A Review of Flooding and Flood Risk Reduction in Nigeria

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Received: 14 December 2015 Accepted: 3 January 2016 Published: 15 January 2016

Abstract

The prevalence of flooding within Nigeria which has been generally attributed to climate change and poor urban planning is an issue of critical importance within the context of national development. Over the period 1985 to 2014, flooding in Nigeria has affected more than 11 million lives with a total of 1100 deaths and property damage exceeding US17*billion*.*Althoughmorefrequentfloodsarerecordedin*$Niger, Adamawa, Oyo, Kano$*and*$Jigawastatespossib$
$forwardaresuggestedbasedonacriticalreviewoffloodinganditsmanagementin$$Nigeria, alliedwithgloballyack$
$floodmodellingandassessmentofvulnerabilitytofloodingarelacking.Ultimately, thisstudymakesrecommend$

Index terms— flooding, developing countries, nigeria, flood risk, climate change, flood modelling, flood vulnerability assessment.

1 Introduction

oncerns for flooding has increased in recent times due to climate change (especially in more frequent and severe rainfall events), sea level rise, rapid population growth and urbanization, the level of awareness of flood risk, the limited efforts towards flood disaster risk reduction in many places and the exposure and vulnerabilities of large numbers of human population **??**Peduzzi et al. 2011 **??** Gill et al. 2004, Action aid 2006, Raaijmakers et al. 2008). The impacts of flooding reported in the last two decades have been significant, amounting to tens of billions of US dollars In Nigeria, flooding and solutions to its impacts are critical issues (Obeta 2014). With history of devastating floods which affected millions of human populations and caused fiscal losses amounting to billions of US dollars, the importance of exploring more realistic flood risk mitigation measures for Nigeria should be paramount **??**OCHA 2012). Flooding in Nigeria are fluvial (resulting from rivers overtopping their natural and manmade defences), coastal (affecting mainly the coastal areas) and pluvial (flash, arriving unannounced following a heavy storm) in nature and have been a major cause of concern for rural areas and cities within the country (Houston et al. 2011, Andjelkovic 2001, Bashir et al. 2012, Douglas et al. 2008). Whilst stake holders' efforts towards tackling the hazard have not yielded satisfactory results, they have been criticized as ad-hoc, poorly coordinated, non-generalizable and not well established (Obeta 2014). However, in the light of 'best practices' in flood risk reduction and 'lessons learned' from other countries' experiences of flooding, it can be argued that such stake holders' efforts are limited due to lack of quality data, which are needed to systematically tackle flooding, poor perception of flooding among the general populace, lack of funds and improved technology as well as poor political will power.

The growing number of flood victims and the constrained sustainable development caused by flooding within the country suggest that much of what is known regarding flooding in the country is deficient on remedies. More critical is the subject-matter of Nigeria being one of the most populated countries of the world with population size estimated at over 170 million people (World Bank 2013). Considering the theory that future population growth will drive future flood risk, this population size along with future estimates spurs C (Guha-Sapir et al. 2013). Over 3700 flood disasters are recorded in the EM-DAT database, covering the period interest towards building the capacities of human populations to cope with flooding.

1985 to 2014 (EM-DAT 2014). These events were responsible for hundreds of thousands of deaths mainly in Asia (most notably China, Thailand and Bangladesh) and adversely affected billions of people mostly through

homelessness, mortality (mainly through drowning), physical injuries, fecal-oral and rodent-borne diseases, vector-borne diseases (mainly in tropical areas) and psychological conditions through depression, anxiety and post-traumatic stress **??**Ahern et). Although the lack of definite measures and capacity to radically tackle the hazard within the country has been arguably overwhelming, concerted efforts in the form of environmental and infrastructural planning, policy directives, social responses, physical intervention and enhanced public enlightenment programmes have been extensively considered (Agbola et al. 2012 **??** Ali & Hamidu 2012, Bashir et al. 2012). Other measures considered are community based early warning systems (Agbonkhese et al. 2014), humanitarian aids from government and private sectors (Adeoye et al. 2009) and appropriate level of preparedness and capacity building (Adedeji et al. 2012). The need for science and technology to embrace environmental education in Nigeria is highlighted (Terungwa & Torkwase 2013) while food hazard mapping as well as assessment of vulnerabilities of lives and properties which play key roles in building community resilience to flooding is considered (Adeaga 2008, Ajibade et al. 2013, Adelekan 2010, Ologunorisa 2004). The importance of reinforcing present strength and capacities of all agencies, including local communities within Nigeria to deal with flood hazard situations is underlined (Obeta 2014).

Despite the attention flooding received in these studies, still the question: "what is the remedy to the recurrent flooding in Nigeria?" remains unanswered. The lack of flood data and other ancillary data which is a major setback towards containing the threats of flooding in the country were raised but not addressed. Attention has solely rested on general knowledge of the causes, impacts and remedies of flooding; suggesting that the broad view of the situation in these studies has been lop-sided and sloppy. The need for more scientific approaches such a flood modelling which drives flood risk management in more developed countries was not highlighted. A general critique, which should provide a nuanced understanding of the strengths and limitations of present efforts to addressing the threats of flooding in the country, is lacking and gaps between increasing flood occurrences and vulnerabilities of local communities were not identified.

