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. This is an aid to reducing the severity of the hazard, exposure and vulnerabilities of environmental systems. 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 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. 2006). 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 to 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; Aderogba 2012b). 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. A typical example is the July 2011 urban flooding

which affected approximately five thousand people with about 25 deaths and direct economic loss that reached 50 billion Naira ($US 250 million). Public utilities including network of roads, bridges and schools were destroyed. Houses collapsed, private homes were submerged, while personal cars were swept away by flood water. (IFRC 2011, Oladunjoye 2011). Such floods are mainly pluvial based flash floods, following a short-duration-high-intensity or long-duration-low-intensity rainfall (Houston et al. 2011a). 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 little 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 & Udeagha 2013, Obeta 2014).

Best practices in flood risk management aim to reduce the likelihood and/or the impact of floods on environmental systems. Integrated approaches which combine structural and non-structural measures to achieve prevention, protection, preparedness, emergency response, recovery and lessons learned are extensively applied (EC 2004, Kazmierczak & Carter 2010, Sayers et al. 2013,). These approaches require sound understanding of flooding, accurate and actionable assessment of flood risk, knowledge-based decision and strong political leadership. Structural measures are technically-based and involve channelization, and the use of natural and man-made barriers to contain waters in rivers and seas. Non-structural measures aim at reducing vulnerabilities and developing the capacities of social systems to cope with floods through multi-disciplinary approaches (Few 2003, Schanze 2006, Miceli et al. 2008, Sayers et al. 2013). They include flood risk mapping, land use zoning and planning, flood vulnerability assessment, flood proofing, flood modelling, institutionalisation of policies, flood awareness campaign, flood insurance, flood forecasting, relocation of properties, resettlement of human population, green infrastructure plan, etc., (Merz et al. 2007, Jha et al. 2012, Smith 2013).

In the light of this standard, measures to tackle flooding in Lagos are at best limited. The problem in Lagos is exacerbated partly due to the lack of readily available data, a general lack of funds and a lack of access to improved technology alongside a lack of political will (Nkwunonwo et al. 2014, Adeloye & Rustum 2011). Flood modelling, provision of flood data and other non-structural approaches to flood risk reduction have been largely ignored. 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 and disturbing scenario is that the Lagos area is a fast growing city within which a great deal of the population currently lives 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 that of more developed countries such as the US, the Netherlands and United Kingdom; and finally, to suggest measures for possible improvements.

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 coordinates of $3.1^0 E$ to 3.4^0

102   *E* longitude and 6.5^0 *N* to 6.8^0 *N* latitude and covers a land area of approximately $1100 km^2$ (or
103   425 sq. miles). It is bordered in the south by the Atlantic Ocean (See figure 1). With a dense
104   network of roads and buildings, and several inland waterways including the Lagos Lagoon
105   which empties into the Atlantic, the conurbation serves as a major hub for transportation,
106   tourism and economic activities in Nigeria. With a population of over 20 million people
107   (LSG 2012), the Lagos metropolis is the biggest city in Nigeria, (although the smallest land
108   area), the second largest city in Africa, and the seventh largest city in the world. The
109   population growth rate in the Lagos metropolis is estimated at 3.2% (World Bank, 2013). The
110   United Nations predicts that Nigeria will be one of the eight countries expected to account
111   collectively for half of the total population increase in the world from 2005–2050, and will by
112   2100, record a population amounting between 505 million and 1.03 billion people (United
113   Nations 2004). High population density is a major impasse in the Lagos region, subjecting the
114   area to lack of space for the myriad of human activities, which often manifests itself in
115   muddled human settlements, overcrowding, slum envelopments, pollution, illegal structures,
116   and other social and environmental disorders.

