Climate Change Vulnerability and Adaptation in the city of Lagos, Nigeria.

by

Olasunkanmi Akerele

Supervised by

Prof. Jose Etcheverry

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FOREWORD

This paper, written in partial fulfillment of the requirements of the MES degree program of York University, Toronto, Canada, is titled “Climate Change Vulnerability and Adaptation in the city of Lagos, Nigeria”. I have chosen Lagos, being a coastal city among several others, particularly in Africa and across the globe, that face the problem of flooding and erosion exacerbated by the extreme weather conditions arising from climate change and anthropogenic factors. The city of Lagos is highly urbanized and cosmopolitan in nature, with high concentration of infrastructure. It has an estimated population of 20 million, generally known as the commercial hub in Nigeria. The inherent potential danger of flooding and erosion have become perennial problems and require solutions.

Therefore, the components of my plan of study which include climate change, vulnerability and adaptation are being used in my paper to analyse the problem of flooding in Lagos. As an illustration, my undertaken of courses such as ‘Climate change science and policy’, ‘Global cities’, ‘Theories and methods of impact assessment’ and my in-depth analysis of literature help me to understand how climate science, climate debates, pattern of rainfall defines the impacts of flooding in many communities, particularly in the low-income areas of Lagos. This also assist in knowing the reasons why Lagos flooding is re-occurring every raining season.

In addition, my major paper explores the climate change, vulnerability and adaptation concepts, as well as considering the global climate change debate, governance and adoption of international best practices to help minimize the effects of flooding to the inhabitants of Lagos. Ultimately, my major paper would support the politicians, as well as policy- and decision-makers, in environmental planning and management of climate

change problems in Nigeria. For these reasons, my major paper will be fulfilling the MES degree requirement.

ABSTRACT

Coastal cities worldwide, located in low-lying topography are faced with challenges arising from climate-change-induced events such as sea-level rise, storm surges and coastal erosion, exacerbated by rapid urban growth, lack of awareness, and limited knowledge of flood risks and solutions. This research focuses on Lagos, a Nigerian mega-city already under impact by frequent floods, erosion and storm surges.

The paper uses concepts of vulnerability, resilience, adaptation and adaptive capacity of communities to analyze adaptation strategies. The paper also analyzes the strategies of the coastal cities that results to adaptation, such as New Orleans, Amsterdam and Dhaka in Bangladesh all of which share similar problems with Lagos but are developing interesting solutions in terms of infrastructure, planning, and resilient policy frameworks.

The research uses a mixed-method approach that relies on analysis of peer-reviewed literature and my own knowledge as a planner in Lagos. The work also puts forward solutions aimed at helping improve Lagos's adaptive capacity and its governmental policy framework, particularly regarding climate change resilience, flooding prevention and erosion solutions.

CHAPTER ONE

1.0 GLOBAL CLIMATE DEBATE: WHO PAYS?

1.1 Summary of the Climate Debate

Although there is consensus about climate change science, there is controversy on how to compensate the countries that contributed less to the problem but will suffer the greatest impact (Meckler, 2017). Meckler (2017) proposes using the international law principles codified by the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (Kyoto), whose focus is that states are challenged by a lack of decision-making transparency and by slow process in adopting new changes in the economy. As a solution, Meckler (2017) proposes an economic framework titled Dynamically Relative and Comparatively Universal Liability Attribution that would assist states to have the same action plans to reduce the impacts of climate change.

At the same time, public opinion has been identified as an important factor in formulating a policy response to the impacts of climate change. Consequently, the UNFCCC emission cutting proposed between 2003 and 2011 resulted in political, environment and climate debates (Aasen, 2015). He also notes the links between values and concern about climate change that are influenced by differences in social status, culture and individual attitudes to information. Mitigation policies have to benefit all stakeholders to ensure that an efficient global response to the problem of climate change is implemented (Aasen, 2015).

Furthermore, Tiani et al. (2015) note that people understand climate change as adaptation and mitigation in Central African countries. This focus aims to design and develop a capacity-building program. The roles of civil society, media and the private sector, according to Tiani and et al. (2015), depend on available information, channels

of information flow, how environmental education is ranked in the various countries, and training programmes carefully designed for journalists, communicators and other media.

According to Nemet et al. (2017), the effort to reduce emissions within the global economy has become difficult because large volumes of CO_2 are retained for a long period in the earth's atmosphere, while the infrastructure that produces energy is also long lived. Therefore, Nemet et al. (2017) raise the issues of innovation and technologies in terms of investments and governmental policies that are required to address climate change. Long-term plans to reduce carbon will depend on strong actions taken now.

As highlighted by Makina and Moyo (2016), institutions in Sub-Saharan Africa are still ignoring local women. Makina and Moyo (2016) note that women are highly vulnerable, particularly those whose means of livelihood are based on agricultural farming, fishing and other natural resources. Women's issues are as well important and should be an integral part in policy making processes to enable institutions to implement effective responses to climate change. Policy intervention of this kind would also help to bring many women out of poverty.

Moreover, poor governance is an issue identified as a factor preventing coastal protection (Gupta & Bavinck, 2017). Sea-level rise combined with growing populations (due to rural–urban migration) in most low-lying coastal areas are also problems faced by both developed and developing countries (Gupta & Bavinck, 2017). Though similar problems are experienced, developed countries are able to manage climate change liabilities better than developing countries (Gupta and Bavinck, 2017).

It is important to note however, that local governments have not been fully empowered to play effective roles in climate change governance. This issue/problem was given as one reason among others why New Zealand could not meet its emission reduction targets (Harker et al, 2015). The concept of Multilevel Governance (MLG); according to Harker et al. (2015), "is a set of general–purpose or functional jurisdictions that enjoy some degree of autonomy within a common governance arrangement and whose actors claim to engage in an enduring interaction in pursuit of common good" (page 487). In addition, MLG, a bottom-up approach, has analytical ability within the local government to enhance governance of climate change and is capable of addressing mitigation and adaptation so national emission targets are met (Harker et al, 2015).

The development and implementation of action plans that address the impacts of changing climate in any area are usually difficult to achieve (Lawrence et al, 2017). As a solution, Lawrence et al. (2017) suggest the adoption of a planning strategy titled Dynamic Adaptive Policy Pathways (DAPP), whereby a policy has many alternative pathways to achieve goals.

Also, the gathering of digital data on a real-time basis by local government decision-makers is increasing due to rapid technological growth (Giest, 2017). The process of using large volumes of data has often resulted in failure of decisions because the acquired data were not in the same format, standards, and structure. Therefore, data management is becoming a concern for local government policy makers, as they may lack the ability to manage such data (Giest, 2017). As a solution, local governments can contract consultants, and collaborate with expert stakeholders outside government departments to manage data (Giest, 2017).

1.2 Climate change and sea-level rise

There is global consensus that climate change is inducing sea-level rise. Climate change is also increasing storm surges, coastal erosion, and flooding of land, buildings and infrastructure (Withey et al., 2016). This reality is capturing the attention of scientists, coastal managers and decision makers (Smith et al., 2016; Hinkel et al., 2015). Scientific studies have been undertaken by the Intergovernmental Panel on Climate Change (IPCC); using modelling and empirical evidence. Also, it has been widely acknowledged that sea-levels are rising (Smith et al., 2016; Hinkel et al., 2015). Due to varying geographical regions and geological processes, the rate of increase of sea level rise is being disputed but common agreement exists about this problem (Smith et al., 2016).

IPCC experts jointly access research findings and decided to use probability statements such as “Likely”, and “very likely” to interpret the extent of a statement being true (Hinkel et al., 2015). Furthermore, Hinkel et al. (2015) explain that statement producing information for sea-level rise in Fifth Assessment Report 5 (AR5) considers other methods which includes semi-empirical models and palaeo-records of sea-level change. Hinkel et al. (2015) process-based model scenario results give a likely estimate of sea-level rise with lower greenhouse gas concentrations (RCP2.6) and highest greenhouse gas concentrations (RCP8.5) respectively. The lowest is from 0.26-0.55 m from 1986-2005 to 2081-2100 and the highest of 0.45-0.82 m for the same period. There are inconsistencies by many scientists, according to Martinez-Grana et al. (2016) on the future rise in sea-level and an estimated global mean averaged between 1901 and 2010 is 1.5-1.9 mm per year which is more than the records of the two previous millennia. This rise in sea-level in 21st century and beyond could create

different regional estimates and pattern from the global average (Martinez-Grana et al. 2016).