For this reason, the present study besides advancing existing knowledge relating to flooding in Nigeria is an attempt to provide answers to key questions with regards to remedy to flood challenges in Nigeria. The importance of flood modelling in flood risk reduction and the need for it to be included in the country's present efforts at reducing the impacts of flooding is emphasized. The study generally is driven by three key issues - (1) to demonstrate the roles more robust and scientific techniques such as flood modelling can play in flood risk reduction within the context of Nigeria, (2) to align the focus of flood risk reduction in Nigeria with the objectives of such a task in more developed countries such as the US, the Netherlands and United Kingdom, and (3) to promote flood risk awareness in the general public as well as to facilitate delineation of more suitable locations for relocation of human populations during flooding in Nigeria. In pursuance of these goals, the study considers the following specific objectives:

? to investigate and summarize evidence of flooding in Nigeria and to critically review efforts towards addressing its threats in the country, ? to identify knowledge gaps relevant to the reduction of flood risk in the country, ? to present flood modelling as a way-forward towards pro-active flood management activities, and ? to make supported recommendations towards building flood resilient communities. The general concept of flooding and its remedies are presented in section 2. The methodology and data for the research are discussed in section 3 while the study area is described in section 4. Section 5 focuses on general discussions on flooding in Nigeria and present efforts at tackling the challenge. Section 6 presents relevant recommendations towards a possible way-forward while section 7 gives a general conclusion of the study.

2 II.

3 Conceptual Framework of Flooding and its Remedies

Flooding along with its severe impacts on human lives, properties and economic activities is globally acknowledged **??**Keith 2013, Penning-Rowsell et al. 2005). Conceptually, flooding is the result of water overtopping its natural and manmade defences and overflowing places not typically submerged (Smith & Ward 1998). It is also a result of sudden arrival of heavy storms, which overwhelms soil infiltration capacity and urban drainage systems. In the literature, it is claimed that flooding is the most widespread hazard phenomenon on natural environments, accounting for more than 40% (both in frequency of occurrence and potential for losses) of the total disasters globally (Nwilo et al. 2012, van der Sande et al. 2003). From wave dynamics, flooding is described as a down-slope propagation of attenuated longitudinal wave motion with inundation extent, depth and duration, as well as water flow velocity (Chow et al. 1988). Various forms of flooding can be identified including fluvial, coastal and those resulting from pluvial events which in recent times have threatened many urban areas (Ward & Robinson 2000, Lauber 1996 **??** Hassan 2013).

Arguably, these urban floods are becoming more widespread nowadays and causing significant loss of life and property due to the large number of population exposed within the cities (EA 2007, Gupta 2007, Jha et al. 2012 Chen et al. 2009, Jeffers 2013). In the US, 32.9% of the total natural disasters in 2012 were hydrological with urban floods accounting for the most part, affecting more than 9 million people and causing about US$ 0.58 billion worth of damage (CRED 2013). The same source shows, for that year, more than US$4.7 billion worth of damage recorded for Europe, and about US$0.83 billion and US$19.3 billion damage for Africa and Asia

respectively resulting from urban flooding. Four different floods that hit United Kingdom cities in 2012 caused a total loss of $2.9 billion, with many human populations affected (CRED 2013).

Increased frequency and intensity of rainfall drives pluvial floods and is a major cause of concern for urban areas (IPCC 2007). Urban areas are significant in the economic and political development of regions and states (Holton 1998, Sassen 2000, Cohen 2004). However, urbanization is an important anthropogenic influence on climate change especially in forcing increased rainfall intensity and frequency (Kalnay & Cai 2003, Seto & Shepherd, 2009). Impervious surfaces which are extensive in urban areas influence local and regional hydrology by increasing surface water runoffs and causing peak discharge and reduced time of peak (Mujumdar 2001 **??** Hümanna et al. 2011). These are pertinent issues to environmental management, urban planning and flood risk reduction. However, urbanization along with rapid population growth in most places for example the developing countries (DCs) have been unaccompanied by adequate urban planning (Adeloye & Rustum 2011).

Flood risk is linked to exposure of social systems to flood hazards (in the form of flood water depth, extent, duration and velocity of flow) and their vulnerabilities (the propensity to be adversely affected by flooding caused mainly by lack of coping capacity) (Birkmann 2006, Crichton 1999, Balbi et al. 2012). It is also the product of likelihood of occurrence of flood hazard and its consequences identified as possible losses resulting from flooding (Brooks 2003, Smith & Ward 1998, Jeffers 2013). Likelihood of occurrence of flooding can be defined as the percentage probability of flood return period. Within research spheres, the likelihood of flood occurrence is generally delineated by the 100-year flood (EA 2010). Globally, these are key issues which are driving activities towards reducing the risk of flooding across various regions and states (Houston et al. 2011, Agbola et al. 2012 **??** EA 2009 **??** Merz et al. 2010).

