Evaluating the Impacts of Flooding on the Residents of Lagos, Nigeria

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Abstract

Globally, flooding is one of the most common environmental hazards resulting in property damage and destruction, population displacement, disruption to day-to-day life, illness and fatalities. Lagos is the most populous city in Nigeria as well as Africa with over 20 million inhabitants and this population has been projected to rapidly increase in the future. The increase in the frequency and severity of flood events in Lagos, therefore, emphasises the need for better flood management practices.

The aim of this thesis is to assess the current flood situation and flood management in five areas of Lagos: Ikeja, Ikorodu, Lekki, Surulere and Victoria Island. A questionnaire survey was conducted with residents in all five areas which differed in population density and income level in order to understand their perception of the flood problem as well as their experiences of flooding. Flood managers were also interviewed in order to better understand the flood management situation from the perspective of the government officials. Daily precipitation data for Ikeja and Victoria Island stations from 1981 to 2015 were analyzed to determine seasonality and identify whether there have been changes to rainfall characteristics leading to flooding including changing seasonality, frequency and intensity of rainfall.

Results revealed overall about 79% of the respondents across the five areas had experienced flooding while living in Lagos. Of which 65% of respondents in Lekki, 61% in Ikorodu, 60% in Victoria Island, 59% in Surulere and 54% in Ikeja had experienced flooding in their current property. Areas such as Lekki and Victoria Island, although, high-income areas in Lagos, are characterized with rapid and unplanned development like Ikorodu, a low-income area. They are low-lying and as such flood-prone especially as the right flood defence measures are lacking. Despite this, Lekki and Victoria Island remain a well sought-after area.

Respondents also revealed health problems, displacement, property damage and disruption to movement as the impacts of flooding experienced. Overall, more men suffered flood impacts compared to women. Location did not have an impact on the flood impacts experienced. Residents believed heavy rainfall was the main cause of flooding in all five areas. Similarly, the flood managers believed heavy rainfall was responsible for the frequent cause of flooding but proposed factors such as increased urbanization, development on floodplains, blocked drainages contribute to the issue of flooding in Lagos. The rainfall data results did not show there had been an increase in the amount of precipitation, there was also no significant relationship between annual and seasonal rainfall with flood events.

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Dedication

To my Dad, Mr Celestine Chukwuemeka Atufu for your constant love and support.

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CHAPTER 1 INTRODUCTION

1.1 Background

Flooding has been identified as the most common of the global natural disasters between 1980 and 2011 (Surminski and Oramas-Dorta, 2014), and it is expected that future climate change will lead to increased flood risk (Tabari, 2020). The risk of flooding has been projected to increase not just due to climate change but also due to an expansion of urban areas and infrastructure. It is therefore essential to develop a better understanding of the impacts of and responses to flooding especially given the growth in the global urban population (Waghwala and Agnihotri, 2019). The United Nations (2018) has suggested that globally, the urban population will rise from 3.6 billion in 2011 to 6.7 billion by 2050.

The increase in the urban population is expected to increase future flood exposure especially in developing countries. The impacts of weather disasters such as flooding have and will be experienced by various populations due to unpredictable seasons (Adelekan, 2016; Tambo, 2016). Although susceptibility to natural disasters is a global issue, developing countries are more vulnerable. Nicholls *et al*., (2007) estimated about 800 million people are currently living in flood-prone areas within developing countries, of whom approximately 70 million experience flooding on an annual basis (Surminski and Oramas-Dorta, 2014).

Mirza (2003) suggested that Africa is likely to experience increasing flood events which could subsequently affect water systems, infrastructure, health and constrain and undermine development. For developing countries, adaptation to flooding will depend on each country's preventive measures well as their future development plans (Mirza, 2003). Nigeria is one of these developing countries that has become increasingly vulnerable to flooding. Between 2009 to 2013, Nigeria experienced impacts from natural disaster events with inadequate infrastructure, conditions of poverty, lack of information about disaster risks and poor housing reported to exacerbate the impacts (Daramola et al., 2016).

Between 1980 to 2013, global economic losses due to flooding was estimated to be over $1 trillion rising to over $20 trillion by 2100 if no flood prevention action, such as decreasing impervious surfaces, maintaining drainage systems, refurbishing structural defences that have become unresponsive over time is taken (Berndtsson *et al*., 2019). The socio-economic development of countries with inadequate drainage systems has been affected by flood events, and with the rise of urbanisation and increasing frequency of flooding, there is also an expected increase in the impacts flooding will have on the residents of these countries (Waghwala and Agnihotri, 2019).

This research focuses on Lagos, Nigeria, a state which has seen an increase in the flood frequency and severity over recent decades. Lagos was the Federal Capital of Nigeria following the amalgamation of several states in 1914 and remained the capital after the country achieved independence in 1960 until 1991 when the capital moved to the more centrally located Abuja (Oduwaye, 2013). The National Bureau of Statistics reported that the Internally Generated Revenue of Lagos increased from over $30 billion in 2010to $35 billion in 2012. Lagos is a coastal state on the Atlantic Ocean coastline of south-western Nigeria and it is a major seaport for the country, accounting for over 80% of the nation's sea transport as well as over 70% of Nigerian air traffic. It is also known as the commercial, industrial and business hub of the country, contributing over $80 billion representing 35% to the national GDP in 2010 (Elias and Omojola, 2015) and just over 60% of the GDP of the non-oil sector of the nation (Adelekan, 2016). Lagos is the most populous state in Nigeria with over 20 million people (National Population Commission, 2016). The UN has suggested that by 2025, the population of Lagos will have risen to 25 million, thereby becoming the third largest megacity on the planet (Elias and Omojola, 2015). The observed significant rapid population growth (Table 1.1) has put a strain on resources and infrastructure and as a result over 70% of the residents of Lagos have been reported as being poor and mainly inhabiting slums in the city (Adelekan, 2016). The State is reported to have over 100 slum communities (Elias and Omojola, 2015). Lagos State is also expected to be the fifth most vulnerable to extreme weather events by 2070 (Nicholls *et al.*, 2007).

Table 1.1: Population (millions) of Lagos, Nigeria from 1960–2015

Year	Population
1960	0.07
1970	2.05
1980	4.38
1990	7.74
2000	13.40
2006	17.60
2010	19.80
2015	23.04

Source: Elias and Omojola, 2015

Lagos has been unable to match the rapid population growth and accompanying urbanisation with the expansion and enhancement of drainage and flood protection infrastructure to mitigate and prevent the recurrent flood problem (Adelekan and Asiyanbi, 2016). Also, due to the high population concentration in Africa, coastal cities like Lagos are highly susceptible to the effects of changing climate due to lack of preparedness and the magnitude of the climatic disasters when they occur (Odunuga *et al*., 2014).

1.2 The Flood Problem in Lagos

According to the Federal Ministry of Environment (FME) (2012), Lagos is one of the few locations in Nigeria with an increasing flood frequency (Nkwunonwo *et al*, 2016). 1947 is the earliest available record of flooding in Lagos when the city was just a small coastal settlement (Daily Times, 1947). Over the years, the occurrence of flood events has changed with a shift towards an increase in their frequency (Odunuga 2008; Adelekan, 2010). Since the 1960s, Lagos has become increasingly susceptible to various types of flooding, though pluvial flooding has accounted for most of the major flood events in Lagos (Olajuyigbe *et al*., 2012). The spatial magnitude and frequency of flooding in Lagos has increased (Fig. 1.1) in intensity and severity as evidenced by flood impacts since the year 2000 by being an annual occurrence during the rainy seasons, to more than once a year due to heavy rainfall and storm surges with both the mainland and coastal areas of the city affected by flooding during rainy season (Nkwunonwo *et al*, 2016; Adelekan, 2016).

Recently, significant flooding occurred in 2010, 2011 and 2012. The 2010 flood in Ikorodu, a flood prone area in Lagos, caused severe impacts after water was released from the Oyan Dam into the Ogun River to prevent overtopping, but this water subsequently flooded the area. In July 2011, 25 people died and over 5000 people were displaced from their homes after 17 hours of rainfall during which 230mm of rain fell, a value more commonly expected over an entire month (IFRC, 2011). During 2011, flooding in Lagos resulted in the Nigerian industry experiencing financial losses estimated at NGN30 billion (USD200 million), this however, does not account for the cost of damage to property and uninsured items. Another extreme flood occurred in June 2012 after precipitation of 200mm resulting in severe disruption and the death of 7 people (Adelekan, 2016).

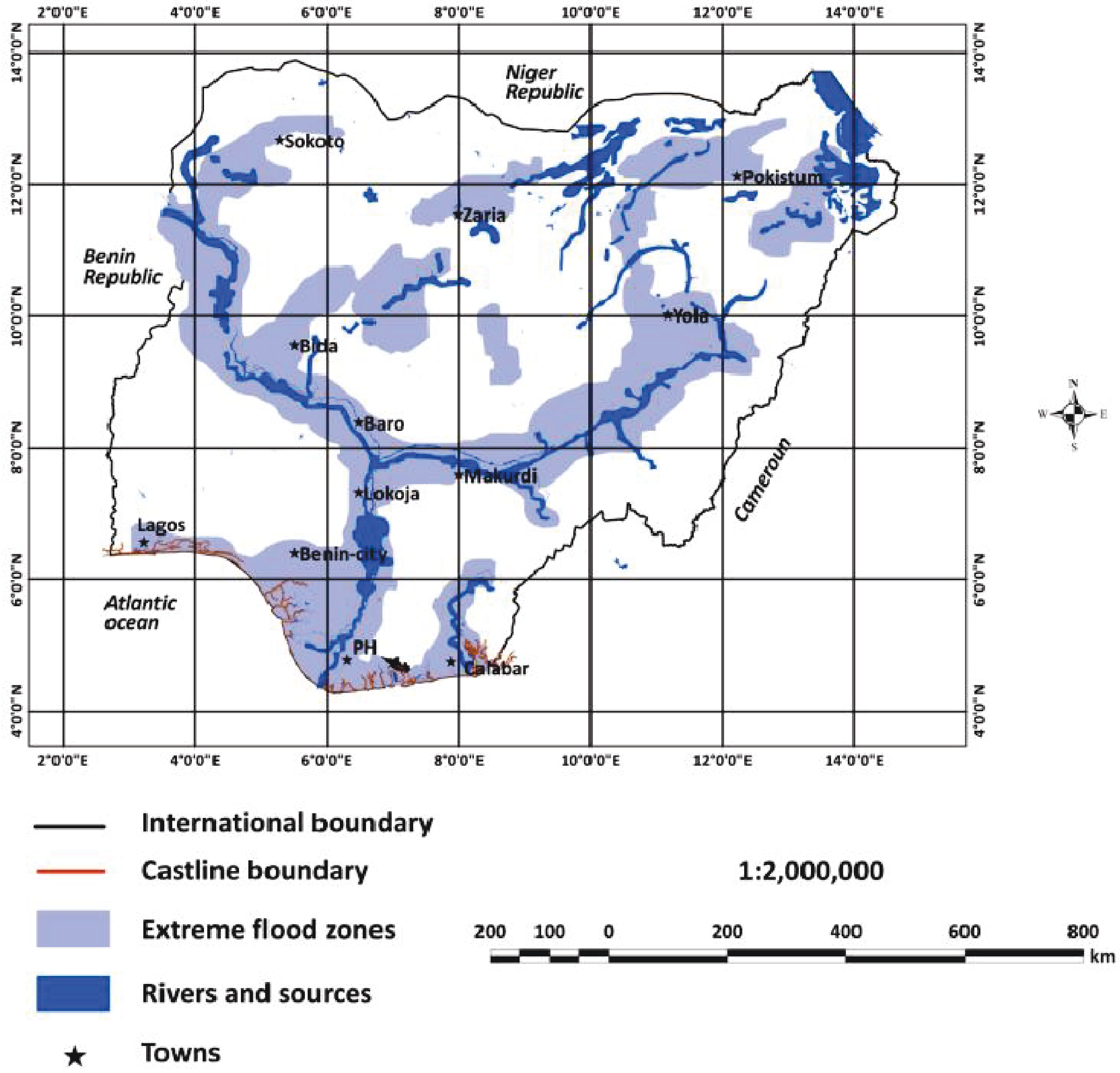


Figure 1.1: Spatial distribution of areas affected by flooding in Nigeria between 2000 - 2012
Source: Nkwunonwo *et al*., (2016)

Increased impervious surfaces due to urbanisation which become overwhelmed during heavy rainfall events, poorly maintained drainage systems and blocked drainages have been highlighted as the main elements which exacerbate flood risk in Lagos (Nkwunonwo *et al*., 2019). Decreasing permeability can therefore play a huge impact. In Houston, Texas, a 50% rise in population led to an increase of about 20% impervious surfaces, giving rise to about 10% more households experiencing flooding (Berndtsson *et al*., 2019). The Longhua Basin of China has seen rapid expansion resulting to over 60% of the land becoming impervious in the last 30 years; this has led to increased flood risk (Du et al., 2015). The rapid urbanisation in Accra, Ghana which has led to increased impervious surfaces has also been attributed as a main contributor of the increased flood events experienced in the city (Amoako and Boamah, 2015). The increasing pervasiveness of urban flooding has had severe impacts on the population and infrastructure, specifically domestic dwellings, commercial and industrial sectors as well as transport systems in Lagos (Nkwunonwo *et al*., 2019). There has also been increased flood frequency due to natural factors and from anthropogenic factors such as lack of or inadequate drainage systems, indiscriminate dumping of waste and ineffective land use planning (Adeloye and Rustum, 2011; Adelekan, 2016) . The understanding of the causes and impacts of flooding is of greater importance to flood risk management and sustainable urban development (Nkwunonwo *et al*., 2019).

Due to the varied adverse impacts on public health, society and economy, flooding has been identified as one of the main concerns for Lagos. The city's characteristics such as its high population, low-lying topography, inadequate drainage systems and network of rivers combine to heighten the risk to different types of flooding. Other characteristics such as the social vulnerability of residents, level of economic activity and the high concentration of infrastructure in low-lying parts of Lagos means flooding could pose a severe threat to sections of the population as well as the local, regional and national economies, (Adelekan, 2016).

1.3 Rationale

Lagos is a suitable location from which to evaluate the impact of flooding on residents of an urban environment as there has been an increase in the frequency and severity of flooding over the years. Also, the city's growing population has made flood preparedness and management a priority (Daramola *et al*., 2016; Elias and Omojola, 2015) since flood defences and prevention measures are currently incapable of managing or mitigating the hazard in Lagos. The focus of flooding in Lagos is driven by the city's dense concentration of urban infrastructure and a growing population. These factors have led to a need for better flood management practices (Adelekan, 2016). Flooding between 2009 and 2013 demonstrated that current flood management strategies are inadequate to the task. Lack of information for affected communities and inadequate flood management infrastructure have enhanced the risks from flooding (Daramola *et al*., 2016).

In the wider context, the capability of public agencies such as The National Emergency Management Agency (NEMA) and the State Emergency Management Agency (SEMA) responses to flooding have also come into question. This is compounded by inadequate funding for planning and flood prevention. Both NEMA and SEMA are responsible for rescue, relief and relocation at national and local levels. However, residents have felt it necessary to take responsibility themselves since they have in some cases, failed to get the relief necessary, or received inadequate relief or reported that the relief came too late thereby making changes to resilience difficult or unattainable (Daramola *et al*., 2016). According to (Adekola and Lamond, 2018), flood management in Nigeria can been described as reactive after flood impacts have been experienced, there is therefore a need for the adoption of more proactive measures to help minimise and prevent the impacts of future flooding (Oshodi, 2013).

Examining historical flooding in Lagos also presents the need to understand the management of flooding in Lagos by evaluating past flood occurrences and its impacts taking into account factors affecting flood risk, putting into perspective what the increase in current and future flood risk means for the increased and increasing population of Lagos. It seeks to provide recommendations and find where challenges exist, in order to reduce flood risk and alleviate impacts of flooding in the city.

1.4 Aims and Objectives

AIM ONE

- To identify residents' experiences during and after flooding and understanding whether changes in flood experience has changed or influenced future flood behaviour.

Objectives:

- To use questionnaires to determine the different experiences and attitudes of residents during floods and to identify factors that might make their experiences different such as identifying residents and areas that are more vulnerable.
- To understand residents' response to flood events experienced, whether or not and how they cope and recover during and flood events in Lagos, Nigeria.

AIM TWO

- To assess flood management measures in place and some of its issues such as drivers and barriers in the different areas chosen for the research in Lagos, Nigeria.

Objectives:

- To identify factors that facilitate or challenges that prevent the implementation of flood management plans and assessing whether residents' responses in terms of flood resilience and management plans compare or contrast to what the flood officials promise or deliver in the different locations in Lagos, Nigeria.
- Evaluating variance in the different flood management/defence strategies as well as in the drivers and barriers to flood management in the different locations in Lagos, Nigeria.