Public in Europe focus on the socioeconomic impact of climate change on the environment due to 213 key flooding incidents that resulted in the deaths of 1,126 persons, and damage worth 52 billion Euros and made European Union issued an official statement via 2007/60/EC (DOUE 60,2007) (Martinez-Grana et al., 2016). Flooding and coastal erosion as hazards and their associated risk solely rest on the level of exposure to the events of climate change, and vulnerability of the features that are at risk. Attempts to lessen or lengthen the rate or frequency of exposure determine the occurrence of hazards and the vulnerability of the features to the risk of hazards (Nkwunonwo et al., 2016; Adelekan & Asiyanbi., 2016).

Coastlines are generally vulnerable to sea-level rise, especially along beaches, coastal wetlands and deltas in Europe, where recreational activities and tourism are thriving but are threatened (Martinez-Grana et al., 2016). Similarly, most cities, industries, harbours and infrastructure developments are situated along Africa's coastlines which are vulnerable to the problems of coastal erosion and flooding. In Eastern Africa for instance, Diop & Scheren (2016) note how marine ecosystems are being challenged particularly for those whose means of livelihood is dependent on those ecosystems for fishing, recreational activities, tourism, transportation and exploration. In addition, concerns are raised in the exploitation of mineral resources within the Gulf of Guinea in West Africa for oil and gas resources offshore of Nigeria, Congo, Gabon, Equatorial Guinea and Angola and some parts in East Africa in northern Mozambique and southern Tanzania for natural gas. However, the most difficult situation globally are the social impacts on coastal settlements and their infrastructures (Diop & Scheren, 2016).

1.3 Overview of Latest Climate Change Science

Climate change, according to the IPCC (2014) is observed by scientists through the aid of remote sensing from satellite imagery, simulation of climate from models and analysis of observed climate. Again, it shows how collaborative efforts by scientists, policy makers in several scientific disciplines and political institutions across the globe can bring more understanding and improvements to the climate system. Also, Fu et al. (2017) and IPCC (2014) linked the cause of 95% of climate change, and its impact such as sea level rise, flooding and coastal erosion to human activities.

Anderson et al. (2016) earth system models were used to project temperature changes in the 21st century. Anderson et al. (2016) and Vezer (2016) documented the robustness of the data and the ability of the model being run with supercomputer to produce climate system information for interpretation and projection. Scollozzi and Geneletti (2017) proposed a framework that will incorporate different scientific fields and help change researchers' and policy makers' perspective of climate change model towards an anticipatory system that is simple and better to manage. The emergence of a technoscientific approach has made climate change measurable with the introduction of mathematics and natural science. Therefore, environmental systems can be observed using quantitative measurements. Similarly, the contributions of social science and humanities have recorded success in the interpretation of climate change science in industrialized and developed parts of the world (O'Lear, 2016).

Accordingly, Anderson et al. (2016); Vezer (2016); O'Lear (2016) recognizes the modest contributions of earlier scientists which included Arrhenius, in 1903, and Callender in 1938 whose works formed the basis of early climate change science. However, O'Lear (2016) went further to bring forth the contributions of the early Greeks in the identification of climate zones using latitude. In addition, political dimensions

expressed through government policies and initiatives help to improve weather predictions, how technological advancements in computer hardware and software are helping increase understanding of global climate change. Though prediction of any system depends on learning and understanding of its structure but systemic thinking, an art and science of making interpretation has help to advance development of climate change (Scollozzi and Geneletti, 2017).

Use of models manipulates dataset to produce evidences for predictions of the climate system (Anderson et al., 2016; Vezer, 2016). However, Scollozzi and Geneletti (2017) suggested that climate change prediction should be seen from systemic perspectives and be able to determine the choice of climate model. The adoption of good criteria in data selection from multiple sources into the model would help to produce better predictions (O'Lear, 2016).

Therefore, there seems to be a general consensus in the literature that climate is changing due to the burning of fossil fuels and changes in land use. Research activities on climate system has been successful and enhanced by coordination of United Nations Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC).

1.4 Overview of my Research

This paper analyzes the challenges posed by climate change induced sea-level rise and storm surges facing many low lying coastal cities, their settlements, infrastructure, and the challenges faced by local managers. More specifically, this paper examines closely the extent to which the city of Lagos is being impacted by frequent flooding, storm surges, and erosion (Adelekan et al., 2015). The paper is aimed at examining the vulnerability of Lagos to the events of climate change and adaptation solutions to extreme weather.

According to Nkwunonwo et al. (2016) and Adelekan et al. (2015) Lagos coastal communities are exposed to climate change and sea-level rise exacerbated by rising urban growth, lack of awareness of the populace, lack of knowledge about risks associated with flooding and lack of trustworthy data to plan. The paper highlights the study of Ajibade et al. (2015) about extreme weather events occurring around the world, exacerbated by climate change and the absence of local know-how to cope, adapt and mitigate. The flooding impacting on many coastal areas including Lagos has already led to the deaths of people (Ajibade et al., 2015).

This paper gives prominence to other Africa coastal cities that are experiencing climate change impacts and rapid urbanization due to high population growth. This phenomenon has caused fears and concern owing to the inability to adopt urban planning strategies. Therefore, the problem could lead to either reduction or expansion in the growth and development of cities (Nkwunonwo et al., 2016; Cobbinah et al., 2015; Riise et al., 2015). The role of gender is also considered in the paper. Reyes et al. (2016) note that women are more vulnerable than men because of socio-cultural and economic factors.

The research notes the impact that climate change has on the provision of food and how it hinders agricultural and fishing activities in many coastal communities in developing countries and Africa (Nkwusi et al., 2015; Adelekan et al., 2015). O'Lear (2016) attempts to express the relationship between climate change and unrest, and conflict arising from reduced food supplies to the people due to increasing droughts and floods.

My study also analyzes various concepts such as resiliency of communities and adaptation to better understand how individuals and communities will cope and adapt to disasters (Daramola et al., 2016; Leykin et al., 2016). This focus ensures that

adequate preparations can be made to cope and reduce losses by the communities living within coastal areas. Equally, my research considers how slums are being managed to improve the standard of living of urban dwellers in rapidly urbanized coastal cities of developing countries (Olthuis et al., 2015). My study relies on a mixed method approach using the academic literature as the main source of information and statistics as secondary data.

The research is focus on the city of Lagos which has a population of about 20 million people living in approximately 1100 km^2 bounded to the south by the Atlantic Ocean (Nkwunonwo et al., 2016). Lagos has creeks and lagoons that facilitate inland water transportation, tourism and economic activities. Lagos is the biggest city in Nigeria and the second biggest in Africa (Nkwunonwo et al., 2016).

1.5 Research Methods

My research study relies on the most recent published academic and grey literatures. This includes World Bank and United Nations publications with synthesis reports (contributions of Working Group I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC). The focus of study includes: theoretical framework of climate change vulnerability, adaptation, capacity, resilience and mitigation. Also, disaster preparedness and managements in coastal cities is examined in the literature.

Technical papers, workshops and conference communique, extracts from online newspapers and video clips from YouTube are used to complement the peer-reviewed literature. The socioeconomic analysis of secondary data, such as interviews/observational (rainfall), census and audiovisual data extracted from the literature give more understanding to the issue. Similarly, socio-political analysis are

undertaken in relation to policies and regulations which include policy briefs from International organizations and development plans of the Federal and States governments.

1.6 Goal and Objectives of the Study

Around the world, coastline communities are vulnerable to climate change and risk of sea-level rise that goes with coastal erosion, increased storm surges, flooding and flow of salt water into the environment. Coastal populations are faced with developmental consequences due to impacts on agricultural land, water resources, economy and infrastructure (Adelekan and Fregene, 2015; Ajibade et al., 2015). Nkwunonwo et al. (2016) recognised impact of climate change in flooding of Lagos. The rainfall pattern has been seeing more high intensity short-duration and more low intensity, long duration rainfall in the last three decades and Lagos has been experiencing annual flooding between July and October of each year. Also (Nkwunonwo et al., 2016; Adelekan and Asiyanbi, 2016) named the flooding occurrence of July, 2011 as a landmark whereby hundreds of thousands of the people were affected and about 25 deaths were recorded. The economic losses estimated by Nigerian insurance sector was between USD 200-250 million. Destruction of public facilities such as roads, bridges, schools, and private homes made the flood event a history with highest claims from Nigerian insurance businesses.

