International Journal of Sustainable Energy and Environmental Research
2015 Vol. 4, No. 3, pp. 64-72
ISSN(e): 2306-6253
ISSN(p): 2312-5764
DOI: 10.18488/journal.13/2015.4.3/13.3.64.72

CLIMATE CHANGE AND FLOOD DISASTER MANAGEMENT IN NIGERIAN URBAN CENTRES: THE ARCHITECTS' PERSPECTIVE

Peter O. Adewale[1]† --- Ahmid B. Siyanbola[2] ---Ajibola O. Olayemi[3]

[1]*Department of Architectural Technology, The Federal Polytechnic, Ado Ekiti, Nigeria*

[2]*Department of Architecture, The Polytechnic, Ibadan, Nigeria*

[3]*Olayemi Design Practice, #4, Ashi Road, Bodija, Ibadan, Nigeria*

ABSTRACT

The threat to lives and property by flood is now becoming very frequent and almost an annual event in many Nigerian urban centres, claiming many lives and property worth several billions of Naira in each occurrence. Although, several studies have traced the causes of the menace to human factors and topography, it has been predicted that the crisis is likely to be exacerbated by climate change with many of the sub-Sahara African countries most vulnerable. This has generated research interest among the scholars. The focus of most of these studies, however, seems to have skewed towards the urban paradigm, typologies, governance and behavioural control only, leaving the input of building professionals virtually untouched. As a prelude to amplifying the role of architects in the fight against the menace, this paper presents the science of climate change and its consequences with emphasis on flood disaster. It holds that integration of control and mitigation of flood risk into an overall design of buildings and other man-made enclosures is essential for the nation to cope with the challenge. It then discusses some of the ways these design goals can be accomplished. It closes by recommending the means by which the strategies can be propagated to the stakeholders.

Keywords: Apocalyptic architecture, Climate change, Design strategies, Flood, Risk control, Urban centres.

Received: 5 September 2015/ **Revised:** 21 October 2015/ **Accepted:** 26 October 2015/ **Published:** 30 October 2015

Contribution/ Originality

This study is one of the very few studies that examine the role of architects in the control and management of flood disaster in the urban centres of the developing nations. It particularly discusses some of the ways flood disasters can be mitigated architecturally.

† *Corresponding author*

1. INTRODUCTION

Flood has been described as one of the major environmental disasters plaguing humanity in recent times. It occurs when a large volume of run-off cannot be contained in its normal path (Olanrewaju and Fadairo, 2003; Olujimi, 2006). While its discharge is influenced by natural factors such as the intensity and duration of rainfall and snowmelt, the topography and geology of stream basins, vegetation and groundwater saturation or other hydrologic conditions preceding storms and snowmelt; land use and other human activities have been identified as one of the major causative agents of flooding, especially in urban centres (Efobi and Anierobi, 2013). The phenomenon which has been claiming many lives and causing more damage to property more than any other natural phenomenon has now become more frequent problems in most urban centres in the developing nations. What was once considered a centenary affair now occurs one in every fifty or even twenty years (Olanrewaju and Fadairo, 2003). Nigeria, in particular has witnessed a significant number of reported floods in the past 50 years. Ibadan alone recorded two cases of disastrous floods in less than a year, apart from the major one that occurred in 1980. Similar cases were recorded in Lagos, Awka, Onitsha, Ondo and other major cities in 33 states in 2012, with extensive damage in each case (Tokunbo and Ezigbo, 2012; Efobi and Anierobi, 2013).

According to National Emergency Management Agency, over seven million people were affected with 18,282 injured and 2.1 million seeking refuge with friends or relatives. Three hundred and sixty-three people were reported to have lost their lives. Many infrastructural facilities were damaged and more than 597,476 houses were destroyed. Economic and social activities were paralysed and oil production in the oil rich Niger Delta was disrupted to the tune of around 500,000 barrels per day, more than a fifth of the nation's oil output. The country was reported to have lost N2.6 trillion to 2012 flood disaster alone (Tokunbo and Ezigbo, 2012).