AIM THREE

- To statistically analyse river flow and precipitation data over 50 years in Lagos, Nigeria for patterns such as changing seasonality of rainfall events, increase in intensity and frequency of rainfall.

Objectives:

- To analyse rainfall distribution for changing seasonality over the years from the data gathered in Lagos, Nigeria.
- To assess rainfall data for changes such as increased intensity and frequency of floods from trends within the data and for changes in river flow data.
- To assess rainfall data and river flow data to identify relationships with flood events from trends within the data over the years.

AIM FOUR

- Use a mixed-method approach to bridge the gap between the flood situation in the five areas in Lagos, the perception of the flood problem and potential solutions by the flood managers, and the flood experience and perception of the residents.
- Objectives:
- To assess data collected from residents and flood officials for similarities relate their perception of changes to precipitation against the historical record.
- Draw conclusions and lessons learned from analysis of data gathered in order to make recommendations for future work.

1.5 Contributions to Gaps in Wider Research on Flooding

Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods (Field et al., 2012). This research focused on fluvial and pluvial floods.

It has been reported that a change in climate will have an impact of the water cycle and how it affects the environment in the form of extreme weather events, one of which is flooding (Pachauri et al., 2014). The fifth assessment report published by the Intergovernmental Panel on Climate Change (IPCC) in 2014 suggested that the risk of flooding will be greater for the vulnerable who lack capable services and infrastructure to protect them from the impacts of flooding (Pachauri et al., 2014). It was also determined that flooding accounts for the largest proportion of casualties and property damage recorded globally with economic losses rising to over 200 billion US dollars in 2010 (Field et al., 2012). While flooding can produce positive impacts for water dependent structures such as in agriculture, it has also resulted in severe negative impacts for people, society and properties globally. Therefore, better knowledge and management is crucial towards reducing flood risk (Nkwunonwo et al., 2015).

An important area not widely investigated is the impacts of floods on the different social classes and welfare, especially gender (Sultana, 2010; Hudson et al., 2019). Gender has differing flood impacts and as such a gender-based flood risk and resilience gap exists (Hudson et al., 2019). Reportedly, women are significant in adaptation as they play more important roles in managing food security and ecosystems during and after flood events (Nellemann et al., 2011). While this is useful, examining how flood impacts gender differently will aid better flood risk management (Hudson et al., 2019). There is a dearth of resources on how flood impacts gender in Lagos and Nigeria. Adelekan (2010), Olajuyigbe et al., (2012), Ajibade et al., (2013) and Nkwunonwo et al., (2015) have however looked at the varied social implications of flooding in Lagos. Ajaero (2017) examined gender perspectives on how the devastating 2012 floods impacted household food security in the rural Anambra state of Nigeria, which revealed women struggled to cope when compared to men. Enete et al., (2016) also examined how flooding led to agricultural loss for farm households from a gender-based perspective, also in Anambra state, Nigeria which also showed resilience was harder for women compared to men due to limited education. Nkwunonwo (2017) concluded that gender variation had a significant impact on the social vulnerability index, revealing men were less vulnerable compared to women in the Alimosho, Agege, and Kosofe areas of Lagos, Nigeria. However, another study showed that while flood impacts suffered by women in low-income households were significantly higher when compared to other social groups of both men and women, women generally reported lower concern on the impacts of flooding when compared to men (Ajibade et al., 2013). Examining gendered differences of flood impacts in this research will add to the research already available as well as aid in the transfer of knowledge towards better understanding flood risk management. With the increasing development of urban areas, surfaces are becoming more impervious, giving rise to more frequent urban flooding (Jha et al., 2012). Examining how floods are managed is therefore useful given the observed population rise in urban areas since the United Nations Department of Economic and Social Affairs has reported that almost 70% of the world's population will live in urban areas by 2050 compared to the proportion of 55% reported in 2018 (UN DESA, 2018). It was reported that the high population of people living in urban areas made the impacts of flooding significant in the 2007 floods in England and Wales, the Pakistan floods of 2010 and the Chennai floods in 2015 (Chen et al., 2009). The flooding of 2007 which affected over 20 countries such as Togo, Niger, Ethiopia, Burkina Faso, Uganda and Mali resulted in displacement of over 1 million people and more than 500 fatalities. Despite the severe impacts suffered from flooding such as fatalities, property damage and economic losses in developing countries, effectively assessing and managing flood risk continues to be limited by the scarcity of available flood data (Domeneghetti et al., 2013; Egbinola et al., 2015, Nkwunonwo et al., 2015). With flooding reportedly an annual event for Lagos in the rainy season, Lagos, Nigeria is one of the many states of Nigeria with insufficient flood and flood management data despite the state being a major economic hub of the country (Nkwunonwo et al., 2015).

With the background of this research focused on flood management, this research intended to contribute to the current knowledge of flooding and flood management in Lagos, Nigeria. From a general overview, achieving this required an extensive evaluation of flooding and flood management in not just Lagos and Nigeria, a developing country but also in the developed world. The below have therefore been gathered as useful areas to explore for this research:

1. Evaluating the relationship between individuals' perception of changing climate and what is evidenced by the precipitation record.
2. Degree to which vulnerability to flooding and responses to flooding are affected by gender and socio-economic status.
3. Analysing Lagos' precipitation data for changes in rainfall characteristics and intensity of rainfall events.
4. Identifying the barriers to effective flood management and resilience in Lagos.

CHAPTER 2 LITERATURE REVIEW

2.1 Flooding - Background

The world's largest natural disasters have been caused by water, with flooding being the most common (Kron, 2015). Over exploitation of natural resources as a result of rising population and poverty has led to more people living in floodplains (Loth et al., 2006). Although flooding has been reported to sustain ecosystems, they can also cause devastating impacts on people and the society resulting in significant losses in both life and on a socio-economic scale. During 2015, flooding resulted in over 3000 deaths around the globe (Table 2.1) (IFRC, 2016).

Table 2.1: Global Number of Reported Deaths by Some Natural Disasters (2006–2015)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Earthquakes including tsunamis	6,692	780	87,918	1,893	226,733	20,946	711	1,120	773	9,526	357,092
Storms	4,329	6,035	140,985	3,287	1,564	3,103	3,105	8,603	1,424	1,260	173,695
Extreme Temperatures	5,104	1,044	1,608	1,212	57,064	806	1,674	1,982	1,168	7,418	79,080
Floods including waves and surges	5,845	8,565	4,026	3,581	8,481	6,151	3,577	9,819	3,574	3,408	57,027
Droughts including food insecurities	208	-	6	2	10,000	10,000	-	-	-	35	20,251
Landslides	1,638	271	504	649	3,427	309	501	236	943	1,000	9,477

Source: Adapted from IFRC, 2016

Over the last decade, countries over the world have recorded more intense and severe floods yearly. In 2010, China recorded a loss of over 50 billion US dollars due to river flooding. USA and Thailand were affected in 2011 by several river flood events which exposed how flood preparedness determines severity of the impacts of flooding (Kron, 2015) as effective flood protection was lacking. Globally, floods have been categorized as the most common type of natural disaster, and over more than 10 years ago, accounted for about 53,000 deaths from 2004-2011 (Alderman et al., 2012). Casualties have been recorded over the years globally (Table 2.2) over the world. 2012 was characterized by "killer floods" were over 50 people died in countries such as Nigeria, Madagascar, Bangladesh, India, the Philippines, Russia, Argentina, Haiti and the United States Kundzewicz et al., 2014). Globally, 2013 was recorded as a year with devastating floods where fatalities and property losses were reported in Colorado (USA), Canada, Australia. These developed countries are not unique in their experience of flooding since in the same year, developing countries were also affected such as China, India, Mexico, Philippines, Bangladesh, Nepal, Mozambique and Zimbabwe (Dewan, 2015; Kron, 2015).

Table 2.2: Flood casualties over time in different regions of the world

Year	Locations	Casualties
1978	India	3800 deaths and 32 million affected
1980	China	6200 deaths and 67000 affected
1988	Afghanistan	6345 deaths and over 160000 affected
1998	China	3656 deaths and over 238 million affected
1999	Venezuela	30000 deaths and over 480000 affected
2004	India	2200 deaths
2004	Nepal	Over 2000 deaths
2004	Bangladesh	Over 2000 deaths
2004	Haiti	2000 deaths
2004	Dominican Republic	2000 deaths
2007	Bangladesh	Over 2000 deaths
2007	India	2030 deaths
2007	Nepal	Over 2000 deaths
2010	Indus Basin, Pakistan	20 million affected, 1760 deaths
2010	Dadeldhura, Nepal	98 deaths, 39000 affected and 8 missing
2012	Nigeria	173 deaths, over 130000 affected
2012	Ghana	2491 deaths
2012	Senegal	19 deaths, over 287000 affected
2012	Cameroon	14 deaths and over 29000 affected
2012	Niger	81 deaths and over 527000 affected
2013	Uttarkhand, India	6500 deaths
2013	Colorado, USA	8 deaths, 6 missing
2014	Balkans Flood	37 deaths, over 10000 displaced
2019	Ethiopia	23 deaths, 570000 affected
2019	Central African Republic	100000 affected
2019	Kenya	120 deaths and 160000 affected

Adapted from: (Kron, 2015; OCHA, 2012; Jonkman, 2005; Dewan, 2015; OCHA, 2019)

Flood disasters and impacts would appear to have increased; however, it has been suggested that this is due to better and improved reporting over time, increased urbanization in flood prone areas without capable drainage systems, a rise in population and inadequate awareness of flood risk (Kundzewicz et al., 2014). More than 3700 flood events from 1985-2010 (Fig 2.1) indicated less flood events in the arid and mountainous regions but also in areas of low population density, which could be a consequence of a lack of reporting. (Kundzewicz et al., 2014).

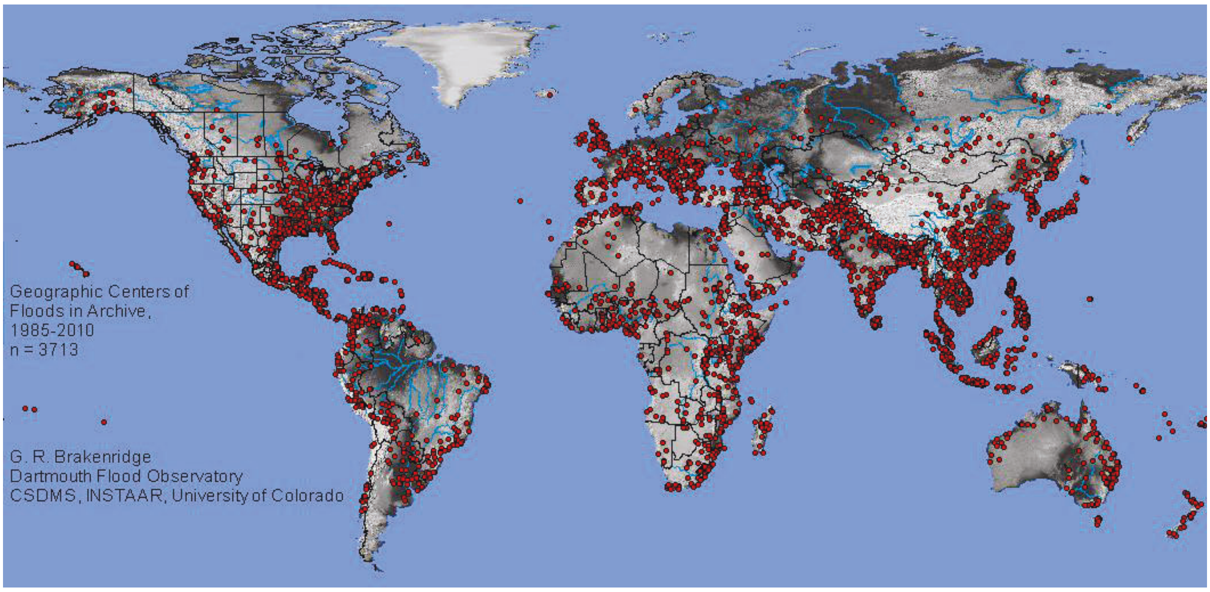


Figure 2.1: Areas affected by large floods from the Dartmouth Flood Observatory archive (1985–2010)
Source: Brakenridge (2010)

Flood risk which is a result of the hazard and exposure has been projected to rise in the future and so it is essential to understand the characteristics of flooding in a bid to better manage flooding (Schumann et al., 2016).

2.2 Characteristics of Flooding

The different characteristics of the climate affects floods, the most important being rainfall with characteristics such as amount, phase (snow or rain), duration and intensity as these determine magnitude and impact of the flood event. Patterns of temperature which accounts for formation of ice jam, snow and ice melt and soil freezing also affect floods. Other characteristics include soil permeability, condition of drainage systems, rate of urbanization, proximity to the sea and sea level and presence of dams, dikes and reservoirs (Kundzewicz et al., 2014).

Douben (2006) suggested that the ability to manage flooding accounted for the longer flood duration observed in developing countries in South America Africa and Asia when compared to the developed countries.

2.2.1 Area Characteristics

Socio-economic, climatic and geophysical factors play huge roles in assessing vulnerability and impacts of flooding. Land use and planning, population density, emergency and warning systems, flood protection and management are factors that influence impacts of flooding. While insufficient resources limits flood protection measures, previous flood experience and a strong capacity to cope could make communities in developing countries more flood resilient than developed countries (Jonkman, 2005).

The catchment areas of the Otamiri (Nekede) and Oramiriukwa (Ulakwo) rivers in Imo State, Nigeria were examined and most of the land cover for both areas have been changed from the original vegetation cover over time (Ezemonye and Emeribe, 2011). However, Nekede which had experienced a higher rate of development had a higher discharge volume at 266.3m3/sec compared to 90.5m3/sec for Ulakwo community both observed in August due to lesser soil permeability and resulting in higher probability of flooding for Nekede (Ezemonye and Emeribe, 2011).

2.2.2 Flood Characteristics

The physical characteristics of a flood event will affect people and lead to casualties such as loss of lives, damage and loss of property, damage to infrastructure, health issues and displacement. These factors also determine the type of flood experienced, they include distribution and amount of precipitation, water depth, level of waters rising, velocity of flow etc. Since the types and causes of flooding can be inter-dependent, for example, tsunamis, storm surges and tidal waves could lead to coastal flooding and heavy rainfall could cause riverbanks to become overwhelmed, classifying the types of flooding can sometimes be challenging to distinguish (Jonkman, 2005). More developed countries have more established flood warning and forecasting systems compared to developing countries which are important in preparedness and protection against flooding. Although the impacts of flooding have been suggested to be higher for developing countries, the developed countries are not immune as seen in recorded flood events across the United States and Europe (Douben, 2006).

Over 80% of all of the 284 hurricanes which struck the United States mainland between 1985 to 2010 has been suggested as being accountable for the high number of the monthly flood fatalities recorded in the contiguous United States from 1959 to 2019 (Han and Sharif, 2021). The physical characteristics of floods were examined for the Otamiri and Oramiriukwa rivers in Imo State, Nigeria and it was determined that higher magnitude of flooding was identified at the start but then reduced at the end of the rainy season (May to October) (Ezemonye and Emeribe, 2011).

2.3 Flood Risk

Risk simply is defined as potential damages from a hazard multiplied by the probability of the hazard's occurrence (Baker, 2007). Flood risk involves a combination of the likelihood of flood occurrence and the magnitude of the potential impacts of the flood event. The higher the probability and the greater the flood impacts, the higher the flood risk (Lamond et al., 2017).

The risk of any hazardous event has always been defined in terms of the probability of the hazard and the impacts of the hazard from a technical perspective. However, it has been suggested that the social perspective of the risk posed by a hazardous event should also be considered (Adelekan and Asiyanbi, 2016; Lavell et al., 2012). This is important because for any hazardous event, which is made worse by the physical occurrence and effects suffered as a result of the event, it is fundamentally a social construction from social choice, constraints and societal action (low confidence) or inaction (high confidence) which in turn translates to understanding of the idea of any hazard, exposure, vulnerability, risk, coping and resilience (Lavell et al., 2012).

Analysing risk technically is limited as it does not reflect the broader concept of risk and the social dimensions of risk experience. Therefore, rather than just considering vulnerability and likelihood of the hazard, exposure should also be taken into account as it gives a broader understanding of the event and risks associated (Adelekan and Asiyanbi, 2016). Exposure is defined by the assets, livelihoods, activities and people in a location that is hazard prone suggesting that if certain elements such as issues of land use change and planning, high population and limited economic resources were not present in certain locations then the potential risk of the event when it occurs will not exist (Cardona et al., 2012) while vulnerability is the susceptibility of people in a hazard prone area to be adversely affected from the event (Cardona et al., 2012).

