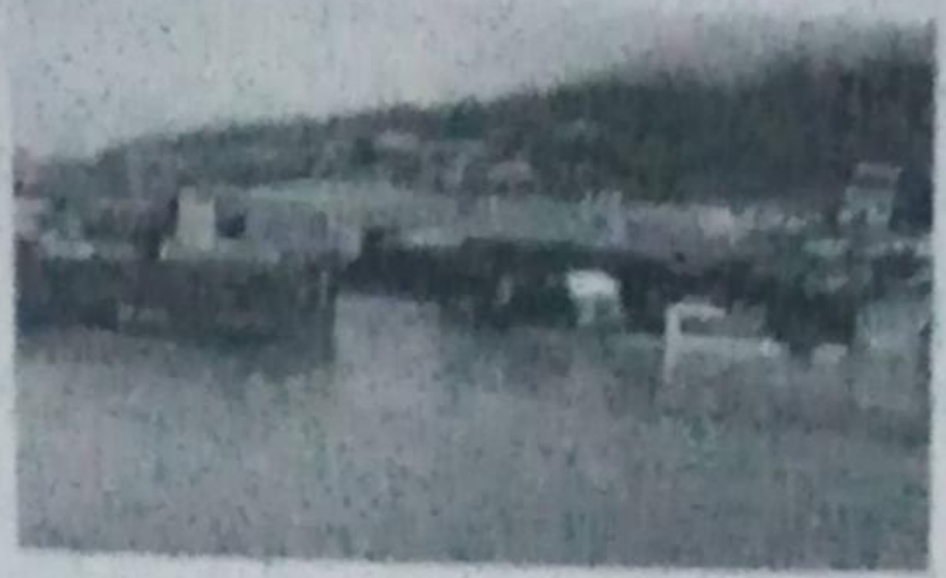

Figure 10: Damage caused by flood in Lokoja. Source: Authors

CONCLUSION

From the study it is clear that most of these communities have had to grapple with floods and its devastating effects in the past but that has not necessarily been translated into the use of adaptive strategies of any kind in their buildings to combat the effects of these floods. Inhabitants have to evacuate their houses and carry their important properties along with them to houses of relations and friends or to internally displaced persons camps pending when the floods recedes and they can return to their daily lives. These inconvenience on the occupants of these settlements and the governments who have to help evacuate and set up emergency rescue and IDP camps for the flood victims can be prevented by incorporating adaptive features of aquatecture to existing buildings through retrofitting them while also ensuring that all new buildings are able to adapt to the floods predicted.

RECOMMENDATIONS

From the study the, these recommendations can be applied to help improve the adaptation of coastal and flood prone communities to flood;

i. The federal government should set up policies and guidelines aimed at promoting the adaptation of coastal and flood prone areas. These guidelines should cover the design and construction of buildings in this area and should be adhered to strictly.

ii. Spatial planning of flood prone communities should be carried out to determine the flood risk of such communities and map out strategies to reduce the vulnerability of these communities.

iii. Adaptive strategies of aquatecture like those noted in the study should be implemented at all phases of the building construction in theses coastal flood prone communities. From the design phase to the construction and finishing stages of the building.

REFERENCE

ACAPS, (2018). *Nigeria Flood Briefing Note Update September 2018.* Retrieved from http://reliefweb.int/report/nigeria/acaps-briefing-note-nigeria-floods-update-26-september-2018

Adegboye, A.A. & Jolayemi, J.K. (2012). Historical rainfall-runoff modeling of river Ogunpa, Ibadan, Nigeria. *Indian Journal of Science and Technology*, 5, pp. 2725–2728

Agbola, B., Ajayi, O., Taiwo, O. & Wahab, B. (2012). The august 2011 flood in Ibadan, Nigeria: Anthropogenic causes and consequences. *International Journal of Disaster Risk Science*, 5, pp. 207–217. http://dx.doi.org/10.1007/s13753-012-0021-3

Amadi, L. & Ogonor, C.U.M. (2015). Climate change, environmental security and displacement in Nigeria: experience from niger delta flood disaster, 2012. *African Journal of Environment Science and Technology*, 9(1), pp. 53–64, http://dx.doi.org/10.5897/AJEST 2014.1749