The widespread displacement led to interruption of economic activities, physical injuries, vector-borne diseases, poverty and death in slum communities located within areas liable to flood. Also, community lifestyle and social relationships are affected because family members are unable to visit victims of flood due to unclean environment and disruption to movements (Nkwunonwo et al., 2016). Consequently, Makoko is a fishing village located in high-valued waterfront in Lagos, but turned into

a sprawling urban area slum. This village lack basic services such as roads, water, and waste disposal thus made it socially vulnerable to the impacts of climate change. Therefore, flood management requires re-development leading to eviction of residents and demolition of residential houses (Nkwunonwo et al., 2016; Riise and Adeyemi, 2015).

Ajibade et al. (2015) debated impacts of flooding on the population irrespective of economic and social-cultural status and found to be dependent on time and space. Moreover, flood impacts studies carried out in Europe, Asia and Latin America has shown that experiences differ from each other and even in similar coastal communities. Therefore, root cause of flooding includes: low-lying topography, land use and land cover, low urban and environmental planning, bad disposal of solid waste, high rate of urbanization and population growth with high population density and large poor population (Nkwunonwo et al., 2016; Ajibade et al., 2015; Elias & Omojola, 2015).

The approach to flood management in Lagos largely centered on technical construction of drainages and canals, and channelization of rivers with natural and man-made barriers and educating the communities on the solid waste disposal and post-disaster relief campaign (Nkwunonwo et al., 2016; Adelekan & Asiyanbi, 2016). Lately, attention of Lagos has shifted to more direct public involvement on climate change mitigation and adaptation activities such as annual climate change summit and establishment of climate change club in schools. Similarly, Lagos has joined international partnership of C 40 Large Cities Climate Leadership Network in 2007 and established a unit within the state's Ministry of Environment to cope with the realism (Adelekan & Asiyanbi, 2016; Elias & Omojola, 2015).

Nigeria federal government has been involved in climate change activities through agencies. This include National Emergency Management Agency (NEMA), Nigeria Hydrological Services Agency (NIHSA), Nigerian Meteorological Agency (NIMET) and National Environmental Standards and Regulations Enforcement Agency (NESREA) (Nkwunonwo et al., 2016; Elias & Omojola, 2015). However, the agencies are doing more than Lagos state and local governments, the result of lack of political will and finances (Nkwunonwo et al., 2016; Elias & Omojola, 2015). In particular, Nkwunonwo et al. (2016) argued that lack of continuity in government to execute projects and implements master plan are the main culprit in Lagos. Again, local governments in Lagos are not independent of the state government to deal with climate change challenges contrary to international best practices in most metropolitan cities of the world such as in Cape Town and Durban in South Africa (Elias & Omojola, 2015).

Therefore, the objective of this paper is to examine the vulnerability of Lagos to the events of climate change and adaptation of her inhabitants to the impacts of the extreme weather. This objective will be met with the following aims:

- Conduct globally best practices survey as a way to reflect on the responses that might help Lagos.
- Analyze how climate change has already impacted people and infrastructure in Lagos and what are the predicted future impacts?
- What policy actions have city, regional, national and international government bodies taken to address climate change?
- What are the most promising avenues of activism and policy development to improve climate change adaptation in Lagos

CHAPTER TWO

2.0 BEST PRACTICES OF COASTAL CITIES

This section provides a brief overview of key lessons on climate change adaptation emanating from leading jurisdictions around the world.

2.1 New Orleans

The city of New Orleans is located at the confluence of the Gulf of Mexico and the river Mississippi. New Orleans, experienced six hurricane events between 1915 and 2005. Hurricane Katrina was the latest. Scientists predict that future hurricanes with greater severity will occur as global temperature increases (Field et al., 2016; Govind, 2016). The protection of New Orleans is difficult due to sea level rise, land subsidence, storm surge, increased intensity (and frequency) of hurricanes, greater rainfall and coastal erosion. The adoption of flood protection using scenarios and models such as 100-year and 500-year flood protection standards for critical infrastructure is important for planners and lawmakers to make decisions on levee protection systems for the city (Wong & Keller, 2017; Govind, 2016).

The flooding due to hurricane Katrina had major socioeconomic and environmental impacts affecting the life of the citizenry. The rapid loss of wetlands due to encroachment from increasing urbanization exacerbates the devastating effects of hurricanes. Therefore, the impact of hurricane Katrina in New Orleans revealed the interactions between resilience and climate change adaptation, social, ecological systems and propels adaptive resilience as a policy (Govind, 2016).

New Orleans adopted resilience as an adaptation approach that aided the community to come out of disaster shock with enhanced vulnerability reduction. This is a shift from the short-term structures such as levees that were widely accepted for flood protection in New Orleans. The Rockefeller Foundation supported a 100 Resilient Cities initiative program that provided the response on which the New Orleans resilience framework

began. Its operation centred on vulnerability assessment which showed the connexion between resilience and vulnerability (Govind, 2016).

Kashem et al. (2016) viewed the theories of social vulnerability and neighbourhood change together to give an understanding of what made people vulnerable to hazards and why those that moved decided to occupy specific areas of a city. This further explained why social vulnerability exhibited differences in indicators which included income, gender, race/ethnicity, and household composition and these could be considered along with exposure to hazards to measure vulnerability to disasters. Therefore, existing indicators of social vulnerability must be considered in adaptation planning.

Accordingly, the New Orleans Master Plan provided examples of climate change adaptation projects including measures of coastal restoration, green infrastructure and improvements in transportation. The Citizen Assisted Evacuation Plan for New Orleans was used as a pre-disaster evacuation strategy to minimize the number of deaths and loss of property (Swamy et al., 2017; Govind, 2016). The strategy utilizes the existing public transportation infrastructures (which include roads, bus stops and buses) within the short period prior to hurricane landfall. This strategy will help in the well-organized evacuation operations of people from designated high risk areas to safe areas where shelters are located for the evacuees (Swamy et al., 2017).

The adoption of an ecological-system based approach to increase resilience from hurricanes and other hazards has also helped to cut the cost of the projects (Govind, 2016). Also, a resilience project undertaken in the city includes greenhouse gas (GHG) emission plan with the aim of reducing the consumption of fossil fuels and increased use of renewable energy and efficiency by the year 2050 (Govind, 2016). The goals of the plan became reality because the stakeholders supported and adopted

resilience to cover risk, uncertainty of storms and hazard mitigation through their commitment and participation (Govind, 2016).

Wetland restoration is a form of ecosystem service strategy to avert the loss of coastal wetlands through Multiple Lines of improving the drainage (MLOD) from hurricanes and flooding. New Orleans uses wetlands whose availability depends on the complex effects of sea level rise, ocean acidification, and extreme weather events (Govind, 2016). The city's drainage systems are not adequate to accommodate the storm water rising from 60 inches (1524 mm) yearly rainfall. Therefore, the idea of an Urban Water Plan (UWP) worth $6.2 billion commenced, grounded on Dutch experience as a resilience measure with the system's ability to temporarily store water described as climate-adaptive design. Moreover, the plan could manage inflow of excess water into the city and help in flood prevention while improving economic development and raising the value of properties among other benefits that are calculate to be worth about $22 billion (Govind, 2016).

Similarly, Field et al. (2016) captured the shift from flood resistant policies to flood resilience which had its origin in the Netherlands. The concept of blue-green infrastructure is "an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations". The concept, incorporates safety and consider risk reduction in human population and infrastructures in its resilience planning. The Lafitte Greenway Project was an example to show the shift by the city planners in New Orleans. In addition, Passidomo, (2016) advanced Lefebvre's concept of the right of a community to the city through the action plans of urban greening and urban agricultural initiatives. These initiatives allow the community to have access to unoccupied urban space within the neighbourhood and engage young people to produce fresh food. This is a post-Katrina

New Orleans attempt that demonstrates the ability of the citizens to participate in the local governance of their neighbourhoods (Passidomo, 2016).