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3.   Flooding in Lagos

120   Over the last two decades, flooding, its causes, impacts and remedies at the local level within
121   the Lagos metropolis have received considerable attention in the literature (Ayoade &
122   Akintola 1980, Action aid 2006, Adelekan 2013, Aderogba 2012a, Soneye 2014). However, a
123   better understanding of the hazard in Lagos requires wide ranging cross-disciplinary
124   discourse not limited to small geographical areas (Aderogba 2012a, Ajibade et al. 2013,
125   2014, Adeloye & Rustum 2011, Oshodi 2013). Various wide ranging impacts of flooding
126   have been assessed in the literature including mortality, physical injuries, displacement of
127   human populations, spread of disease, submergence of buildings, destruction of urban
128   infrastructure and disruption of economic activities (Ugwu & Ugwu 2013, Adigun et al.
129   2013, Ajibola et al. 2012, Aderogba 2012b, Olajuyigbe et al. 2012).

130   A number of factors have been highlighted with reference to the extent and severity of
131   flooding in Lagos. These include climate change with more intense rainfall, topography of
132   the area, land use/land cover modifications, influence of canals, lagoons and beaches
133   (Aderogba 2012a, Aderogba et al. 2012, Odunuga 2008). Others are urbanization and
134   population growth, poor urban planning and poor environmental management along with
135   anthropogenic activities especially in indiscriminate disposal of solid waste (Lamond et al.
136   2012, Adeloye and Rustum 2011). Tidal and co-tidal influences and frequent incursion from
137   the Atlantic into the lowlands during heavy storms is also implicated (Ojinnaka 2013).
138   Alongside these physical influences, the development of slum settlements and poor
139   perception of flooding among local communities, urban residents and the general public are
140   critical factors which contribute to the vulnerabilities of social systems to flooding in the area
141   (Agbola & Agunbiade 2007, Nkwunonwo 2013, Ayoade & Akintola 1980, Odunuga et al.
142   2012, Oloke et al. 2013, BNRCC 2008).

143   In relation to possible hazard mitigation and adaption responses, researchers have
144   suggested several options. Adedeji et al. (2012) highlighted the importance of building the
145   capacity for flood preparedness through spatial planning and land management. Ogunsote et
146   al. (2011) suggested combating environmental degradation through sustainable landscaping.
147   The need for sustainable management of solid waste was recommended by Folorunsho &
148   Awosika (2001). A stand for adopting proactive measures to risk management and adaptation
149   was taken by Komolafe et al. (2014), while constant geophysical and hydrological evaluation
150   of rising groundwater levels was emphasised by Oyedele et al. (2009). Adelekan (2013)
151   reiterated the UNISDR recommendation which calls for the participation private sectors in

152 risk management through investment decision in building and construction. Other factors
153 besides flood prevention are also important to reduce the potential impacts of flood events.
154 The humanitarian relief supply chain for victims of flooding in the Lagos area was
155 investigated by Soneye (2014). Additionally, the patterns of flood vulnerability and resilience
156 among women (Ajibade et al. 2013), and the vulnerability of coastal communities (Adelekan
157 2010) in the Lagos area have been investigated. In relation to the planning framework,
158 sustainable housing development and functionality of planning laws and regulations as well
159 as the role of governance in flood management in Lagos area and indeed in Nigeria have been
160 examined by a number of authors including Aluko (2011) and Oshodi (2013).

161   Despite these extensive studies, there are significant gaps in knowledge which exist in
162 terms of the vulnerabilities of local communities, urban residents and the general public and
163 therefore constrain effective flood risk management in Lagos. Urban flooding in particular
164 has arguably not received the attention it deserves. A general critique, which should provide a
165 nuanced understanding of the strengths and limitations of present efforts to addressing the
166 threats of flooding in the Lagos area, is lacking. The lack of flood data and other ancillary
167 data which is a major setback towards containing these threats has not been fully addressed.
168 Although as an unprecedented measure, Lagos state government has made significant efforts
169 at providing high resolution air-borne LiDAR (Light Detection and Ranging) data and
170 topographic maps which promote research towards flood risk in the area. Since these dataset
171 are mainly vended, the poor access of researchers to them arguably undermines their
172 usefulness. Importantly, the focus of these studies which solely rested on general knowledge
173 of the causes, impacts and remedies of flooding suggests that the global view of the situation
174 have been imperfect. More scientific approaches such as flood modelling which drives recent
175 approaches to flood risk management in more developed countries are generally lacking.

