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Review Article: A review and critical analysis of the efforts towards urban flood reduction in the Lagos region of Nigeria

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Abstract

Urban flooding has been and will continue to be a significant problem for many cities across the developed and developing world. Crucial to the amelioration of the effects of these floods is the need to develop a knowledge base of the magnitude and frequency of these floods. Within the area of flood research, attempts are being made to gain a better understanding of the causes, impacts and pattern of urban flooding as an aid to reducing the risks it poses. This research reviews flood risk within the Lagos area of Nigeria over the period 1968–2012. During this period, floods have caused harm to millions of people physically, emotionally and economically. Arguably over this period the efforts of stakeholders to address the challenges appear to have been limited by, among other things, lack of reliable data, lack of awareness among the population affected, and lack of knowledge of flood risk mitigation. It is the aim of this research to assess the current understanding of flood risk and management in Lagos and to offer recommendations towards future guidance.

1 Introduction

Flood events and impacts in recent times have arguably been unprecedented and affected the lives of hundreds of millions of people across the world. These impacts have been shared by both developing and developed countries (DCs) with rapid urban expansion taking place on many flood prone areas. Concerns for flooding and the associated human impacts are clearly of global significance, especially when allied with the fears of climatic change and associated changes in rainfall events and sea level rise. The rapidly growing urban environments in many areas correspond with a lack of urban planning strategies, the deterioration and lack of capacity of urban drainage infrastructure and an increased rate of development on floodplains (Gill, 2004; CII 2001). Additionally, the increasing densities of populations (particularly in the urban areas of most DCs such as Lagos), alongside the poor level of awareness

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and the limited efforts of many stakeholders towards flood risk reduction are critical issues undermining possible efforts towards addressing the hazard (Action aid 2006; McMichael et al., 2006; Raaijmakers et al., 2008). The present research attempts to clarify these issues using a synthesis and analysis of available historical flood data in the Lagos, spanning the period 1968–2012. This research contextualises the current situation and puts forward relevant recommendations for more effective remedies to alleviate the threats of flooding in the area.

Flooding and flood risk reduction are issues of grave significance within and around the Lagos metropolis, (Aderogba, 2012a, b). It is clear from previous studies (for examples: Ajibade et al., 2013, 2014; Adelekan, 2013), that flooding in the area has been devastating, affecting hundreds of thousands of people and causing considerable economic loss amounting to millions of US dollars. Such floods are mainly pluvial based flash floods, following a short-duration-high-intensity or long-duration-low-intensity rainfall (Houston et al., 2011). To tackle this challenge, the Lagos state government in particular and various stakeholders in general, have been active with measures which have arguably so far been of limited assistance to the victims of flooding. It is claimed that these measures which are aimed at both prevention and control of flooding, have been unprecedented in Nigeria and clearly demonstrate practical commitment to fighting the flood hazard (Njoku and Udeagha, 2013; Obeta, 2014). However, in the light of best practice in flood risk reduction and lessons learned from other countries experiences of flooding, it can be argued that such measures are at best limited. The problem in Lagos is exacerbated partly due to the lack of readily available data, a general lack of funds, a lack of access to improved technology alongside a lack of political will (Nkwunonwo et al., 2014; Adeloye and Rustum, 2011). It is argued that flood modelling and a lack of provision of flood data alongside other non-structural approaches to flood risk reduction seems to have been largely ignored.

It is argued that the level of existing knowledge regarding the state of affairs of flooding in Lagos is unsatisfactory and fails to assist in providing a potential solution to ways of reducing the impacts of flooding on the human population. The more critical

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and disturbing scenario is that the Lagos area is a fast growing city within which a great deal of the population currently live within areas prone to flooding. Within this framework, the present study attempts to address the challenges of flooding in the Lagos metropolis through a review of literature and flood information covering the hazard in the area and how it has so far been managed. In particular, the authors stress the importance of flood modelling in flood risk reduction and the need for it to be included in the present and future efforts at reducing the impacts of flooding in the Lagos area. This study in general and the recommendations in particular are driven by three key aims. Firstly, to understand the unique situation which exists in Lagos in relation to flooding. Secondly, to align the focus of flood risk reduction in the Lagos area with the objectives of such a task in more developed countries such as the US, the Netherlands and UK. Finally, to suggest area here improvements can be made in data collection, flood modelling and management.