2.2 Amsterdam

The landscape of the Netherlands is dotted with prominent features such as deltas, estuaries and marshlands with about two-thirds of the country's landmass below sea-level. The country's cities, Amsterdam, Rotterdam, and Utrecht all have similar water management and, governance structures and are all under the threat of climate change impacts. This reality includes coastal exposure and inland flooding identified under the IPCC 5th Assessment Report (AR5) (Stavenhagen, 2017; Araos et al., 2016; van der Steen et al., 2016).

The Dutch flood risk management and safety, governance systems are under the control of the national and regional governments classified as being 'in the public interest' to protect the citizens from floods. This focus is evident in the many dikes, embankments, canals and waterways found in the country since 1795 (Wiering & Winnubst, 2017). However, the approach incorporates community-based interests in flood protection. The collective actions by the various stakeholders which include farmers, landlords and government official to discuss measures that would reduce flood risk as a means to convey social justice (Wiering & Winnubst, 2017).

The Dutch government is able to sustain efficient flood risk management that focus on prevention through the sharing of risks and responsibilities for mitigating flood destruction. The private sector tends to increase its ability to adapt and reduce the impact of disasters. However, the government has made an effort to perfect the approach by introducing spatial planning measures into management policies which include the taxpayer funded system and public compensation scheme. This ensures that private sector agents are responsible to cover their own risks (Husby, et al., 2016).

Many European cities including Amsterdam and Rotterdam adopted the UNFCCC approach of ecosystem based adaptation that promotes management, conservation and restoration of ecosystem services to help reduce climate change exposure, for instance, increasing urban green infrastructure, and re-instating forests to serve as buffers and prevention of flooding in communities. The concept has its basis in resilience whose foundation is in applied ecology (Spaans & Waterhout, 2017; Geneletti & Zardo, 2016). Moreover, Amsterdam attempted to develop a rain and climate proof plan that emphasizes water management plan in a 'sponge like' manner based on a Three-step plan of delaying, storing and draining water (Stavenhagen, 2017). Alongside Rotterdam and Utrecht, Amsterdam collaborated and exchanged ideas on best practices in their long-term water management plan, urban planning strategy and involvement of stakeholders due to their similar stakes in water governance (Stavenhagen, 2017).

The successes recorded in the rain and climate proof strategy are linked to the autonomy being enjoyed by the municipal governments of Amsterdam and of other cities (Stavenhagen, 2017). Dutch cities can access funds from municipal levies, taxes and can count on the European Union to execute projects. Leading Dutch cities are also active in international cooperation and partnerships, such as the 100 Resilient cities and they also involve stakeholders and the public in strategic planning. In addition, Amsterdam supports its water and energy efficiency strategies with a strong policy framework with specific goals for operation to protect the environment and to achieve a 'climate-neutral city'. The year 2025 and 2040 are the targets of the city to reduce greenhouse gas (GHG) emissions by 40% and 75% respectively compared to 1990 levels. (Markus & Savini, 2016).

The second Delta Committee report from 2008 revealed actions to protect the economic benefits derived at the Dutch Delta. Amsterdam initiated strategies, centred on prevention by improving dykes with the goal to limit flood damage and ease emergency evacuation of infrastructures within its control (van der Steen et al., 2016; Markus & Savini, 2016).

2.3 Bangladesh (Dhaka)

Bangladesh is a country located within the world's largest delta where the highest occurrences of storm surges are experienced due to the adverse impact of global climate change. The deltaic region of Bangladesh which includes Dhaka, the capital city supported a compact population of about 100 million people which are vulnerable to climate change and sea-level rise. Many rivers that traverse the country do flood; inundating the land area to about 60%, thereby exposing inhabitants to the danger of flooding when there are storm surges. About 300,000 and 138,000 deaths related to storms were documented in 1970 and 1991 respectively (Younus, 2017; Chowdhury and Moore, 2017; Ayeb-Karlsson et al., 2016). The 2015 World Risk Index ranked the country as the sixth most at risk of natural disaster, a fact exacerbated by poverty and food insecurity (Ayeb-Karlsson et al., 2016).

However, the government's coastal region policies which included the Bangladesh Climate Strategy and Action Plan and the National Roadmap for National Adaptation Plan and Sixth Five-Year Plan did not have specific guidelines to address adaptation and vulnerability issues (Younus, 2017).

Therefore, climate change experts in the IPCC and United Nations related organizations have argued for actions to increase the people's adaptability to the impacts of climate change. The proposed formation of a Community–based adaptation committee (CBAC) concept will increase community involvement. The contributions

from their resources would serve as a response to governance apart from the existing local government administration. The scope of the CBAC in this case should include placing local adaptation needs in order of preference by the community, and government should allocate funds based on the funds from the proposed Copenhagen Accord. These efforts will probably help reduce vulnerability and increase adaptation capacity (Younus, 2017).

Agricultural practice is the major livelihood in Bangladesh with about 47% of all employment. The sector's contribution to GDP is about 19% (Islam & Nursey-Bray, 2017; Ayeb-Karlsson et al., 2016). The resilience of the Bangladeshi people is seen in their agricultural practices to cope with the problems of climate change and ecological, disruption. Adaptation strategies adopted in Bangladesh include: seasonal and temporary migration, changing the method and approach of practising agriculture, introduction of traditional knowledge in farming, increased use of locally available materials, and sources of livelihoods (Chowdhury & Moore, 2017; Ayeb-Karlsson et al., 2016). However, Islam & Nursey-Bray, (2017) identified the absence of culture-specific practices and limited use of technological innovation in agricultural practices as key obstacles to climate change adaptation.

Adaptation planning requires participation of the community through the practice of community need assessments to produce strategies to meet local interests and abilities to strengthen the community preparation for disaster and increase adaptive capacity (Shaffrila et al., 2017; Ayeb-Karlsson et al., 2016).

However, Mostafa et al. (2016) recognize the significance of adaptation finance as posited in the Paris Agreement. Communities that are vulnerable to climate change could have access to funds but the ways to carry out and disperse the funding needs to be detailed with clarity. In addition, several other funding sources from other United

Nations related agencies meant for climate change vulnerability such as the Adaptation Fund and Green Climate Fund may be difficult to access by countries designated as Least Developed Countries (LDC) such as Bangladesh.

Islam & Nursey-Bray (2017) and Mostafa et al. (2016) have acknowledged the activities of the Bangladeshi government to establish institutions to implement adaptation policies. Conversely, several issues threaten achievements which included failure to coordinate all the agencies of government, corruption and other associated concerns that rendered the government less able to manage climate change issues.

Key Bangladeshi governmental institutions are required to respond to help build social networks amongst the various categories of people (Islam & Nursey-Bray, 2017). This focus includes state actors and civil society, which serve as mediators between farmers, and other similar organizations. Also, there is a need to build new partnerships between organizations, such as government owned, private companies, non-governmental organizations and local farmers. In addition, Islam & Nursey-Bray, (2017) posited that improved adaptive capacities are vital when co-operation exist between stakeholders and formal institutions and there is a link between climate research and the impact of climate change vulnerability.

CHAPTER THREE
3.0 CONCEPTUAL FRAMEWORK AND DEFINITIONS

3.1 Key Vulnerability Concepts for Research

The concept of vulnerability (Turner, 2016; Yenneti et al., 2016) has been widely used along with adaptation and resilience concepts by policy makers and social scientist. The IPCC (2014) expressed vulnerability to “encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt” Similarly, Beroyer-Eitner (2016) suggested no clear definition for vulnerability as different terms are displayed to convey the same understanding and close to the meaning of vulnerability are resilience, adaptability, adaptive capacity, risk, sensitivity and fragility. However, Beroyer-Eitner (2016) definition of vulnerability is in agreement with the hazards and environmental change working knowledge of social researchers as “the degree to which a system, subsystem, or system component is likely to experience harm due to exposure to a hazards, either a perturbation or a stress/stressor”

Furthermore, Dumenu and Obeng (2016) defined vulnerability “as the degree to which a system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes” hence exposure, sensitivity and adaptive capacity play a significant role in the process. The fact that human society responds to the global threats of climate change impact in several ways makes the terms look similar and often replace each other. Their usage as adaptation and resilience concepts have basis in cultural ecology whereby individuals, social groups and human society co-exist. Hence, the idea is to reduce the impact of flood and drought hazards (Dumenu & Obeng, 2016). In addition, adaptation response to hazards is understood as technical prevention compared to resilience that involves human absorption (Turner, 2016).