Driven by the predictions of worsened flood risk in the future coupled with the notion that floods are inevitable phenomenon which can never be fully constrained within the natural environment **??**Milly et Flood risk reduction is a multi-disciplinary approach which integrates structural and non-structural measures to achieve the key elements of risk management which are: prevention/mitigation, protection, preparedness, emergency response, recovery and lessons learned (Zhu et al. 2011 **??** EC 2004, Tarlock 2012, UN/ISDR 2007). The realization of these key elements appeared to have undermined structural measures which basically include engineering works aimed at containing water disruptions in rivers, thereby reducing exposure to flooding and susceptibility to flood damage (WMO 2008). On the contrary, non-structural measures do not involve physical constructions; instead focus is on knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training, education and research and include: flood insurance, assessment of vulnerability to flooding which provides information that will enable the classification of a given population with regards to their lack of capacity to cope with the hazard, flood risk/hazard mapping, creating public awareness, relocation of exposed human populations, land-use zoning, flood proofing, flood forecasting and flood early warning systems **??**WMO 2008 The success of flood risk reduction can be said to depend to a large extent on knowledge-based decision, robust institutional framework and flood risk communication. Knowledge-based decision uses available information relating to flooding to draw conclusions on possible strategies to be adopted for flood risk reduction. The creation of awareness in stake holders and local communities regarding flooding and its impacts is driven by flood risk communication. Institutional framework includes government response procedures, policies, regulations, guidelines as well as to government agencies engaged in planning and managing flood emergency conditions or in helping victims to cope and recover speedily from extreme flood events (Obeta 2014). Invariably, these three factors require information relating to flood hazard and its consequences which flood risk/hazard maps or some form of graphical representation delineate within an area, as well as public opinion, research findings, empirical results and expert knowledge.

Research has shown that flood characteristics (most notably flood water depth, extent and duration as well as flow velocity) obtained through accurate assessment of flooding are required to produce flood risk/hazard maps (de Moel et al. 2009, Merz et al. 2007). Thus for flood risk/hazard mapping accurate assessment of flooding should not be ignored. Meanwhile, the making of these maps is of scientific significance as it requires critical understanding of the drivers of flood hazard/risk. In the flood risk/hazard assessment literature, flood modelling plays considerable roles. Under the EU commission directive on flood, the United States flood control policy, national flood insurance program (NFIP) and other regionallybased flood risk management policies, the relevance of flood information to both flood risk/hazard mapping and flood risk reduction highlights the significance of flood modelling. For this reason, the key roles of flood modelling can be summarized as follows:

? Description of flow behaviour around groups of buildings and other complex geomorphological features especially in assessment of urban flooding (Bates et al. 2010).

? Ability to provide critical information for strategic planning of flood defence measures and effective flood risk management such as temporal inundation information about the onset, duration and passing of a flood event. (Zerger, 2004 **??** Grimier 2013).

? Leads to an improved understanding of the flood phenomena, provides insight into the causes of flooding and guide through more appropriate measures to be taken to reduce flood damage (Chow et al. 1988).

? Promotes understanding of the complicated nature of flow patterns around floodplain and promotes

? Serves as the basis for flood forecasting, flood early warning system and flood damage estimation, as well as provides the basis for the decision making of flood risk management (EA, 2007).

? Serves as the basis for producing flood risk/hazard maps that community officials or the general public can use to evaluate their flood risk and analyse possible evacuation procedures (de Moel 2009).

Flood modelling generally predicts flood hazard characteristics such as water flow depth, flow velocity and inundation extent which are required for estimating the likelihood of flood hazard and its impacts required for flood risk/hazard mapping (Moussa and Bocquillon 2009, Chow et al. 1988). Although possible ways of acquiring these data include ground survey methods and remote sensing technology, however, ground survey methods often require enormous field work and keeping of long-term records while remote sensing requires expert knowledge. The cost of acquiring remote sensing data and software for processing them can be overwhelming. Although in a number of investigations, globally available datasets such as Advanced Specborne Thermal Emission and Reflection Radiometers Global Digital Elevation Model (ASTER GDEM), Shuttle Radar Topographic Mission (SRTM) and global flood data have been utilized (Ho et al. 2010, Manfreda et al. 2011). However, it can be shown that due to scale and accuracy requirements, these global datasets do not provide realistic estimates of flood assessment and using them as basis for making decision towards flood management can be misleading (van de Sande et al. For this reason and on the basis of effectiveness and robustness as well as enhanced efforts in flood risk mitigation in Nigeria, the present study makes argument in favour of flood modelling. Although, existing flood models are rife with limitations which may constrain their applications in Nigeria, however, developing bespoke flood models for Nigeria can be a priority. This need for flood models was emphasized by the DG of Nigerian Hydrological Services Agency (NIHSA 2013) in a recent mission statement:

"?in view of flooding in Nigeria, governments at all levels should create awareness on the need for communities to relocate to safer terrain. Moreover, while the current trends in climate variations prevails, the need to develop flood modelling and early warning systems cannot be overemphasized? There is also need to carry out a comprehensive flood hazard mapping for all areas considered at risk of flooding in the country?" III.

4 Method and Data

A search process to identify the body of literature relevant to flooding and efforts towards addressing its threats in Nigeria was undertaken. Combination of terms such as "flooding and management in Nigeria", "flooding and human health in Nigeria", "flooding and modelling in Nigeria" and "flooding and climate change in Nigeria" was applicable to the search. Overall, 429 publications were identified of which 17 focused on the causes of flooding in Nigeria, 132 addressed the impacts, 181 discussed the remedies, 54 looked at climate change issues, 14 discussed public perception of flooding while 31 addressed urban management and planning. These findings are fundamental to discussions presented in this paper. The scientific quality of these papers was assessed based on the publishing journal. This is consistent with academic standard and regulations. Although locally published articles provided most of the information to establish the case in the present study, however, the greater weight was given to articles published by Elsevier, Science Direct, Taylor and Francis, Wiley and sons, ASCE, Nature, Sage, Springer and Copernicus publishers and on International conferences.