2 Description of the Lagos metropolis of Nigeria

The Lagos metropolis is a densely populated low-lying coastal area on the south-western part of Nigeria, West Africa. The city is located within geographical coordinate of 3.1–3.4° E longitudes and 6.5–6.8° N latitude and covering a land area of approximately 1100 km^2 (or 425 sq. miles) is bordered in the south by the Atlantic Ocean (see Fig. 1). With a dense network of roads and buildings, and several inland waterways including the Lagos Lagoon which empties into the Atlantic, the conurbation serves as a major hub for transportation, tourism and economic activities in Nigeria. With a population of over 20 million people (LSG 2012), the Lagos metropolis is the biggest city in Nigeria, (although the smallest land area), the second largest city in Africa, and the seventh largest city in the world. The population growth rate in the Lagos metropolis is estimated at 3.2 % (about the rate of Palestine and Uganda: World Bank, 2013). The United Nations predicts that Nigeria will be one of the eight countries expected to account collectively for half of the total population increase in the

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world from 2005 to 2050, and will by 2100, record a population amounting between 505 million and 1.03 billion people (United Nations, 2004). High population density is a major impasse in the Lagos region, subjecting the area to lack of space for the myriad of human activities, which often manifests itself in muddled human settlements, overcrowding, slum envelopments, pollution, illegal structures, and other social and environmental disorders.

3 Flooding in Lagos

Over the last two decades, flooding, its causes, impacts and remedies especially in local communities, local council districts Authorities (LCDA) and various local government areas (LGAs) within the Lagos metropolis have received considerable attention in the literature (Ayoade and Akintola, 1980; Action Aid, 2006; Adelekan, 2013; Aderogba, 2012a; Soneye, 2014). However, a better understanding of the hazard in Lagos requires wide ranging cross-disciplinary discourse not limited to small geographical areas (Aderogba, 2012a; Ajibade et al., 2013, 2014; Adeloye and Rustum, 2011; Oshodi, 2013). Various wide ranging impacts of flooding have been assessed in the literature including mortality, physical injuries, displacement of human populations, spread of disease, submergence of buildings, destruction of urban infrastructure and disruption of economic activities (Ugwu and Ugwu, 2013; Adigun et al., 2013; Ajibola et al., 2012; Aderogba, 2012b; Olajuyigbe et al., 2012).

A number of factors have been highlighted with reference to the extent and severity of flooding in Lagos including climate change with more intense rainfall, topography of the area, land use/land cover modifications, influence of canals, lagoons and beaches, urbanization and population growth, poor urban planning and poor environmental management along with anthropogenic activities especially in indiscriminate disposal of solid waste (Lamond et al., 2012; Aderogba, 2012a; Aderogba et al., 2012; Odunuga, 2008; Adeloye and Rustum, 2011). Tidal and co-tidal influences and frequent discharges from the Atlantic into the lowlands during heavy storms are also

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implicated (Ojinnaka, 2013). Alongside these physical influences, the development of slum settlements and poor perception of flooding among local communities, urban residents and the general public are perceived as critical factors which contribute to the vulnerabilities of social systems to flooding in the area (Agbola and Agunbiade, 2007; Nkwunonwo, 2013; Ayoade and Akintola, 1980; Odunuga et al., 2012; Oloke et al., 2013; BNRCC 2008).