176   Flood modelling is an important hydrological tool for flood hazard assessment. Flood
177 hazard data such as water depth, inundation extent and flow velocity for particular historical
178 flooding events are provided on the basis of flood modelling procedures. Flood modelling
179 appears to be expensive in the interim for reasons such as data requirement, technology and
180 skill. Therefore, many engineers who want to be economical prefer the traditional structural
181 approach of flood protection. But an issue that is not often considered is the reliability of
182 structural measures without accurate flood hazard data. From the point of view of cost benefit
183 analysis (CBS), the area will derive maximum benefits in the long run if flood modelling is
184 the basis of any flood management operations. Flood modelling plays important roles in the
185 making of flood hazard and risk maps. Comprehensive flood risk/hazard map would increase
186 public awareness of flood risks and inform stakeholder decision making about mitigation
187 options. Under the framework of integrated flood management approaches, flood risk
188 awareness and knowledge-based decisions are indispensable. Academic curricula that
189 consider flood modelling procedures in Lagos are mainly theoretically and on the periphery.
190 The uncertainties associated with flood modelling can discourage investment of resources
191 into it. To the best of the authors' knowledge, no public agency in Lagos undertakes the
192 procedure as a specific role.

193   Relatively few studies have highlighted the relevance of flood modelling and its
194 implications with paucity of topographic data (Nkwunonwo et al. 2014, van der Sande et al.
195 2012) although Adeaga (2008) implemented a flood hazard mapping and risk management in
196 north eastern part of Lagos. Although flood modelling was mentioned, the question regarding
197 solutions to these problems remains largely unanswered.

198   Data on the widespread occurrence of flooding in the Lagos area dates back to the
199 early 1960's and highlights the importance of addressing the impacts of climate change and
200 poor urban planning (Odunuga 2008, Oyebande 1974, Etuonovbe 2011). Whilst coastal and
201 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, pluvial flooding in Lagos area has occurred annually since 1960 (Oyebande 1974). According to previous studies flood threats in Lagos are more frequent 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. This also raises a question about warning and evacuation systems. Table 1 shows a summary of major flooding events and associated threats in the Lagos metropolis of Nigeria from 1968 to 2012.

Flooding in Lagos triggers concerns for environmental management, urban development, governance and the vulnerability of urban residents and local communities. Other factors of concern are humanitarian needs and services especially primary health delivery (Soneye 2014, Ajibade 2013, Lamond et al. 2012). Solid waste management is a top priority since indiscriminate dumping of waste in drainage systems is common. Water that is sold in polythene sachets is the major source of drinking water for residents. Many people who patronise the product litter the environment with the polythene sachets or dump them in drainage facilities. Being a non-degradable waste, it accumulates over time and blocks these drainage facilities. There has been difficulty in addressing such a critical issue. Flood water depth, inundation extent and duration as well as depth averaged velocity are all factors that affect flooding in the Lagos area. The lack of capacity to cope with the hazard and the inability to quickly recover from losses following the hazard has been clearly problematic for many affected human populations in the area (Adelekan 2010). Figure 2 illustrates 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 events (see figure 3 below). Although a number of floods have occurred in the Lagos area, keeping track of events in the country is challenging. Principally, data relating to hydrology 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 (for example: IFRC 2012). The problem with media evidence is that they often do not have ethical and empirical groundings.

The present study discusses the challenges faced by Lagos in managing and reducing flood risk impacts. The data for the study were obtained from various online databases (for example: NEST 1991, Guha-Sapir et al. 2013) and published data on historical flooding in Lagos, Nigeria. Ultimately, the authors argue that the lack of more robust techniques such as flood modelling and assessment of vulnerability accounts for limitation in the efforts towards addressing the challenges of flooding in the Lagos area.

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, 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. Advice to the dwellers of flood plains and wetlands to relocate.
4. Demolition of homes in the flood prone areas.
5. Proposed resettlement scheme for the residents of Ogun river catchment areas.

