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INNOVATIVE ARCHITECTURE FOR FLOOD RESILIENCE: A RESPONSE TO SUBMERGED NIGERIAN CITIES

Adegboyega T. Durowoju
[1]*G D Architects Ltd., Croydon, UK*

Prolonged rainfall and overflowing river banks have made flooding a common problem in Nigeria. Recent flood events in 2018 have been described as the worst in 40years. Available records show that more than 825,000 people have been affected across the country while properties worth billions of Naira have been destroyed. Climate change has induced significant impacts on Nigeria such as aggravating urban flooding exacerbated by human activities. In addressing this challenge, a strategic approach is required to enable communities to adapt to the consequences of flooding, create sustainable environments whilst developing technological and innovative solutions. This study utilizes secondary data from the National Emergency Management Agency [NEMA], research papers and newspaper articles to unravel the anthropogenic factors that contribute to the incessant floods. Key lessons were synthesized and the evidence suggests that there is recognition of the need to take action on the impacts of climate change. Going forward, innovative adaptation solutions should be incorporated into development management plans with all efforts geared towards sustaining livelihoods and assets of people. The research takes into account some examples as a tool for the development of innovative knowledge and concludes by recommending sustainable practical suggestions that could reduce the impact of flooding in the Nigerian built environment.

Keywords: climate change, flood, innovative architecture, resilience, sustainability

INTRODUCTION

Flooding is a general condition of dry land being submerged in water [Ward, 1978] which occurs from overflowing tidal waters, heavy rainfall and extreme climatic events. Odufuwa et al, [2012] noted that floods are the most widespread and frequent of natural hazards of the world resulting in fatalities in the region of 20,000 persons annually [UN-Water, 2011] thereby confirming that only very few countries are immune from floods. The growing flood scenarios worldwide have resulted in the loss of human lives, the displacement of persons, loss of property and destruction of the environment. Asides from spells of prolonged heavy rainfall, flooding is attributable to changes in built-up areas. Rapid population growth and migration have led to increased urbanization with 70million people exposed to flooding globally [Peduzzi et al, 2009; Raaijmakers et al, 2008]. In 2016, the UN Habitiat in its World Cities Report projected that by 2030, the urban population of developing countries will double, while the area covered by cities could triple. This

[1] gdurowoju@gmail.com; a.t.durowoju@edu.salford.ac.uk

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has generated slums and squatter settlements with limited or no access to potable water, electricity, sanitation and waste disposal [Dimuna and Omatsone, 2010]. Urbanization creates a varied set of challenges in communities and these include large areas of ground covering with buildings, roofs, roads and pavements thus creating obstructions to natural water channels [Douglas et al, 2008]. Incidences of destructive flooding in Nigeria is not a recent phenomenon with records dating as far back as 1951 [Agbola et al, 2012]. The National Emergency Management Agency [NEMA] in Nigeria reported that as at October 9, 2018, a total of 103 Local Government Areas [LGAs] across 10 states in the country, were impacted by severe flooding with an estimated 1.9 million people affected. 561,442 people have been internally displaced while 351,236 are in need of immediate humanitarian assistance [Sumaina, 2018; AFP, 2018].

Disasters reveal the links between building design and urban layouts thereby confirming that communities are vulnerable to the impacts of extreme natural events [Geis, 2000; Adeyeye, 2016]. This paper focuses on the aspects of resilience and hazard planning that need to be considered as part of the solutions for resilient innovative architecture based on documented contemporary examples. The integrated approach to flood resilient architecture confirms that there are benefits to be derived from integrating a suite of practical measures that will minimize flood water ingress and destruction into buildings.

METHOD AND DATA

The search process employed in this study was to identify the body of literature relevant to flooding and habitation in Nigeria with a view to addressing the threats and consequences of flood impacts. Mitigation impacts and opportunities that are missed in designing out social, building deficiencies and infrastructural vulnerabilities are also reviewed. Published academic papers and articles provided most of the information used to establish the study. The data that provided the flood updates, affected population and weather forecasts was sourced mainly from the administrative records of NEMA and ACAPS [Assessment Capacities Project – an independent humanitarian information provider]. Flood events recorded in newspaper articles such as This Day, Vanguard, Punch, Tribune, The New York Times, The UK Guardian and the Nigerian Guardian were also utilized.