In relation to possible hazard mitigation and adaption responses, the importance of building the capacity for flood preparedness through spatial planning and land management is highlighted (Adedeji et al., 2012). Other relevant measures such as combating environmental degradation through sustainable landscaping (Ogunsote et al., 2011), sustainable management of solid waste (Folorunsho and Awosika, 2001), the need for proactive measures to risk management and adaptation (Komolafe et al., 2014), constant geophysical and hydrological evaluation of rising groundwater levels (Oyedele et al., 2009) and the participation of private sectors in risk management through investment decision in building and construction (Adelekan, 2013) have been considered. Other factors besides flood prevention are also important to reduce the potential impacts of flood events. The humanitarian relief supply chain for victims of flooding in the Lagos area was investigated by Soneye (2014), additionally, the patterns of flood vulnerability and resilience among women (Ajibade et al., 2013), and the vulnerability of coastal communities (Adelekan, 2010) in the Lagos area have been investigated. In relation to the planning framework, sustainable housing development and functionality of planning laws and regulations as well as the role of governance in flood management in Lagos area and indeed in Nigeria have been examined by a number of authors including Aluko (2011) and Oshodi (2013). Despite some detailed studies which have examined these various factors, flood modelling, which supports recent approaches to flood risk reduction is generally lacking. Relatively few studies have highlighted the relevance of flood modelling and its implications with paucity of topographic data (Nkwunonwo et al., 2014, van der Sande et al., 2012) although Adeaga (2008) implemented a flood hazard mapping and risk management

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in north eastern part of Lagos. Although the aforementioned studies explored flooding in Lagos, it could be argued that the question regarding solutions to this problem remains largely unanswered. Urban flooding in particular has arguably not received the attention it deserves. The lack of flood data and other ancillary data which is a major setback towards containing these threats has not been fully addressed. Although as an unprecedented measure, Lagos state government has made significant efforts at providing high resolution air-borne LiDAR (Light Detection and Resolution data and topographic maps which promote research towards flood risk in the area. However, the poor access of researchers to these datasets arguably undermines their usefulness.

Importantly, it is argued that the attention of these studies with regards to flooding in the Lagos area has solely rested on general knowledge of the causes, impacts and remedies of flooding, suggesting that the global view of the situation in these studies have been imperfect. The need for more scientific approaches such as 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 Lagos area, is the significant gaps in knowledge which exist in terms of the vulnerabilities of local communities, urban residents and the general public.

Data on the widespread occurrence of flooding in the Lagos area dates back to the early 1960's and highlights the importance of addressing the impacts of climate change and poor urban planning (Odunuga, 2008; Oyebande, 1974; Etuonovbe, 2011). Whilst coastal and fluvial floods often occurred in the historic years of flooding in the Lagos area, pluvial floods have been more widespread in recent times (Olajuyigbe et al., 2012). With the exception of 1973, the drought year, such flooding in Lagos area has occurred annually since 1960 (Oyebande, 1974). According to previous studies the threats of flooding in Lagos appears to be more severe for Lagos Island, Apapa, Ikeja, Mushin, Surulere and parts of Ikorodu (Oyebande, 1974; Odunuga, 2008). Floods in Lagos usually occur between July and October (rainy season) with severe consequences. Table 1 shows a summary of major flooding events and associated

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threats in the Lagos metropolis of Nigeria from 1968 to 2012. One example of a typical event is the 2011 July flooding, caused by a severe storm that lasted 17 h. The flood affected more than 10 thousand people with deaths exceeding 100 and a range of severe damage to public infrastructure. Many houses were submerged by flood water whilst property and vehicles were destroyed due to the intensity of the flood. An estimated economic loss of about 50 billion Naira (USD 320 million) was recorded (Oladunjoye, 2011)

Flooding in Lagos triggers concerns for environmental management, vulnerability of urban residents, the general public and local communities within the area, humanitarian needs and services, primary health delivery, solid waste management, urban development, and governance (Soneye, 2014; Ajibade, 2013; Lamond et al., 2012). Additionally, some features such as flood water depth, inundation extent and duration as well as depth averaged velocity, all which influence the level of flood impacts in the many places, appear to be of concern in the Lagos area. The lack of capacity to cope with the hazard and the inability to quickly recovery from losses following the hazar as been clearly problematic for many affected human populations in the area (Adelekan, 2010). Figure 2 exemplifies the magnitude of flooding experience in the Lagos area of Nigeria. From a global and regional perspective Lagos is among the top twenty cities with increasing numbers of the present and future population exposed to flooding (see Table 2). In Nigeria, Lagos is one of the few locations with more frequent flooding in more rural areas (see Fig. 3 below). Although a number of floods have occurred in the Lagos area, critical concerns develop with regards to keeping track of events in the country. Principally, data relating to hydrolmet nd historical flood events are often lacking (Ajibade et al., 2013). Much of the readily available data on flooding relates to events of higher magnitudes and return periods (Guha-Sapir et al., 2013). Often only journalistic and non-quantitative evidence are available (e.g. IFRC 2012).