251 There are also specific actions which have been taken by local authorities and stakeholders.
252 Odunuga (2008) recognized several flood preventive and curative initiatives ranging from
253 community self-assistance actions to World Bank assisted programmes. Recently, key
254 initiatives which include the Drain Dock and The Emergency Flood Abatement Gang
255 (EFAG) were launched by the government of Lagos state to improve current efforts towards
256 addressing the challenges of flooding. The ministries of Environment, Works and Health as
257 well as the Lagos Metropolitan Development and Governance Project (LMDGP) have a
258 number of initiatives aimed at controlling flood hazard in the area including waste
259 management programme, shoreline protection, low carbon emission, school advocacy
260 programme and climate change club. The promotion of sustainable drainage infrastructure
261 and sustainable access to basic services for urban residents and the general public are a top
262 priority as discussed in section 3. Lagos is the first in Nigeria to carry out a detailed
263 topographic mapping of the area with LiDAR (Light detection and ranging) data acquisition
264 and GIS based analysis aimed at addressing the challenges of flooding. In addition, the
265 Nigerian government and international community have been active with measures to address
266 the challenges of flooding at various locations within the country including the Lagos area
267 (Olorunfemi 2011, NIHSA 2013). Besides engineering works such as dams, bridges and
268 sustainable urban drainage systems as well as financial assistance to victims of flooding
269 which appears to be a common practice, there are few other activities. These are undertaken
270 by the National Emergency Management Agency (NEMA), Nigeria Hydrological Services
271 Agency (NIHSA), Nigerian Meteorological Agency (NIMET), the National Environmental
272 Standards and Regulations Enforcement Agency (NESREA) which by 2009 Nigerian Acts
273 supersedes the Federal Environmental Protection Agency (FEPA). It is not intended to
274 discuss the structure, specific roles and the unique position of these agencies vis-a-vis Lagos
275 flooding. Such discussions can be found in Obeta, (2014). However, it is important to
276 mention that for the whole of Nigeria, NEMA essentially coordinates the management of all
277 disaster including flooding.

278 Despite the recent initiatives these developments have been criticised as weak while
279 the roles of the institutions are not clearly defined (Adeaga et al. 2005, Oshodi 2013, Soneye
280 2014, Nkwunonwo et al. 2014, Adelekan 2015). Efforts are being made to facilitate
281 evacuation and provide flood victims with urgent humanitarian needs. Sustainable urban
282 drainage system, environmental sustainability and policy, social responses, physical
283 intervention and environmental management are also in the agenda (Aderogba et al. 2012,
284 Olajuyigbe et al. 2012, Aderogba, 2012b, Adeaga 2008, Ilesanmi 2010). However, the
285 increasing number of people affected, the effectiveness of these efforts is challenged. Whilst
286 it is unreasonable to claim that the weakness of these flood mitigation measures probably
287 leads to more frequent flooding in the area, the fact that such measures have not improved
288 Lagos with regards to the idea of "living with floods" is fundamental.

289 The UNISDR idea of living with floods rather than fighting them is the underlying
290 framework of flood risk management. This tends towards a policy whereby society adapts to
291 floods by being prepared and having the right attitude towards damage reduction (van Ogtrop
292 et al. 2005). It stems from three key considerations: (1) the limitations or failures of
293 traditional flood control technologies especially structural measures; (2) the need for a
294 people-friendly means of addressing the challenges of flooding and (3) the goal to lessen all
295 impacts of extreme floods while at the same time exploiting all benefits of ordinary floods
296 (UNISDR, 2004; Di Baldassarre & Uhlenbrook 2012). These are also the objectives of best
297 practices that can be identified from a wide range of sources, for example Ashley et al.
298 (2007), Fratini et al. (2012) and Sayers et al. (2013).

299 Critically, current measures undertaken by flood management agencies appear to
300 control flood rather than mitigate its impacts on human populations and urban infrastructure.