The study area

Nigeria is a West African country situated in sub-Saharan West Africa. It is north of the equator and covers a land area of 923,768km^2. It is bordered by the republics of Benin, Niger, Chad and Cameroon. The coastline along the Atlantic Ocean ids 853km long with hydrological features that include the rivers Niger and Benue which meet at a confluence in a city called Lokoja. The two rivers then flow southwards past the Niger Delta and empty into the Atlantic Ocean [Nkwunonwo et al, 2015]. Nigeria's population is presently estimated to be more than 170 million people [Obeta, 2014; NPC, 2007].

Figure 1: Map of Nigeria [Inset is Africa showing Nigeria's location]
Source: ACAPS https://www.acaps.org/search?search_query=map+of+nigeria

Flooding in urban areas

Flooding since late August 2018 in Nigeria has affected some 826,000 people in 12 states as reported by NEMA in September 2018. The numbers displaced are as articulated in the NEMA data shown in Table 2. The deluge has displaced thousands of people and claimed 199 lives. Pathetic stories captured by some local and international newspaper articles on flooding in Nigeria are as stated in Table 1 below.

Table 1: Newspaper and article headlines on flooding in 2018

	Date	Author	Article Headline
Punch	11.05.2018	Nnodim	35 states to experience flooding this year - NIHSA
Tribune	15.07.2018	Olukoya	Many feared dead, scores missing as flood wreaks havoc in Ogun
The New York Times	17.09.2018	Searcey	Floods in Nigeria Kill More Than 100, Wiping Out Homes and Farms
Vanguard	18.09.2018	Adekola	100 die in severe flooding in Nigeria
The Guardian [Nig]	27.09.2018	AFP	Death toll climbs in Nigeria flooding

More than 150,000 hectares of farmland have been inundated and 321 roads and bridges destroyed. A state of national disaster has been declared in four states severely affected by flooding. [UN-OCHA, 2018].

Table 2: Flood situation reports by NEMA for 2018

	Date	Affected Population	Internally Displaced Persons	Displaced Persons living with friends and family	States Affected	National Disaster States
Report No. 1	21.09.2018	327,052	77,460	19,155	12	4
Report No. 2	24.09.2018	441,251	141,369	80,642	12	4
Report No. 3	27.09.2018	176,299	176,299	109,820	12	4

Flooding has impacted urban areas of Nigeria. The perception and impacts have been comprehensively studied and reported in academic journals [Ayoade and Akintola, 1980; French et al, 1994; Muoghalu and Okonkwo, 1998; Ologunorisa, 1999]. Land use changes, rainfall characteristics, removal of vegetation have all contributed to the increased frequency, magnitude and duration of flooding in urban areas. This occurrence is commonplace amongst the urban poor and it has

severe consequences [Douglas et al, 2008]. Governments consider the areas inhabited by the urban poor as informal settlements therefore they are regarded as being outside the accepted urban and town planning management systems, thereby neglected and ultimately vulnerable. Case studies of urban flooding have been carried out in numerous Nigerian cities such as Lagos, Port Harcourt and Ibadan. Parts of Lagos are two metres below sea level coupled with the fact that many slum dwellings are built on stilts over wetlands and swamp areas thereby exposing the vulnerability of these poor communities. These low-lying wetlands in Lagos settlements are supposedly natural flood basins. Lokoja was virtually submerged due to rising waters during prolonged rainfall with levels reaching 11m [Adekunle, 2018]. It, therefore, becomes inevitable that increases in rainfall will affect certain dwellings more frequently. These instances require interventions from the relevant agencies.

'The 2003 World Development Report notes the pronounced difficulties the poor face when disaster strikes. Developing countries are particularly vulnerable because they have limited capacity to prevent and absorb the effects [of natural disasters]. People in low-income countries are four times as likely as people in high-income countries to die in a natural disaster…. Poor people and poor communities are frequently the primary victims of natural disasters; in part because they are priced out of the more disaster-proof areas and live in crowded, makeshift houses… poor families are hit particularly hard because injury, disability and loss of life directly affect their main asset, their labour. Disasters also destroy poor households' natural, physical and social assets, and disrupt social assistance programmes.' [World Bank Independent Evaluation Group, 2006: p48].

The perceived causes of flooding

The flooding events in Nigeria are attributable to anthropogenic factors classified under four main themes:

- Hydrological factors;
- Waste management factors;
- Institutional factors; and
- Awareness factors.