The present study has so far discussed the challenges faced by Lagos in managing and reducing flood risk impact he data for the study were obtained from various online databases (e.g. NEST 1991; Guha-Sapir et al., 2013) and published data on

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historical flooding in Lagos, Nigeria. Ultimately, the authors argue that the lack of more robust techniques, such as flood modelling and assessment of vulnerability of social systems to flooding, towards addressing the challenge flooding in the Lagos area, account for the limited success in the efforts by stakeholders.

4 The management and reduction of flood risk in Lagos

General measures to tackle the challenges of flooding in Lagos have been discussed by Oshodi (2013). Recently, some of the ongoing practices have included:

1. Expansion of drainage infrastructure within the city heartland.
2. Annual debris removal from principal drainage facilities within the city heartland.
3. Advise to the dwellers of flood plains and wetlands to relocate.
4. Demolition of homes in the flood prone areas which are always considered as the major sources of flood challenges especially in the low income communities.
5. Proposed resettlement scheme for the residents of Ogun river catchment areas

There are also specific actions which have been taken by local authorities and stakeholders. Odunuga (2008) recognized several flood preventive and curative initiatives ranging from community self-assistance actions to World Bank assisted programmes. Recently, key initiatives which include the Drain Dock and The Emergency Flood Abatement Gang (EFAG) were launched by the government of Lagos state to improve current efforts towards addressing the challenges of flooding. The ministries of Environment, Works and Health as well as the Lagos Metropolitan Development and Governance Project (LMDGP) are active with a number of projects towards controlling flood hazard in the area including waste management programme, shoreline protection, low carbon emission, school advocacy programme and climate

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change club. The promotion of sustainable drainage infrastructure and sustainable access to basic urban services for urban residents and the general public are a top priority. Lagos state emerged as the first in Nigeria to carry out a detailed topographic mapping of the area with LiDAR (Light detection and ranging) data acquisition GIS based analysis aimed at addressing the challenges of flooding. In addition, the Nigerian government and international community have been active with measures to address the challenges of flooding at various locations within the country including the Lagos area (Olorunfemi, 2011; NIHSA 2013). Besides engineering works such as dams, bridges and sustainable urban drainage systems as well as financial assistance to victims of flooding which appears to be common practices, some of the key objectives to addressing the challenges of flooding are undertaken by the National Emergency Management Agency (NEMA) and other agencies including the Nigerian Meteorological Agency (NIMET), Nigeria Hydrological Services Agency (NIHSA) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) which by 2009 Nigerian Acts supersedes the Federal Environmental Protection Agency (FEPA). NEMA essentially coordinates the management of disaster in Nigeria. To tackle flooding in various locations within the country, the agency coordinates policy formulation, assessment of the state of preparedness of all other relevant agencies, data collation from relevant repositories, education of the general public on flooding and interaction with state emergency management agency (SEMA) towards the distribution of relief materials and funds to disaster victims within states and local government areas. Recently, NEMA signed a memorandum of understanding with NESREA and National Orientation Agency (NOA) to intensify efforts towards flood risk management in Nigeria (NEMA 2013). NESREA is mainly concerned with the protection and development of the Nigerian environment. To tackle flooding, the agency enforces strict compliance on all environmental laws, guidelines, policies, standards and regulations in Nigeria. The agency also enforces compliance with provisions of international agreements, protocols, conventions and treaties on the environment to which Nigeria is a signatory. NIHSA provides reliable and high quality hydrological

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and hydrogeological data and services on a continuous basis for the country. The agency's action are targeted towards assessing the status and trends of the nation's water resources including its location in time and space, extent, dependability, quality and the possibilities of its utilization and control. Since, 2013, the agency has been creating awareness of flooding through the "flood outlook" initiative (NIHSA 2013). Other activities of NIHSA include; provision professional advice to various levels of government in Nigeria on all aspects of hydrology, collaborates with NIMET to issue flood forecast and contributes towards creating awareness of flooding among local communities. NIMET furnishes the country with weather report, and other meteorological information, issues alerts and early warning and forecast on impending flood disasters within the country.