Baker (2007) suggested that floods can be defined depending on perception by two labels: common-sense perception and "act of God" perception. The common-sense view defines floods as damaging excesses of water that lead to impacts such as property damage while hydrologists define floods as water flows specified by technical measures of magnitude and frequency. The "act of God" label which is commonly attached to flood events globally suggests a natural or divine cause implying that people have no responsibility or control over flood occurrence, while carrying on detrimental activities such as development on floodplains. Examining flooding in these different ways helps it assume meaning for people, for example, according to perception and despite awareness of flood risk, people could choose to carry out measures that alleviate future flood risk or not (Baker, 2007). It has been reported that although floods lead to immediate and long-term impacts across individual households to communities, the perception of risk does not equate to rational behaviours towards future flood prevention (McEwen et al., 2018).

2.4 Vulnerability

Vulnerability can be defined as the degree to which a system is susceptible to, and or is unable to cope with, adverse effects and changes in the environment (Schneider *et al*., 2007). Vulnerability is a function of sensitivity, exposure and adaptability (Parry et al., 2007). Vulnerability itself depends on two main factors: the hazard and the capacity to cope with the adverse effects (Linnekamp *et al*., 2011).

It has been reported that deaths, property loss and impacts on economies have been experienced and will be experienced from floods and as a result, understanding flood vulnerability and risk is very important (Lee *et al*., 2014). Identifying flood vulnerabilities in terms of areas and populations help in reducing and preventing the impacts of certain events such as flooding. Vulnerability to certain events have been projected to increase due to climate change, mostly anthropogenic in nature which would cause increased mortality rates, increased intensity and frequency of extreme events such as precipitation and storm surges and other events such as melting glaciers (Schneider *et al*., 2007).

Vulnerability is very important in achieving better flood management as it determines the impact of the disaster (Adeagbo et al., 2016). Therefore, the overall investment in flood defence measures is an important aspect of managing floods, however, these need to be continuously monitored and improved on. Investing in flood defence measures which manages flood risk will ensure people, infrastructure, properties and the environment are protected from flooding (Tapsell et al., 2002). Since flood risk is a product of vulnerability (Fig 2.2) it is important to also consider the other dynamics associated with flood risk. Eliminating one or more of these dynamics reduces or prevents flood risk (Kazmierczak and Cavan, 2011).

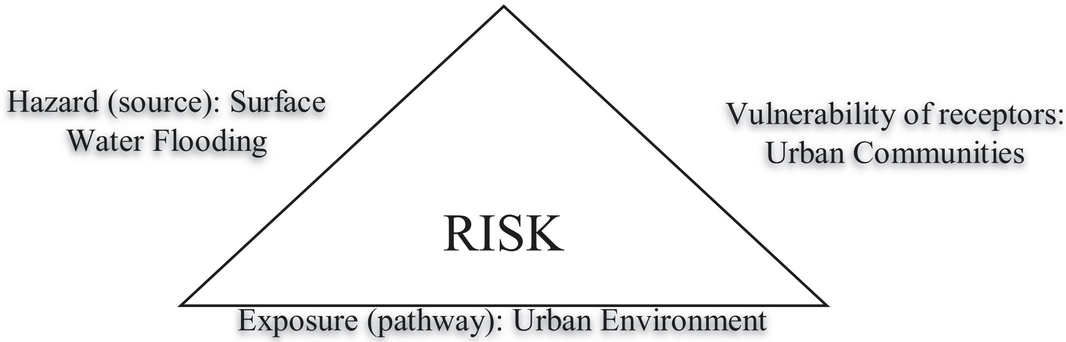


Figure 2.2: Flood Risk Triangle

Source: (Kazmierczak and Cavan, 2011)

Globally, there has become a need to improve the understanding of vulnerability to flooding and flood risk as well as development of methods in which these two elements can be better managed as it plays a huge role in minimising flooding and its impacts (Balica et al., 2012).

2.5 TYPES AND IMPACTS OF FLOODING

This research focused on flash flooding and river flooding and as such has been discussed below.

2.5.1 Flash Flooding

Flash flooding is the most common type of flooding usually caused by heavy rainfall (Tschakert et al., 2009) and can also occur from the release of water after a levee or dam break (He et al., 2018). Flash flooding is a natural hazard that poses severe life threats and the risk of damage to buildings and infrastructures. This type of flooding occurs when heavy precipitation events last for a prolonged period and sometimes even over a brief period (Etuonovbe, 2011) with severe impact on people, communities and the environment (Kron, 2015). Its potential to cause harm largely depends on the capability of the flood defences to withstand and not become overwhelmed by the amount of precipitation (Casteller et al., 2015).

Flash floods are problematic because they are the most common type of flooding and while they are associated with excessive precipitation, it is the rapidity of the event that makes flash floods dangerous and damaging as it can catch people unaware and unprepared as well as resulting in drowning and severe injuries from the debris-laden waters (Doswell, 2003). This poses significant dangers for people and are responsible for many lives lost each year as there is usually less time available for predicting them (Jonkman, 2005). For example, an estimated 5,000 people lose their lives annually from flash flooding in the Himalayas (Nellemann et al., 2011).

Flash flooding usually occurs from intense local precipitation and is characterized by increased water levels (Queensland Floods Commission of Inquiry, 2012). December 2010 was described as the wettest period in record for Queensland and the second wettest for the whole of Australia after 1917-1918 floods. Between November 2010 to January 2011, Queensland, Australia experienced unusual torrential precipitation (Table 2.3) which led to severe impacts from flash flooding resulting in 33 fatalities and affecting more than 75% of the state's population (Queensland Floods Commission of Inquiry, 2012).

Table 2.3: Four Major Rainfall Events resulting in the Queensland Floods

Dates	Description	Outcome
28/11/2010 - 22/12/2010	A sequence of large-scale precipitation events across Queensland.	Major flooding of rivers across the Southern half of the state.
23/12/2010 – 28/12/2010	A single six-day rainfall event covering almost the entire state.	Flooding in Central and Southern Queensland with Inundation of cities such as Bundaberg Emerald and Rockhampton as well as towns such as Theodore.
10/01/2011 – 12/01/2011	Concentrated rainfall event on the scale of several hundred kilometres occurring directly over several small river basins.	Flooding in Brisbane and Ipswich cities and many other towns.
10/01/2011	Intense rainfall from a thunderstorm complex over several hours directly over a region with steep topography channelling the flow.	Flash floods in Toowoomba and the Lockyer Valley.

Adapted from Australian Government Bureau of Meteorology (2011).

About 1,000 residents in Queensland as well as the entire population of Theodore had to be evacuated after all the buildings except the police station was affected by flash flooding in December 2010 (Fig 2.3) (BBC, 2010). The rivers also had overflown compounding the impacts on the residents. Theodore's river had risen by more than 50cm while that of the city of Bundaberg was expected to reach 750m, 30m higher than the highest recorded level of 1954 (BBC, 2010).

Flash flooding accounts for the main cause of weather-related hazard and deaths with almost 100 lives lost annually (He et., 2018). In July 1997, Fort Collins, Colorado, experienced flooding which caused over 250 million USD property damage, 5 deaths and 62 people hospitalised due to injuries after total precipitation amounted to almost 500 years return frequency (Weaver et al., 2000). The 1976 Big Thompson Canyon flood has been recorded as the most severe flood recorded in Colorado resulting in property damages of 35 million USD, the death over 130 people and more than 400 homes and 50 businesses destroyed (Kim et al., 2014). More recently in September 2013, severe flooding which has been unmatched in the previous 35 years occurred in Boulder Creek, Colorado, USA after heavy rainfall fell (Lukas et al., 2013). The severe

September 2013 flooding in Colorado resulted in the United States President declaring a state of emergency after more than 400mm of precipitation; more than half of the annual total, was recorded which resulted in the collapse of the Louisville County Road bridge, closure of schools and people trapped in creeks and canyons (Kim et al., 2014). Newcastle, United Kingdom experienced flash flooding in June 2012 after heavy rainfall which caused road closures, traffic disruption and closure of most of the public transportation. After intense rainfall in December 2016, more than 15,000 properties became flooded in parts of Cumbria, United Kingdom (Rubinato et al., 2019). Developed countries are not unique in their experience and impacts of flooding as it is believed that developing countries suffer more severe impacts from flooding (Dewan, 2015) with more people leaving in flood prone areas (Kron, 2015).

In China, more than 950 deaths are recorded annually as a result of multiple flash floods making the impacts of flash flooding even more severe especially since over 100 million people live in flood prone areas (Rubinato et al., 2019). China has recorded significant economic losses and casualties as a result of high intensity flash floods (He et al., 2018). Since 1950, China has recorded about 280,000 deaths as well as average annual economic losses of more than 130 billion since 1990 (He et al., 2018). After the 2010 flash flooding reported in Zhouqu County, Gansu Province, about 1765 people were considered dead or missing (Rubinato et al., 2019). More recently in July 2016, 26 provinces of Central and Northern China Experienced flash flooding which affected more than 30 million people (Rubinato et al., 2019). As socio-economic development continues to increase in China, the frequency and magnitude of flash floods and their associated impacts will also increase rapidly over time (He et al., 2018).

El-Sheikh El-Shazli which is a remote town in Eastern desert of Egypt with a population of about 1,500 people who mostly shepherd animals or sell local herbs, coffee and charcoal. However, almost one million people visit the town annually due to it being an important religious festival site. The flash flood in 1996 which affected El-Sheikh El-Shazli resulted in recorded deaths, municipal services were affected and highways disrupted (Gohar and Kondolf, 2017). Significant development has since occurred since 1996 in the form of shrines, guesthouses, housing and service buildings which has led to blocked flash flood flow paths, increasing flood risk as well as exacerbating the magnitude of any potential flood damages (Gohar and Kondolf, 2017).

Heavy rainfall which resulted in flash flooding in south-eastern Tanzania resulting in the death of 13 people, over 18,000 affected, more than 1,000 latrines collapsed and

1,746 houses completely destroyed in January 2020. This event also damaged local services and infrastructures such as roads and schools, destruction of thousands of livelihoods and damage to property and about 495 acres of farmland (Brown, 2020). Flash floods result in significant losses and damages and are considered to be more deadly compared to river floods (Jonkman, 2005).

2.5.2 River Flooding

While flash flooding is rapid which can occur in a single event within hours, river floods are slower, typically occurring over days or months as they occur in large basins consisting of individual rivers such as the Nile and are from many individual rainfall events distributed over several days (Jonkman, 2005; Bucherie et al., 2021). In fact, within one river flood event, several flash flood events can occur (Doswell, 2003). River flooding occurs when a river overflows outside of its capability inundating properties and infrastructures. River flooding can also be followed by a breach of dikes or dams next to the river (Brown, 2020). The flood can be caused by various sources: high precipitation levels, not necessarily in the flooded area, or other causes such as blockage of river flow and melting snow (Jonkman, 2005).

Extreme river flooding occurs in different parts of the world (Tanoue et al., 2016). In the 19th century, the Colorado river flooded twice from heavy winter precipitation in February and the summer's snow melt in June (Cecil-Stephens, 1891). For example, 1890 to 1891 accounted for the wettest winter on the Pacific coast after torrential rainfall over a long period of time resulting in the Colorado River reaching the highest levels of 33 feet and 6 inches in February 1891 recorded at Yuma since 1850. The increased water levels also resulted in New River's water level rising, however, the effects were not observed until the following summer. In June 1891, waters trickled, its volume increasing daily and after two weeks, it was reported that the Indian Wells region of 3,200sqm had been flooded by New River (Cecil-Stephens, 1891).

Before Colorado became a state, floods were recorded in 1826 from the Republican and Arkansas Rivers and since then flood events have been recorded with severe impacts such as loss of properties estimated at 19,000 USD along the Arkansas Valley and 100 deaths recorded in Pueblo in June 1921 after the Arkansas river overflowed (Follansbee and Sawyer, 1948). Historically the 1927 Mississippi River flood remains the most severe flood that has impacted the United States inundating parts of Missouri, Mississippi, Arkansas, Illinois, Louisiana, Kentucky and Tennessee leaving about 27,000sqm underwater which led to more than 135,000 buildings damaged, crops ruined, 250 deaths and the displacement of 700,000 people across the seven affected states (RMSa, 2007). More recently, the 2019 Mississippi and Missouri river flooding have been identified as the longest lasting flood events since the great flood of 1927 resulting in soils remaining wet for three to four months and impacts such as disruption and damage to infrastructure, businesses, homes (Pal et al., 2020). The river flooding also resulted in the loss of over 1 billion USD in manufacturing, navigation and farming (Pal et al., 2020).

In the United Kingdom, some of the most serious flooding occurred in 1947 after deep snow which covered most of the parts of the country melted rapidly, affecting more than thirty of 40 counties over a period of two weeks, displacing tens of thousands of people from their homes and inundating about 700,000 acres of land. The 1947 flooding was caused by rapid melt of the snow as well as additional precipitation from successive southwesterly depressions. Since it was after the Second World War, this period was characterised by rationing and significant post-war deprivation rather than the maintenance of flood defences. At the time, flood insurance did not exist and the economic impacts were not considered to be national but rather local (RMSb, 2007). The 1947 floods which was widespread in the United Kingdom from the Avon River in Somerset to the Medway and Great Stour in Kent, the River Thames inundated parts of west London, in Caversham, Reading, more than 1500 homes were reportedly flooded and the overflow of river Trent in Nottingham resulted in more than 80 factories and 3000 homes becoming inundated was not unique but European countries such as Poland, Spain and Germany were also affected (RMSb, 2007).

Developing and developed countries suffer various impacts as a result of river flooding, a major one being damage to crops and agriculture. In Bangladesh, wheat and rice are primary foods however, a specific rain-fed rice called "Aman" grown in Bangladesh was severely affected after the 1998 floods in Bangladesh. Over 80% of deep water "Aman", 91% of transplanted "Aman" were damaged and lost rendering the country lacking food (Dewan, 2015). Yaere, a northern province in Cameroun which in their local language translates to an area that floods periodically is known for its agricultural benefits. However, after heavy rainfall during the rainy season, the soil becomes impervious, inundating the area. The Logone river also overflowed starting from September and lasted between three to four months with water depths between 0.7m to 1.2m and affecting people from carrying out their farming, cattle grazing and fishing practices (Sighomnou, 2003). After the excessive rainfall at the end of April 2012 which resulted in river flooding in the Tone catchment of Currymoor in England, one of the most adversely affected areas. More than 650ha was flooded for over two weeks with water depth reaching 2.5m in some areas and in less than two weeks, an additional 150ha had become flooded as well (Morris and Brewin, 2014). This affected agricultural grassland for grazing as well as the fish stock from Currymoor and despite the installation of additional pumping capacity, the flood water levels still remained high for more than two weeks making the waters anoxic. When the water levels dropped, pumping of the flood waters also stopped to prevent further damage to the fish stock, this extended the duration of flooding to about 6 weeks (Morris and Brewin, 2014).

2.6 Gender-Related Impacts of Flooding

The increasing number of flood events and impacts experienced over the world is of growing concern. For example, between 1999 to 2008, flooding impacted a significant number of people across the world: 22 million (Africa), 28 million (North and South America), 1 billion (Asia) and 4 million (Europe). More people were affected in Pakistan by the 2010 flood than the collective impact of the 2004 Indian Ocean tsunami, the 2005 Kashmir earthquake and the 2010 Haiti earthquake (Nellemann et al., 2011).

Globally, the factors that make women more vulnerable were grouped in terms of physiological and biological differences: where the gendered codes of dressing in some cultures inhibits movement during extreme flood events and for women who are pregnant, limited access to the hospital during flood events, social norms: which sees women possessing less power in most societies and discrimination in access to resources (Neumayer and Plümper, 2007).

Neumayer and Plümper (2007) suggested that the human impact of flooding is not determined completely by nature but rather dependent on the connectivity of social, economic and cultural factors (Neumayer and Plümper, 2007). Women are more vulnerable to the impacts of flooding than men due to unequal social and cultural norms even more so in developing countries than developed countries (Nellemann et al., 2011). While there is insufficient long-term data that shows women and girls are disproportionately affected by flooding when compared to men as well as inadequate data that shows how flooding is experienced as a gendered event, it is believed that not all women experience disasters such as flooding the same way (Bradshaw and Fordham, 2013).

Bradshaw and Fordham (2013) determined that exploring impacts of disasters such as flooding should include linked themes such as social accessibility and exclusion as well as gender. This is because when gendered impacts are examined, women and children are grouped together without providing further context to better understand how the figures can be better understood. For example, in the 2008 UNICEF UK's 'Our climate, our children, our responsibility' report, women and children accounted for 80% of the 200,000 people who were displaced from their homes during the 2007 floods in Uganda. Whether or not this is representative of the usual population dynamics such as income levels and level of education or if this is an unusually large number, remained unclear (Bradshaw and Fordham, 2013).