Perhaps, more worrisome is the report flagged by IPCC (2012) which predicts that these events would be more severe and more frequent in the future as a result of climate change, with 33 countries of the world most vulnerable. Sixty-one per cent of these countries are said to be based in sub-Saharan Africa, with Nigeria ranking sixth on the list (Ocampo, 2013; Dongman *et al.*, 2014). Several authors have carried out studies on urban flooding in Nigerian cities. Many of these studies, however, centred on the typologies, underlying determinants and social consequences (Olanrewaju and Fadairo, 2003; Olujimi, 2006; Ogba and Utang, 2008). Some have focussed on the intensity of the problems over time and space (Tokunbo and Ezigbo, 2012) while others concentrated on governance and institutional mechanisms (Oriola, 2012; Efobi and Anierobi, 2013). Information is, however, scarce on how this event can be controlled architecturally. This body of knowledge which mainly has impact only on the pathway of flood needs to be further extended to include the role of the professionals in tackling the problem. Such inclusion will have a positive impact on the source, pathway, the receptor and the consequences. The purpose of this paper is to examine the science of climate change and flood disaster with a view to determining the role of architect in the fight against the menace.

2. CLIMATE CHANGE AND FLOOD DISASTER: AN OVERVIEW

Climate is defined as an average condition of weather of a place recorded over a long period of time usually between 30 and 35 years. It includes patterns of temperature, precipitation (rain or snow), humidity, wind and seasons (Chad and Berry, 2014). It is an important part of natural environment to which so many systems are tied. All living things – man, animal and plant function well under certain climatic conditions. A small change in climate, therefore, has the tendency of affecting all the constituents of natural ecosystems.

Climate is usually affected by natural processes such as changes in the sun's energy, shifts in ocean current, etc., which in turn affect the weather, oceans, snow, ice, ecosystems and society. Small changes in the average temperature of the planet Earth, for example, can translate to large and potentially dangerous shifts in local climate and weather. The planet has warmed and cooled many times during the 4.65 billion years of its history (Hart, 2006). At present, Earth's climate has been observed to be facing a rapid warming. Scientists have reported that the Earth's average temperature has risen by 1.4^{0}F over the past century. They, however, argued that all the natural processes are not enough to explain the warming (Hart, 2006; IPCC, 2007; NRC, 2010). According to them, most of the warming has been caused by human emissions of greenhouse gases, which come from a variety of human activities including burning fossil fuels for heat and energy, clearing forests, fertilising crops, storing waste in landfills, raising livestock and producing some kind of industrial products.

As explained by the scientists, the greenhouse gases including water vapour, carbon dioxide (CO_2), methane, nitrous oxide, etc. trap a portion of the heat that are released into the space by the Earth's surface in form of long-wave infrared radiation, thus causing the Earth to retain more heat than it reflects into space (Ocampo, 2013; Dongman *et al.*, 2014). This ultimately resulted in increase in global temperature. Several studies have raised alarm over rapid increase in the amount of these gases being released into the atmosphere through human activities (Hart, 2006; IPCC, 2007; NRC, 2010; IPCC, 2012). Carbon dioxide concentration which was reported to be 281 parts per million (ppm) in 1750, has increased to 368 ppm in 2006, representing 31%. This translates to 1.5 ppm increase per year. The concentration of nitrous oxide, which traps 300 times more than does the same amount as CO_2 has equally been reported to be 17% more than it was during the preindustrial period (IPCC, 2007).

Greenhouse emissions are not the only way by which humans alter the climate. Activities such as agriculture or road construction can change the reflectivity of earth surface, leading to local warming or cooling. This is more pronounced in urban centres which are often warmer than surrounding less populated areas (NRC, 2010). Emission of aerosols (which reflects or absorb sun's energy) and ozone layer depletion have also been linked to global warming. The layer which shields the Earth's surface from direct ultraviolet rays from the sun is rapidly eroded by certain substances released into the atmosphere through human activities such as space rocket and satellite launching, nuclear weapon testing and industrial activities (Akeredolu and Olatunji, 2008; Olamide *et al.*, 2008).

The resultant effect of this warming is increase in humidity as a result of more water evaporating from the oceans, which in turn will increase rainfall (about 1% for each Fahrenheit degree of warming). Not only does the warming accelerate water evaporation, it causes the surface layer of the ocean to warm as well, expanding in volume and thus raising sea level. Warming will also melt much glacier, especially around Greenland, thus further swelling the sea. Already, the sea levels have been reported to have risen by 25 cm during the 20th century. A further rise of 9 – 88 cm has further been predicted to occur in the 21st century. Storms are expected to be more frequent and more intense which subsequently raise the sea level. As the sea invades the mouths of rivers, flooding from run-off will increase upstream (Hart, 2006).

