



This discussion paper is/has been under review for the journal Natural Hazards and Earth System Sciences (NHESD). Please refer to the corresponding final paper in NHESD if available.

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

U. C. Nkwunonwo^{1,2}, M. Whitworth², and B. Baily³

¹Department of Geoinformatics and Surveying, University of Nigeria, Enugu Campus, Nigeria

²School of Earth and Environmental Sciences, University of Portsmouth, Portsmouth, UK

³Department of Geography, University of Portsmouth, Portsmouth, UK

Received: 28 April 2015 – Accepted: 11 May 2015 – Published: 16 June 2015

Correspondence to: U. C. Nkwunonwo (ugonna.nkwunonwo@port.ac.uk)

Published by Copernicus Publications on behalf of the European Geosciences Union.

NHESD

3, 3897–3923, 2015

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

AbstractIntroduction

ConclusionsReferences

TablesFigures

◀▶

◀▶

BackClose

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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; Adelaye 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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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 areas where 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 km² (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

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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



5

10
15
20
25

U. C. Nkwunonwo et al.



3903

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 hazard has 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 hydrolmetry and 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 impacts. The data for the study were obtained from various online databases (e.g. NEST 1991; Guha-Sapir et al., 2013) and published data on

Efforts towards urban
flood reduction in the
Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures



Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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

NHESSD

Efforts towards urban flood reduction in the Lagos region

A vertical navigation menu on the right side of the slide. It consists of a list of buttons and links, each with a corresponding icon to its left. The items are: 'Title Page' with a document icon, 'Abstract' with a document icon, 'Introduction' with a document icon, 'Conclusions' with a document icon, 'References' with a document icon, 'Tables' with a document icon, 'Figures' with a bar chart icon, a navigation section with four arrow icons (double left, double right, single left, single right), 'Back' with a left arrow icon, 'Close' with a right arrow icon, 'Full Screen / Esc' with a full screen icon, 'Printer-friendly Version' with a printer icon, and 'Interactive Discussion' with a speech bubble icon.

- Title Page
- Abstract
- Introduction
- Conclusions
- References
- Tables
- Figures
- Navigation icons: double left arrow, double right arrow, single left arrow, single right arrow
- Back
- Close
- Full Screen / Esc
- Printer-friendly Version
- Interactive Discussion

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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.

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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



- 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.
- 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.
 - 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

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 be 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 recommendations 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

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Action Aid: Climate Change, Urban Flooding and the Rights of the Urban Poor in Africa: Key Findings From Six African Cities, Action Aid International, London, 2006.

Adeaga, O.: Flood Hazard Mapping and Risk Management in Parts of Lagos N. E., available at: <http://www.gsdi.org/gsdiconf/gsdi10/papers/TS13.3paper.pdf> (last access: 10 March 2015), 2008.

Adeaga, O., Savic, D. A., Bertoni, J. C., Mariño, M. A., and Savenije, H. H. G.: A sustainable flood management plan for the Lagos environs, in: Sustainable Water Management Solutions for Large Cities: The Proceedings of the International Symposium on Sustainable Water Management for Large Cities (S2): Held During the Seventh Scientific Assembly of the International Association of Hydrological Sciences (IAHS) at Foz Do Iguaçu, Brazil, 3–9 April 2005, No. 293, International Assn of Hydrological Sciences, 226–229, 2005.

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

A vertical navigation menu on the right side of the slide. It consists of a list of items, each enclosed in a light blue rounded rectangle. The items are: 'Title Page' (highlighted in dark blue), 'Abstract', 'Introduction', 'Conclusions', 'References', 'Tables', 'Figures', a double left arrow '◀◀', a double right arrow '▶▶', a single left arrow '◀', a single right arrow '▶', 'Back', 'Close', 'Full Screen / Esc', 'Printer-friendly Version', and 'Interactive Discussion'.