Despite the recent initiatives it has been argued that these developments have been acutely flawed (Oshodi, 2013; Adeaga et al., 2005; Soneye, 2014; Nkwunonwo et al., 2014). Key roles have been recognized especially in facilitating the evacuation of victims affected by floods and providing them with urgent humanitarian needs, ensuring sustainable urban drainage system, promoting environmental sustainability and promoting policy, social responses, physical intervention and environmental management (Aderogba et al., 2012; Olajuyigbe et al., 2012; Aderogba, 2012b; Adeaga, 2008; Ilesanmi, 2010). However, the increasing number of people affected by flooding challenges the effectiveness of these objectives. Whilst it is unjustifiable to claim that the weakness of these flood mitigation measures probably leads to more frequent flooding in the area, the fact that such measures have not improved Lagos with regards to the idea of "living with floods" is fundamental.

Critically, these measures appear to control flood rather than mitigate its impacts on human populations and urban infrastructure which is the aim of recent integrated approaches of managing floods. The poor perception of flooding by the general public and the gendered vulnerability which have been highlighted in Odunuga et al. (2012), Ajibade et al. (2013) and Adelekan (2010) appear not to have been addressed by these measures.

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It can be argued that flood modelling which promotes flood risk reduction in the US, the Netherlands and UK has been too often been ignored. This raises the question of how flood risk mitigation can be realistic in the absence of accurate flood data and scientific means of acquiring such data. Arguably, limited efforts have been made towards knowledge based decision of flood risk reduction since a comprehensive flood risk/hazard map needed to widen the awareness of flooding in the general public and urban residents in Lagos as well as to inform decision of stakeholders to flood risk mitigation has not been produced.

5 Flooding in Lagos – the way forward?

Based on the review of research discussed here and in relation to lessons learned from other countries' experiences of flooding and "best practices" in flood risk reduction (Sayers et al., 2013; Kazmierczak and Carter, 2010), the following recommendations are key issues fundamental to success in flood risk reduction. These recommendations are based on three key issues which are: the understanding and demonstration of the roles more scientific approaches such as flood modelling, can play in flood risk reduction within the context of the Lagos. Secondly, the need to align the focus of flood risk reduction in the Lagos area to the objectives of similar measures in more developed countries such as the US, UK and the the Netherlands. Thirdly, the need to promote awareness of flooding among local communities, urban residents and the general public and to delineate more suitable locations for relocation of human populations during flooding events. Further specific recommendations include:

1. The government of Lagos state should as a matter of urgency prioritize legislation and provision of resources towards flood hazard and flood risk mapping for the whole of Lagos state. This is the basis of flood risk mitigation within the European Union framework, which requires all constituting states to prepare flood

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hazard/risk maps as a propeller towards promoting the concept of living with floods (EC 2004).

2. Flood risk reduction under the "living with floods" idea is multi-disciplinary indicating that various industries can assist in reducing the impacts of flooding. This is the case in UK in particular (EA 2010). Thus, in view of widening the awareness of flooding in the general public, there is need for improved collaboration between the Lagos state government and federal ministries, departments and agencies such as NEMA, NESREA and NIHSA.

3. Flood alert and flood early warning systems should be improved within the Lagos area. The UK flooding of 2012 which affected many urban areas in Yorkshire with minimal impact on human population reveals the importance of flood alerts and flood early warning systems when followed with strict compliance (Pitt, 2008).

4. 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 Lagos, it is recommended that the role of FEMA in this regard should be extended to the state and whilst encouraging insurance companies to commence sensitization exercises for properties owners to take positive step in that direction.

5. Enforcement of environmental standards and laws is often a key factor towards containing adverse effects of climate change including flooding (UN/ISDR 2007). Indiscriminate waste disposal, construction along flood plain and indiscriminate car parking, among other anthropogenic activities which influence flooding in Lagos are illegal. In view of addressing these matters, NESREA should embark on arrest, prosecution and proportionately fine urban residents who violate these laws.