Hydrological factors: Water is the key element that underpins the impacts of climate change in human environments albeit the challenges vary from one location to the other [IPCC, 2014]. Prolonged heavy rainfall and overflowing riverbanks are natural phenomena but the damage and associated losses are attributable to the consequences of human activity or the lack of it [Douglas et al, 2009]. Urbanization and rapid growth in Nigeria compelled the urban poor to live on floodplains. Fluvial floods account for the majority of the flood threats experienced in locations along the plains adjoining major rivers in Nigeria, including rivers Niger, Benue and Hadejia. Historically, Lagos state appears to have experienced most of the flooding in the country but the states in Nigeria mostly affected by such floods are Adamawa, Kano, Niger, Jigawa, Kaduna, Cross River and Kebbi [Iloje, 2004]. Lagos flooding has been attributed to its exposure to coastal influence and rapid population growth. Streets become rivers and drainage systems become submerged [Searcey, 2018].

Pluvial floods occur during the rainy season which falls between the months of July and October with the effects seen largely in urban areas of Nigeria. The volume of rainfall in recent times is unprecedented and as a result the drainage systems coupled with the infiltration capacity of the soil are insufficient [Houston et al, 2011]. The infiltration capacity of the soil is largely impeded by attributable to urbanization given that there is an increased presence of impervious surfaces [Kalnay & Cai, 2003]. Strategies required to support urbanization and anthropogenic activities appear to be lacking and the approach to tackling flood rests largely on general knowledge [Nkwunonwo et al, 2015].

Waste management factors: Poor solid waste disposal is a factor in impeding the free flow of water. Dumping of refuse in drainage and river channels is commonplace in urban areas [Onibokun and Kumuyi 1999; Olaseha and Sridhar 2004]. There are no provisions for waste bins and communities either lack the resources to hire private refuse collectors or through lack of cohesion. Waste left in water and drainage channels is made up of leftover food, degradable leaves, clothing items, plastic bottles and cellophane bags with the anticipation that the rains will wash them from the gutters into the streams and rivers. These items eventually accumulate and impede the free flow of water and they in turn act as catalysts for flooding as the drainage channels eventually get blocked with heaps of debris. Douglas et al [2008] reported in their study on urban areas that the residents of the study area in Lagos were reluctant to accept waste dumping as a cause of flooding thereby refusing to recognize personal responsibility for flooding problems.

Institutional factors: These are attributable to government ministries who have the responsibility and role of assessing flooding potentials including mitigation and flood reduction measures for the country. The Federal Ministry of Works and Housing and the Federal Ministry of the Environment are responsible for the two agencies under their supervision who are directly responsible for disaster management, these agencies being the Federal Emergency Management Agency [FEMA] and National Emergency Management Agency [NEMA]. NEMA co-ordinates disaster management in Nigeria at the federal level, ensure relief materials are readily available for distribution to flood disaster victims in the respective states and the general education of the public.

Weak institutional frameworks: The existing frameworks are culpable in the management of the urban environment. Agbola et al [2012] in their study reported that the severe floods that occurred in Ibadan in 2011 were attributable in part to buildings erected on floodplains, indiscriminate refuse disposal and illegal parking of vehicles in unauthorised locations throughout the city. These illegally erected structures obstruct the free flow of water and they are also vulnerable to flooding. Some residents with the illegally built dwellings claimed to have approved building plans but it was evident that most of the properties investigated in the study had violated statutory setback regulations. Efficient policy and environmental management are required to eliminate the ignorance exhibited by property owners who claimed ignorance of the effects of building close to river banks. A lack of official attention to maintaining drainage networks for rapidly growing megacities such as Lagos is a major factor to the causes of flooding [Douglas et al, 2008].

In order to manage the devastating effects of flooding on the built environment, it is imperative that urban development is structured and integrated into a masterplan and development agenda for urban areas in particular or the cities concerned. This requires concerted efforts from all relevant institutions and more importantly built environment professionals to affect policy and its implementation at all levels. From the foregoing, the origins of flooding that results from climate change and urbanization and its resultant effect on buildings, dwellings in particular, require solutions that will assist the locality affected to adapt to the impact. This paper seeks to offer suggestions for urban and architectural resilience that will maximise the ability of built assets to withstand and recover from the impacts of extreme natural occurrences.