Therefore, exploring gendered vulnerability means understanding the reasons why women have lesser access to resources such as education, income and medical which makes adapting and coping with flood risk easier (McDowell et al., 2020) as access to education could mean better awareness on floods and flood protection. Bradshaw and Fordham (2013) found that the roles men and women play in societies is linked to their vulnerability to flooding since women generally have limited access or control over money, assets and how they are managed.

Although men could also become more vulnerable due to the societal expectations of them to be main providers and protectors, women experience more pressures such as domestic responsibilities, productive roles in terms of work and in some cases the responsibility of community engagement (Bradshaw and Fordham, 2013). These roles contribute to their vulnerability often making them time poor and usually generating little and, in some cases, lesser income than men or no income at all which is useful towards flood protection (Bradshaw and Fordham, 2013). In that light, it was determined that in societies with high gender inequalities, women will be more vulnerable than men (Neumayer and Plumper, 2007) in terms of response and recovery from flood events. For example, five times more women than men died after the 1991 cyclone and floods in Bangladesh due to early warning information distributed by men to men in public (Ikeda, 1995).

After the 2010 river floods of Pakistan's Lai Basin, access to information and knowledge of flood early warning systems (EWS) was explored from gendered perspective revealing that bureaucracy prevented the information from reaching the vulnerable groups of people (Mustafa et al., 2015). The Pakistan Meteorological Department (PMD) are responsible for disseminating forecasts and early warnings to minimise impacts. However, it was revealed that the information is first disseminated to the National Disaster Management Authority (NDMA) and then to the provincial secretaries, who ensure it gets to the lowest revenue official known as the '*Patwari*' level of the Pakistan Meteorological Department (PMD). Unfortunately, the information did not go past this level as it was assumed that once the patwari had the information, the warning had been delivered (Mustafa et al., 2015). Furthermore, when it was highlighted that women should be informed as well on the risk of flooding during interviews with government officials, most of the interviewees believed men to be the protectors, with a respondent from the NDMA stating, '*we do not say that the women or children should not be made aware about what is going to happen during flood, but they should all be trained to save themselves along with family in order to support their men and lessen their burden. This will increase the chances of saving more lives, property and livestock etc. In the urban set up this is already in practice'* (Mustafa et al., 2015).

It was observed that 92% of men were aware of the early warning system (EWS) compared to women at 69% in Central Nepal while in East Nepal, 100% of the men were aware of the EWS compared to 61% of women who were aware of the EWS (Brown et al., 2019). There was also a difference in how men and women receive flood warning information. Overall, most men (71%) received their flood warnings from formal sources such as government officials while a larger proportion (51%) of women received their information from informal sources such as neighbours, family members and community members (Brown et al., 2019).

Neumayer and Plumper (2007) suggested that developed countries which have better rights for women meant relatively lesser disparities in gendered impacts of flooding when compared to the developing countries. While the scale of disparities differed between developed and developing countries, developed countries still showed that women were more vulnerable when compared to men. This could be due to access to income and education compared to poorer countries (Bradshaw, 2013) which aid in response and recovery from flooding. For example, more than 16% women compared to about 8% of men reported a lack of awareness due to having lesser information on post-flood actions aimed at reducing risk to their water becoming contaminated after flooding in the developed country of the Republic of Ireland (McDowell et al., 2020). Health impacts of flooding in England showed that for mental stress, women were more affected compared to men with results suggesting that this is due to more women having a greater emotional connection and the main responsibility of their homes, wellbeing and children as well as getting homes back to normal after flooding (Tapsell et al., 2003). More women suffered from post-traumatic stress (Tunstall et al., 2006). In Peru, flood impacts affect women negatively in two ways according to the women. One was economically since their income relied on informal, businesses usually based at their homes in the form of small shops which in the event of flooding are affected by disruption and damages. They also identified severe impacts on their mental health in the form of depression, anxiety and stress associated with displacement. However, these impacts suffered by the women could not be compared to those suffered by men as a result of patriarchal norms which discouraged men from discussing their mental health (Brown et al., 2019).

100% of the male respondents and 91% of the female respondents believed that women were more affected by the negative impacts of flooding when compared to men in Nepal. Men attributed this disparity to lack of physical strength compared to men and perceived vulnerabilities such a menstruation and pregnancy, physical vulnerability and social roles such as caring for the children, the elderly and looking after the home. However, women stated they were more vulnerable due to the restrictive nature of their traditional clothing and the societal norm which prioritised men in making decisions in the occurrence of flood events (Brown et al., 2019). The gender-differentiated impacts of flooding in the Budalangi floodplains of Kenya was analysed and found that women suffered specific impacts from flooding such as: not encouraged to learn to swim thereby increasing mortality rate in the event of flooding, limited movement due to dress codes, where men are the heads of households, women are prohibited from leaving the house without their husbands, lesser education on how to respond and deal with flooding. Others include lesser access to early warning systems, lesser involvement in decision and policy making, loss of food and resources which might make coping difficult and women reported sexual harassment from men who distribute relief food (Mukuna, 2015). A parent at Budalangi primary school stated "*As a woman, I can say floods first of all burden women. They are overburdened with domestic chores in the IDP camps. They have to queue for clean water from the tanks, fetch firewood which in most cases is wet, take care of ailing members of their families, look for food if the relief food delays and in some cases most of the women turn to prostitution so as to provide for their families. You know most of the local leaders are men and they also appoint men to be in charge of relief food. Some of the food* *distributors threaten women that unless they befriend them then they won't get their supplies. This forces some women to become prostitutes during their stay in IDP camps and it increases chances of HIV/AIDS.*" (Mukuna, 2015).

Most of the data available towards quantifying gendered differences of the socio-economic impacts of disaster continue to focus on post-disaster impacts. However, attempts have been made through the use of mixed methods research, with some recommending and making suggestions on key factors that could measure the direct impacts on women before and after flooding (Bradshaw and Fordham, 2013).

Evaluating gendered differences presents another area of focus for reducing flood risk. It is important to note that women also play key roles in the development of sustainable adaptation measures due to the multiple and sometimes simultaneous roles and responsibilities they possess, parts they play in productive spaces as well as their knowledge in areas such as biodiversity, agriculture, income generation, households as well as in socio-cultural and political relations and institutions. Globally women account for about 43% of agriculture's workforce and over 50% in Africa and Asia, hence, important in determining measures for adapting to ensure food security and environmental sustainability from climate related disasters (Nellemann et al., 2011).

2.7 Flood Management

Globally, flood protection remains a major importance (Eijgenraam et al., 2012). Understanding flood risk, a result of the probability and consequences of flooding is useful towards effectively managing flooding (Raadgever et al., 2014).

Flood risk management involves data collection, assessing risk, evaluating options, decision making as well as implementation and reviewal to aid minimising, managing and redistribution of flood risks (Hall et al., 2003). Flood risk management is often fragmented (WMO, 2008) with the different types of flooding examined differently and usually involves different decision makers with their specific objectives (Samuels et al., 2010). Hall et al., (2003) further explained that flood risk will be viewed by a government flood risk manager on a national basis and in terms of improving and minimising impacts on infrastructures, services and natural resources. However, an individual will view flood risk in terms of how it affects them, their family and community in social, environmental, health and economic contexts.

Hall et al., (2003) believed that the flooding systems which involves the physical processes of flooding, people living on floodplains and their infrastructures, individuals and organisations in the private and public sectors vulnerable to flooding and flood impacts, are constantly evolving. This therefore means that the ways in which flood risk will be managed will also change (Hall et al., 2003) and as such a holistic or integrated method of managing flood risk would be more efficient towards managing flooding (Samuels et al., 2010).

Integrated flood risk management identifies the interdependencies between the risk management steps, their analyses, cost and efficacy in a changing environmental, social and economic backdrop (Hall et al., 2003). Integrated flood risk management improves on the flood risk management decisions and processes because it combines multiple players and decision makers across different sectors (WMO 2008, Samuels et al. 2010). Since flooding can either be beneficial or adversarial, integrated flood risk management proposes evaluating all of the processes that might lead to flooding together and utilizing floodplains to minimise the impacts of flooding (Hall et al., 2003). This also involves different groups and processes working together and sharing information including but not limited to examining the types of flooding collectively, flood defences available, the services and infrastructures that are impacted in an environmental, economic and social context, flood risk management organisations, flood insurers as well as the broader stakeholders involved in decision making that aids flood management (Hall et al., 2003).

Integrated flood risk management improves on flood risk management on a social, economic and environmental basis. It is, however, important to note that achieving integrated flood risk management involves continuous review and can be challenging as it involves the different fragments working together (Cumiskey et., 2019).

2.7.1 United States of America

Historically, most of the flood management in the United States of America involved the use of structural defences to tackle flooding. Flood management in the United States of America has undergone several changes from the “levees only policy” by the construction of levees from the 1860s to manage flooding totally which was identified as ineffective after the 1927 Mississippi floods suggesting that the non-uniformity of the levees across states in the country was the issue. This then led to the construction of dams, reservoirs in the twentieth century in order to control flooding in 1928 through the Flood Control Act of 1928 by Congress and as such the focus has now become mitigating flooding severally with every change caused by a devastating flood event (Tarlock, 2012). This construction of levees and reservoirs which encouraged building on floodplains, created a false sense of security as observed in the 1993 and 2011

Mississippi river flooding after the levees and dams became overwhelmed and broke showing these defences only minimised rather than prevented the impacts of flooding (Tarlock, 2012). Additionally, using these structural methods encourages settlement in flood-prone areas and insurance companies pose protection so it becomes dependent on the landowners, thereby, transferring responsibility of flooding along floodplains from the government (Tarlock, 2012), not considering the issue of insurance being unaffordable to some.

In the 1990s, the use of green infrastructure (GI) was introduced in urban planning and employs the use of green spaces to aid infiltration of rainwater and promote biodiversity benefits (Fletcher et al., 2014). Low impact development (LID), a popular method of flood mitigation (Kaykhosravi et al., 2019) aims to design with nature as proposed for Vermont and Prince George's County Maryland in the 1990s. This was also introduced in the United States of America with its main objective being reducing the cost of flood management (Fletcher et al., 2014).

Integrated flood management where structural measures are combined with effective land-use planning is becoming widely advised and as such, currently the Federal Emergency Management Agency (FEMA) has started adopting flood protection and management innovations with advances in hazard mapping which enables risk managers to identify future risks (Tariq et al., 2020). However, with the flood control measures in the United States of America being mostly reactive by adapting after major flood events, there is the issue of the sustainability of this approach over time (Tarlock, 2012).

2.7.2 The Netherlands

The Netherlands has a long history of managing flooding, beginning in the Middle Ages (van de Ven, 2004). The goal is ensuring flood management measures provide an acceptable level of flood risk. Therefore, flooding and flood management have shaped Dutch society and culture (Kolen et al., 2012).

Managing flooding by focusing on flood risk was introduced after the 1953 coastal flooding which affected the South Western Delta area. The government formed a Delta Committee that focused on flood risk in order to identify the best flood defence based on cost and risk reduction (Kolen et al., 2012).

The Netherlands invested in flood defences to protect from river and coastal flooding in the form of dunes and levees similar to America since much of the Netherlands is below sea level (Jha et al., 2012) and below high-water levels in rivers which may cause floods (Eijgenraam et al., 2012), with a total of 3500 kilometres of dikes constructed in Netherlands as a result of its continued investment in flood defence. As a result, there has been both social and economic development from areas built in delta areas which has both an increased flood risk as well as a lesser probability of a flood occurrence (Kolen et al., 2012). The government also ensures flood protection and management structures are maintained by reportedly spending approximately one billion Euros every year (Eijgenraam et al., 2012).

Since about a quarter of the Netherlands is below mean sea level on the Rhine and Meuse Rivers, more than half of the country will experience flooding without effective flood management structures from storm surges at sea or high discharges in the rivers and this has led to its advancement in flood control (Pilarczyk, 2006). While Netherlands historically adopted post-disaster response method similar to America by constructing levees, the severe impacts of flooding experienced in 1953 led to management of flooding on a risk basis which optimises cost and benefit leading to the flood defence structures tested every six years with current knowledge on strength and hydraulic capacities (Kolen et al., 2012). After a 2004 Water Safety Policy evaluation revealed that the Netherlands was unprepared for the impacts of extreme flooding, a 2008 and 2009 risk analyses for The Netherlands showed that while the probability of a flood event was low, a flood event could prove disastrous. Therefore in 2009, the Dutch Government shifted the focus of flood management to focus on the probability of flooding and the different stakeholders by integrating the following three areas Prevention, Land use planning and Emergency management (Kolen et al., 2012).

Kolen et al., (2012) suggested that integrated flood management is a better way of managing flooding by including actors such as architects, community leaders, engineers, social scientists, disaster management experts and spatial planners in the decision making and implementation process.

2.7.3 England and Wales

Since the 1990s, England's method for managing flooding has been through risk assessment, similar to the Netherland's earlier approach, by considering people, properties, infrastructure, agriculture and economic losses with responsibility shifting from solely the government to include others such as the Environment Agency (EA), the Lead Local Flood Authority (LLFAs), Insurance Industries, Water companies, NGOs, Maritime Coastal Authorities (MCA) etc (Sayers, 2013). After the 2000 floods in England, DEFRA (Department for Environment, Food and Rural Affairs) published the Making Space for Water (MSW) strategy in 2005 which ensured that all sources of flooding as well as their solutions were considered. The aim of the MSW focused on four themes for managing flood risk on both national and local levels. They include reducing threat to people and their property, delivering the best economic, social and environment result which aligns with sustainable development, determining a holistic method of managing flood risk and securing resources and funding that will help achieve the aims of the strategy. The Future Water strategy was published in 2008 by DEFRA after the 2007 floods highlighted how the changing climate would affect the future and proposed improved collaboration around planning and promoting sustainable urban drainages (Sayers, 2013). The Future Water strategy aimed that by 2030, flood risks have been sustainably managed with a better understanding and effectively managing surface water (Sayers, 2013). England's flood risk management approach by focuses on prevention, protection, preparedness, emergency response and recovery. After the Flood and Water Management Act 2010 for England and Wales, the Environment Agency, who are presently mainly responsible for managing flood risk (Wagstaff et al, 2021), produced a Corporate Plan for 2011-2015 requiring developers to ensure new buildings were flood resistant, this means buildings constructed prior to this did not have to be flood resilient (Nquot and Kulatunga, 2014). While the goal of flood resistant buildings is to hinder water from flooding a property, resilience deals with minimising the damage when the water has flooded the property (Driessen et al., 2018). To be flood resilient, there has to be the three capabilities, to resist, absorb and recover and to adapt and change which need to be co-ordinated to ensure efficacy. While England has all three largely developed, the Netherlands focuses mostly on its capability to resist (Driessen et al., 2018).

In July 2020, the Environment Agency published the National Flood and Coastal Erosion Risk Management strategy for England in order to prepare and ensure flood resilience until the year 2100 with three proposed long-term ambitions for a sustainable flood risk management (Wagstaff et al., 2021). They include improving flood resilience currently and in the future against climate change, investing in development that is flood resilient both in the present and in the future as well as ensuring the country is capable of responding and adapting to flooding through increasing awareness and knowledge. A major theme that underpins England's method of flood management is its aim to reduce flood risk not just for the present but for the future as well as improved collaborations among the flood management stakeholders (Environment Agency, 2020).

In the last decade, there has been growing interest in Natural Flood Management in the United Kingdom which also aims to reduce flood risk by adapting to the natural environment, rather than measures which work against it, an example is catchment-based flood risk management (Connelly et al., 2020).

2.7.4 China

The developed countries are not unique in their plan to reduce flood risk. As urbanisation continues globally, runoff generation is increased due to increased impervious surfaces in areas where capable flood management systems are lacking (Jia et al., 2020).

China has also experienced changes in flood management over time after most of the major rivers were affected in the 1990s floods and saw focus shifting from just building flood control structures such as levees to adopting an integrated flood management which also considers land use planning and population of people living in flood prone areas through a series of established laws and policies such as the "Water Law" in 1988 which informed regulations and water resources management changes (Xiong et al., 2016) and was later revised in 2002. The "Law of Soil Water Conservation" was formed in 1991 which improved on legislations and laws regarding water management and soil erosion. The "Law of Flood Control" was introduced in 1997 with a goal to protect from river flooding and improve water and soil conservation in river basins. Others include administrative regulations like" Regulation of Flood Proofing", "Regulation of River Course Management" and "Guide to Safety Building of Flood Storage and Detention Basin" (Hai-lun, 2004).