Consequently, Turner (2016) and Yenneti et al. (2016) traced the origin of vulnerability to ensuring food security by making food available to individuals and groups of people to reduce poverty. Also, it is being described as a means to avoid destruction through reduced exposure of people to climate hazards. Dumenu & Obeng (2016) and Yenneti et al. (2016) classified vulnerability into two features: physical and social vulnerability. The physical vulnerability expresses exposure and state of natural hazards while social vulnerability is about system capacity and the use of social economic factors. Moreover, Yenneti et al. (2016) noted the greater contributions of social vulnerability to climate change research than physical vulnerability.

Therefore, Dumenu and Obeng (2016) defined the concept of social vulnerability to climate change "as the degree to which a system is susceptible to the effects of climate change owning to interplay of social, economic and demographic factors". He goes on to clarify the capacity of the communities to withstand the impact of climate change with the mathematical expression below:

$$SV = f \cdot [1/n\,(DF + EF + SF)]$$

Where, SV = social vulnerability, DF = demographic factors, EF = economic factors and SF = social factors, and n = number of social vulnerability factors.

Hence, the resilience of the community is their capacity or the state of human condition that is derived from the integration of demographic, economic and social indicators.

Furthermore, Yenneti et al. (2016) posited social vulnerability in a different framework that combined exposure, sensitivity and adaptive capacity. Exposure is referred as the level at which a system is exposed to the influence of climate variations while sensitivity is the extent to which a system is either affected harmfully or usefully. The adaptive capacity supports the system to cope despite the hazards by taking actions that will minimize the impact of the climate change. In fact, the resilience concept focusses on a system that maintains its original state even though is under the impact

of hazards. Therefore, inability to implement adaptive capacity with high sensitivity and exposure could lead to vulnerability however, adopting it signifies resilience to the impact of climate change (Daramola et al., 2016; Yenneti, 2016). Thus, Daramola et al. (2016) defines adaptive capacity "as resources with dynamic attributes, i.e. resources that are robust, redundant or rapidly accessible. These resources interact with the stressors such as natural hazards to yield different outcomes for individuals, families and communities".

Adaptive capacity and resilience concepts in particular bring more understanding to impact of climate change to the urban poor. Most slum areas exposed to flood have poor housing construction although areas inhabited by the rich have adequate resources to undertake repairs and regular maintenance of infrastructure (Yenneti et al., 2016). However, adoption of integrated assessment models and household surveys approaches could be used in social vulnerability assessment to quantify vulnerability (Yenneti et al., 2016). There is no agreement on method of assessment but researchers consider aim of the research, geographical location and socio-economic indicators based on exposure, sensitivity and adaptive capacity of location and availability of public data (Senapati & Gupta, 2017; Yenneti et al., 2016). For these reasons, Senapati & Gupta (2017) and Yadav & Barve (2017) note why indicators are carefully selected, certified and classified in hierarchical structure by experts. Also, numerical weights are assigned using pair-wise comparison matrices for vulnerability measurements.

Due to these, vulnerability indicators are used to acquire and access information on a subject matter to give better understanding on policy response/strategies for intervention (Beroyer-Eitner, 2016). Yadav & Barve (2017) vulnerability indicator examples include population density and literacy rate. Senapati & Gupta (2017)

recognized the inability of researchers, policy makers and local governments to analyse data and information from vulnerability assessment of coastal community. Again, made it difficult to formulate good policy because of the interdisciplinary state of vulnerability measurement.

Public institutions such as government agencies, universities and research laboratories lack technological information to manage climate change science of mitigation and adaptation strategies. Therefore, collaboration with private-sector firms could assist to prevent failure (Harnett, 2017; Haley, 2016). Similarly, Harnett (2017) acknowledged problems in learning and exchange of ideas on climate science, policy action and understanding of climate risks. Consequently, this may halt good investment decisions and reduce awareness of investors, policy makers and the public. However, to achieve the target of less than 2°C of global warming as noted by Harnett (2017), requires collective adoption of mitigation and adaptation strategies by government, businesses and the people. Pension funds help to reduce vulnerability to the impact of climate change and improve the management of the economy.

In addition, adoption of urban green infrastructure as a concept supports a city's adaptation to climate change (Matthews et al., 2015). The concept is the multi-functional green spaces such as green roofs, alleys and streets, urban forests, public parks, community gardens and urban wetlands. These spaces are linked together due to similar economic, ecological and social benefits, as well as same planning and management approach. Therefore, it is widely accepted by planners due to its capability to reduce storm-water runoff and serve as recreational ground for the people.

Furthermore, Matthews et al. (2015) underpin biophysical factors that are interrelated such as the nature of built environment, planning systems, institutional framework and

governance structure. These are working together as motivating factors to achieving adaptive climate change response.

Moreover, the concept of Nature-Based Solution (NBS) as noted by Nesshover et al. (2017) is similar to the concepts of sustainable development, biodiversity and natural capital as defined and used in policy documents in the management of natural environments by the United Nations. NBS is one of the solutions to climate change mitigation and adaptation problem when incorporated into the existing policy framework on spatial planning, stakeholder's participation, and transdisciplinary knowledge with exchange of ideas and understanding of the process (Nesshover et al., 2017). The concept has wide application because its foundation is based on nature's power to help reduce climate change disaster risk and increase food security. Also, it can contribute to sustainable development with good ecosystem management. Despite this, the concept faces the challenge of managing nature due to complex interrelationships with existing concepts thereby creating the problem of knowledge-gap (Nesshover et al., 2017).

Moreover, the concept of social networks is centred on relationship, bonding, linking and trust developed during friendship, social connection and membership in the same organization. In addition, the network comprises relationship between different actors that may include individuals, households, families and many organizations such as media, political and religious (Islam and Walkerden, 2017). The authors also argue that this network becomes beneficial as a form of resilience and recovery during and after disaster.

Ultimately, relevant policy response to address climate change impact should consider issues of social and environmental justice in other to reduce poverty and social inequality, and maintain sustainable development. Environmental justice in this situation is linked to distribution, procedures and recognition of environmental issues

to ensure fairness or equity (Popke et al., 2016; McLean et al., 2016). Furthermore, (Popke et al. (2016) argues that environmental justice brought more understanding on environmental outcomes to protect people's interest, grounded on equitable distribution of hazards, processes, legal framework, public policy, and engagement of all identified groups.

Correspondingly, climate change features (McLean et al., 2016; IPCC, 2014) require collective actions and international cooperation for effective mitigation. The recent effort at the international negotiations at Paris 2015 considered the inequality of climate change impact and the problems of mitigation and adaptation of GHG emissions across the globe. IPCC climate policy guidelines are made to be the standard which national and sub-national and local government have used to support their adaptation strategies and action plans. Also, IPCC (2014) articulated the activities of UNFCCC and the role of the Kyoto protocol to implements agreements signed under the convention in Cancun and Durban at 2010 and 2011 respectively. The Kyoto protocol also aided emission reduction plans of it Clean Development Mechanism (CDM) and allowed marketing of GHG emissions through emission offsets to help developing countries. Likewise made fund available through UNFCCC Adaptation Fund for investments (IPCC (2014). Equally important are international cooperation and arrangements that included International Cooperation for Supporting Adaptation Planning, Loose Coordination of Policies, Offsets Certification Systems, Green Climate Fund, Linked Cap-and-Trade Systems and Harmonized Carbon Taxes (IPCC, 2014).

The International Bar Association (IBA) 2014 report (Olawuyi, 2016) focuses on human rights violations of local communities and risk management strategies. The IBA guidelines and institutional framework are a risk management strategy that ought to

focus on human rights mixed with accountability, justice and information access. Therefore, their integration into the design, approval, and financing of climate projects would reduce human rights violations.