Innovative architecture for flood resilience

Adeyeye et al [2016] posit that living with water requires innovative architectural solutions which should incorporate a culture shift by professionals and the larger public. Built environment professionals will need to work with the government and the public to deliver solutions that are sensitive to nature i.e. living with nature, and not against it. Architects should be the catalysts for change on the understanding that architectural solutions presented to a community should be adaptable rather than being generic [Morgan, 2015]. In the same vein, to be innovative, architects must become more responsive to their users and environments [Rahim, 2006]. Aravena, the Chilean starchitect, posits that architects like to build things that are unique, but if something is unique it cannot be repeated, so in terms of it serving many people in many places, the value is close to zero [Chatel, 2018].

Housing design and construction technology have been developed to cope with the challenges of flooding. Designs for resilience are processes and strategies that engage solutions to adapt nature as confirmed by Walker et al [2004:p1], 'Resilience 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.' Being resilient in the development sense goes beyond preparing for the inevitable – 'floods'. There are a degree and expectation that requires a certain level of preparation that takes into consideration the gradually changing conditions, albeit localized, from singular or combined coastal, pluvial or fluvial sources. The way we design and build is the first and foremost method of minimizing human and property losses [Gees, 2000] and in the same vein, the building forms the 'last line of defence' of resilience strategies. Building projects should integrate a series of many small measures that are informed by the natural systems support resilient design [Watson and Adams, 2010; Adeyeye and Emmitt, 2017]. Hurricane Katrina devastated large parts of New Orleans in 2005. Significant redevelopment has occurred since then using the same parcels of land but with more resilient innovative architecture. 'The same type of single, free-standing houses as the residents had before was built but had features such as stilts or floating foundations incorporated into the design. This meant that the effects of future flooding were mitigated without changing significant community functions' [Morgan, 2015: p41]. Examples of these house types are shown in plates 1 and 2.

Plate 1: Bild Designs homes for the Make It Right Organisation, 2012. https://www.pinterest.co.uk/pin/313844667752817629/ [accessed 15 April 2019]

Plate 2: Shigeru Ban house for the Make It Right Organisation, 2009. https://www.pinterest.co.uk/pin/841680617840690543/ [accessed 15 April 2019]

Floating communities

K. Olthuis in the Netherlands has developed amphibious structures which rest on floating concrete foundations to floating houses and houseboats - some of them are even islands [plate 3]. These developments are also known as 'going with the flow' where the body of water remains intact and the building is made to fit into the existing environment.

Plate 3: Floating Cities and Communities – A floating apartment complex near Naaldwijk, Netherlands by Koen Olthuis, 2015. https://www.waterstudio.nl/the-floating-dutchman/ [accessed 15 April 2019]

Bangladesh experiences annual flooding of varying severity for up to three months annually, from the outflow of the Himalayas. One solution adapted is as shown [in plate 4] where an elevated plinth is used to protect the dwelling.

Plate 4: A house in Bangladesh situated on an elevated 'compacted earth' plinth S.B. Linkon, [2017].

Contemporary flood resilient architecture

A common form of construction is building on stilts that relies principally on being able to predict the highest flood level with the structure creating a natural elevation to avoid the property being submerged. The stilts can be constructed from steel framing or concrete columns [Lisa, 2012].

Plate 5: Sol Duc Cabin – Lisa [2012] https://inhabitat.com/the-prefab-sol-duc-cabin-by-olson-kundig-architects-rests-lightly-on-four-stilts/ [accessed 15 April 2019]

Property Flood Resilience [PFR]: an innovative suite of measures for property flood resilience exist in the UK. They are aimed at minimizing the ingress of water into traditional domestic masonry construction buildings. Beddoes et al [2018] in their study on flood risk reduction recognize the need to demonstrate that properties can be protected externally. These measures include the following:

- door and aperture guards;
- flood doors and external wall treatment;

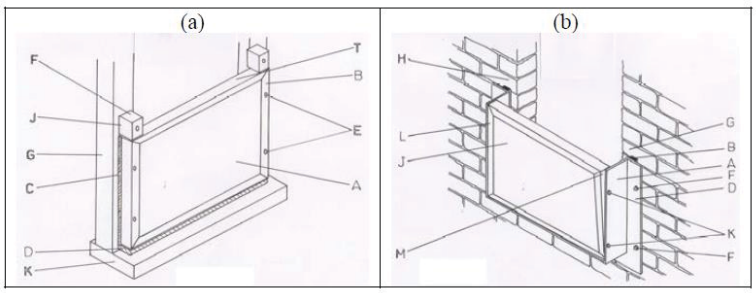

Figure 2: Door guards
Source: Beddoes et al [2018]