- Title Page
- Abstract
- Introduction
- Conclusions
- References
- Tables
- Figures
- ◀◀
- ▶▶
- ◀
- ▶
- Back
- Close
- Full Screen / Esc
- Printer-friendly Version
- Interactive Discussion



Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Adedeji, O. H., Odufuwa, B. O., and Adebayo, O. H.: Building capabilities for flood disaster and hazard preparedness and risk reduction in Nigeria: need for spatial planning and land management, *Journal of Sustainable Development in Africa*, 14, 45–58, 2012.

Adeloye, A. J. and Rustum, R.: Lagos (Nigeria) flooding and influence of urban planning, *Urban Design and Planning*, 164, 175–187, 2011.

Aderogba, K.: Qualitative studies of recent flood and sustainable growth and development of cities and towns in Nigeria, *International Journal of Academic Research in Economics and Management Science*, 1, 1–25, 2012a.

Aderogba, K.: Global warming and challenges of floods in Lagos metropolis, Nigeria, *Academic Research International*, 2, 448–468, 2012b.

Aderogba, K. Martins, O. M., Oderinde, S., and Afelumo, T.: Challenges of poor drainage systems and floods in Lagos metropolis, Nigeria, *International Journal of Social Science and Education*, 2, 412–427, 2012.

Adelekan, I.: Vulnerability of poor urban coastal communities to flooding in Lagos, Nigeria, *Environ. Urban.*, 22, 433–450, 2010.

Adelekan, I.: Private Sector Investment Decision in Building and Construction: Increasing, Managing and Transferring Risks: Case Study of Lagos, Nigeria, *The United Nations Office for Disaster Risk Reduction, Global Assessment Report on Disaster Risk Reduction*, 1–9, 2013.

Adigun, F., Abolade, O., and Yusuf, A. A.: Incidence of flood and its impacts: empirical evidence from Ajeromi-Ifeledun, Lagos State, Nigeria, *International Journal of Innovative Research and Studies*, 2, 239–254, 2013.

Agbola, T. and Agunbiade, E.: Urbanization, slum development and security of tenure: the challenges of meeting millennium development goal (MDG 7) in metropolitan Lagos, Nigeria, in: *PRIPODE Workshop*, Nairobi, Kenya, 11–13 June 2007.

Ajibade, I., McBean, G., and Bezner-Kerr, R.: Urban flooding in Lagos, Nigeria: patterns of vulnerability and resilience among women, *Global Environ. Chang.*, 23, 1714–1725, 2013.

Ajibade, I., Armah, F. A., Kuire, V. Z., Luginaah, I., McBean, G., and Tenkorang, E. Y.: Assessing the bio-psychosocial correlates of flood impacts in coastal areas of Lagos, Nigeria, *J. Environ. Plann. Man.*, (ahead-of-print), 58, 445–463, doi:10.1080/09640568.2013.861811, 2014.

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Ajibola, M. O., Izunwanne, E. M., and Ogungbemi, A. O.: Assessing the effects of flooding on residential property values In Lekki Phase I, Lagos, Nigeria, *International Journal of Asian Social Science*, 2, 271–282, 2012.

Aluko, O.: Sustainable housing development and functionality of planning laws in Nigeria: the case of cosmopolitan Lagos, *Journal of Sustainable Development*, 4, 139–150, 2011.

Ayoade, J. O. and Akintola, F. O.: Public perception of flood hazard in two Nigerian cities, *Environ. Int.*, 4, 277–280, 1980.

Building Nigeria's Response to Climate Change (BNRCC): Vulnerability, Impacts and Adaptation, *Climate Change in Nigeria*, available at: www.info@climatechange.org, last access: 10 March 2015, 2008.

CII: Climate Change and Insurance, Chartered Institute for Insurance, London, 2001.

EA (Environment Agency): Working With Natural Processes to Manage Flood and Coastal Erosion Risk, Environment Agency, London, 2010.

EC (European Commission): Flood Risk Management – Flood Prevention, Protection and Mitigation, Communication From the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions, Brussel, 2004.