The data that provided much of the evidence regarding the prevalence of flooding in Nigeria was sourced from EM-DAT database, Nigerian ministry of Environment and from previous studies.

5 a) Description of the study area

Nigeria, a sub-Saharan West African country, is on the Gulf of Guinea, east of the Greenwich and north of the equator. The country, made up of 36 states including the federal capital territory (FCT), Abuja, lies between latitudes 4° and 14°N, and longitudes 2° and 15°E, with a total land area of 923,768 km 2 (See figure 1), and borders with Republics of Benin and Niger, Chad, and Cameroon. It maintains a large expanse of coastline, over 853 km in magnitude, with hydrological features which includes the rivers Niger and Benue, both of which confluence at Lokoja, and flows further southwards through the Niger Delta into the Atlantic ocean.

The 2006 census confirmed over 140 million people in Nigeria, but this population has grown steadily, and is presently estimated at more than 170 million people, making the country the seventh most populous country in the world (NPC 2007, World Bank 2013). According to United Nations projections, Nigeria is one of the eight countries expected to account collectively for half of the total population increase in the world from 2005-2050, and will by 2100, record a population amounting between 505 million and 1.03 billion people (United Nations 2004). Rapidly growing population along with urbanization which appear not to be accompanied by corresponding strategies to support humanitarian needs and anthropogenic activities characterize Nigeria. This concern has not received adequate attention in the literature, especially with regards to the implications of future urban scenarios on environmental sustainability. In 2012, the country experienced the worst flooding in more than 40 years as a result of heavy storms that lasted many days. The incidence affected 32 states with 24 considered severely affected (NEMA 2013). The floods lasted from July to October that year and affected 7.7 million people with more than 2 million others reckoned as internally displaced (IDPs). More than 5000 people were physically injured along with over 5900 houses which were destroyed. The lack of a comprehensive flood record, a gap in knowledge which the present study attempts to address, seems to constrain both a better understanding of the spatial and temporal distribution of the hazard across the country and efforts towards addressing the challenges. Although reports from the media and humanitarian agencies highlight the gravity of flood situation in the country, inconsistency of flood narratives in Nigeria is overwhelming (Olalekan 2013).

During flooding episodes in Nigeria, there is often an increase in journalistic and non-quantitative evidence which whilst rife with uncertainties seem to exaggerate the impacts of flooding in the country. **??**owever From table 4, it can be shown that flooding over the period under review has affected more than 11 million people with death toll exceeding 1100 in all. The economic implication of these events has exceeded 17 billion US dollars. Whilst these records are overwhelming in view of the country's gross economic reserve, human resources, environmental management and sustainable development, variations in the frequency of occurrence of floods that appear to vary among individual states are highlighted.

Based on the table, it can be shown that although flooding is common among various states of Nigeria, more frequent floods are recorded in Lagos, Niger, Adamawa, Kano, Oyo and Jigawa states. Whilst Lagos state flooding can be attributed to coastal influence among other key factors, the influence of rivers such as Niger, Benue, Ogun and Hadeja may account for the rest of the states with more frequent floods. These findings are consistent with the result of a recent investigation of flood prone zones in Nigeria (figure 3) carried out by the federal ministry of environment (FME 2012).

Comparing the most devastating floods in the world between 1985 and 2014, it can be clear where Nigeria stands in global and regional perspectives in term of economic and human impacts of flooding. Considering the 2012 floods in Nigeria which are reputed as the worst in more than 40 years, Nigeria ranks third in the world, within the period under review, following Peoples Republic of China and Soviet Union and topmost in Africa, overtaking Mozambique and Algeria in terms of economic loss. This reality should inspire more proactive efforts towards addressing the challenges of flooding in the country. Apart from China which presently reputes as the most flood prone country in the world, characterized by recurrent perennial floods due to among other things, the influence of population growth and mainly the River Yangtze (Zhang et al 2006). The fact that other countries with known extreme flooding experience (for examples: Netherlands, the US, Brazil, United Kingdom and many other European countries) are presently ranked below Nigeria suggest among other things that more effective flood risk mitigation measures are presently in place in those countries.

The Netherlands with more than half of the country at or below sea level experienced a severe flood in 1953 which devastated majority of the nation's economic and human infrastructure. The estimated impact of the flood was 1835 deaths and 1 billion Dutch guilders (US$ 558 million). That flood challenged various stake holders, particularly the local communities and Dutch government towards more effective strategies of mitigating the threats of flooding. The result of this is seen in the reduced impacts of flooding in the country in recent times. The flood of 1972 in the US caused 238 deaths, 357 injuries, about 1335 homes destroyed with estimated fiscal loss of over 800 million US$. In the UK, the 1947 floods were considered the worst in recent history with overall impact estimated at merely £4.5 million (USD$ 6.81 million) at current value, with millions of devastated human populations, farm animals and agricultural products (EA 1993). Recent floods in the US and UK have not reached this magnitude in their impacts. For Brazil, compared to the floods of 2010, the flood of 1967 which claimed 610 lives, costing about US$1.2 was considered the deadliest in that country's history.