ANALYSIS AND DISCUSSION

i. The impact of flooding in Nigeria continues to raise concerns for environmental and solid waste management, urban development and the vulnerability of the general public. The paper highlighted that coastal areas such as Lagos appear to have experienced the most flooding due to urban growth and proximity to wetlands whilst other inland areas in close proximity to rivers such as Niger, Benue and Ogun account for the remainder of areas that experience frequent floods [Figure 3: BBC, 2018]. Certain communities demonstrate an overwhelming level of irresponsibility when faced with the challenges of flooding and these include non-compliance with planning laws, non-adherence to flood alerts and advance

warnings including a lack of perception of flooding issues [Aderogba, 2012]. Efforts need to be concentrated on education and compliance.

ii. The prevailing trend by NEMA and institutions saddled with the responsibility of addressing the threats of flooding appears to be evacuation. 'Best practice' flood risk reduction procedures must be developed to prevent and respond to issues of flooding. Research and development together with the development of appropriate flood reduction measures is required. Flood risk policies that are underpinned by preventative, sustainable and flood-proof measures similar to those that exist in developed countries such as the UK and the Netherlands must be developed [Driessen, 2018; Adedeji, 2012].

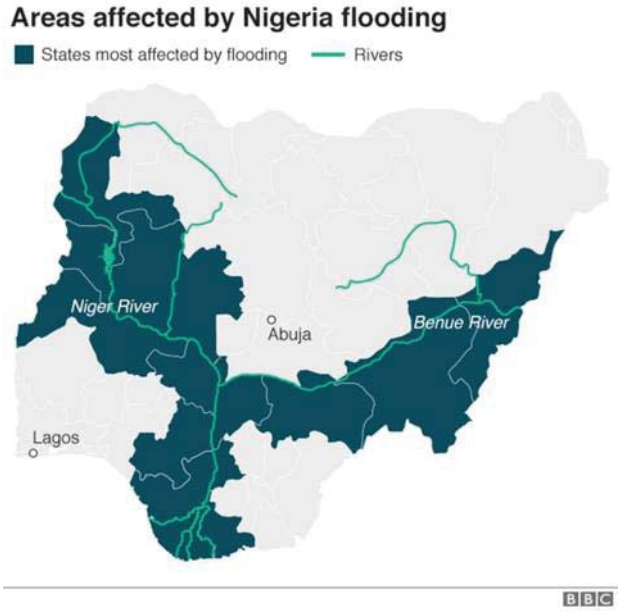

Figure 3: Map of Nigeria showing states most affected by flooding.
Source: BBC News [2018]

Enforcement of environmental laws is required to curtail the effects of climate change and by extension flooding. Indiscriminate car parking, construction along riverbeds, indiscriminate waste disposal and other illegal anthropogenic factors must be made punishable offences.

Capacity building of the population is required to enhance the peoples' abilities to prepare and cope with the hazards of flooding. The paper also proposed the adoption of innovative architectural solutions and technologies that can cope with the challenges of flooding whilst also being sensitive to nature, in order to lower the risk of flooding in urban and low-lying areas. These include building on stilts, raised floor plinths and the use of flood doors.

CONCLUSIONS

The devastations caused by flooding in Nigeria has had severe impacts on people, infrastructure and economic life. This has been linked to climate change and the efforts employed to tackle the impact of flooding appear to be reactive. Flooding is widespread in the country but the awareness and knowledge of the wider population are lacking. The paper presented improvised and practical suggestions

of building designs and building types as solutions in anticipation of flood resilience from examples that have been 'tried and tested'. However, architecture for flood resilience cannot be executed in isolation of urban scale strategies as both are integrated. The scope of this paper was limited to the issues surrounding mitigating damage to individuals lives and properties alongside design solutions that can be adapted on future developments in floodplains. Looking at the scale of the devastations created by climate change in recent months, the government appears ill-prepared and limited in dealing with the consequences of flooding. In view of the fact that the country has one of the fastest growing urban areas and population density in the world, the perceived lack of preparedness and obvious negation of the anthropogenic factors that are associated with flooding leaves a large sector of the urban poor exposed. Help is required at all levels to improve drainage, regulate developments and to provide security of tenure for properties. Weak institutions and regulatory bodies need to take responsibility for ensuring compliance with planning and urban development regulations. Lastly, individuals must be made aware of the consequences of their actions and accept responsibility for inaction or making bad decisions.