301 Thus the main objectives of integrated approaches to flood risk management cum living with
302 floods idea are defeated. Little action has been undertaken to raise public awareness of flood
303 risk or to address gendered vulnerability, as highlighted by Odunuga et al. (2012), Ajibade et
304 al. (2013) and Adelekan (2010).
305   Flood modelling is used to promote flood risk reduction in the US, Netherlands and
306 United Kingdom, but in Nigeria it is too often ignored. This again raises the question of how
307 flood risk mitigation can be realistic in the absence of accurate flood data and scientific
308 means of acquiring such data. Arguably, limited efforts have been made towards knowledge
309 based decision of flood risk reduction and increasing public awareness of flood risks.
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5.   Flooding in Lagos- the way forward?

313 The review of flood management covered in this paper suggests several recommendations for
314 reducing flood risk in Lagos. These recommendations are based on three key issues which
315 are: the understanding and demonstration of the roles more scientific approaches such as
316 flood modelling, can play in flood risk reduction within the context of the Lagos. Secondly,
317 the need to align the focus of flood risks reduction in the Lagos area to the objectives of
318 similar measures in more developed countries such as the US, UK and the Netherlands. This
319 is aimed at improving collaborations between Lagos and those places with what appears to be
320 a more effective flood risk management. Thirdly, the need to promote awareness of flooding
321 among local communities, urban residents and the general public and to delineate more
322 suitable locations for relocation of human populations during flooding events. Further
323 specific recommendations include:
324

325 1. The government of Lagos state should as a matter of urgency prioritize legislation and
326   provision of resources towards flood hazard and flood risk mapping for the whole of
327   Lagos state. This is the basis of flood risk mitigation within the European Union
328   framework, which requires all constituting states to prepare flood hazard/risk maps as a
329   propeller towards promoting the concept of living with floods (EC 2004).
330

331 2. Flood risk reduction under the "living with floods" idea is multi-disciplinary indicating
332   that various industries can assist in reducing the impacts of flooding. This is the case in
333   UK in particular (EA 2010). Thus, in view of widening the awareness of flooding in the
334   general public, there is need for improved collaboration between the Lagos state
335   government and federal ministries, departments and agencies such as NEMA, NESREA
336   and NIHSA.
337

338 3. Flood alert and flood early warning systems should be improved within the Lagos area.
339   The UK flooding of 2012 which affected many urban areas in Yorkshire with minimal
340   impact on human population reveals the importance of flood alerts and flood early
341   warning systems when followed with strict compliance (Pitt 2008).
342

343 4. Flood insurance is a non-structural approach which many property owners have
344   benefitted from in developed countries following flood disasters. To support the roles of
345   flood insurance in Lagos, it is recommended that the role of FEMA in this regard should
346   be extended to the state and whilst encouraging insurance companies to commence
347   awareness campaign for properties owners to take positive step in that direction.
348

349 5. Enforcement of environmental standards and laws is often a key factor towards
350   containing adverse effects of climate change including flooding (UN/ISDR 2004).

Indiscriminate waste disposal, construction along flood plain and blockage of drainage facilities, 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 success of flood risk reduction in 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. Flood management cost each Dutch adult about US$ 110 annually (Kazmierczak & 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. To support this, more education is required to make the public more aware about flooding and its consequences. Qualitative research such as CBA, involving the local community should be encouraged.

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, Netherlands, China and UK. This is a strong pointer and indicator that more research is required for Lagos. Equally, the universities and research agencies should be encouraged to include flood awareness and management in their curricula and programmes. 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 plays a key role in flood risk mitigation and the government of Lagos state has made an unprecedented attempt to improve its data 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, 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.

6. Conclusion

Flooding is a global occurrence, but the impacts in many urban areas in the developing countries can be overwhelming. One of such urban centers is Lagos, Nigeria. It is easier to understand the threats of flooding in Lagos by the attention generated both in the media and in much literature relating to social and environmental sciences. 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 offers a general view of flooding rather than scaling the hazard to the local level. 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 various LGAs which may never have flooded over the period considered. It is important to investigate these places with view to finding out how they defend themselves 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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