In view of these analogies, it can be argued with regards to these countries, that considerable progresses have been made at reducing the impacts of flooding especially on human population and critical infrastructure whilst building the resilience of the people and encouraging adaptability strategies. For this reason, Nigeria's position in global and regional perspective requires that various stake holders should focus attention on ways of improving more effective flood reduction measures for the country such as inclusion of flood modelling techniques. This need is more urgent considering climate change scenarios, poor urban planning, along with a number of remote factors such as the topography of the country (most places for example the Lagos metropolis, are almost flat), anthropogenic activities (mainly through indiscriminate disposal of solid waste, concentration of slum developments, noncompliance with regulations, sloppy attitude towards weather warnings and alerts, roadside car washing), poor perception of flooding among local communities, poor legislation and enforcement of regulations, and the presence of large hydrological network (for example rivers Niger and Benue, canals, harbour, lagoons and beaches and the Atlantic ocean) which are influencing flooding and other conditions in Nigeria **??**Ologunorisa 2005, Aderogba et

6 b) Present efforts towards tackling flooding in Nigeria

The means of tackling flooding in Nigeria include but not limited to structural measures (such as dams, bridges and drainage systems), policy formulation, physical intervention, social measures and research, relocation of human populations and relief assistance to internally displaced persons (Olorunfemi 2011, Odunuga 2008 **??** NIHSA 2013, Obeta 2014). These efforts are driven by institutional approach (including government ministries, departments and agencies), local communities and the general public, humanitarian organizations and international bodies, the media and the academia.

Institutional approach in Nigeria is as old as disasters in the country and generally includes agencies and departments under the Federal Ministry of Environment (FME). For tackling floods in the country, the key institutions include: Federal Emergency Management Agency (FEMA), National Emergency Management Agency (NEMA), State Emergency Management Agency (SEMA), Local Emergency Management Agency (LEMA), National Orientation Agency (NOA), National Environmental Standards and Regulations Enforcement Agency (NESREA) which by 2009 Nigerian Acts supersedes the FEPA, Nigerian Meteorological Agency (NIMET) and Nigerian Hydrological Services Agency (NIHSA) (Ibitoye 2007).

With NEMA as a coordinating body, specific actions towards tackling flooding in Nigeria can be conceived as follows: policy formulation, data collation from relevant agencies, education of the general public on flooding, distribution of relief materials to disaster victims within the states and local government areas (LGAs), protection and development of the environment through enforcement of all environmental laws, guidelines, policies, standards and regulations in Nigeria, as well as enforcing compliance with provisions of international agreements, protocols, conventions and treaties on the environment to which Nigeria is a signatory (key roles of NESREA), provision of reliable and high quality hydrological and hydrogeological services and data on a continuous basis (key roles of NIHSA, which since 2013 has been creating awareness of flooding through the "flood outlook" initiative), flood forecast and weather report along with other meteorological information (NIMET).

Specific actions by local communities and the general public, humanitarian organizations and international bodies, the media and the academia are equally acknowledged **??** among families in Nigeria offers a comparative advantage in the event of flooding as individuals within family setting offer mutual assistance to cope with the hazard and to recover speedily from losses incurred. In many flooding incidences in Nigerian cities, the general public has often converged at the scenes the incidence to offer help to victims, assist in evacuation of those displaced and in protecting property from further damage. Many IDPs easily find shelter and other humanitarian needs from families and friends while awaiting intervention by authorities. However, unlike the developed countries, the vulnerabilities of local communities to flooding in Nigeria may indicate among other factors the overwhelming lack of responsibility towards flooding and ways of addressing its challenges. For examples failure to comply with environmental laws and regulations and to adhere to weather warnings and alerts are possible situations where lack of responsibilities of local communities and the general public is highlighted (Aderogba 2012a). The indifference of most people towards research questionnaires and surveys most likely compounds the situation.

Humanitarian response to flooding in Nigeria has been overwhelming. Almost in all cases of flooding in Nigeria have victims received humanitarian supports with most notably the International Federation of Red Cross (IFRC), United Nations, World Bank, Foreign countries including UK, the United States, China, Japan, France as well as religious organizations including the Catholic, Anglican and Pentecostal churches and missionary societies. The 2012 flooding saw humanitarian response amounting to over US$70 million (OCHA 2012).

Considerable attention has been given to flooding in Nigeria through research and scientific studies. However, the need for science and technology to embrace environmental education in Nigeria has been identified (Terungwa & Torkwase 2013). Similarly, the media have played important roles in reporting flooding in Nigeria, but as argued by (Olalekan 2013), there have been inconsistencies in flood reporting in the country which may be attributed to some disconnect between the media and agencies tackling flooding in the country particularly the NEMA. Despite these progresses, there are a number of critical issues regarding these present efforts at tackling flooding in Nigeria (Obeta 2014, Agbola 2012, **??**olawole et al. 2010). With regards to facilitating the evacuation of victims affected by floods and providing them with urgent humanitarian needs, the level of dissatisfaction and agitations from large numbers of the flood victims, especially the IDPs, queries the effectiveness of these measures. Although it is unjustifiable to claim that the limitation with these present efforts probably leads to more frequent flooding in the country, however, the fact that such measures have not improved the country with regards to the idea of "living with floods" is clearly acknowledged (Adelekan 2010, Adebayo & Oruonye 2013, Akintola & Ikwuyatum 2013).

V.