REFERENCES

Abraham, E. (2018). Understanding climate change adaptation in Africa: Key Considerations. Management of Environmental Quality, 29(1), 165-179.

ACAPS, Map of Nigeria, https://www.acaps.org/search?search_query=map+of+nigeria [Accessed 31 March 2019].

Adedeji, O. H., Odufuwa, B. O., & Adebayo, O. H. (2012). Building capabilities for flood disaster and hazard preparedness and risk reduction in Nigeria: need for spatial planning and land management. Journal of sustainable development in Africa, 14(1), 45-58.

Adekola, O. (2013). 'The Inconsistency of the flood narrative in Nigeria'. E-International Relations. https://www.e-ir.info/2013/02/04/the-inconsistency-of-the-flood-narrative-in-nigeria/ [Accessed 31/03/2019].

Adekunle (2018). Vanguard Newspaper '100 die in severe flooding in Nigeria', 18 September [Online] Available at: https://www.vanguardngr.com/2018/09/100-die-in-severe-flooding-in-nigeria/ [Accessed 12 June 2019].

Adeoye, N.O., Ayanlade, A., & Babatimehin, O. (2009). Climate change and menace of floods in Nigerian cities: Socio-economic implications. (Original Article) (Report). Advances in Natural and Applied Sciences, 3(3), 369.

Aderogba, K. A. (2012). Qualitative studies of recent floods and sustainable growth and development of cities and towns in Nigeria. International Journal of Academic Research in Economics and Management Sciences, 1(3), 1.

Adeyeye, K., Codinhoto, R. and Emmitt, S., 2016, July. Integrated Design for Flood Resilience. In International Conference on Integrated Design (pp. 251-264). University of Bath.

Adeyeye, K. and Emmitt, S., 2017. Multi-scale, integrated strategies for urban flood resilience. International Journal of Disaster Resilience in the Built Environment, 8(5), pp.494-520.

Agbola, B.S., Ajayi, O., Taiwo, O.J. and Wahab, B.W., 2012. The August 2011 flood in Ibadan, Nigeria: Anthropogenic causes and consequences. International Journal of Disaster Risk Science, 3(4), pp.207-217.

Ayoade, J and F Akintola (1980), "Flood perception in two Nigerian cities", Environment International Vol 4, pages 227–280.

Bankoff G. (2001) Rendering the world unsafe: 'vulnerability' as Western discourse, Disasters, 25 19–35.

Bashir, O.O., Oludare, A.H., Johnson, O.O. and Aloysius, B., 2012. Floods of fury in Nigerian cities. Journal of Sustainable Development, 5(7), p.69.

BBC News (2018). 'Nigeria floods kill more than 100' 17 September [Online] Available at https://www.bbc.co.uk/news/world-africa-45546695 [Accessed 12 June 2019]

Beddoes, D.W., Booth, C.A. and Lamond, J.E., 2018. Towards complete property–level flood protection of domestic buildings in the UK. Urban Water Systems & Floods II, 184, p.1127.

Brisibe, W.G., Assessing Architects' Knowledge of flood Resilient and Adaptable Buildings in Yenagoa, Nigeria.

Chatel, M. (2018). Spotlight: Alejandro Aravena. https://www.archdaily.com/789618/spotlight-alejandro-aravena [Accessed 27/10/2018]

Daglio, L. (2014). Building with water: innovative approaches for sustainable architecture.

Dainty A. R. J. and Bosher L. S. (2008), Afterword: Integrating resilience into construction practice. In Hazards and the Built Environment: Attaining Built-in Resilience [Bosher L. S. (ed)]. Taylor and Francis, London.

Design FAQ - New Orleans. (2012). Retrieved from http://makeitright.org/what-weknow/library/article/design-faq/

Douglas, I., K. Alam, M. Maghenda, Y. McDonnell, L. McLean, and J. Campbell. (2009). Unjust Waters: Climate Change, Flooding and the Urban Poor in Africa. Environment and Urbanization 20 (1):187–205.