Incidentally, this warming has been projected to increase worldwide by 2^0F to 11.5^0F by 2100 (IPCC, 2012) amounting to more frequent and more intense flooding than it is currently being experienced in the urban centres. According to Ocampo (2013) and Dongman *et al.* (2014) 33 countries of the world are predicted to be at extreme risk. Unfortunately, sixty-one per cent of these are based in sub-Saharan Africa including Nigeria who is ranked sixth among the countries that would be worst hit. The study warns that if no mitigating steps are not taken, flooding will cause damage totalling $1 trillion annually by the year 2050. Further complicating the situation is the revelation about the life span of $CO_{2,}$ which indicates that it will take one hundred years for nature to dispose of the current amount of the gas in the atmosphere. Thus, if the concentrations of the gas should cease growing today, the whole world still stands the risk of being starred by the global warming effects in the next one hundred years. The foregoing suggests that man's response to these challenges should not be limited to combating efforts alone but should also include adequate adaptation strategies that would minimise the impending catastrophes. In this regard, an architect who is deeply involved in the production of structure that houses man and his property during flooding has a very big role to play.

3. ARCHITECTURE AND SOCIETY: AN X-RAY OF DUTIES AND RESPONSIBILITIES

From earliest times, architecture has been playing a significant role in the physical and socioeconomic development of a society. It translates the society's dreams into a three-dimensional form which reflects the needs, values and desires of the group or individual that produces it. It is in this context one would appreciate the rationale behind the use of such an enduring material and stable form by the Egyptians builders to erect monumental tombs which was a calculated attempt to concretise their belief in life after death and the splendour of Pharaoh during the ancient civilization (Badawy, 1979; Cruickshank, 1999). Furthermore, the richer architectural detail and preponderance of magnificent temples over residential buildings does not only reflect the religious system of this society who held nature responsible for incessant flood and harsh climate they frequently suffered from, but also the emphasis the ancient Egyptians placed on religion as a means through which these nature gods can be placated (Badawy, 1979).

This is also true of the succeeding civilisations. The Greek architects established mathematical rules of ratios and proportions to shape their buildings as a means by which an ideal state could be reached in architecture - an idea that was precipitated by their philosophy of idealism and perfection which permeated all spheres of life (Tate and Smith, 1986; Salingaros, 2006). We, thus, see in Parthenon a clear representation of the Greek mythology, pride and exemplary democratic life. Meeting halls were therefore one of their commonest public buildings. In ancient Rome, however, recreational buildings such as circuses, thermae, etc. dominated the streetscape of its cities whose people loved public life more than the Greeks (Senosiain, 2003). Through unprecedented lofty structures, the Gothic architects also could tell generations after generations what the preoccupations and beliefs of people were during the medieval times. They used materials that aid visual connection between the inside and outside of their churches to articulate their own concept of divinity as being limitless. Pointed arches, flying buttresses, spires and vertical development were also used to direct the attention of the worshippers to heaven (Encyclopaedia Britannica, 1988; Sutton, 1999).

Architects' response to issues are not limited to reinstating the positive values and beliefs of a society alone; it also responds to an event that poses threat to life and property or that which presents itself as national or global tragedy. In this case, the invention of mass production technology and skyscraper in the Western world during the Industrial Revolution come handy. According to Adewale *et al.* (2008) the industrialised building technology and skyscraper in America and European countries were inspired by scarcity of land, and the need to house the teeming population brought about by the event. Bunkers and fallout shelters also emerged after the Second World War as a concrete response to political, social and existentialities of anxieties of the atomic age.

In recent times, attention and desires of the society appear to have been shifted to more of environmental concerns than social needs and values as the whole world is being ravaged by diverse forms of environment-related disaster, especially flood which according to the scientists would be aggravated by climate change. Given the startling revelation of the existence of this phenomenon and the increasing urbanisation coupled with poor governance, it seems that most Nigerian cities cannot escape from reality of the impending apocalypse. The duty of architects, planners and government, therefore, is to build resilient cities with infrastructure that can stand up to flooding. There is need to evolve an apocalyptic architecture of the twenty-first century – a kind of design that integrates control and mitigation of flood risk into an overall design of buildings and other man-made enclosures. It is through this creative abilities the architect's role as a problem solver can be brought to bear.