7 Recommendations

Based on these critical issues relating to tackling flooding in Nigeria, lessons learned from other countries' experiences of flooding and "best practices" in flood risk reduction (Water UK 2008, Pitt 2008 **??** Sayer et al. 2013), the authors propose that inclusion of flood modelling in the present effort will be a way forward towards a more proactive flood risk reduction within the country. In addition to this proposal, the following recommendations are relevant: **??**003). Whilst this policy highlights the relevance of flood modelling, it also underlines strong commitment towards tackling flooding across the region of Europe. A policy of such will benefit West Africa in general and Nigeria in particular. However, whilst a regional policy towards flood risk map may be unrealistic for West Africa in the interim, a strong legislation that requires each state of Nigeria to produce a flood hazard/risk map is recommended for Nigeria. This will to a large extent strengthen existing institutional framework and stimulate increased responsibility towards flood risk reduction among the states in the country. ? Flood risk reduction under the "living with floods" idea is multi-disciplinary indicating that various industries can assist in reducing the impacts of flooding. In UK, evidences of collaboration from various companies and institutions towards addressing flood challenges are undisputable (EA 2010, Water UK 2008, Pitt 2008). Thus, the need for multinationals and banking industries in Nigeria to sponsor research and promote sustainable development within Nigerian cities, as well as augment humanitarian supports to improve the living standards of local communities whilst reducing their vulnerabilities and building their resilience to flooding should not be ignored.

? Flood insurance is a non-structural approach which many property owners have benefitted from in developed countries following flood disasters. To support the roles of flood insurance in Nigeria, it is recommended that

the role of FEMA in this regard should be extended to states and whilst encouraging insurance companies to commence sensitization exercises for properties owners to take positive step in this direction.

VI.

8 Conclusion

Critical issues relating to widespread flooding in Nigeria have been explored with view to charting a more proactive solution towards addressing the challenge within the country. Fluvial and coastal types of flooding are experienced in Nigeria. However pluvial flooding which is a major cause of concern for urban areas within the country appears to be more frequent and arguably unprecedented from the point of view of flood impacts. Over the period 1985 to 2014, the effects of flooding on people, properties and economic activities have been arguably overwhelming. Whilst virtually all states in Nigeria have experienced the hazard, more frequent floods are experienced in Niger, Adamawa, Oyo, Kano and Jigawa states, possibly due to the influence of rivers Niger, Benue, Ogun and Hadeja. Lagos state seems to have experienced most of the floods in the country and this has been associated to poor urban planning and climate change with more frequent and intense rainfall.

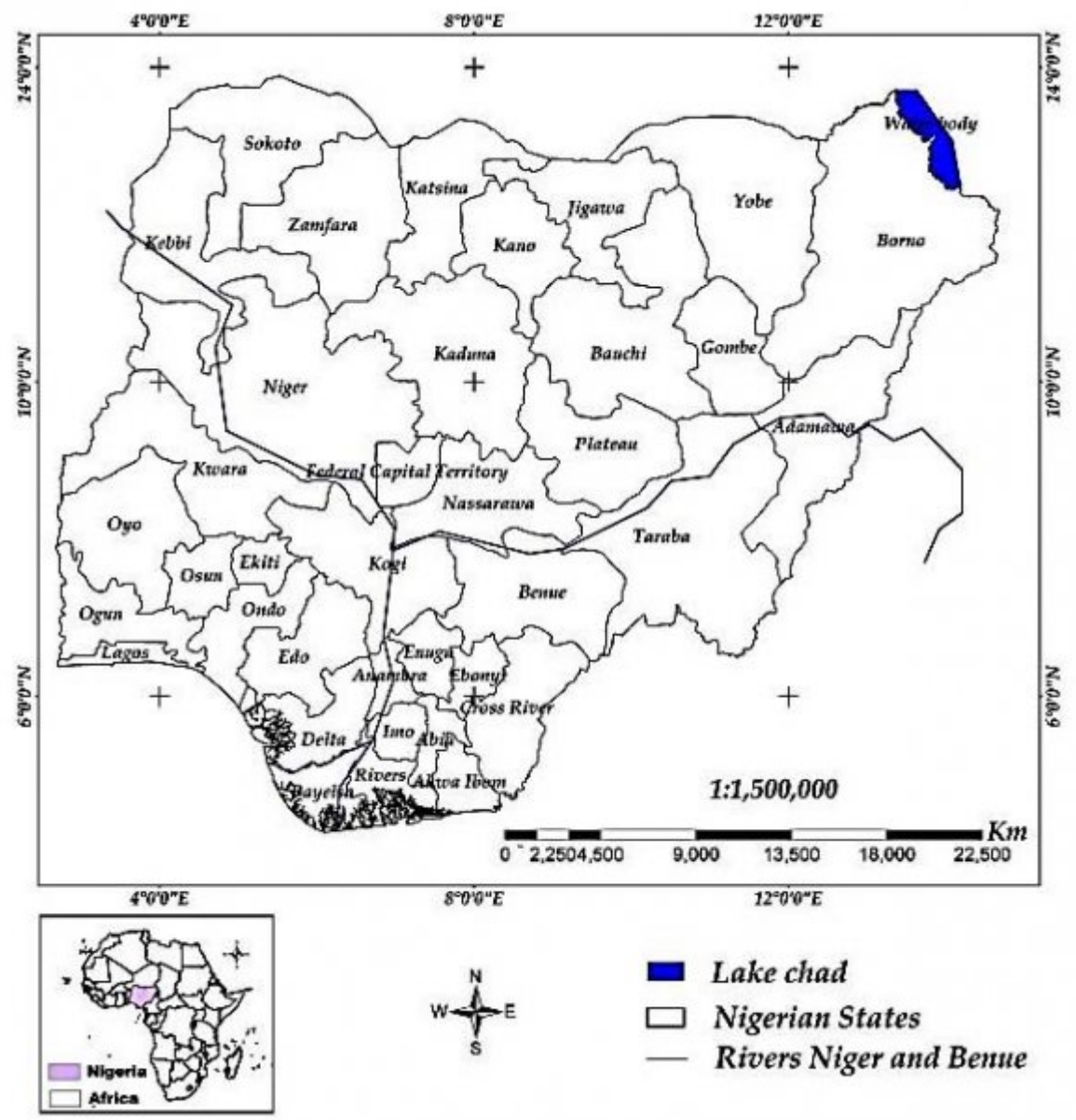
Present efforts at tackling flooding in Nigeria appear to be limited and have been grossly criticized as ad-hoc, poorly coordinated and not in line with globally acknowledged 'best practices' in flood risk reduction. Whilst such practices do not seem to be governed by the idea of 'living with floods and not fighting them', which dominates in flood risk reduction literature and many international and regional flood management policies such as the European Union Flood Directive, flood modelling approaches are evidently lacking.