3.2 Vulnerability and Adaptation of Coastal Cities to Sea Level Rise

The major causes of sea level rise are rapid thermal expansion and melting of glacier experienced by oceans in the high latitude regions. As a result, the global mean sea level rises to an estimated 20 cm in the last century and close to 2.0 m this century (Lyle and Mills, 2016; King et al., 2016; IPCC, 2014). Furthermore, Tano and et al. (2016) argued that the cause could be enlarged due to local subsidence activities within and around deltaic areas.

Though sea level rise phenomenon is important in climate change study, its occurrences, impacts and projections have been subjected to controversy in the literature because of the role it played in the management of the coast (Carrasco et al., 2016). He also identified observed relative sea level rise occurring locally as being the threats and causes of flood hazards and various storm surges prevailing in coastal cities. Therefore, an integrated coastal zone management framework was used as a hands-on adaptation measure to reduce vulnerability of coastal communities and infrastructure. Consequently, vulnerability assessment of coastal cities to risk of flooding, erosion and incursion of salt water would assist the government and managers of the coasts to plan and adopts adaptation strategies to minimize impact of the problem (Carrasco et al. 2016).

As a follow-up, Tano et al. (2016) examine the coastal vulnerability index (CVI) of 566 km Ivorian coast stretching into three zones along Gulf of Guinea in West Africa. The CVI method uses information and data obtained from geomorphology of the landform,

rate of shoreline retreat, local subsidence, wave's height and rate of sea level rise from tidal gauges. Similarly, the review of vulnerability assessment of Ghana coastlines in Boateng et al. (2017) suggested that entire coastline assessed would help government make sound decisions on adaptation policy and supports the planning process of scientists and coastal managers. Correspondingly, Boateng et al. (2017) divided the coast of Ghana into three and adopted the CVI method of vulnerability assessment with the use of Geographic Information System (GIS), a computer based system which differs from the approach used in Tano et al. (2016). However, the two studies revealed that the coasts of Ivory Coast and Ghana are highly vulnerable and collaboration with stakeholders and inclusion of socio-economic data would be required to improve the use of CVI as a method for vulnerability assessment.

Lyle and Mills (2016) analyzed the city of Vancouver's acceptance of Coastal Flood Risk Assessment (CFRA) modelling that has been used to detect coastal facilities and areas vulnerable to hazards and risk of flooding. It has helped the city planners and politicians to evolve planning strategies to combat flooding and make Vancouver a resilience city. Equally, the development of the city's hazards mapping will enhance the CFRA model to better identified vulnerable areas.

It is important to note however, that coastal regions especially in the United States (US) analysed in Xinyu et al. (2016) are very important despite their vulnerable position to the impact of coastal flooding and storm surges. The authors are saying that coastal regions of the US are among the highest contributors of Gross Domestic Product (GDP) that pushes the overall economy. The assessment was based on the economic value of coastal amenities that are at risk of sea level rise. The results serve as decision support in adaptation planning.

Accordingly, Xinyu et al. (2016) adaptation measures are localised but used by planners and coastal managers to estimate cost and value of coastal facilities and amenities when sea level rises. Also, the use of hedonic prices modelling is about cost-benefit analysis whereby values of lost coastal amenities are computed. However, planners and managers encountered difficulties to match good adaptation alternatives with the model due to lack of thorough analysis of coastal amenities.

Consequently, solutions to the impact of sea-level rise are the focus of local government institutions in the US as the closest government to the people. Therefore, the study of 36 local plans that covered 15 coastal cities produces Local Comprehensive Plans (CMPs) and hazards mitigation plans (Xinyu et al. 2017). The study had limitations due to inadequate planning toolkits, and required information and incentives in the localities for sea level rise planning however Xinyu et al. (2017) addressed the issue with suggestions such as toolkits expansion for long-term benefits and strong coordination of the stakeholders to help coastal managers and planners in the U.S. and other countries.

CHAPTER FOUR

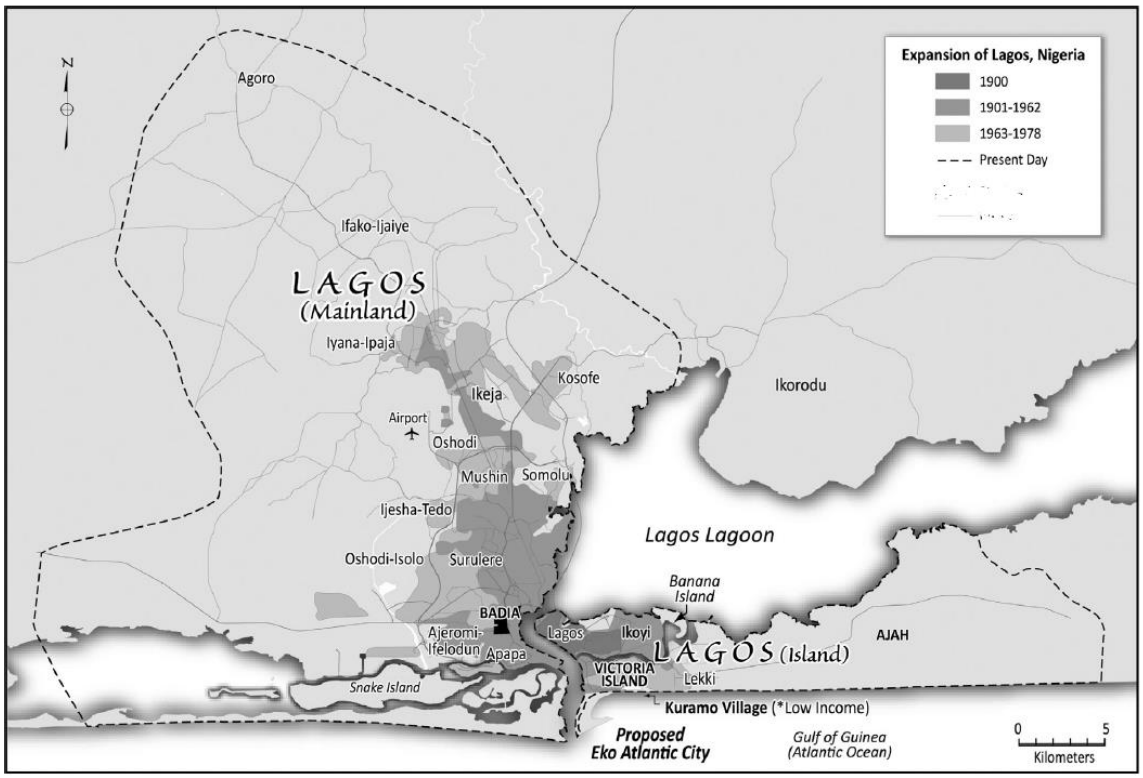
4.0 OVERVIEW OF THE CITY OF LAGOS

4.1 Overview of Climate Change Challenges in Lagos

Lagos in Nigeria is situated on a small narrow plain found in the south western part of the country. The state is bound to the north and east by Ogun state, west by the Republic of Benin and by the Atlantic Ocean to the south. Lagos occupies an area of approximately 3, 577 km^2 with about 22% of its area covered by lagoons and creeks (Nkwusi et al. 2015; Elias and Omojola, 2015).

Lagos is the commercial centre of Nigeria, and hosts 75% of all the nation's industries. In addition to this, Lagos' population at independence (October 1 1960) was about 763,000 people which helped make it the capital of the country. Although, the capital was afterward relocated to Abuja, Lagos retains its commercial hub status (a fact that draws people from all parts of Nigeria). Lagos' population rose to 2,025,000 by 1970, and reached 16,864,000 by 2010. By 2015 Lagos has reached an estimated population of 18 million and has an annual population growth rate of 6% (Nkwusi et al. 2015; Elias and Omojola, 2015).

By 2010, the Lagos contribution to Nigeria's Gross Domestic Product (GDP) stood at about 36% equal to an estimated value of US$80.61 billion. However, the non-oil contributions were estimated to be 62%. Therefore, Lagos internally-generated revenue (IGR) is amongst the highest in Nigeria (Nkwusi et al. 2015; Elias and Omojola, 2015).



(Figure 1) ***Adapted from Ajibade, I. and McBean, G., (2014). Climate extremes and housing rights: A political ecology of impacts, early warning and adaptation constraints in Lagos slum communities***

Lagos is experiencing rapid development, along with most coastal cities in Africa, and is today one of the fastest growing mega-cities in the world. The large population, exacerbated by the impacts of climate change, poverty and inadequate infrastructure encourages the growth of low-income communities. For instance, Makoko a slum community is inhabited by about 100,000 people that are living without roads and are highly dependent on fishing and the nearby saw mill industries as means of livelihood (World Bank, 2016; Riise and Adeyemi, 2015).