EM-DAT (The International Disaster Database) – Centre for Research on the Epidemiology of Disasters – CRED: Flooding Data For Nigeria, available at: www.emdat.be/ (last access: 10 March 2015), 2014.

Etuonovbe, A. K.: The devastating effect of flooding in Nigeria, in: FIG Working Week, 2011, May, available at: http://www.fig.net/pub/fig2011/papers/ts06j/ts06j_etuonovbe_5002.pdf (last access: 10 March 2015), 2011.

FME – Federal Ministry of Environment: Bulletin on Ecological Disasters, FME, Abuja, Nigeria, 2012.

Folorunsho, R. and Awosika, L.: Flood Mitigation in Lagos, Nigeria through Wise Management of Solid Waste: a case of Ikoyi and Victoria Islands, Nigerian, UNESCO-CSI workshop, 19–23 November 2001, Maputo, 2001.

Gill, S.: Literature Review: Impacts of Climate Change on Urban Environments – Draft Copy (with contributions from Pauleit, S., Ennos, R., Lindley, S., Handley, J., Gwilliam, J., and Ueberjahn-Tritta, A.), The Impact of Flooding on Urban and Rural Communities, available at: http://www.sed.manchester.ac.uk/research/cure/downloads/asccue_litreview.

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



pdf, last access: 15 August 2014, Centre for Urban and Regional Ecology, University of Manchester, UK, 2004.

Guha-Sapir, D., Hoyois, P., and Below, R.: Annual Disaster Statistical Review 2012: The Numbers and Trends, CRED, Brussels, 2013.

5 Houston, D., Werritty, A., Bassett, D., Geddes, A., Hoolachan, A., and McMillan, M.: Pluvial (Rain-Related) Flooding in Urban Areas: the Invincible Hazard, Joseph Rowntree Foundation, York, UK, 2011.

IFRC (International Federation of Red Cross and Red Crescent): Nigeria: Floods – July, available at: Disaster: <http://reliefweb.int/disaster/fl-2012-000138-nga>, last access: 10 March 2015, 2012.

10 Ilesanmi, A. O.: Urban sustainability in the context of Lagos mega-city, *Journal of Geography and Regional Planning*, 3, 240–252, 2010.

Kazmierczak, A. and Carter, J.: Adaptation to Climate Change Using Green and Blue Infrastructure, a Database of Case Studies, GRaBS project, University of Manchester, Manchester, UK, 2010.

15 Komolafe, A. A., Adegboyega, S. A. A., Anifowose, A. Y., Akinluyi, F. O., and Awoniran, D. R.: Air pollution and climate change in Lagos, Nigeria: needs for proactive approaches to risk management and adaptation, *American Journal of Environmental Sciences*, 10, 412–423, 2014.

20 Lagos State Government (LSG): Abstract of Local Government Statistics, Lagos: Lagos Bureau of Statistics, Ministry of Economic Planning and Budget Secretariat, Alausa, Ikeja, 2012.

Lamond, J., Bhattacharya, N., and Bloch, R.: The role of solid waste management as a response to urban flood risk in developing countries, a case study analysis, in: *Flood Recovery Innovation and Response*, edited by: Proverbs, D., Mambretti, S., Brebbia, C., and de Wrachien, D., WIT Press, Southampton, 193–205, 2012.

25 McMichael, A. J., Woodruff, R. E., and Hales, S.: Climate change and human health: present and future risks, *Lancet*, 367, 859–869, 2006.

NEMA (Nigerian Emergency Management Agency): Report on Flood Disasters in Nigeria, Government Press, Abuja, 2013.

30 NEST (Nigeria Environmental Study/Action Team): Nigeria's Threatened Environment: a National Profile, Ibadan, Nigeria: NEST, IRC Main, Abuja, Nigeria, 824 NG91, 9582, 1991.

Nicholls, R., Hanson, J. S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Château, J., and Muir-Wood, R.: Ranking of Port Cities With High Exposure and

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Vulnerabilities to Climate Extremes, OECD Environment Working Papers, No. 1, OECD Publishers, University of Southampton, UK, 2008.