Dimuna, K. O., & Omatsone, M. E. O. (2010). Regeneration in the Nigerian urban built environment. Journal of Human Ecology, 29(2), 141-149.

Driessen, P., Hegger, D., Kundzewicz, Z., van Rijswick, H., Crabbé, A., Larrue, C., ... & Raadgever, G. (2018). Governance strategies for improving flood resilience in the face of climate change. Water, 10(11), 1595.

E-International Relations (2013). https://www.e-ir.info/2013/02/04/the-inconsistency-of-the-flood-narrative-in-nigeria/ accessed 31/03/2019.

Enete, I. C., Officha, M. C., Ezezue, A. M., & Agbonome, P. C. (2012). Adapting Nigeria cities to climate change using design options: a review.

FME (Federal Ministry of the Environment) (2012). Bulletin on Ecological Disasters, Abuja, Nigeria. FME.

Fehrenbacher, J. (2015, July 8). Inhabitat Interview: Koen Olthuis of WaterStudio. NL Talks About Design for a Water World [Web log post]. Retrieved from http:// inhabitat.com/interview-koen-olthius-of-waterstudionl/.

French, G, L Awosika and C Ibe (1994), "Sea-level rise in Nigeria: potential impacts and consequences", Journal of Coastal Research No 14, Special Issue, pages 1–45.

Geis, D. E. (2000). By design: the disaster resistant and quality-of-life community. Natural Hazards Review, 1(3), 151-160.

Houston, D., Werrity, A., Bassett, D., Geddes, A., Hoolachan, A. and McMillan, M., 2011. Pluvial (rain-related) flooding in urban areas: the invisible hazard.

Iloje, N.P. (2004), A New Geography of Nigeria. Lagos, Longman publishers.

Inter-Governmental Panel on Climate Change (IPCC) (2014), "Climate change 2014: impacts, adaptation and vulnerability. Summaries, frequently asked questions, and cross-chapter boxes. A contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change", in Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D.,

Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. and White, L.L. (Eds), World Meteorological Organization, Geneva, 190pp. (in Arabic, Chinese, English, French, Russian, and Spanish).

Jiboye, A. D. (2011). Urbanization challenges and housing delivery in Nigeria: The need for an effective Policy framework for Sustainable Development. International Review of Social Sciences and Humanities, 2(1), 176-185.

Kakulu, I. I., & Brisibe, W. G. Increasing flood resilience in buildings through adaptable designs: learning from the Bayelsa experience.

Kalnay, E. and Cai, M., (2003). Impact of urbanization and land-use change on climate. Nature, 423(6939), p.528.

Linkon, S. B., (2017). Autonomy in Building Process to Adapt the Climate Change Impacts: A Study of the Coastal Settlements in Bangladesh.

Lisa, A. (2012). Olson Kundig Architects' Prefab Sol Duc Cabin Rests Lightly on Four Stilts [Web log post]. Retrieved from http://inhabitat.com/the-prefab-solduc- cabin-by-Olson-Kundig-architects-rests-lightly-on-four-stilts/.

Morgan, P. (2015). Architecture of resilience: how can architecture instil resilience within communities in the face of future disasters? Unpublished M Arch dissertation. Unitec Institute of Technology.

Muoghalu, L.N. and Okonkwo, A.O., 1998. Effects of Urban Flooding in Awka, Capital of Anambra State, Nigeria. Environmental Review, 2(2), pp. 112-121.

National Population Commission (NPC), (2007), 2006 Population and Housing Census: National and State Population and Housing tables: Priority Tables I-IV, Abuja FCT, Federal Republic of Nigeria.

National Population Commission, (2009). Nigeria Demographic and Health Survey, 2008. National Population Commission, Abuja, Federal Republic of Nigeria. Maryland, USA: ICF Macro Calverton.

Nnodim, O. (2018). Punch Newspapers '35 states to experience flooding this year – NIHSA' 11 May [Online] Available at https://punchng.com/35-states-to-experience-flooding-this-year-nihsa/ [Accessed 12 June 2019].

Nkwunonwo, U., Malcolm, W. and Brian, B., (2015). Flooding and flood risk reduction in Nigeria: Cardinal gaps. Journal of Geography & Natural Disasters, 5, p.136.