Similarly, the rising population and anthropogenic activities (such as reduction in vegetation cover and increase in built-up areas), have made Lagos a source of urban heat that is continuously changing and is leading to increasing land surface temperatures that cause a recurring Urban Heat Island (UHI) effect. UHI detrimentally impacts the urban microclimate, thermal comfort and, human health leading to high

mortality rates and a poor general urban living environment (Ayanlade, 2016). As a result, Nkwusi et al. (2015) revealed that 93% of the farmers in urban Lagos believe that urban temperature increases are responsible for the loss of seedlings of key crops.

Furthermore, Ezeh et al. (2016) classify rainfall as a natural resource because of its importance in economic development. (please note that most agriculture in Africa depends on rainfall). Furthermore, Nkwusi et al. (2015) have noted that local farmers have observed a decrease in rainfall patterns in Lagos (i.e. with a 79% downward trend in the last 10 years). Analysing rainfall data is crucial for creating better planning models to help in the prediction and forecasting of rainfall and to avoid the related impacts of climate change (Ezeh et al. 2016). In addition, Ezeh (2016) notes that available data in some developing countries like Nigeria, may not be suitable for most models used for prediction and forecasting because of lack of data.

The Federal Government of Nigeria (2014) has analysed Nigeria's coastline, which reveals that vulnerability to sea-level rise (SLR) increases from the western part of Nigeria along the coastline from Lagos (with 2mm increases per year predicted towards the east through Warri and about 3 to 5 mm in Calabar). These observations indicate that SLR adaptation actions should focus on addressing the different conditions of Lagos' coastline sectors.

Figure 2: Flooding in Herbert Macaulay Street, Lagos

(Image source: Author)

Figure 3: Flooding in Makoko/Iwaya Road,Lagos

(Image source: Author)

Figure 4: Victoria Island Flood, Lagos

(Source: Adapted from Enviro News Nigeria- Online)

Figure 5: Highway Flood, Lekki Lagos

(Source: Adapted from Enviro News Nigeria- Online)

Figure 6: Street Flood, Lagos

(Source: Adapted from Enviro News Nigeria- Online news)

4.2 Measures Adopted to Address Challenges

Extreme weather conditions are increasingly occurring in Nigeria (particularly in Lagos). It is crucial to emphasize that Lagos is very susceptible to the growing incidence of weather disasters, environmental degradation, unemployment and high mortality rates due to its geographical vulnerability to climate change (Ebhuoma et al., 2017; Aich et al., 2016; Adeagbo et al., 2016).

Therefore, Ebhuoma et al. (2017) is suggesting that low-income rural households need to improve their adaptive capacity and resilience. At the same time, they note that education and awareness information on climate change, farmland irrigation, early warning and monitoring, crop insurance and migration are equally important (Ebhuoma et al., 2017). These authors also note that policy developers should identify the best type of policy intervention and easy to use asset-based adaptation frameworks that encourage individuals, households and communities to set aside resources meant for emergency response during extreme weather conditions. That resiliency approach includes viewing resources as asset portfolios and capital assets that can inform the deployment of physical, human, natural and social assets.

Ebhuoma et al. (2017) note that social capital is helping to bring many poor rural household and individuals together within the community to form a network built on trust, mutual understanding and reciprocity exchanges. They note that cooperation among network members allows them to adopt action plans that are mutually benefiting (such as food production and procurement of capital assets). In addition, explaining how asset portfolios were used to reduce impact of a flood disaster in Nigeria in 2012, they note that victims (especially farmers), use a form of social capital bonding named “Osusu” to promote financial capital to boost food production while the elderly adopted measures which includes food rationing and begging for food to avert

hunger. Similarly, some households have sold off their valuable assets when no financial assistance was forthcoming from relatives or government.

Asset	Long term strategies to build resilience	Implications for household food security
Housing	Because the study sites are coastal communities and coupled with poor drainage facilities, house foundations are raised about 1 – 2 m off the ground. Used concrete blocks to build houses because it is more unlikely to collapse in the event of a series of heavy rainfall unlike houses built with mud.	By protecting their houses from the impacts of heavy rainfall events, they Minimise the knock-on effect on their financial capital they are likely to incur (e.g. renovation exercises) if such measures are not taken, which can compromise their ability to continue in food production.
Foodstuffs	Processed cassava (garri) is placed in an airtight sack bag, the bag is then placed on an elevated wooden platform of about 0.5 m above ground level. This ensures that there is food (garri) for at least a year. This strategy gives the farmers enough time to plant, harvest and process the cassava tubers to ensure annual household food security. For those whose foundations are not well elevated above ground level, heavy rainfall events often lead to excessive moisture in the house. This, in turn, results in the emergence of mould. Damp conditions and mould cause food items store on the floor to decay. Consequently, shelves are constructed on the walls where food is preserved. Fish is preserved by roasting it. This ensures that fish is available for consumption for about five months.	Adequate food storage means less cash expenditure on food, which means more financial resources are left to address other pressing needs.
Health	Preparing and consuming a local herbal drink (agbo) during the rainy seasons as a preventative measure against malaria. Keep house and surroundings neat and tidy Use mosquito nets to prevent mosquito bites when sleeping.	The health of households is crucial to ensure increased output, as farming is subsistence. Thus, if any of them take ill, it can snowball into household food insecurity.

Table 1: ASSET ADAPTATION STRATEGIES TO BUILD LONG TERM RESILIENCE TO CLIMATE CHANGE

(Source: Author's Fieldwork and Ebhuoma et al. (2017)

Adeagbo et al. (2016) argue that the National Health Insurance Scheme existing in Nigeria, should be covering disaster related emergency care for all members of the informal sector and rural areas. However, Daramola et al. (2016) notes that the National Emergency Management Agency (NEMA) and the State Emergency Management Agency (SEMA), which are the governments' established agencies whose operations include search and rescue, victim's relocation and provision of relief materials need to do more than they currently do. At the time of writing (2017), preparations for disasters are reactive not preventive and do not include post-disaster assessment as a way of improving disaster prevention and/or management.

On the other hand, Elias and Omojola, (2015) have identified Lagos as a leading jurisdiction in Nigeria due to its efforts in enhancing climate change vulnerability reduction. As evidence they cite the establishment of a climate change unit within the Lagos Ministry of Environment (or LME, whose mandate is to increase the rate of awareness through campaigns in urban Lagos). This new climate change unit has established Climate Change Clubs in the state to harness high schools to promote key initiatives (such as a campaign titled 'Lagos State Energy Kids' to encourage the use of renewable energy). Furthermore, LME is elaborating a government urban renewal program and an integrated climate change adaptation strategy to protect infrastructure sensitive to climate change and adoption of climate change adaptation policy between 2012 and 2014.

Consequently, climate change adaptation policy, is serving as the main foundation from where all government agencies are drawing plans to implement the state's climate change mitigation and adaptation programs, for instance, waste reduction

strategies that support private sector participation, Independent Power Projects and urban tree planting (Elias and Omojola, 2015). Although, it must be noted that public participation is limited, local government in Lagos is crucial because it is, the closest government to the people in terms of climate change governance. However, poor funding remains as a barrier for the Lagos local government increase its public engagement levels.

CHAPTER FIVE

5.0 CONCLUSION

5.1 Policy gaps and Identified problems

The impact of climate change in Lagos is already resulting in a rise in incidence of flooding events, disruptions in local economic activities, and the displacement of many inhabitants from their homes (often leading to physical injuries and death in extreme cases). The government disaster preparedness and response capabilities against climate disasters are currently limited to remedial approaches of search and rescue, relocation of victims and providing relief materials. Lagos is also already experiencing outbreaks of vector-borne diseases (such as malaria in many low-income areas), that are rapidly enhanced due to the lack of good roads, clean water sources and proper waste disposal facilities. Furthermore, the ad-hoc health cost experienced by local inhabitants may not be covered by the Nigerian National Health Insurance Scheme.