Given the relevance of flood risk/hazard mapping within the framework of flood risk reduction, the specific roles of flood modelling are presented. Basically, it is shown that flood modelling simulates flood hazard data (flood water depth, extent, and duration as well as flow velocity) for flood risk/hazard mapping. However, the dearth of these data among other factor constrains efforts at tackling flooding in Nigeria. Although ground survey and remote sensing approaches can be applied to acquire these data, limitations inherent in these approaches undermine their applications in Nigeria.

With flood modelling presented, recommenddations which the authors deemed relevant towards achieving the key drivers of this study were made. Most importantly, bearing in mind that flooding cannot be constrained within human environment and that it will worsen in the future, the need for Nigerians to create a society where social systems are resilient to the hazard is recognized.

It is recognized that a major limitation of this study is in the negligence of flood events prior to 1985. This is due to the lack of accurate and well-coordinated historical data for those periods. However the study recommends this for future investigations, especially with regards to developing a repository where various historical flood data can be lodged, irrespective of their magnitudes and return periods. There is urgent need for bespoke flood models for simulating flood hazard in Nigeria in line with the objectives of NIHSA. That way the barriers associated with existing flood models such as copyright restriction, limited calibration and strict insistence on quality data requirement to run the commercial flood models in Nigeria can be overcome. [1]

Figure 1: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Jigawa
Yobe
Borno
Niger
Kaduna
Bauchi
Gombe
Adamawa
Plateau
Kwara
Federal Capital Territory
Nassarawa
Taraba
Oyo
Osun
Ekiti
Kogi
Benue
Ogun
Ondo
Lagos
Edo
Enugu
Anambra
Ebonyi
Cross River
Delta
Imo
Abia
Rivers
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Figure 2:

Figure 3: A

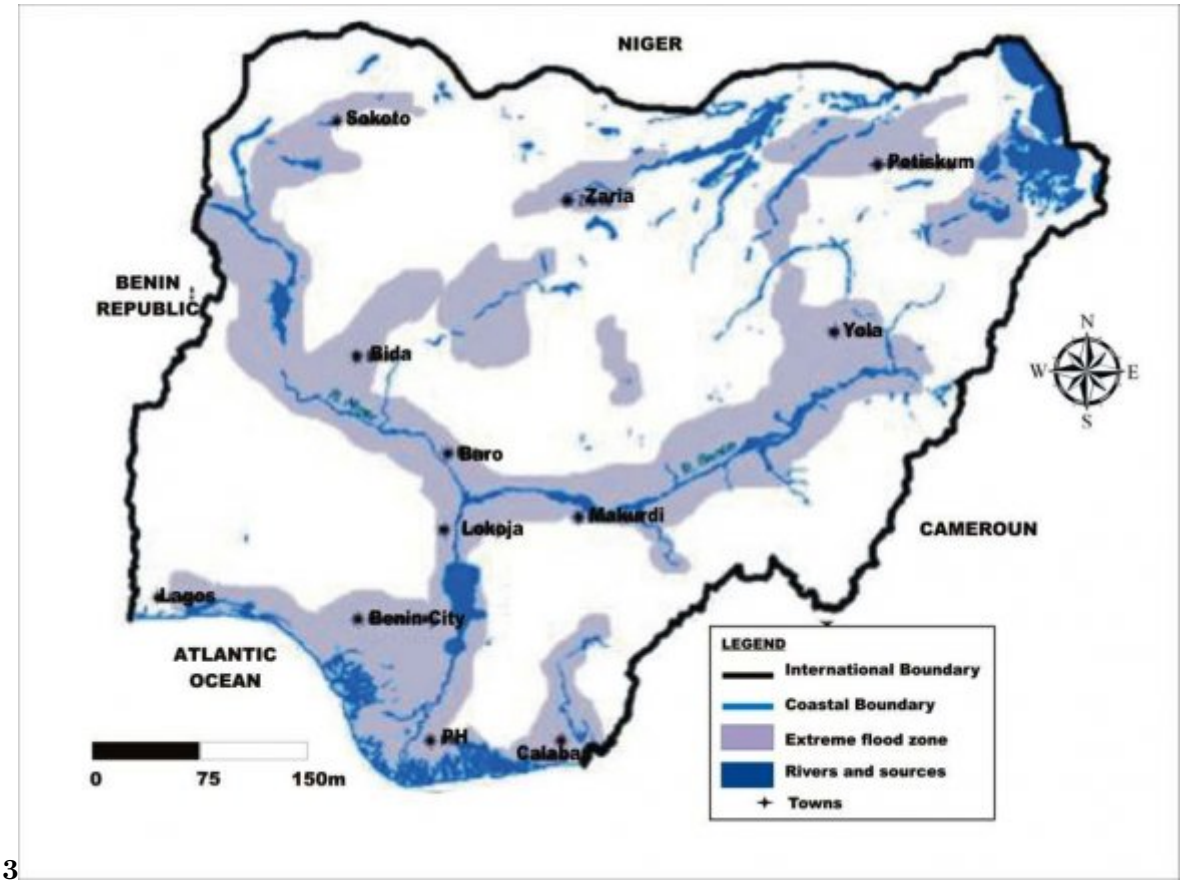
Figure 4:

1

Figure 5: Figure 1 :

2

Figure 6: Figure 2 :



3

Figure 7: Figure 3 :

1

Rank	Country	Urban Agglomeration	Exposed Population (Current)	Exposed Population (Future)
1	India	Calcutta	1,929,000	14,014,000
2	India	Mumbai	2,787,000	11,418,000
3	Bangladesh	Dhaka	844,000	11,135,000
4	China	Guangzhou	2,718,000	10,333,000
5	Vietnam	Ho Chi Minh City	1,931,000	9,216,000
6	China	Shanghai	2,353,000	5,451,000
7	Thailand	Bangkok	907,000	5,138,000
8	Myanmar	Rangoon	510,000	4,965,000
9	USA	Miami	2,003,000	4,795,000
10	Vietnam	Hai Phòng	794,000	4,711,000
11	Egypt	Alexandria	1,330,000	4,375,000
12	China	Tianjin	956,000	3,790,000
13	Bangladesh	Khulna	441,000	3,641,000
14	China	Ningbo	299,000	3,305,000
15	Nigeria	Lagos	357,000	3,229,000*
16	Cote d'ivoire	Abidjan	519,000	3,110,000
17	USA	New York	1,540,000	2,931,000
18	Bangladesh	Chittagong	255,000	2,866,000
19	Japan	Tokyo	1,110,000	2,521,000
20	Indonesia	Jakarta	513,000	2,248,000

[Note: (Source:Nicholls et al., 2007, OECD, Paris) and 25 days respectively (See table 3) (Aderogba 2012). It is shown from EM-DAT database that most floods in Nigeria lasted up to 79 days. Thus based on these features, the dangers posed to human lives and properties by flooding in Nigeria can be appreciated (See figure2).]

Figure 8: Table 1 :

2

on data sourced from EM-DAT, CRED and Dartmouth Flood Observatory (DFO) databases and from previous studies (examples: Adeoye et al. 2009, Adebayo and Oruonye 2012, Agbola et al. 2012, Obeta 2014), the widespread nature of flooding in Nigeria can be investigated
Against this background, the present study brings together available flood data on historical flooding in Nigeria from 1985 till 2014 (see table 4). This move extends recent investigations by Adebayo and Oruonye (2012), Adeoye et al. (2009), Etuonovbe (2011), Agbola et al. (2012) and Obeta (2014). It is believed that this record will give incentive for awareness of flooding among vast human population and local communities, as well as promote future investigations towards predicting probabilistic flooding for the country and formulating more effective ways of addressing the challenges of flooding.
, based
Highest values are

Figure 9: Table 2 :

4

S/No.	DATE (BEGAN)	CITY (LGAs)	STATE (S)	DURATION (DAYS)	CAUSE (S)	NO OF PEOPLE AFFECTED	MORTALITY	SIZE OF LAND (KM 2)	ECONOMIC LOSS (billion US$)	AFFECTED HOUSES
1.	13-Sept-2014	Ibadan and environs	Oyo	1	Torrential rainfall	10000	15	N/A		Many
2.	14-Apr-2013	Various	Southern area	5	Torrential rainfall	81506	19	N/A		Many
3.	July 2012	Many*	32 States in Nigeria	120	Heavy rain, dam/levee break,	7705378	363	Large expanse of farmlands.	16.9	Many* Registered IDPs amount to more than 2000000.

[Note: © 2016 Global Journals Inc. (US) Volume XVI Issue II Version I © 2016 Global Journals Inc. (US)]

Figure 10: Table 4 :

Figure 11:

.1 Acknowledgement

The author wishes to thank the Surveyors Council of Nigeria (SURCON) for the provision of supplementary grants towards this research. Most of the secondary flood data were accessed from the centre for research in epidemiology of disasters (CRED), Nigeria Environmental Study Action/Team (NEST). All the authors whose previous work and published data have contributed to the present study are acknowledged, and so are the efforts of the reviewers of this paper.

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