Like the United States of America (Tarlock, 2012), China's government has built 85000 reservoirs, over 120 flood retention and storage structures along the seven major rivers of Huaihe, Yellow, Yangtze, Soughua, Liaohe, Pearl River Basin and Haihe as well as more than 280,000 kilometres of dikes due to its flood vulnerability and aimed at minimising flood impacts (Hai-lun, 2004).

In 2013, the Chinese Central Government proposed a widespread utilisation of the "Sponge City" program to address the increased flood issues in China, with financial incentives offered to encourage the use in 30 pilot cities. The Sponge City program aimed to improve evapotranspiration, infiltration, collection and reusing generated runoff (Zevenbergen et al., 2018). While an important part of the Sponge City Program is learning from related flood experiences across the globe (Zevenbergen et al., 2018), a Sponge City is defined as a city which can operate sustainably by taking flood management, improvement of water quality, water conservation and natural protection of the ecosystem into consideration into development (Li et al., 2017). The Sponge City program combines different methods such as the use of green infrastructures and low impact development (LID) in Canada and the United States of America, sustainable urban drainage systems (SUDs) in the United Kingdom and water sensitive urban design (WSUD) in Australia (Li et al., 2017; Zevenbergen et al., 2018). Wuhan is known as China's main Sponge City as a result of its large investment in green and blue infrastructure with over USD 2 billion spent on projects such as artificial lakes which extract water from inhabited areas during heavy rainfall events, water channels capable of handling large volumes of water during flooding and urban gardens, greenspaces and parks for infiltration purposes during rainfall events (Oates et al., 2020). These projects have improved the flood impacts in Wuhan. After the Sponge City infrastructure was completed in 2015, 70% of the total precipitation is now being collected by rainwater gardens which house over 400 plant species, saving yearly watering costs of more than USD 220,000 for the city, this is one of its benefits over grey infrastructure (Oates et al., 2020) with others such as savings on development and maintenance costs as well as its improvements on quality of life. An average of 85% of the total precipitation from June to July 2009 was retained by the green roof of the Ethical Culture Fieldston School in the Bronx, New York (DiGiovanni et al., 2009).

It has however been suggested that the Sponge City program is limited by its feasibility with infrastructure and renovation plans, insufficient cooperation amongst groups and stakeholders and the need for better national and local education and guidance so it can be adopted by towns as well as cities (Li et al., 2017; Zevenbergen et al., 2018). Zhou and Penning-Roswell (2021) also highlighted a pilot's significant cost of more than USD 15 million which has not guaranteed effective flood protection since 19 of the 30 pilot cities experienced flooding in the summer of 2016. The Sponge Cities program is useful towards alleviating flood impacts, but its development also poses challenges as not all areas are homogenous in nature and their geographical and hydrological processes will be affected during construction (Li et al., 2016).

In December 2013, President Xi Jinping proposed a plan to reduce the impacts of flooding events in China in response to annual frequency of severe flooding inspired by the use of SUDS in the United Kingdom and design of the defence measures of Australia. However, the impacts of this plan are yet to be realised (Rubinato et al., 2019).

For the twenty-first century, China has adopted a river basin master plan (Fig 2.3) for flooding management by managing the hazard, exposure and vulnerability to the environment and society (Koboyashi and Porter, 2012). A major goal of the river basin master plan is water resources protection by building reservoirs that collect flood waters, lower ineffective evapotranspiration from land cover changes and improving aquatic ecosystems (Zhang et al., 2018). Provision of water and flood management information to the public and stakeholders on river basin management planning was part of the European Union (EU) Water Framework Directive (WFD) which was adopted in England and Wales showed better awareness among the public which helped inform flood protection and management (Benson et al., 2014).

In examining integrated flood risk management, it is important to note that flood risk can never be completely eliminated and enhancing the capacity for adaptation and coping with flood events will aid resilience (Jha et al., 2012). It was suggested that integrated flood risk management is better because it is a holistic approach which balances flood risk and current needs with the future needs for sustainability (Jha et al., 2012).

Figure 2.3: China's River Basin Master Plan

Adapted from: Koboyashi and Porter (2012)

2.7.5 African Region

Approximately 17% of the world's population live in Africa and this has been projected to increase to 23% by 2050. More than 50% of Africa's population live in rural areas along rivers and floodplains which puts them at increased flood risk as effective flood protection is lacking. Therefore, in order to be sustainable and resilient to flooding, flood risk needs to be examined towards effective flood risk management (Lumbroso, 2020).

While China is combining structural measures as well as non-structural measures, most African countries still focus heavily on structural measures in a bid to control the flood waters (Lumbroso et al., 2016). In many African countries, flood management still focus on outdated methods, with insufficient continuous professional training and development given to the flood officials (Lumbroso, 2020). It is believed that while structural measures such as reservoirs and flood paths can be effective, they also transfer flood risk from one area to another and while this might work in some locations, in others, it can have catastrophic impacts (Jha et al., 2012).

Early Warning Systems (EWS) have been used since the 1980s in West Africa for food security rather than flood management, with flood management efforts in many African countries instead focusing on recovery after flooding (Tarchiani et al., 2020). Of the fifty-four African countries, only South Africa, Djibouti and Cameroon determined early warning systems for flooding as effective towards reducing flood risk while Mozambique and South Africa were the only two African countries that had produced flood risk maps over the last two decades with Mozambique reportedly making efforts to map its major river basins since the 2000 floods (Lumbroso et al., 2016). Efforts towards simulating runoff and forecasting flood behaviour are scarce as a result of poor gauging of precipitation and runoff (Tarchiani et al., 2020).

Adopting a risk-based approach towards flood management, while not new, is beneficial because it targets flood risk reduction by aiming to understand the risk dynamics of a floodplain and identifying the key element that needs addressing towards reducing the flood risk (Tariq, 2020). Also measuring its success over time is also useful through assessing effectiveness (have the objectives been achieved), flexibility (is it adaptable to over time), equity (have all sections of the population been addressed), efficiency (is it cost-beneficial) and sustainability (will the measures remain effective over time) (WMO, 2015).

CHAPTER 3 FLOODING – The Nigerian and Lagos Context

3.1 Introduction

Despite efforts by international, national and locally funded NGOs, the risk of flooding has increased in many parts of the developing world (Surminski and Oramas-Dorta, 2014).

Globally, hydrological catastrophes amount to over 50% of natural disasters that have caused about 19% damages, 20% deaths, affected 140 million people and amounted to $70 billion losses (Mind'je et al., 2019). Although flooding is a global problem, developing countries experience greater flood impacts as a result of more intense rainfall events during the rainy season (Tambo, 2016). Other factors such as lack of flood preparedness and incapable drainage systems (Daramola et al., 2016) have led to developing countries finding it harder to tackle and manage rising flood events (Adelekan, 2016). Flooding in Nigeria is mostly caused by heavy rainfall which on its own is not necessarily an issue but due to inadequate drainage systems, becomes problematic (Tawari-Fufeyin et al., 2015).

Historically, flood events in Nigeria have had significant impacts on many of the individual States within the country (Table 3.1). In the 2012 floods alone, 30 out of the 36 states were affected with about 1.3 million people displaced and over 400 fatalities in what was considered the worst flooding in over 40 years (NEMA Nigeria, 2013). In 2012, water from Cameroun's Lagdo Dam was released between 2nd July and 17th September 2012 leading to expensive flooding in the Niger Delta (Tawari-Fufeyin et al., 2015) South of Idah, the Niger River created a temporary lake resulting in floods (Earth Observatory, 2017). The floods started in Central Nigeria in Plateau State in July and by August had spread to Borno, Cross River, Ebonyi, Nasarawa, Bauchi, Gombe, Katsina and Kebbi States; with Benue, Kaduna, Taraba, Niger and Kano being affected in September (Fig 3.1). Delta and Bayelsa were then affected between September and October. About 3,000 people were displaced from their homes in the town of Yenagoa, Bayelsa, and were temporarily housed in the State's sports complex (Tawari-Fufeyin et al., 2015).

Table 3.1: Examples of the impact of floods in Nigeria, 1970s to 2005.

State affected	Disaster/Hazard	Impacts	Number of people affected	Date and Year
Lagos	Heavy Rainfall and Floods	Collapsed buildings, loss of homes, markets and properties	Over 300,000 annually	Early 1970s to present
Kano	Heavy Rainfall and Floods	Loss of homes, schools and farms	300,000 (1988) and 20,445 (2001)	1988 and 2001
Kogi	Heavy Rainfall and Floods	Loss of farms, homes and schools	1,500	March/May 2001
Adamawa	Floods	Loss of homes and farms	500	April 2001
Ekiti	Heavy Rainfall and Floods	Loss of homes and schools	2,100	April 2001
Imo	Heavy Rainfall, Windstorms and Floods	Loss of 1,000 homes	10,000	April 2001
Ondo	Heavy Rainfall	Loss of schools and homes	800	April 2001
Abia	Heavy Rainfall	Loss of homes	500	July 2001
Taraba	Floods	Loss of homes and property damage	Over 50,000	August 2005

Adapted from Etuonovbe (2011)

Figure 3.1: Nigeria's 36 states and the Federal Capital Territory (FCT)
Source: (Etuonovbe, 2011).

Nigeria has been adversely affected by flooding which has had an impact on millions of the population and caused significant losses including over 3000 fatalities and of over US $ 200 million of damage to property and possessions in just the flood events of July 2011 (IFRC, 2011). The United States of America in over 20 years experienced significant economic losses amounting to tens of billions of US dollars (Nkwunonwo et al., 2015). While the cost of damage from flooding in developing countries is lower when compared to that of the developed countries, the financial impact is significantly greater when wages, lack of insurance cover and GDP is taken into consideration. Increasing urban populations along with a lack of proper planning policies in developing countries coupled with inadequate flood defences further worsens flood severity (Field et al., 2012; Adelekan, 2016).

3.2 Flooding Situation in Lagos

Over 20 million people live in Lagos State, an economically important region of Nigeria as many of the headquarters of the nation's financial institutions are found here along with the highest number of small businesses in the country. Many of these have been affected and will be significantly affected by flooding in the future (Ajibade and Asiyanbi, 2016).

Due to the adverse socio-economic and public health impacts, flooding is a growing concern for Lagos (Adelekan, 2010; Ajibade et al., 2013) especially due to its coastal location, low-lying topography and network of rivers. Flooding could be from either natural or anthropogenic causes or a combination of both. The type of flooding is usually characterised by the cause or causes of the hazard. For example, urban flooding from inadequate drainage systems as well as impervious surfaces exacerbated by heavy rainfall, flash flooding from heavy rainfall, river flooding from overflowing rivers, coastal flooding from ocean storms and tidal waves (Etuonovbe, 2011). Over time, the climate variability and changing land use, specifically urbanization, have increased the flood risk (Schlef et al., 2018), and the economic losses (Zhang et al., 2008). Lagos has seen an increase in the area of impervious surfaces from 200km^2 in 1960 to 1140km^2 currently (Adeloye and Rustum, 2011).

The earliest documented flooding in Lagos was only relatively recently in 1947 when Lagos was just a small coastal settlement. Since then, the frequency of flooding has increased with varied impacts on residents as recorded in the floods between August 1973 and July 1974 (Table 3.2) caused by heavy rainfall (Adelekan, 2016).

Table 3.2: Major flood events and their causes in Lagos, Nigeria (1968-2012)

Dates	Cause(s)	Duration (Days)
June 1969	Short Duration-High Intensity Rainfall	10
July 1970	Winds, Short Duration-High Intensity Rainfall	Unspecified
July 1971	Heavy Rainfall	5
June 1972	Heavy Rainfall	Unspecified
June 1974	Heavy Rainfall	Unspecified
July 1988	Heavy Rainfall	2
July 1990	Heavy Rainfall	2
May, June, July 1999	Unspecified	Unspecified
June, July, September 2000	Heavy Rainfall	2
July 2002	Heavy Rainfall	3
June 2004	Heavy Rainfall	2
July 2005	Heavy Storm	5
August 2007	Heavy Rainfall	15
October 2008	Heavy Rainfall	Unspecified
July 2009	Heavy Rainfall	Unspecified
October 2010	Heavy Rainfall	Unspecified
July 2011	Heavy Rainfall	5
October 2011	Heavy Rainfall	9
October 2012	Heavy Rainfall	Unspecified

Adapted from: Nkwunonwo et al., (2016); Nkwunonwo, (2016).

3.3 Causes and Types of Flooding in Lagos, Nigeria

Fluvial, pluvial and coastal flooding have been the most frequent types of flooding recorded as far back as the 1940s in several states, towns and cities of Nigeria (Nkwunonwo et al., 2015). However, this research focused on pluvial and fluvial flooding in Lagos.

Pluvial flooding has been ranked globally as the most common type of flooding (Borga et al., 2011). However, anthropogenic factors that change an area's characteristics have been reported to increase the likelihood of damaging floods; in particular land use change associated with urbanisation (Adeloye and Rustum, 2011). Other factors that have exacerbated flood issues for Lagos over decades include poor urban planning (building on and along floodplains); some of which leads to overflow of rivers, inadequate drainage systems, poor wate collection and disposal facilities (Adeloye and Rustum, 2011; Adelekan, 2010; Adelekan, 2016; Odunuga, 2008).

3.3.1 Heavy Rainfall and Flash Flooding

Flash floods are common in Lagos (Obiefuna et al., 2013) and Nigeria during the rainy season especially during 2012 which was the worst in more than 40 years (Earth Observatory, 2012). They are usually characterized by strong torrents, after excessive rainfall flows through urban roads, or over riverbeds or low-lying coastal areas, with the ability to overwhelm properties, infrastructures and people (Xia et al., 2011). They could occur after a rainfall event within a few hours or even in minutes, they also could occur when no rainfall event has occurred; for example, after a dam or levee breaks or after a sudden water release by an ice jam. As a result of how quickly they occur, flash floods give very limited time for warnings and preparations which often lead to extremely dangerous consequences mostly in the loss of lives and properties making them very disastrous events (Collier, 2007).

Across Europe, the frequency of flash floods increased between the years 1975-2001 annually and over 5 million people in England and Wales have been estimated to be at risk each year from flooding (NERC, 2013). Flash floods have also resulted in huge losses of properties, for example, the 2010 floods in Pakistan resulted in the loss of vehicles and Boscastle, United Kingdom in 2004 suffered a serious flash flood event which occurred under 5hours of heavy rainfall (Brigandi et al., 2007), resulting in about 116 cars also washed away and lost, with millions of pounds in damages generated; this still remains one of the United Kingdom's best recorded flood events (Xia et al., 2011).

In August 2007, heavy rainfall affected over 7 states in Nigeria; Lagos included and resulted in the displacement of over 200 families as torrential rain fell within a brief period of time, submerging areas. This led to residents initially moving to safer locations in other areas, mostly with relatives and friends until they could find other accommodation (DREF, 2007). More recently, flooding caused by excessive rainfall occurred between 12 to 13 September 2021 in Central Abuja, the federal capital state of Nigeria, leading to four deaths, 26 cars swept away and the damage of more than 160 houses (Davies, 2021). In August 2006, Sudan experienced torrential rainfall which caused flooding resulting in damage to about 10,000 homes, 167 deaths and more than 160,000 people affected by the event. Since 1991 flooding in Ghana has affected two million people. In 2007, Ghana experienced food shortages, 56 deaths and over 300,000 people affected due to flooding caused by heavy rainfall after 250mm of precipitation was recorded over 3 consecutive days during the rainy season from July to September (Tschakert et al., 2009).

Flooding initiated by heavy rainfall occurs occasionally in the Sahel savanna region of Niger in West Africa, local and national newspapers identified almost 80 damaging rainfall and flood events from 1970 to 2000, of which just three individual flood events lead a total of 28,000 people made homeless, damage to almost 6000 houses, and financial losses of over $4 million (Tarhule, 2005).

The earliest available historical record of flooding dates back to 1947 when Lagos was just a coastal settlement (Daily Times, 1947). Since then, it has been suggested that flood frequency and occurrence has risen significantly (Adelekan, 2010). The 2010 flood in Ikorodu, July 2011 (Fig 3.2) and June 2012 floods have been recorded recently. The 2010 floods in Ikorodu occurred after the Oyan Dam burst upstream unto the Ogun River's course causing overflow into the Ikorodu area. The July 2011 flood was caused by over 230mm of rain falling over just 17 hours on 10 July 2011. This rainfall event is equivalent to normally expected total for the whole of July. The flood event had serious consequences including the displacement of over 5000 people, loss of goods and properties estimated at NGN30 billion (USD200 million) by the Nigerian insurance industry and about 25 fatalities (IFRC, 2011). It is however important to note that a large number of properties lost due to the flood were uninsured and owned by poor and middle-class residents, some of whom live in informal settlements. In June 2012, over 210mm of rainfall was recorded (IFRC, 2011).