6. The reaction to the 1953 floods in the Netherlands has arguably made the Dutch an exemplar in terms of flood management (Vis et al., 2003). Invariably, the

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success of flood risk reduction in the Netherlands is built on a strong commitment to resist any attempt of a repeat of history. The people are committed, and so is the government implying that collective efforts underlie success towards addressing the challenges of flooding. It cost each Dutch adult about USD 110 annually towards flood management in the Netherlands (Kazmierczak and Carter, 2010). For this reason, we recommend that urban residents and the general public in Lagos need to engage more fully in flood management and control. Some of the ways they can be part of this goal of flood risk reduction is to adhere to environmental laws and comply to flood alerts and early warning systems. It could also be argued that more education is required to make the public more aware about flooding and its consequences including qualitative research involving the local community.

7. Globally, it appears research is proportional to success towards addressing the threats of flooding. From a routine Google scholar search, literature relating to flooding in Lagos appears insignificant compared to those of the US, the Netherlands, China, UK, etc. This is a strong pointer and indicator that more research is required for Lagos. Equally, the universities and research agencies should be empowered to include in their curriculum studies and programmes tailored towards improving flood awareness and management. More research should be directed towards developing bespoke hydrologic and hydraulic flood models for simulating flood hazard and other hydrological parameters in the area.

8. Globally, accurate data play a key role in flood risk mitigation and the government of Lagos state has made an unprecedented attempt by the acquisition of LiDAR datasets, although access to this datasets has been limited due to funds. Given the importance of these datasets and the need to optimize their usefulness for the Lagos area, we recommend subsidizing these datasets for universities and research institutions. Additionally, we also recommend further improvement on

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data acquisition such as SAR (Synthetic Aperture Radar) for flood modelling within the Lagos area country.

6 Conclusions

Flooding is generally a global occurrence, but the impacts in many urban areas in the developing countries such as Lagos can arguably overwhelming. It is easier to understand the threats of flooding in the Lagos area by the attention generated both in the media and in many social and environmental science literature. Flood waters have impacted upon the local population, destroyed critical infrastructures and disrupted economic activities. However, based on "best practices" in flood management and flood risk reduction in the context of "living with floods", the actions of the state government and other stakeholders towards addressing the challenge of flooding in the Lagos area have arguably been limited. Unfortunately, relevant data on flood events are not readily available and the means of building a community resilient to flood threats have continued to elude present efforts.

The present review is an attempt towards addressing the challenges of flooding in and around Lagos. Looking to the future, the research argues that flood modelling and assessment of vulnerability are requisite for more effective results towards addressing the challenges of flooding in the Lagos area and indeed in Nigeria. Some recommendation are made to support the argument and to optimize the available LiDAR (Light Detection and Ranging) topographic data in the Lagos area in pursuance of the idea of living with floods, which are the ethos behind the recent ongoing integrated flood management approaches

The major limitation of this study, is in the level of information available with regards to flooding in the Lagos area. The majority of the research generalized flooding rather than discretizing the hazard based on local government areas (LGAs). If flood data had been available for LGAs, it would have offered better understanding of the spatial distribution of flooding over the epoch considered. In addition, there are places within

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various LGAs which may never have flooded over the period considered. It is important to investigate these places with view to finding out their source defense from flooding. It was not intended in this study to address flood modelling and vulnerability assessment. However, the authors recommend future research that focuses on developing bespoke flood models for simulating flood hazard in the Lagos area of Nigeria.

Author contributions. This work was carried out in collaboration between all authors. Nkwunonwo Ugonna designed the study, performed the statistical analysis, managed literature searches, wrote the protocol and wrote the first draft of the manuscript Whitworth Malcolm and Baily Brian reviewed the first draft and made academic contributions. All authors read and approved the final manuscript.

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Table 1. A summary of major flooding events and associated threats in the Lagos metropolis of Nigeria from 1968 to 2012.