Amangabra, G.T. & Obenade, M. (2015). Flood vulnerability assessment of Niger Delta states relative to 2012 flood disaster in Nigeria. *American Journal of Environmental Protection*, 3(3), pp. 76–83

Anderson, H. C. (2014). Amphibious architecture living with a rising bay. *A thesis presented to the faculty of California polytechnic state university, San Luis Obispo*

Balica, S.F., Wright, N. G. & Van Der Meulen, F. (2012). A *flood vulnerability index for coastal cities and its use in assessing climate change impacts.* https://doi.org/10.1007/s11069-012-0234-1

Brooks, N., Nicholls, R. & Hall, J. (2006). Sea level rise: coastal impacts and responses. Norwich WBGU ISBN 3-936191-13-1 Berlin

Cooper, J. A. G. & Navas, F. (2004). Natural bathymetric change as a control on century-scale shoreline behaviour. Geology 32,513–516

Cowell, P. J., Stive, M. J. F., Niedoroda, A. W., De Vriend, H. J., Swift, D. J. P., Kaminsky, G. M. & Capobianco, M. (2003a). The coastal tract. Part 1: A conceptual approach to aggregated modelling of low-order coastal change. J Coast Res 19:812–827

Cowell, P. J., Stive, M. J. F., Niedoroda, A. W., Swift, D. J. P., DeVriend, H. J., Buijsman, M. C., Nicholls, R.J. & Roy, P.S.(2003b). The coastal tract. Part 2: applications of aggregated modelling of lower-order coastal change. J Coast Res 19:828–848

Douben, N. (2006). Characteristics of river floods and flooding: a global overview, 1985–2003. Irrigation Drainage 55:S9–S21 (published online in Wiley InterScience)

Du Gommes, R., Guerny, J., Nachtergaele, F.& Brinkman, R. (1997) Potential impacts of sea-level rise on populations and agriculture. FAO, Rome

Eghenta, I.R., Udo, G.O. & Otegbulu, A.C., (2015). Using hedonic price model to estimate effects of flood on real property value in Lokoja Nigeria. *Ethiopian Journal of Environmental Studies and Management*, 8(5), pp. 507–516. http://dx.doi.org/10.4314/ejesm.v8i5.4

Fenster, M. S. & Dolan, R. (1996) Assessing the impact of tidal inlets

on adjacent barrier island shorelines. J Coast Res 13:291–310

IPCC (2007a) Climate change: impacts, adaptation and vulnerability. Contribution of working group II to the fourth Assessment report of the intergovernmental panel on climate change. In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, New York

IPCC (2007b) Intergovernmental panel on climate change. AR4, fourth assessment report: Climate Change 2007

Kumar, P. K. D. (2006) Potential vulnerability implications of sea level rise for the coastal zones of Cochin, Southwest Coast of India. Environ Monit Assess 123:333–344

Mirza, M. M. Q. (2003) Climate change and extreme weather events: can developing countries adapt? Clim Policy 3:233–248

Nicholls, R. J., Wong, P. P., Burkett, V.R., Codignotto, J. O., Hay, J. E., McLean, R. F., Ragoonaden, S. & Woodroffe, C. D. (2007) Coastal systems and low-lying areas. In: Climate change 2007: impacts, adaptation and vulnerability. *Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change.* Cambridge University Press, Cambridge

Nkeki, F.N., Henah, P.J. & Ojeh, V.N. Geospatial techniques for the assessment and analysis of flood risk along the Niger-Benue basin in Nigeria. *Journal of Geographic Information System*, 5, pp. 123-135. 2013 http://dx.doi.org/10.4236/jgis.2013.52013

Oladokun V. & Proverbs, D. (2016) *Flood risk management in Nigeria: A review of the challenges and opportunities.* https://doi.org/10.2495/SAFE-V6-N3-485-497

Pirazzoli, P. A., Regnauld, H. & Lemasson, L. (2004) *Changes in storminess and surges in western France during the last century.* Mar Geol 210:307–323

Regnauld, H., Pirazzoli, P. A., Morvan, G. & Ruz, M. (2004). *Impact of storms and evolution of the coastline in western France.* Mar Geol 210:325–337

Williams, E. (2009). Aquatecture: Architectural adaptation to rising sea levels. *Graduate Theses and Dissertations.* http://scholarcommons.usf.edu/etd/85