4. DESIGN STRATEGIES FOR CONTROLLING AND MITIGATING FLOOD RISK

From the preceding remarks, it is obvious that an architect has a fundamental role in evolving an innovative design that does not only prevent flood hazards but also provides safety net for the inhabitants in case there is flood. This can be achieved by following the design guidelines suggested below:

(i) Site Investigation

Design process should begin with thorough understanding of the site conditions by looking at the context and topography within which the land is set. By relating these conditions to human comfort, one can determine appropriate responses in type and time for site planning, landscaping, architectural form and construction. A very basic appraisal of the potential that a site has to flood is very essential. A designer, therefore, has to arm himself/herself with such information as sources of flood water (e.g. high sea levels, groundwater level, intense or prolonged rainfall leading to run-off and increased flow in river and sewers), the receptors (i.e. the people and assets likely to be affected by flooding) and the pathways by which the flood water reaches those receptors (e.g. river, channels, river and coastal flood plains, drains, sewers and overland flow).

(ii) Site Planning and Landscaping

In a large scheme involving group(s) of buildings, efficient grouping of buildings according to the degree of flood risk can help reduce consequences of flood. Robust recreational uses, for instance, can be located in the most hazardous part of the site, whilst highly vulnerable functions can be sited at an elevated portion of the site. In designing for flood risk, a good proposal is the one that follows the natural topography. This will ensure that the new development does not alter the flood path. However, in a situation this is not possible, care must be taken to retain at least the same level of storage capacity of flood water as the initial site investigation has revealed. Buildings like residential buildings, community facilities, hotels and club houses can be located in the high risk area with control and mitigation. In the area with medium flood risks, industries, offices, land and building for agriculture and forestry can be proposed with mitigation.

This can be complemented by interesting landscape design that utilises soft paving materials. This will not only provide visual amenity but also plays an active role in surface water management and biodiversity (Adewale *et al.*, 2008). The design can further be enhanced by providing dry pond which provides a more significant storage capacity for attenuation of rainfall during peak storms events and makes a positive contribution to the amenity and ecological value of the site. Filter beds and swales will equally help in reducing the volume of water entering the storms or sewer system. Hillsides can also be terraced to slow flow downhill.

(iii) Structural Defences

Coastal and river flooding can be controlled along the pathway with structural defences such as river walls, barriers, levees and barrages. These will prevent the flood from getting to the receptors whenever the river or canal overflows its bank. These measures, to certain extent, provide defence against the risk.

(iv) Raising Accommodation Level

Occasionally the primary defences and the water storage systems do fail. They can, at times, be overcome by severe flood. In order to control this, it will be necessary to raise the level of habitable accommodation above the design flood level and provide safe access via the low risk area higher up the gradient. In a situation where this is not possible, buildings could be designed in such a way that occupants could be rescued by boat or helicopter probably through the balconies or roof gardens.

(v) Materials and Services

Building fabric and components should be designed and specified to be resistant or resilient in order to achieve an end product that integrate both functions required by the user and the need to mitigate the risk of flooding. Tanked reinforced concrete and reinforced block work are systems of choice in this case. Hard-wearing screened flooring is equally a good choice as it maintains its integrity and is easy to clean after flood. Solid walls could be finished in cement plasters or tiling at least up to dado level. Alternatively, finishes can be designed to be removable or sacrificial and easily replaced in the zone affected by flooding.

Electrical and heating systems should be distributed at higher level rather than under the ground floor and drop down within walls and sockets. Electrical sockets must be set above the flood level at dado rather than skirting level to give a reasonable degree of waterproofing.

5. CONCLUSION AND RECOMMENDATIONS

This paper has examined the science of climate change and its linkage with flood disaster. It revealed that warmer climate and frequently extreme storm events will put even areas not normally prone to flooding increasingly at risk. It has also demonstrated how architecture has been responding to national and global issues. It admitted that flood risk is a design challenge that is becoming increasingly relevant. The paper contended that architect as a problem solver and as professional who is deeply involved in the production of structure that houses man and his property during flooding has a big role to play in the world sustainable development agenda that makes adequate preparations for the coming apocalypse. It stressed that control and mitigation of flood risk need to be integrated into an overall design of buildings and other man-made enclosures for the nations of the world to cope with the challenge. According to the paper, some of the ways by which this design goal can be achieved included land use zoning, raising accommodation level above the flood level, use of resilient materials, etc.

The application of these techniques coupled with other flood disaster management techniques will go a long way in controlling and mitigating the flood risk which has been predicted to become more severe and more frequent in the future, if they are given wide publicity. This can be done by making it part of the course materials in the mandatory continuous professional development programmes. The budding architects can be made to imbibe this culture right from the school by introducing flood risk control and mitigation in the curriculum. This should also be enshrined in the National Building Codes.