S/No.	Date	LGA(S) Affected	Duration (days)	Cause (S)	No of people displaced	Mortality	Economic loss (N)	Affected houses/others
1.	Jul 2005	Lagos city	5	Heavy storm	3000	25	Millions	N/A
2.	Oct 2012	Lagos city*	Many days, unspecified	Heavy Rain	Thousands	> 50	Millions, unspecified	Many*, including interruption of traffic and other activities
3.	Jul 2011	Lagos island, Mainland, Mushin	2 days	Heavy Rain	10 000	100	Millions, unspecified	Many*
4.	Oct 2010	Lagos island, Apapa, Kosofe,	Many days, unspecified	Heavy Rain	Thousands	20	Millions, unspecified	Many* including interruption of traffic and other activities
5.	Jul 2009	Lagos city*	Many days	Heavy Rain	Many	Nil	Millions, unspecified	Many*
6.	Oct 2008	Lagos city*	N/A	Heavy Rain	Not specified	No data	Millions, unspecified	Many* including interruption of traffic and other activities
7.	Aug 2007	Ikorodu, Kosofe and Abeokuta	15	Heavy Rain	5000	17	Millions, unspecified	5000
8.	Jun 2004	Lagos city	2	Heavy Rain	1000	Nil	Millions	Drainages
9.	Jul 2002	Lagos city	3	Heavy Rain	200	2	Millions	Many*
10.	Jun, Jul, Sep 2000	Victoria Island Ikoyi	2	Brief Torrential Rain	500	Nil	Millions, unspecified	Tens of thousands
11.	May, Jun, Jul 1999	Mushin and Idiaraba	N/A				70 000 000	
12.	Jul 1990	Lagos city	2	Heavy Rain	3000	5	Thousands	Many*, not specified
13.	Jul 1990	Lagos city	2	Heavy Rain	500	Nil	N/A	Hundreds of inhabitants
14.	Jun 1974	Idiaraba, Ikorodu, Surulere and Yaba	Many days, unspecified	Heavy rain	Thousands	Nil	N/A	
15.	Jun 1972	Lagos Island	N/A	Heavy rainfall	Not specified	Nil	N/A	Traffic was disrupted, Few houses
16.	Jul 1971	Lagos Island	5	Heavy rainfall	Not specified	Nil	N/A	Traffic was disrupted, Few houses
17.	Jul 1970	Lagos Island	N/A	Winds, accompanied by short duration, high intensity rain	Nil	Nil	5000	Few
18.	Jun 1969	Surulere and Yaba	10	Short duration, high intensity rain	Nil	Nil	N/A	Many*, not specified
19.	Jun 1968	Lagos Island Ijora.	N/A	Heavy storm	Nil	Nil	6000	Traffic was disrupted, Few houses

Source: EM-DAT (2014), FME (2012) and published works.
* Grouped instead of treating as separate variables due to lack of data.

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Table 2. Top 20 countries ranked in terms of population exposed to coastal flooding in the 2070s, including both climate change and socio-economic change) and showing present day exposure. Source: Nicholls et al. (2007), OECD, Paris. *Highlight is by authors.