NIHSA (Nigeria Hydrological Services Agency): 2013 Flood Outlook, available at: , last access: 10 March 2015, 2013.

5 NIMET: Nigerian Meteorological Agency: Nimet Weather Dat Pack-1, available at: <http://nimet.gov.ng/content/nimet-weather-data-pack-1>, last access: 10 March 2015, 2012.

Njoku, J. D. and Udeagha, M.: Assessing the flooding potentials of Oguta lake watershed using remote sensing technology, Paper presented at 5th Annual National Conference, Abuja, organized by the Nigerian Association of Hydrological Sciences (NAHS) at University of Nigeria, Nsukka, 21–30, 2013.

10 Nkwunonwo, U. C.: Land use/land cover mapping of the Lagos metropolis of Nigeria using 2012 SLC-off Landsat ETM+ Satellite Images, International Journal of Scientific and Engineering Research, 4, 1217–1223, 2013.

Nkwunonwo, U. C., Whitworth, M., Baily, B., and Inkpen, R.: The development of a simplified model for urban flood risk mitigation in developing countries, in: Vulnerability, Uncertainty, and Risk Quantification, Mitigation, and Management, ASCE, USA, 1116–1127, 2014.

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

Odunuga, S.: Urban Land Use Change and the Flooding in Ashimowu Watershed, Lagos, Nigeria, PhD thesis, University of Lagos, Nigeria, 2008.

20 Odunuga, S., Oyebande, L., and Omojola, A. S.: Social-economic indicators and public perception on urban flooding in Lagos, Hydrology for Disaster Management: Special Publication of the Nigerian Association of Hydrological Sciences, NAHS, Abuja, 82–96, 2012.

25 Ogunsoye, O. O., Adedeji, Y. M. D., and Prucnal-Ogunsoye, B.: Combating environmental degradation through sustainable landscaping in emerging mega cities: a case study of Lagos, Nigeria, in: Proceedings of the 24th World Congress of Architecture “UIA2011 TOKYO”, 25 September–1 October, Tokyo, Japan, 16–21, 2011.

Ojinnaka, O.: Hydrography in Nigeria and Research Challenges, FIG Working Week 2013, Environment for Sustainability, TS05E – Hydrographic Education and Standards – 6439 (1–11), Abuja, available at: http://www.fig.net/pub/fig2013/papers/ts05e/TS05E_ojinnaka_6439.pdf, last access: 10 March 2015, 2013.

Oladunjoye, M.: Nigeria: July 10 Flooding – Lagos Gives Relief Materials to Victims, Daily Champion Newspaper, available at: <http://allafrica.com/stories/201109080792.html>, last access: 8 February 2015, 2011.

Olajuyigbe, A. E., Rotowa, O. O., and Durojaye, E.: An assessment of flood hazard in Nigeria: the case of mile 12, Lagos, Mediterranean Journal of Social Sciences, 3, 367–375, 2012.

Oloke, O. C., Ijasan, K. C., Ogunde, A. O., Amusan, L. M., and Tunji-Olayeni, P. F.: Improving urban residents' awareness of the impact of household activities on climate change in Lagos State, Nigeria, Journal of Sustainable Development, 6, 56–64, 2013.

Olorunfemi, F. B.: Managing flood disasters under a changing climate: lessons from Nigeria and South Africa, Paper presented at NISER Research Seminar Series, NISER, Ibadan, 3 May 2011, 1–44, 2011.

Oshodi, L.: Flood management and governance structure in Lagos, Nigeria, Regions Magazine, 292, 22–24, doi:10.1080/13673882.2013.10815622, 2013.

Oyebande, L.: Drainage protection to urban lands: an environmental challenge, Nigerian Geographical Association Conference, 16–21 December 1974, University of Nigeria, Nsukka, Enugu, 1–7, 1974.