Fig 3.2: 2011 flood in Ikorodu after heavy rainfall
Source: (NewsBite, 2011).

In Chennai, India, a population of over 4.5 million were affected by flooding from extreme rainfall event with a recorded precipitation of 490 mm on 1 December 2015 (Selvaraj et al, 2016). Although it has been suggested that residents need drainages structurally capable of withstanding flood waters especially during heavy rainfall to prevent impacts of flooding (Dalu et al., 2018), this however, is not enough. A case study found that despite Eldoret municipal's central business district in Kenya having proper drainage networks, issues such as clogged drainages and impermeable urban surfaces have prevented water flowing freely during heavy rainfall which leads to flooding (Ouma and Tateishi, 2014). Insufficient storm water management capacity, indiscriminate dumping of waste in the drainage systems and development on floodplains compounded the flooding problem as a result of extreme rainfall events in areas such as Victoria Island, Ikeja Government Reservation Area (GRA) (Fig 3.3) and Lekki (Nigerian Tribune, 2017; Blaskovic, 2017). With heavy rainfall, the process or mechanics of run-off and water retention is greatly affected especially when combined with the area's topography (Garambois et al., 2014).

Figure 3.3: Flooding in Ikeja GRA, Lagos

Source: Nigerian Tribune (2017)

3.3.2 The Relationship Between Climate Change and Flooding

The climate has been projected to change globally which will lead to extreme rainfall events and an increased flood risk recorded (World Bank, 2011; Seneviratne, 2012). More frequent extreme weather events are effects of the changing climate of Nigeria, this has been projected to increase in the future and will exacerbate the issue of flooding (Haider, 2019).

Odjugo (2010) examined climate change and its impacts in Nigeria. From 1901 to 2005, the rainfall pattern in Nigeria showed a general decline (Fig 3.4) with rainfall amount reducing by 81mm and a major decline evident from the early 1970s and carried on until 2005.

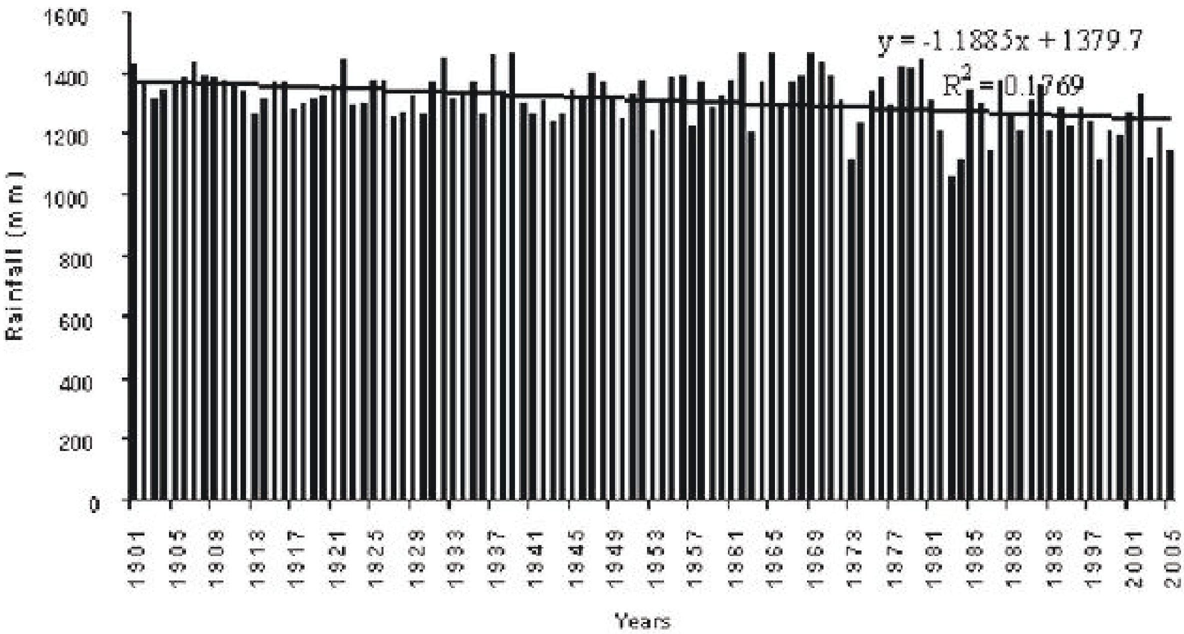


Figure 3.4: Annual Rainfall Distribution in Nigeria (1901-2005)
Source: Odjugo (2010)

From 1941 to 1970, late onset of rain was recorded in just a few locations in Nigeria which reportedly spread to most parts of the country from 1971 to 2000 due to the late onset and early cessation of precipitation, resulting in a shortened rainy season for that time period; save for just a small amount in Central Nigeria with normal conditions (Haider, 2019).

Lagos will become the fifth most vulnerable city to climate change threats by 2070 (Nicholls et al., 2007). For Lagos, the issue of changing rainfall patterns over the years has reportedly compounded the issue of flooding with drainage systems incapable of handling the amount of water generated after heavy rainfall events (Adelekan, 2012). Lagos experiences rainfall throughout the year due to its equatorial climate, however most of the heavy rainfall occurs in the rainy or wet season (Israel, 2017; Nkwunonwo et al., 2015). Nigeria has two seasons: the dry and wet season. The dry season is from November to March while the rainy season lasts from March/April to September/October. Sojobi et al., (2016) explored Lagos' changing climate and concluded that the summer months account for the highest rainfall total with the year 1968 at over 1600mm rainfall (Fig 3.5) followed by the winter months. However, there did not appear to be a steady decline over the years.

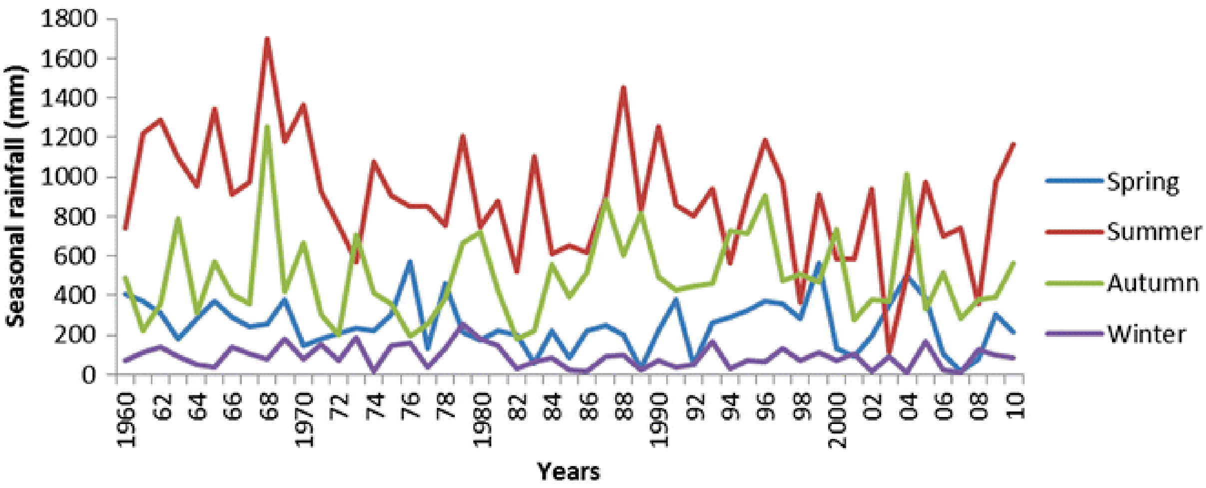


Figure 3.5: Seasonal Rainfall for Lagos State (1960-2010)

Source: Sojobi et al., (2016)

Between 1988 to 1998, 13 separate flood events were identified as having affected Lagos with more than half of the events attributed to storm surges and the remainder due to rainfall during the rainy season (Adelekan, 2016). Since 2000, increased flood frequency as a result of changing rainfall pattern has been significant over time on both the mainland and island areas of Lagos (Adelekan, 2016) as evident in the 2010, 2011 and 2012 floods.

3.3.3 Fluvial Flooding

Fluvial flooding can be caused by rainfall and large volume of runoff from rivers. They usually occur in both rivers and large rivers in the inland areas. It occurs in large rivers along floodplains while for rivers in inland areas, it occurs from short-length flash flooding where very high and excessive rainfall could lead to destruction of lives and properties within a brief time (Olajuyigbe et al., 2012). It has been reported that extreme rainfall triggers flooding which has the potential to put immense pressure on water resources (Yang et al., 2010). Lagos possesses an abundance of water resources in the form of rivers, lagoons, creeks and lakes. The major rivers flowing through Lagos are Yewa, Ogun, Osun, Owo and Aye (Oteri and Ayeni, 2016).

According to McEwen (1989), higher than average rainfall periods contributes to the varied hydrological response of a catchment to extreme precipitation as observed at Marchmont House's higher than average annual precipitation amounts for the 1870s to 1880s, resulting in increased number of moderate floods over this period. Lagos also reportedly had a higher-than-average annual rainfall across six areas examined from 2000 to 2012 (Oteri and Ayeni, 2016). Durowoju et al., (2017) concluded that while Ikeja station's results showed some significant relationship between extreme rainfall and maximum river discharge, due to environmental factors such as variations in weather stations and distance from the coast, the connection between maximum river discharge and extreme rainfall was not always significant as Lagos-Roof station did not show any significant relationship after examining data for both stations as well as the Yewa river in Lagos.

Due to the impacts of flooding experienced such as loss of lives, displacement, property damage and loss of properties (Adelekan, 2016), in Lagos due to the state's vulnerability to flooding, evaluating relationships between daily rainfall and daily river discharge and their implications for flooding in Lagos is essential, however, there is a dearth of information on this (Durowoju et al., 2017). Although the Lagos State Government has provided better drainage systems and cleaner water channels, since the river flooding of 2007, Ikorodu remains vulnerable to river flooding as it experienced flooding yearly from dams bursting, rivers overflowing, blocked canals and heavy rainfalls as seen in Ikorodu's 2010 floods occurred after the Oyan Dam burst upstream unto the Ogun River's course which overflowed into the Ikorodu area (Fig 3.6) (Adelekan, 2012).

Fig 3.6: 2010 Ikorodu Flooding

Source: (Etuonovbe, 2011)

Bangladesh also experiences flooding frequently; river flooding being one major type of flood experienced. Once the monsoon rains begin in June, rivers become overwhelmed that they start overflowing. Residents experience severe river floods as their rivers are characterised by high velocity flows and rapid rises as a result of extremely high rainfalls (Monirul et al., 2003). The Mississippi-Missouri river flooding of 1993 and 1995 resulted in damages, loss of properties, damages to infrastructures, towns and cities more than 200km away (Aderogba, 2012).

On the other hand, since the 1947 floods in the United Kingdom, flood defences have been improved along most rivers especially those surrounding very high populations (RMS, 2007). The Netherlands used to be well above sea-level but due to socio-economic developments from land use, things changed. Cultivation led to draining of the moorlands leading to dehydration and oxidation of the high moorlands resulting in rise of sea and river levels after subsidence from cultivation and settlement, all these increasing flood risks (Tol and Langen, 2000). They experienced extreme and severe river floods in 1313 and 1315 resulting in the death of between 5% - 10% of the population. This was an essential motivator for the creation of defences for controlling the water. By 1850, a major change occurred with engineers taking control and over time, improvements were made structurally to protect against the floods (Tol and Langen, 2000).

There is a popular saying among the Dutch that "God created the world, but the Dutch, Netherlands." They experienced great river floods in the Rhine delta in the past but with effective planning, adaptation measures and flood management practices in place, they have been able to reduce the extent of flood risks and hazard. They believed that adaptation should be an interaction between the climate and the society; as this is more important than dwelling on how the climate affects society (Tol and Langen, 2000; Hudson et al., 2008).

3.3.4 Relationship between Land Use Planning, Management and Flooding

Over 50% of the world's population live in urban areas and it has been estimated that by 2050, this will rise to almost 70% with Africa and Asia accounting for 35% of the growth (UN, 2018). Nigeria's population was projected to reach 189 million by 2050 as estimated in 2018 (UN, 2018), however this has proved a significant underestimate as Nigeria's population exceeded 195 million in 2018 (World Bank, 2019). Around the globe since 2000, urban areas, especially in developing countries have experienced rapid development driven by increasing population, and with this rapid development, there is an increased need for urban areas to manage key environmental issues such as flooding (Avashia and Garg, 2020).

Factors such as rise in population and urbanisation have led to increased demand for land (Aribigbola, 2008). Poor land use policy planning and management is a common cause of urban flooding in most developing countries today. Lack of adequate policies on land use and planning give rise to the erection of buildings where flood risk may be high and as a result the inhabitants suffer when flood occur (Adeloye and Rustum, 2011). Nigeria is one of the developing countries with poor land use planning and management and as a result, the inappropriate use of land has increased flood occurrence (Obayelu, 2013). As flood events have become increasingly frequent, the effect of land use change is evident in the reduced ability of vegetative cover to alleviate flood risk and potential impacts of flooding. This importance of natural vegetation extends to protecting low-income and slum households as a form of natural insurance against the impacts of flooding (Dalu et al, 2018). With increasing urban development, there is also an increase in impervious surfaces on roads which have been reported to affect the capability of natural drainage systems (Douglas, 2017). Therefore, heavy rainfall is not the exclusive cause of urban flooding as land use changes in urban areas contribute to flooding (Dalu et al., 2018).

Urbanization decreases infiltration as well as evapotranspiration, leading to increased surface runoff. In the Meuse catchment, 4% more surface water was generated during flooding, thus, potentially increasing flood risk from 1975 to 1992 after land use changed. The soil's moisture storage capacity reduced from 210mm just before the period of flooding in 1975 land use to 1992's land use capacity amount of 198mm; an evapotranspiration difference of 6% (De Roo et al., 2001). Lagos has also experienced land use change due to urbanization from 3.85 km^2 to almost 1200 km^2 (Okude and Ademiluyi, 2006) which has led to implications for flood risk. It was reported that in Lagos, built-up areas rose from 48.97km^2 to 282.78km^2 at 10.61km^2/y, swamps reduced from 344.75km^2 to 165.37km^2, water body decreased from 685.58km^2 to 654.98km^2 at 0.16km^2/y, mangroves decreased from 88.51km^2 to 19.95km^2, bare land rose from 24.32km^2 to 72.73km^2 at 2.2km^2/y; and vegetation decreased marginally from 1369.15km^2 to 1361.08km^2 at 0.37km^2/y; all between 1984 and 2006 (Obiefuna et al., 2013). Of the 54.78km^2 total surface area of the Haidian community of Beijing, 30% is made up of pervious surfaces while 70% of this is impervious and runoff from these impervious surfaces resulted in 59% to 67% of the runoff when compared to only 3% to 13% of the pervious areas (Liu et al., 2014).

Land use varies with both the rural and urban society and land use changes affects the hydrology of the area, thereby, causing increased flood hazards and risks in both the metropolis and slum communities as seen in the case study of Lagos, Nigeria after nine poor urban areas showed flooding had become worse between 2002 to 2006 (Adelekan, 2010). In Eastern Cape, South Africa, different land use changes were linked to the level of severity of damages that household experienced after flooding, with factors such as topography and proximity to water bodies influencing flood impacts experienced (Dalu et al., 2018). Similarly, six times greater runoff was observed in Kampala in areas with land use changes when compared to areas that had not undergone any vegetation alterations (Dalu et al., 2018).

Land use and its subsequent change is therefore a key factor towards effectively managing flood risk (Avashia and Garg, 2020) as urban development leads to increased impervious surfaces, changes in natural vegetation, loss of wetland and blocking water ways over years of changes to the land; this has contributed to issue of flooding in Lagos (Adelekan and Asiyanbi, 2016). There is therefore the need for effective land use planning and management to minimise issues such as flooding for the purposes of ensuring overall sustainable development (Aribigbola, 2008). Land use management in Nigeria focuses on granting statutory right of occupancy and planning approval for land use without adequate monitoring of constructions and their outcomes. This lack of monitoring is responsible for the adoption of alternative land use systems which sometimes could be due to higher demands for land use from urban sprawl but as a result, leads to encroachment on land (Obayelu, 2013). In Nigeria, buildings are erected on some land either too close to coasts or lacking proper flood defences. Despite the existence of laws and policies, urban land use management problems persist in Nigeria. Better understanding of the problems and how to tackle them is crucial to improving land use laws, policies and management to ensure future environmental sustainability (Aribigbola, 2008).

3.3.5 Waste Disposal and its Contribution to the Flooding Problem

Globally, improper waste disposal has been reported to cause blocked drainages and water ways, thereby reducing their effectiveness in storing and conveying and as a result, leads to flooding. It is especially important that better waste management is considered towards reducing the risk implications it poses during a flood occurrence (Lamond et al., 2012). Proper waste disposal and management remains one of the world's major environmental problems which although is highly significant in developing countries, is also an issue in developed countries (Obayelu, 2013).