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

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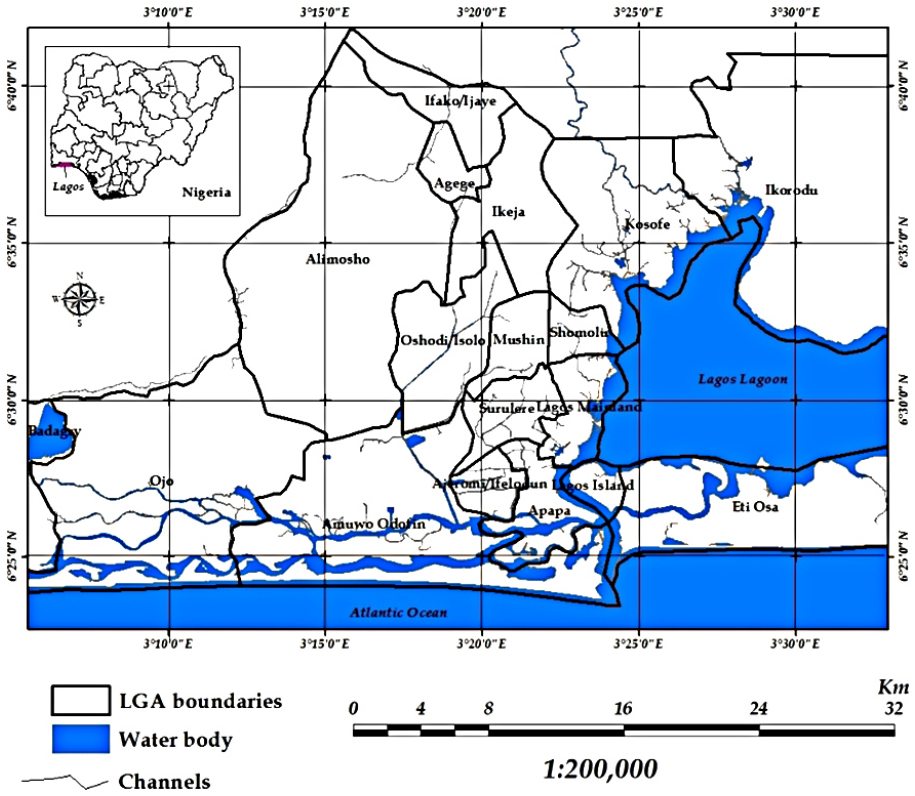

Figure 1. The Lagos metropolis of Nigeria. Inset showing the location of Lagos State in Nigeria. Source: drafted by authors.

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(a) (b)

(c) (d)

Figure 2. Some flooding scenes examples in the Lagos metropolis of Nigeria: **(a)** living room submerged by flood water, **(b)** residential building submerged, **(c)** local community affected by flood waters, and **(d)** expressway overwhelmed by flood water Source: authors' images of flooding in Lagos, Nigeria.

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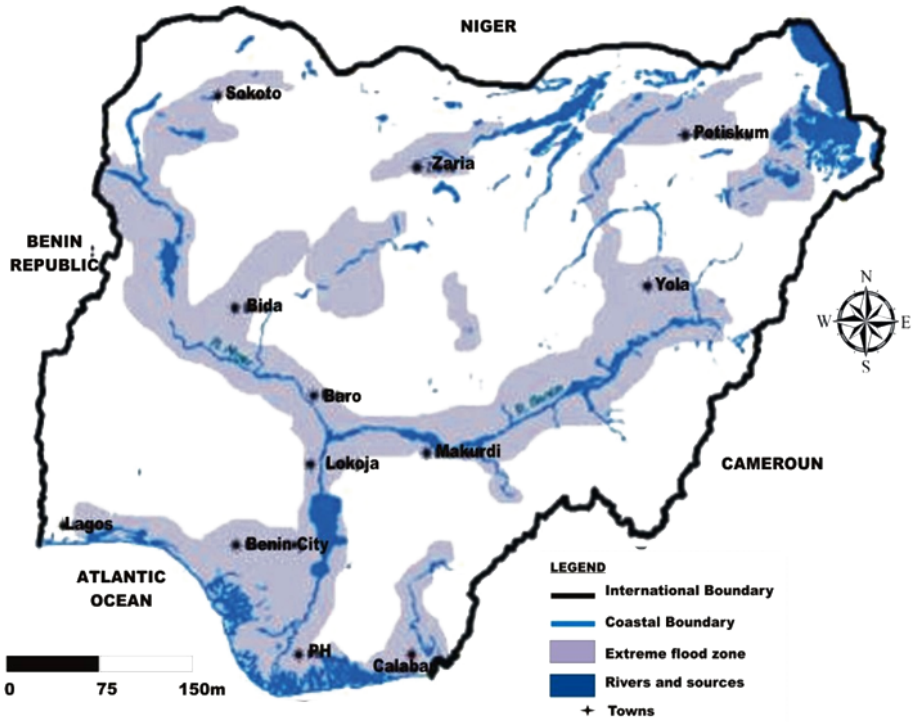

Figure 3. Spatial distribution of areas affected by extreme floods in Nigeria between 2000 and 2012. Source: Federal Ministry of Environment (2012).

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