REFERENCES

Adewale, P.O., A.B. Siyanbola and S.O. Siyanbola, 2008. Towards a sustainable building design construction technology for the 21st century: The promise of industrialised building technique. Environ-Link, 2(2): 11- 21.

Akeredolu, R.A. and A.J. Olatunji, 2008. Causes and consequences of ozone depletion in the atmosphere: Implications for global warming. Environ-Link, 2(1): 121- 129.

Badawy, A.M., 1979. Ancient Egypt in: Encyclopedia Americana. Connecticut: Encyclopedia Americana Corporation.

Chad, M. and K. Berry, 2014. It is cold, it is hot, it is climate. Available from www.umich.edu/gs265/climate [Accessed 18-05-2014].

Cruickshank, D., 1999. Sir Bannister Fetcher's history of architecture. 20th Edn., New Delhi: CBS Publishers.

Dongman, B., S. Hochrainer-Stigler, L. Feyen, C.J.H. Aert, R. Mechler, W.J.W. Botzen, L.M. Bouwer, G.P. Rojas and P.J. Ward, 2014. Increasing stress on disaster-risk finance due to large floods. Nature Climate Change, 4(4): 264 - 268.

Efobi, K. and C. Anierobi, 2013. Urban flooding and vulnerability of Nigerian cities: A case study of Awka and Onitsha in Anambra State, Nigeria. Available from www.iiste.org [Accessed 20 -05-2014].

Encyclopaedia Britannica, 1988. The history of Western architecture. New encyclopaedia Britannica. 15th Edn., Chicago: Encyclopedia Britannica Inc.

Hart, J., 2006. The environment. Microsoft encarta. Redmond, W.A: Microsoft Incorporation, Inc.

IPCC, 2007. Summary of policy makers. In: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of Intergovernmental Panel on Climate Change, Parry, M.L., Carzini, O.F., Palutikaf, J.P., van der Linden, P.J. & Harrison, C.E. Eds., Cambridge University Press, Cambridge.

IPCC, 2012. Summary of policy makers. In: Managing the risks of extreme events and disasters to advance climate change adaptation field, C.B.V., Barros, T.F., Stocker, D., Qin, D.J., Dokken, K.L., Ebi, M.D., Mastrandrea, K.J., Mach, G.K., Plattner,SK., Allen, M. Tignor, M. & Midgley, P.M. (Eds). A Special Report of Working Groups I & II of Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

NRC, 2010. Advancing the science of climate change, national research council. Washington, D.C., U.S.A: The National Academies Press.

Ocampo, A.R., 2013. Sub-Saharan Africa, Southern Asia most at risk from climate change. Business Insight. Available from www.devex.com [Accessed 17-05-2014].

Ogba, C.O. and P. Utang, 2008. Integrated approach to urban flood adaptation in the Niger delta. Paper Presented at FIG Working Week, Stockholm, Sweden, 14 -19 June.

Olamide, E.V., A.A. Akanmu and F.F. Ogunyemi, 2008. An overview of environmental implications of Ozone layer depletion. Environ-Link, 2(2): 100- 107.

Olanrewaju, D.O. and G. Fadairo, 2003. Flooding as an induced environmental problem: A case study of Ala River in Akure, Nigeria. Journal of the Nigerian Institute of Town Planners, 16(1): 85-95.

Olujimi, J.A.B., 2006. Rivers and streams in Nigeria urban centres: Ascribing roles to the communities. In: Urban environmental sustainability: Interventions and responses, Fadamiro, J.A., Atolagbe, A.M. O. & Olujimi, J.A.B. Eds., Akure Urban Design Research Team. pp: 169 -180.

Oriola, E., 2012. Strategies for combating urban flooding in a developing nation: A case study from Ondo, Nigeria. Available from www.linkspringer.com/article [Accessed 20-05-2014].

Salingaros, N., 2006. A theory of architecture. Salingen: Umbau-Verlag.

Senosiain, J., 2003. Bio-architecture. Oxford: Architectural Press.

Sutton, I., 1999. Western architecture: A survey from ancient Greece to the present. London: Thames and Hudson.

Tate, A. and C.R. Smith, 1986. Interior design in the 20th century. New York: Happer and Row Publishers.

Tokunbo, A. and O. Ezigbo, 2012. Floods claim 363 lives,displace 2,1 people says NEMA. This Day. Available from http//Allafrican.com [Accessed 17-05-2014].