Oyedele, K. F., Ayolabi, E. A., Adeoti, L., and Adegbola, R. B.: Geophysical and hydrogeological evaluation of rising groundwater level in the coastal areas of Lagos, Nigeria, B. Eng. Geol. Environ., 68, 137–143, 2009.

Pitt, M.: Lessons From the 2007 Floods, Pitt Review, London, 2008.

Raaijmakers, R., Krywkow, J., and van der Veen, A.: Flood risk perceptions and spatial multi-criteria analysis: an exploratory research for hazard mitigation, Nat. Hazards, 46, 307–322, 2008.

Sayers, P. B., Hall, J. W., and Meadowcroft, I. C.: Towards risk-based flood hazard management in the UK, Proceedings of ICE Civil Engineering, 150, 1 May 2002, 36–42, 2002.

Sayers, P., Li, Y., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y., and Le Quesne, T.: Flood Risk Management: a Strategic Approach, UNESCO, Paris, 2013.

Soneye, A.: An overview of humanitarian relief supply chains for victims of perennial flood disasters in Lagos, Nigeria (2010–2012), Journal of Humanitarian Logistics and Supply Chain Management, 4, 179–197, 2014.

Ugwu, L. I. and Ugwu, D. I.: Gender, floods and mental health: the way forward, International Journal of Asian Social Science, 3, 1030–1042, 2013.

NHESSD

3, 3897–3923, 2015

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



United Nations: World Population to 2300, United Nations Department of Economic and Social Affairs, Population Division, New York, 2004.

UN/ISDR: United Nations International Strategy for Disaster Reduction: Living with Risks: a global Review of Disaster Reduction Initiatives, 2004 Version Volume 1, available at: UN/ISDR http://www.unisdr.org/files/657_lwr1.pdf, last access: 10 March 2015, 2004.

van de Sande, B., Joost, L., and Hoyng, C.: Sensitivity of coastal flood risk assessments to digital elevation models, *Water*, 4, 568–579, 2012.

Vis, M., Klijn, F., De Bruijn, K. M., and Van Buuren, M.: Resilience strategies for flood risk management in the Netherlands, *International Journal of River Basin Management*, 1, 33–40, 2003.

World Bank: World Bank Population Growth Rate 2009–2013, available at: retrieved from population growth (annual %): <http://data.worldbank.org/indicator/SP.POP.GROW> (last access: 10 March 2015), 2013.

NHESSD

3, 3897–3923, 2015

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



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.