Municipal solid waste management is an increasing environmental problem for Nigeria because of increased population pressure and socio-economic factors which subsequently cause and escalate effects of other environmental issues such as flooding from lack of regular waste collections (Efe, 2013). The classification of waste management as a low priority in developing countries can exacerbate the risk of flooding in particular areas: inadequate understanding and awareness of the consequences that poor waste management has on the health and society of the public, they are viewed as low status

jobs offering lesser salaries and as a result there is a dearth of expertise or training and the low salaries could lead to absenteeism (Lamond et al., 2012). It has been suggested that this has led to inadequate waste collection and disposal especially in lower-income communities that become neglected altogether compared to the high-income communities where resources are directed to (Lamond et al., 2012). The implication for flood risk is seen in the indiscriminate dumping of waste, for example, 40% of Kumasi's waste in Ghana are dumped illegally and ends up in the river (Lamond et al., 2012).
Illegal dumping of waste in Nigeria has blocked the storm water drainage system runoff causing localised flooding. Adetunji and Oyeleye (2013), noted that in Apete, Oyo State, poor waste management was the main contributing factor to flooding. In Kano state, Nigeria, the lack of regular street collection of deposited waste has led to the blocking of drainages and creating health issues for residents of the area (Butu and Msheila, 2014). Most residents have little or no access to solid waste collection services. This is due to lack of proper land use planning resulting in the creation of alternative settlements where the narrow streets make these areas inaccessible to collection trucks. Due to this lack of proper waste disposal and collection services many residents in the areas affected resort to illegally dumping waste on the side of the road and even in drainage channels (Butu and Msheila, 2014). Kano's case is not singular as Lagos residents have also been reported to dump waste indiscriminately (Fig 3.7).

Figure 3.7: Waste dumped by roadside and in drainage in Lagos
Source: (Shiru at el., 2019)

In Lagos State, waste dumped on streets over time (Figs 3.8 & 3.9) are washed into drainage channels during heavy rainfall or blown by wind, resulting in blockage and flooding (Abolade et al., 2013). The generation of solid waste by Nigerian cities has increased over time depending on factors such as rise in population (Efe, 2013) and rapid urbanisation (Table 3.3) with Lagos having the highest amount of solid waste generated from 625,000kg in 1980 to 1,570,000kg in 2010 posing challenges for waste management and flooding (Obayelu, 2013). In Ughelli, Delta State, the amount of solid waste generated over the years has increased on average of 15,540kg per year of solid waste ending up in the Ughelli dump while 1104.7kg of waste per household per year is never collected. A major cause of flooding in this area was because of indiscriminate dumping of refuse causing the blocking of the storm drains (Efe, 2013).

The situation of improper waste disposal exacerbating the flood problem is not restricted to Nigeria. In the United Kingdom, it has been suggested that blocked drains and sewers can cause flooding; giving rise to the need for better monitoring of methods of waste disposal (Lamond et al., 2012). In Accra, Ghana, 25 people died due to flooding caused by the blocking of drainage channels by household waste in July 2015 (Lenkiewicz, 2016). Due to the lack of regular and enforceable waste collection, drainage channels became what was perceived to be a suitable site for getting rid of waste from streets and houses. After the Marikina River in Philippines was cleared and restored in order to reduce flooding and enhance the location, a strict policy on waste collection forbidding waste from being dumped outside homes except on waste collection days was introduced with penalties as enforced for non-compliant residents. Although this helped reduce flooding, an inundation of waste was observed further upstream the river (Lamond et al., 2012). Yoada et al., (2014) has therefore reiterated the need for better waste disposal.

Fig 3.8: Waste dumped on a street in Lagos carried by Precipitation in 2018
Source: (Punch Newspapers, 2018)

Figure 3.9: Waste dumped on a street over time carried by 2017 flood waters in Lagos
Source: Ikem (2017)

Table 3.3 Estimated volumes of solid waste generated (1000 kg) in some Nigerian cities

Urban Areas	1980	1985	1990	2000	2005	2010
Lagos	625	681	786	998	1,008	1,570
Kano	320	349	402	535	63	824
Aba	132	144	170	237	301	434
Ibadan	351	282	441	560	715	999
Port-Harcourt	211	230	265	284	467	633
Ughelli	9	12	15	17	19	22
New Busa	6	6	7	10	12	14

Adapted from: (Efe, 2013)

Better waste disposal is therefore important as even small steps taken towards improving better waste management despite the current challenges being experienced have proven to make a difference in effectively managing flood risks (Egbinola et al., 2015).

3.3.6 Improper Planning and its Contribution to the Flooding Problem

Globally, the rise in urbanization presents challenges for the effective management of urban planning as increased urbanization results in modified flow paths and increased impervious surfaces that lead to flooding even more where proper planning is inadequate or lacking (Bertilsson et al., 2019). The increase in urbanization and rapid population growth across the world has led to megacities that are sometimes characterised by flood events and environmental deterioration due to rapid development with inadequate infrastructures (Bertilsson et al., 2019).

The Nigerian Urban and Regional Planning Decree 88 in 1992 was introduced after observations of improperly planned development showed management was lacking and the case study of Ikeja identified the planning law to be lax (Soyinka, 2013). In 2010, the Lagos State Urban and Regional Planning Development Law was then adopted for the state in order to control development and address physical planning issues (Oshodi et al., 2018). One of the causes of flooding in Lagos and Nigeria is lack of planning or improper planning for urbanization (Adelekan, 2010; Adeloye and Rustum, 2011). Proper urban planning usually involves measures such as prevention of development in areas with a high flood risk, building and maintaining capable drainage systems that prevents urban flooding from increased runoff (Adeloye and Rustum, 2011). Physical planning aims to use decision making processes to manage relationships between the human and natural systems for sustainability purposes (Soyinka, 2013).

Muench & Muench (1968) examined the history of planning in Lagos against that of Ibadan and although Lagos was an older city compared to Ibadan, in 1968, the state had considerable better planning compared to Ibadan. However, this is not the current situation for Lagos as seen in its increased population and the poorly planned and rapid development which has contributed to the flood issue of Lagos (Okude and Ademiluyi, 2006). The slum areas of Kalerwe, Katanga, Kivulu and Bwaise in Kampala, Uganda have reportedly begun to experience unprecedented flooding due to the illegal construction of homes in the floodplain areas which have now seen less infiltration as surface water runoff increased six times more than what occurs in natural terrain (Douglas et al., 2008). The improperly planned informal communities in the Maili Saba slums in Nairobi, Kenya were constructed with insufficient, weak materials, making residents at risk to flooding (Douglas et al., 2008). Residents of Iwaya/Makoko in Lagos, Nigeria are also at risk to flooding as they reside in a low-lying area built on stilts above swamps (Fig 3.10) which are natural flood basins. (Douglas et al., 2008).

Figure 3.10: Houses in the Iwaya/Makoko area
Source: Esiebo (2016)

Adelekan (2010) believed that improper planning puts the lower income residents, who make up 70% of Lagos, at a higher risk to flooding as the low-income settlements are usually constructed in areas already at risk to floods. This is usually due to the fact the lower-income residents are unable to afford safer areas and as urbanization and economic activity increases, there is an increased strain placed on the environment. Although the urban poor has been considered as one of the vulnerable group of people to flooding and the issue of improper planning further contributes to their flood risk (Adelekan, 2010), it is important to note that the issue of improper planning contributing to flood risk is an issue for the population of Lagos and not particular to just the urban poor of Lagos (Obiefuna et al., 2013). The case study of Ikeja; a mixture of high- and middle-income earners, showed that planning measures were not enforced adequately, poor integration of the planning, implementation and control of projects, lack of clarity on control action for development and incapable planning structures (Soyinka, 2013).

Urban flooding as a result of improper planning is therefore a product of urbanization and the proper planning policies in place to regulate the development and land use planning of the urban environment is therefore widely recommended (Jha et al., 2012). Government in developing countries have as a result, initiated physical planning policies to tackle flood impacts, however, its effectiveness is lacking as evident in the continuous prevalence of flooding and its impacts over the years in many African cities (Nkwunonwo et al., 2015). As a result, it has been suggested that more integrated flood management measures that combine structural and non-structural measures be employed. They will, however, require proper governance and enforcement (Nkwunonwo et al., 2015; Adelekan, 2016).

3.3.7 Inadequate Storm Drainages and its Contribution to the Flooding Problem

Drainage issues are worsened by urban activities as impervious surface generate increased runoff and as a result of lax planning laws as well as their subsequent improper enforcement, developments are erected without considering drainage systems (Parkinson, 2003). One of the main causes of flooding in Lagos is the inadequate or incapable storm drains usually compounded by the indiscriminate dumping of waste in the drainages (Aderogba et al., 2012). Drainage systems play a huge part in reducing flood risk especially for low-income communities, usually in high flood risk areas built on floodplains (Parkinson, 2003) and the implications of flooding could prove severe especially for those without the resources for coping and resilience (Parkinson, 2002). Residents of Cape Town, South Africa suffered flood impacts as a result of flooding due to the inadequacy of the drainage systems that become polluted with waste and stormwater. Some residents construct informal settlements in the form of shacks for free in a bid for space, usually close to job opportunities. The lack of proper planning and the topography of the area which is low-lying, and buildings constructed on a floodplain further compounded the issue (Armitage, 2011). In Ghana, informal settlers are vulnerable to flooding as this area is on a floodplain and similarly lacks adequate drainage as well as the maintenance of the drainage systems (Anornu and Oduro-Kwarteng, 2011). In the case of Mile 12, a low-income area in Lagos, flooding occurs due to several factors; one of which is inadequate drainages. The drainages are usually blocked from indiscriminate dumping of waste as the area is also characterised by poor waste management (Olajuyigbe et al., 2012). The issue of inadequate drainage systems, however, is not particular to just the urban poor population as high-income areas such as Victoria Island and Ikoyi have also been reported to have inadequate drainage systems (Olajuyigbe et al., 2012).

3.4 Impacts of Flooding

Globally, it has been reported that two-thirds of deaths directly linked to flooding are due to drowning and one-third by health impacts (Dewan, 2015). However, the impacts of flooding to millions in developing countries pose a larger threat to life, health and well-being than in developed countries due to inadequate flood defences and buildings on floodplains. Africa and Asia account for the 95% of people annually affected by floods globally and 73% of the total direct economic damage suffered (Alfieri et al., 2018).

A group of women in inner Kwara, Nigeria depend on irrigated vegetable farming located along floodplains. During flooding, their farms are washed away and it can take a while to redevelop, rebuild and replant rendering them unemployed for several months and unable to provide for their families (Olorunfemi and Raheem, 2013). From 2009 – 2013, Nigeria suffered flood events across several states and due to factors, such as: inadequate information about flood risks, poor housing, poverty and inadequate flood defences; the impacts suffered recorded deaths and losses. It has been suggested that the severity is represented by an intersection of human preparedness and the flood event (Daramola et al., 2016). The impacts of flooding are not particular to Nigeria. Across the world, people have suffered flood impacts such as deaths, missing people, displacement, loss of income and economic loss.

Over one million people were affected by one of the most severe flood events experienced in 2007 by more than 20 countries in the northern region of Africa, with countries such as Sudan, Uganda, Ethiopia, Burkina Faso and Niger reported as severely affected, about 500 deaths and over 1.2 million people reportedly displaced (Egbinola et al., 2015). Sixteen west African countries were affected by the September 2009 floods affecting more than 500,000 people; Ghana, Senegal, Niger and Burkina Faso were reportedly the countries most affected by the extreme event (Di Baldassarre et al., 2010).

Every year in Nigeria, residents become displaced by floods and also experience significant losses such as money and property as well as some of their basic necessities. (ARB, 2012). In July 2011, about 35,000 people were affected; while the following July 2012, the number of flood-affected people rose to about 2 million (ARB, 2013). During the rainy season (March to September) seasonal flash floods occur and the Disaster Management Agency for Nigeria reported that 12 out of the 36 states of Nigeria experienced flooding in 2011 and deaths were recorded from the heavy rainfall. It was reported that 357,000 people were at risk to floods annually and was estimated to increase to over 3million people by 2014 (ARB, 2012). After the 2012 floods across Nigeria, a total of 2,100,000 people were displaced and about 363 deaths were recorded (ARB, 2013).

The impacts of flooding can be best described as mostly social as they lead to effects on people and their interactions with their communities, thus, linking the economic, social and biophysical environments. The impacts include physical and psychological health, economic, disruption (Fig 3.11), and changes in the community as well as evacuation of affected residents who may be put into temporary accommodation (DEFRA, 2005). Understanding the social impacts of flooding is therefore imperative.

Figure 3.11: Disruption to movement caused by flooding

Source: (Volunteer Assistant, 2018)

3.4.1 Socio Economic Impacts

This includes the cost of impacts suffered from the start of the flood event to its end such as: cost of temporary living accommodation, cost of draining out the water and also the cost of re-selling a home which will become harder to sell as it has flooded previously and might be on a floodplain (DEFRA, 2005). Socio-economic impacts also include impacts suffered by the society, for example, pressure will be placed on the area and facilities such as transport systems in the area. Communities possessing essential facilities such as: hospitals, pubs, bars, schools, churches and museums among others may find it difficult to recover from flood events and as such may need to re-build which could also take up some time before its ready and normal working hours will be disrupted causing a significant impact in the community (DEFRA, 2005).

These types of impacts are direct and can be felt as soon as a flood event occurs. For example, inundated roads, submerged buildings, people unable to get to work, victims becoming trapped in buildings due to damaged bridges and blocked roads, children unable to go to school and traders unable to conduct business due to submerged stores as was the case in the Niger Delta region of Nigeria (Bariweni et al., 2012).

Loss of commercial and industrial services and the cost of re-building has the potential to drive away future investments in areas where floods occur (DEFRA, 2005). Small and local businesses in areas where floods occur are also affected because in most communities, these small businesses play a vital role as it provides employment and also meets other essential needs of the community and when floods occur, all these are at risk of being lost. For example, between December 2010 and January 2011, Rockhampton in Queensland, Australia experienced a flood event which affected the community but especially small businesses in the area (Zaman, 2012). The Queensland Chamber of Commerce and Industry realised that small businesses were especially affected by flood with one in five businesses experiencing economic losses between Australian $10,000 to Australian $15,000. The airport was closed and could not operate for one month which further affected most businesses. Additional impacts included loss of power supply, motor vehicles, stock, equipment and buildings as well as an 11% reduction in annual profit from sales (Zaman, 2012). Flood losses have been estimated to be high especially for most of Asia as well as parts of South and Central America when compared to economic losses for Africa (Fig 3.12) from 1985-2003. The map's surface does not present values of economic losses for the different regions but instead shows the increasing risk decile ranked based on calculations of economic risk.

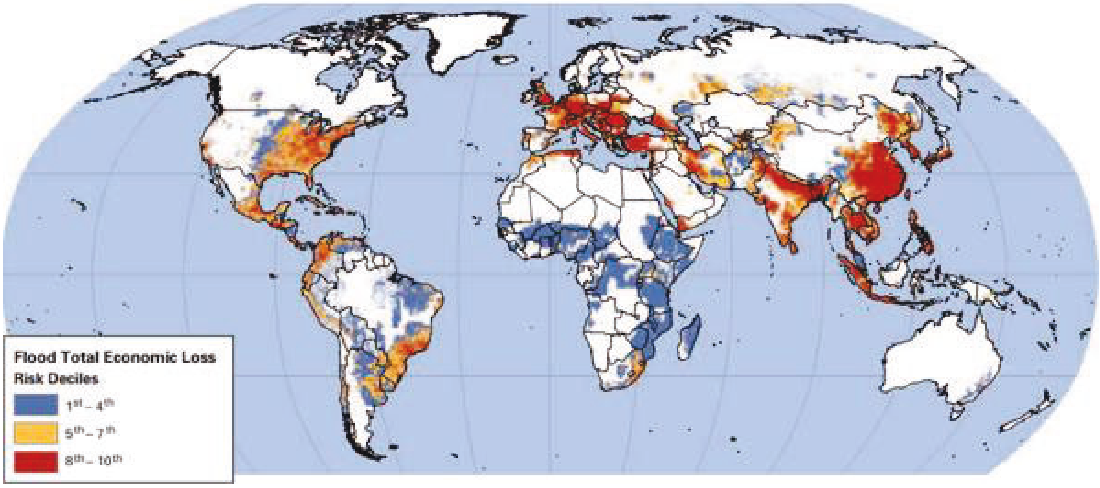


Figure 3.12: Distribution of Global Economic Loss to Floods from 1985 to 2003

Source: (Maxx *et al*., 2005)

Globally, almost $60billion USD worth of damages from hydrological disasters was recorded in 2016, with 98.8% of the damage due to flooding, close to the proportion of the previous decade which was 99.6% (Guha-Sapir et al., 2016). From 1985 to 2014, the EM-DAT recorded more than 3500 flood disasters globally Floods accounted for most of the disasters that affected the United States of America in 2012 resulting in damages worth just over 0.5 billion US Dollars and affecting more than 9 million people, cities in the United Kingdom saw damages worth 2.9 billion US Dollars after four different flood events in 2012.