The lack of efficient waste disposal facilities in Lagos has rendered the drainage system of the city ineffective due to frequent blockages that are caused by waste that is frequently improperly dumped. Also, this problem is exacerbated whenever there is heavy rainfall (usually between the months of June and July). As a result, critical infrastructures such as roads, canals and bridges in most parts of the city (including high-income areas) are often flooded. In short, frequent flooding events are constantly-slowing down local economic activities, making mundane social activities and everyday life very difficult, and regular preventing the daily movement of inhabitants and vehicles within Lagos.

Another issue compounding the above problems, is the inability of government agencies to engage local people through programmes that enable to share solutions

and exchange ideas. Furthermore, there is a marked absence of coordination within Nigerian government agencies at all levels.

The current situation of Lagos is a contrast to what is happening in many leading developed and developing countries, where local governments are increasingly becoming active participants in climate change governance and policy development. Since, local governments are the closest ones to the people they hold an advantaged position to help implementing and improving climate change adaptation strategies. That position is hampered by a widespread limited access to funding, which has been identified as a key challenge to achieve an effective local government.

5.2 Policy proposals

Although, leading governments at the national and state levels have made attempts to reduce the impacts of climate change through institutional arrangements. The analysis presented in this paper indicates that changes are needed to existing policies. First, flood management needs to focus more on increasing public awareness about the disposal of solid waste rather than building more drainage channels. Second, it is imperative to encourage collaboration and exchange of ideas amongst government institutions in Lagos state and also between the state and national institutions.

Finally, the government of Lagos needs to fine-tune its climate change policies and emulate the resilience strategies implemented by the leading Dutch cities of Amsterdam and Rotterdam. In addition, the government of Lagos should continue to participate and support the international initiative of 100 Resilience cities (100RC), to learn and build actions from similar cities to benefit the inhabitants of Lagos.

5.3 Pathway forward for Lagos

Lagos occupies an important position as the commercial nerve centre of Nigeria and as its former federal capital. The never-ending flooding episodes of Lagos are, exacerbated by climate change and by the low lying topography of the city and, its rapidly growing population. Furthermore, the city's limited environmental planning itself is becoming a growing threat to public infrastructure (bridges, roads, buildings), local economic activities, human well-being, and is threatening lives.

The global best practices, analyzed in this paper, to help Lagos are summarized below:

- Adopt resilience-based ecological approaches. This strategy can help to manage, conserve, and restore ecosystem services (such as restoration of the coastal wetlands that controls the flow of excess water into the city when there is storm surges), and to represent a key strategy to prevent flooding. The restoration of urban green infrastructure especially forests, to serve as buffers to prevent flooding in urban communities is also essential.
- Promote the exchange of ideas and collaboration on long-term best practices focusing on urban water governance between Lagos and related cities (i.e. Accra and Cotonou two cities in the West African Sub-region that are also vulnerable to similar climate change events).
- Develop new partnerships and increase participation in international cooperation arrangements (such as the 100 resilient cities initiative) to help develop a new Lagos strategic plan that would assist to reduce vulnerabilities to disaster.
- Adoption of the Community–Based Adaptation Committee (CBAC) approach to enable community members to participate in the development and

implementation of local administrative governance systems of climate change adaptation.

- Implement the ecosystem adaptation approach initiated by the UNFCCC (which is a strategy that the cities of Amsterdam and Rotterdam have already adopted). This strategy is relevant to Lagos and needs to be adopted to restore and conserve ecosystem services such as urban green infrastructure and forest regeneration that can be used as green space and as storm buffers that serve as resilience strategies to address flooding in local communities. This concept of blue-green infrastructure can be achieved through out-reach and awareness campaigns, which the city of Lagos has already began with Nigerian government agencies in Lagos (i.e. through the climate change unit of the State's Ministry of Environment). In addition, the concept could be funded and supported through the Adaptation Fund or the Green Climate Fund under the United Nations Framework Convention on Climate Change (UNFCCC). Since the Adaptation Fund became available in 2007, countries such as India, Costa Rica, Kenya and Morocco have benefited from it (the Lagos government should apply to the fund through the Federal Government of Nigeria).

- Encourage the Nigerian government to urge all wealthy governments to increase funding levels of the Adaptation Fund and the Green Climate Fund of the United Nations Framework Convention.
- Encourage the Lagos government to continue to participate in the 100 Resilient cities network that is being supported by the Rockefeller Foundation and whose resilience framework has helped in developing the New Orleans vulnerability assessment framework, which provides a strong model for Lagos.

The future of Lagos as a mega-city requires comprehensive and integrated approach that will minimize the impacts of flooding. This focus needs to include better urban development and planning systems, enforcement of environmental and planning regulations, and re-evaluation of the existing drainage system to determine their ability in-terms of size to reduce flooding. Also, there is a need for new systems to gather rainfall data (e.g. to understand better the cycle of flood occurrences), and for teaching local people about the risks of indiscriminate refuse and solid waste dumping into drainages. Equally, the role of the federal government in funding and participation in the ecosystem initiatives would ensure the implementation of new solutions to manage better flood threats.

Finally, further research is required or better flood modelling data to produce a flood hazards map of Lagos. In addition, more research focus is needed to analyze impacts and to produce an urban flood vulnerability index map.

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7.0 APPENDIX

MONTHLY RAINFALL (MILLIMETRES) IN VICTORIA ISLAND LAGOS (1990-2005)												
	January	February	March	April	May	June	July	August	September	October	November	December
1990	10.6	4.9	TR	131.8	84.3	446.3	532.8	33.3	274.8	169.4	94.3	62
1991	3.1	20.4	111.8	264.2	212.4	389.7	358.1	45.2	269.7	84.7	2.7	TR
1992	TR	TR	22.4	51.5	139.7	270.3	202.9	22.9	246.5	77.6	30.2	13.7
1993	0.7	27.1	28.1	87.5	171.3	280	91.4	26.5	96.6	127.2	108.6	19.4
1994	18.6	14.1	79.3	43.4	161.7	209.3	34.7	39.2	241	212.3	20.5	8
1995	TR	64	63.7	97.9	146.8	343.1	108.6	139.3	149.9	197.9	48.3	4.7
1996	4.8	25.4	109.8	135.2	293.3	599.5	401.3	206.3	135.4	166.6	36.5	10.2
1997	1.2	TR	170.2	227.5	348.4	454.6	145	31.7	221.5	183.7	65.3	14.3
1998	8.2	7.7	43.1	87.1	106.4	48.8	30.4	16.5	55.5	236	33.7	16.7
1999	TR	29.1	113.9	364.5	92.3	250.7	334	109.1	161.2	183.1	141.8	5.9
2000	6.2	0.6	9	80.7	181.9	198.9	126.7	98.3	444.1	120.2	4.5	2.2
2001	46.8	14.1	74.7	216.5	111.8	271.2	176.8	31.3	174.2	154.6	70.6	TR
2002	64.6	44	76.5	159.5	221.9	372.1	296	85.3	189.1	245.8	30.4	49.2
2003	74.8	16.7	17	244.1	208.6	383	101.7	34	160.5	139.9	152.5	0.6
2004	142.3	86.6	58.8	177.4	310.5	709.6	64.9	44.1	387.1	233.1	92.9	13.8
2005	TR	151.3	90	246.9	336.6	526.7	461.7	48.5	122.2	134.4	26.5	4.5
Mean Total Rainfall (mm)	31.825	36.14286	71.22	163.5	195.49	359.6	216.7	63.2188	208.08125	166.66	59.95625	16.08571

SOURCE: *Nigerian Metrological Agency (NIMET) Lagos, Marine*. TR: Trace (not measurable)

The Untold story of Palms Bay Estate. Abijo GRA. Ibeju Lekki. Lagos. Nigeria
https://www.youtube.com/watch?v=WtaYPylkj1U

Flood in Victoria Island and Lekki axis
https://www.youtube.com/watch?v=ucKVzTBkoZM

Lagos Flooding: The Deplorable State Of Mushin Olosa, Ikeja Roads
https://www.youtube.com/watch?v=zUZdvtQecfw

Lagos Flood

https://www.youtube.com/watch?v=v9bAhXcpgWE

Rainy day in Lagos

https://www.youtube.com/watch?v=40QNgHXTzVM