Obeta, M.C., 2014. Institutional approach to flood disaster management in Nigeria: the need for a preparedness plan. British Journal of Applied Science & Technology, 4(33), pp.4575-4590.

Odufuwa, B. O., Adedeji, O. H., Oladesu, J. O., & Bongwa, A. (2012). Floods of fury in Nigerian cities. Journal of Sustainable Development, 5(7), 69-79.

Olaseha, I. O., and M. K. C. Sridhar. 2004. Community Mobilization for Drainage Improvement: Experience from Three Communities in Ibadan, Nigeria. International Quarterly of Community Health Education 22 (10): 77–85.

Ologunorisa, E., 1999. Flood hazard perception and adjustment in Ondo, Southwestern Nigeria. Journal of Nigerian Affairs, 4(2), pp.172-193.

Olotuah, A.O. and Taiwo, A.A., 2016. Architectural curricula and the sustainable reconstruction of flood-devastated housing in Nigeria. In Planning for Community-based Disaster Resilience Worldwide (pp. 46-59). Routledge.

Olthuis, K., (2015). The Floating Dutchman. https://www.waterstudio.nl/the-floating-dutchman/ (accessed 15 April 2019).

Onibokun, A. G., and A. J. Kumuyi. 1999. Ibadan. In Managing the Monster: Urban Waste and Governance in Africa, edited by A. G. Onibokun, 1–10. Ottawa: International Development Research Centre.

Olukoya, O. (2018). Tribune Newspaper 'Many feared dead, scores missing as flood wreaks havoc in Ogun' 15 July [Online] Available at http://dumelafrica.com/many-feared-dead-scores-missing-as-flood-wreaks-havoc-in-ogun-tribune-newspaper/ [Accessed 12 June 2019].

Peduzzi, P., Dao, H., Herold, C., & Mouton, F. (2009). Assessing global exposure and vulnerability towards natural hazards: the Disaster Risk Index. Natural Hazards and Earth System Sciences, 9(4), 1149-1159.

Raaijmakers, R., Krywkow, J., & van der Veen, A. (2008). Flood risk perceptions and spatial multi-criteria analysis: an exploratory research for hazard mitigation. Natural hazards, 46(3), 307-322.

Rahim, A. (2006). Catalytic Formations: Architecture and digital design. London: Taylor & Francis.

Searcey, D. (2018). The New York Times 'Floods in Nigeria Kill More Than 100, Wiping Out Homes and Farms' 17 September [Online] Available at https://www.nytimes.com/2018/09/17/world/africa/nigeria-floods.html

Sumaina, K. (2018). This Day Newspaper 'NEMA: 1.9m People Affected by Flood in 2018' Available at: https://www.thisdaylive.com/index.php/2018/10/16/nema-1-9m-people-affected-by-flood-in-2018/ [Accessed 30 November 2018].

The Guardian UK (2013). 'Nigeria floods test government's disaster plans' 28 August [Online] Available at: https://www.theguardian.com/global-development/2013/aug/28/nigeria-floods-disaster. [Accessed 12 June 2019].

The Guardian Nigeria (2018). 'Death toll climbs in Nigeria flooding' 27 September [Online] Available at: https://guardian.ng/news/death-toll-climbs-in-nigeria-flooding/. [Accessed 12 June 2019].

UN-OCHA (2018). Nigeria Floods – July 2018. https://reliefweb.int/disaster/fl-2018-000120-nga accessed 27/10/2018.

UN-Water. Cities coping with water uncertainties. Media Brief, UN-Water Decade Programme on Advocacy and Communication. 2011.

UN (2016). World Cities Report. https://unhabitat.org/un-habitat-launches-the-world-cities-report-2016/ accessed 27/10/2018.

Walker, B., Holling, C.S., Carpenter, S. and Kinzig, A., (2004). Resilience, adaptability and transformability in social–ecological systems. Ecology and society, 9(2).

Ward, R. (1978). Floods: A geographical perspective (Focal problems in geography). London (etc.): Macmillan.

Watson, D. and Adams, M. (2010), Design for Flooding: Architecture, Landscape, and Urban Design for Resilience to Climate Change, John Wiley & Sons, Hoboken, NJ.

World Bank. Independent Evaluation Group. (2006). Hazards of nature, risks to development: An IEG evaluation of World Bank assistance for natural disasters. World Bank.