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

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

Title Page

Abstract

Introduction

Conclusions

References

Tables

Figures

◀

▶

◀

▶

Back

Close

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

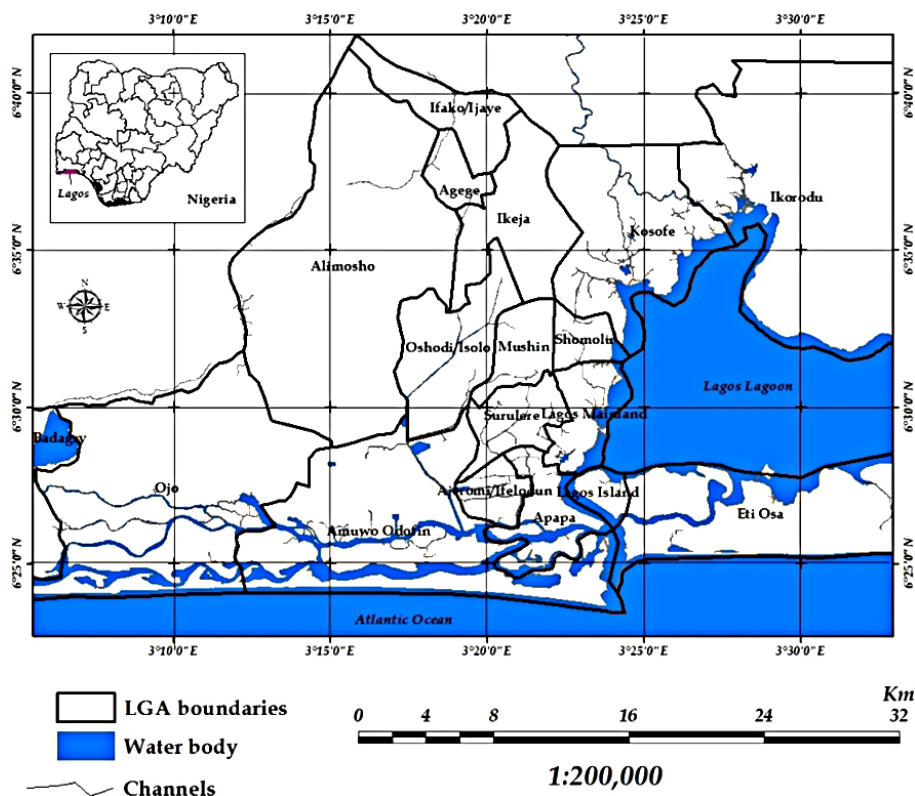


Figure 1. The Lagos metropolis of Nigeria. Inset showing the location of Lagos State in Nigeria. Source: drafted by authors.

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)




(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.

Efforts towards urban flood reduction in the Lagos region

U. C. Nkwunonwo et al.

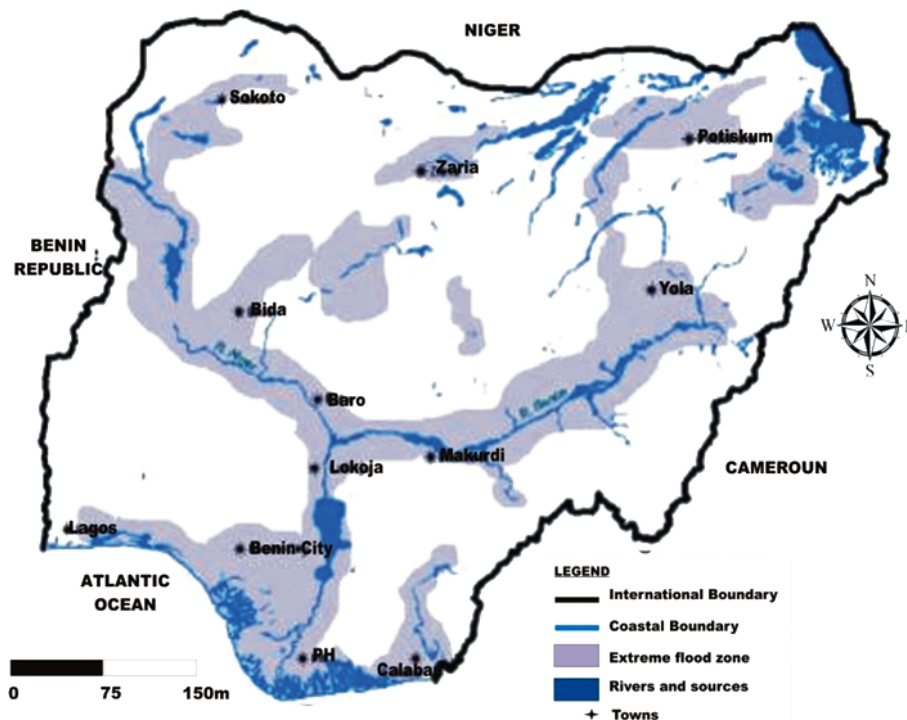


Figure 3. Spatial distribution of areas affected by extreme floods in Nigeria between 2000 and 2012. Source: Federal Ministry of Environment (2012).

[Title Page](#)
[Abstract](#)
[Introduction](#)
[Conclusions](#)
[References](#)
[Tables](#)
[Figures](#)
[◀](#)
[▶](#)
[◀](#)
[▶](#)
[Back](#)
[Close](#)
[Full Screen / Esc](#)
[Printer-friendly Version](#)
[Interactive Discussion](#)