It has been suggested that the economies of developing countries will be more distressed than that of the developed countries and that poor households suffer more economic losses, with the flood characteristics and household income levels being a huge factor (De Silva and Kawasaki, 2020). China recorded losses of more than $30 billion during the 2017 flood event (Hu et al., 2019). Malawi's government recorded $335 million as the total cost of damages from flooding between 2014 to 2015 (McCarthy et al.,2017) and Tanzania's Dar es Salaam recorded losses after the December 2011 flood event where the total costs of property damages amounted to 7.5 million Tanzania shillings and the government recorded total costs for relief at 1.83 billion Tanzania shillings (Anande and Luhunga, 2019). This is also similar for cities in Nigeria where significant losses have been recorded due to flooding (Nkwunonwo et al., 2015). Over 30% of respondents of a study carried out by (Odunuga et al., 2012) lost between $84.75 to $8474.58 in their businesses due to flooding from a singular storm event in Lagos. In Northern Nigeria, it was reported that over 2 million people were displaced, 5,800 injuries and over 7.7 million people affected after the 2012 floods (Kwari et al., 2015).

Socio-economic impacts also include effects suffered from the inability to live in previous accommodations which have become flooded, having to live in damp and wet environment, cleaning up and drying the house as well as re-building. Over 30 million people were estimated to have been displaced from their homes globally due to natural disasters: 98% of them being climatic events and flooding being one of the disasters, in 2012. North-east India and Nigeria suffered the highest impacts in terms of displacement (Fig 3.13) from floods in 2012 after homes became flooded with 6.9 million people in India and 6.1 million people in Nigeria displaced, representing 41% of the global amount of displacement. Countries: especially low-income countries, with low-lying coastal areas and the poor were the most vulnerable to flood hazard (NRC, 2013). Families in Nigeria co-habit and in the event of flood disasters, this is an advantage compared to other countries. In Nigeria, observed behaviour is finding the most possible natural means to adapt in the event of severe issues. This practice has caused significant loss of lives and properties, still, it has proven to be a viable solution in emergency situations (Nkunonwo et al., 2015).

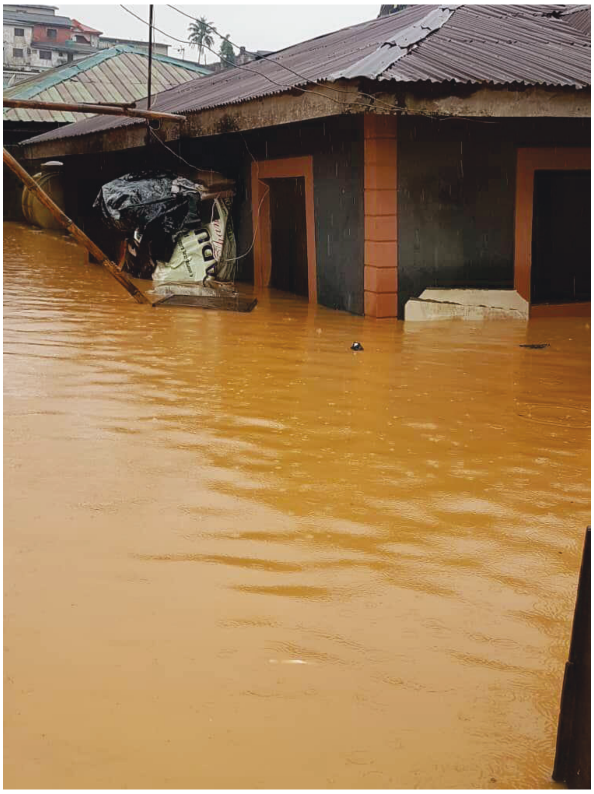


Figure 3.13: Flooded Property in Surulere, Lagos

Source: (Volunteer Assistant, 2018)

Informal settlers of Kathmandu's riverbank reportedly coordinated with their neighbours to build their flood defence based on local understanding of the area which often is not a long-term solution (Dangol and Carrasco, 2019). Across Nigerian cities during flood events, the practice of cohabitation has helped as internally displaced people are offered shelter from friends and families while awaiting relief (Nkunonwo et al., 2015). Flooding affected communication and electricity lines, causing disruption to the latter, roads become disrupted causing limitations to movements (Figs 3.14a & Fig 3.14b) and in 2012, the National Emergency Management Agency recorded over 2 million displacements, 5,800 people injured, almost 600,000 homes affected by the floods (Fig 3.15) and more than 7.7 million people affected by the extreme flood events of 2012 (Kwari et al., 2015).

Figure 3.14a: Disruption to Movement due to Flooding in Lagos
Source: Kazeem (2017)

Figure 3.14b: Lagos roads disrupted by flooding

Source: (Odita, 2019)

Figure 3.15: Flood waters inside Residential Property in Lekki, Lagos

Source: Awojulugbe (2019)

3.4.2 Impacts of Flooding on Women and Girls

Exploring how impacts differ based on gender is beneficial since men and women experience disasters differently and general research findings do not reveal the specific needs and risk for groups of women and men (Ajbade et al., 2013). While there has been extensive research addressing flooding in Lagos and Nigeria, there is a dearth of research on the gender differentiated impacts of flooding in Lagos and Nigeria (Ajaero et al., 2018).

With several highlighted examples of how women are more vulnerable to the impacts of flooding than men such as the case of Bangladesh where 90% of those who died in the 1991 cyclone and floods were women, more women than men reportedly found flood resilience difficult as they were either not provided with relief items or restrictions on mobility making accessibility of relief items a challenge (Neumayer and Plumper, 2007; Ajibade et al., 2013).

In most developing countries like Nigeria where women are mainly responsible for the home, the responsibility of ensuring their homes are back to normal in terms of food security and wellbeing also lies with them (Ariyabandu, 2003). The unequal gender impacts are further reinforced by customary laws, globalization processes, and hyper-urbanisation (Enarson and Morrow, 1998). These factors make response and recovery from flooding for women even more difficult (Ajbade et al., 2013). For example, land which is most productive in agriculture, for households headed by women, they are unable to access economic recovery after flood events as customary or statutory laws prohibit women having land and property rights across the world (Schroeder, 1997; World Bank, 2001; World Bank, 2007). However, adaptation was found to be easier for female-headed household farmers in the rice farming communities of Nueva and Ecija, Philippines who had relatively better education levels compared to the men which meant they could take on higher managerial roles (Tatlonghari and Paris, 2013).

It was suggested that while grouping women as a single autonomous group does not consider the other inter-sectionals of factors such as age, class, race, culture etc and how that translates to power in the environment, poverty is a major determinant of whether or not a group of women will recover better or faster from flooding (Enarson et al., 2006). Five local government areas in Anambra state, Nigeria around floodplains were examined to understand whether differences existed in livelihood security after flooding experienced by female-headed households and male-headed households.

Results revealed that more female-headed households found recovery after flooding difficult compared to male-headed households with income being the major determinant (Ajaero et al., 2018). Due to the nature of jobs of the men in these areas being more diverse (technicians, traders, artisans, farmers, civil servants) compared to those of the women (housewives and petty traders), post-flood recovery lasted longer for women (Ajaero et al., 2018).

Ajibade et al., (2013) explored three different income levels in Lagos (Nwokoro and Agbola, 2011); Victoria Island (high income), Ajah (middle income), Badia (low income) to evaluate if flood impacts differed for women in these areas using mixed methods research. Overall results revealed that women in the high- and middle-income areas fared better compared to the women in the low-income area. One respondent in the high-income area believed men were more affected as they had the tendency to be protectors during flood events (Ajibade et al., 2013).

Women in the low-income area were mostly single mothers or in polygamous marriages where the men provided little to no support. As a result, they often become the breadwinners from trading as well as looking after their households despite being already subjected to insecurity, illiteracy (only 1% educated to tertiary level), poverty, domestic violence and gender inequality in the household (Ajibade et al., 2013). One of the respondents, identified as Tina stated, "*This place is a ghetto, so you can't really say much about husbands. Husbands do not matter much in this type of situation, they give little. Most women here are single mothers, while some have husbands, but their combined income is still very small. Most men are Okada riders (bike riders) while others are conductors and transporters; they belong to the union. Most of the union members have more than five wives. They just give the women whatever they have. So, the women have to cater for themselves and their children*."

Results very much focused on impacts experienced during flood events, highlighting the difficulties faced around mobility, health and food security as stated by Joy, a single mother in Badia and Kate, a trader and mother to four children, "*Floods disturb my business, I cannot sell. The pure water distributors will not come down to this area; they always place the bags at the main road, so I am forced to go back and forth carrying the bags on my head. When it rains heavily, I can't go out, getting food also becomes difficult. If we don't have someone who is strong enough to go out and buy food, we may not eat"* (Joy, 45, single mother, interviewee, Badia June 16, 2011).

Kate, 38, interviewee, Badia, June 16, 2011, also added "*Flood increases the work that* *woman do at home. We would need to fetch more water so that we would be able to have water to clean and wash. For those with babies, they would have to take care of the baby more so that the baby would not be exposed to cold and germs. It is also a woman that takes the children to school and looks after what the family would eat, even if her husband gives her money she has to go out and buy food. Husbands only give money but wives have to go out to buy the food even during raining periods. To say the truth, heavy rain and flood bother us, women, more."* (Ajibade et al., 2013).

3.4.3 Impact of Flooding on Health

Floods could either have primary (direct) or secondary (indirect) health impacts (Table 3.4). Primary impacts result from immediate exposure to the flooded area, examples are mortality from drowning, disruption of health services and injuries. Flood events not only affect people but also buildings causing certain direct effects which could be as a result of consequences of contact with contaminants or water consequences (Kelman and Spence, 2004).

Secondary health impacts are effects associated with indirect exposure to the flood waters and they include contamination of water sources, respiratory illnesses. infectious diseases and other health issues as a result of people being displaced (Du et al., 2010; Hajat et al., 2003). There also have been recorded long term health impacts of flooding such as mental health issues, social disruptions (Du et al., 2010; Hajat et al., 2003) and has caused almost 53,000 deaths globally. Throughout the flood event and in the immediate aftermath, the cases of certain diseases can increase leading to greater loss of life, or long-term health impacts to people. Examples of these diseases include leptospirosis, hepatitis E and gastro-intestinal diseases in populations that may have been displaced and in very unhygienic areas (Alderman et al., 2012).

Table 3.4: Health Impacts of Flooding

Health Impacts	Pre-onset phase	Onset phase	Post-onset phase
Primary	Injuries	Death (drowning) Injuries	- Respiratory Infections - Mental Health - Skin Infections - Faecal-oral disease (Cholera, Typhoid, Hepatitis A and E) - Vector and Rodent borne disease
Secondary	-	-	Health issues related to: - Damage to water and sanitation infrastructure - Damage to healthcare infrastructure - Population displacement - Chemical contamination and damage of food and water supplies - Damage and destruction of properties

Adapted from Few et al., (2004)

Although, there has been limited data published on the health impacts suffered as a result of flooding, it has been reported that since 1900, flood impacts have resulted in over 6.8 million deaths and more than 1.3 million injuries (Table 3.5) globally with Asia accounting for 98% of the deaths (Few et al., 2004). In 2017, several flood events led to significant health impacts: in Niger led to 60 deaths and from a food production and financial impact, over 15,000 cattles died and crops were lost. Guinea recorded 10 deaths, Burkina Faso recorded more than 200 tons of food destroyed and 12 deaths, Ghana recoded 7 deaths while in Nigeria, over 100,000 people were affected (UN OCHA, 2017).

Table 3.5: Health Impacts of Flooding from 1900 to 2004

Regions	Deaths	Injuries
Asia	6,757,000	1,177,000
North and South America	96,000	41,000
Africa	19,000	23,000
Europe	10,000	22,000

Adapted from Few et al., (2004)

It is believed that floods will bring about a subsequent increase in the global issue of morbidity, diseases, economic and social disruptions and will continue to make health facilities stressed especially in low-income countries; these low-income countries have the highest vulnerability to floods and prevalence rate of floods (Alderman et al., 2012). Heavy rainfall makes it easier for contaminants such as toxic substances, sewage or animal wastes to contaminate water supplies leading to the rise in water-borne diseases and other health impacts in the aftermath of flooding (McMichael et al., 2006).

3.5 Flood Management in Lagos

Across the African continent, national governments have initiated systems for governing response and adaptation to climate extremes such as flood events. However, emerging institutional frameworks are currently unable to effectively manage the adaptation systems being put in place as they have been designed to be reactive for short-term response and would therefore require government support (Niang et al., 2014). As a result, the government of various African countries have started to supplement harder measures such as constructing embankments and dams with softer measures such as utilising intact wetlands in order to better manage flood risk as the softer measures are effective and relatively less expensive (Niang et al., 2014).

In Lagos, two parties contribute to flood risk management, they are: Public agents and private agents. Lagos State Government represented as the public agent is mainly responsible for flood management in Lagos (Adelekan, 2016) and the approaches they have in place for managing flood risk includes structural and non-structural measures. Klijn et al., (2008) believed that employing structural and non-structural methods for sustainable development is key towards achieving acceptable residual risk as it involves achieving several goals over time. It has also been suggested that these measures should also involve a continuous and holistic process of societal analysis, adjustment and adaptation of policies with actions taken towards reducing flood risk as well as modifying vulnerability and resilience of susceptible systems (Sayers et al, 2013; Adelekan, 2016). In addition to the public agents, recently, private agents such as households, communities and real estate developers have contributed to the management of flood risk in Lagos. Some other private agents who are sources of support for flood management include NGOs, Religious Institutions and Family Friends (Adelekan, 2016). In Nigeria, examples of structural measures include river channelization, dredging and constructing as well as widening of culverts and bridge throughways while non-structural measures include improving the management of waste (Egbinola et al., 2017).

3.5.1 Structural Measures

Structural measures simply are physical developments or applying engineering techniques aimed at reducing the impacts of flooding (Sun et al., 2012). They exist in the form of drainage networks, dams and coastal embankment in West Africa; however, a major issue is in their sufficiency and management (Ouikotan et al., 2017).

After the frequent flooding experienced by the residents of Victoria Island, the Lagos state government constructed the Lagos Bar Beach Breakwater in 2006 (Okude and Taiwo, 2006). Between 2007 to 2011, projects such as dredging of 32 rivers which spanned over 50km and the drainage of about 100,000 hectares of land was completed. In 2011, five channelization projects were completed as well as the maintenance of existing drainages (Table 3.6).

The earliest plan made in a bid to manage flooding in Lagos was a drainage master plan which was developed in the form of the 1974 Lagos Mainland drainage master plan; also designed and executed the same year for the Mainland areas. In 1992 and 1998, two drainage master plans were designed particularly for certain areas of Lagos in order to tackle the different types of flooding experienced as well as since then (Table 4.14). More recently, the government of Lagos has reviewed the plans and developed a new drainage master plan for the state to last from 2016-2036 and proposed to be completed in phases (State Flood Manager, 2018). Just like the drainage master plan of most West African cities, Dakar’s first drainage plan was designed in the 1960s and due to a lack of political interest, this was not reviewed until 2013. Accra’s drainage master plan was reviewed in 1995, however, due to insufficient funding and institutional constraints, the recommendations were not made (Ouikotan et al., 2017).

Table 3.6: Structural measures by the Lagos state government

Years	Structural Measures
1974	• Development of Lagos Mainland storm water drainage layout
1992	• Apapa and Lagos Island storm water drainage master plans • Concrete lining of drainage channels within Apapa and Lagos Island
1998	• Development of Greater Lagos Drainage Master Plan
2006	• Construction of a breakwater on the Lagos Bar Beach section of Atlantic coast
2007-2011	• c100,000 hectares of land drained • Construction of 69 km concrete secondary sea water drainage to prevent coastal flooding • Dredging and maintenance of almost 60km of 32 rivers
2011	• Execution of five channelization projects • Maintenance of existing network of drains • City wide dredging of drainages
Ongoing	• Demolition of houses in selected flood-prone areas

Adapted from Adelekan (2016)

3.6.2 Non-structural Measures

Non-structural measures unlike structural measures do not involve physical developments but rather rely on using practices, knowledge and understanding to improve and minimise flood impacts through education and raising awareness, training, implementation of laws and policies (Sun et al., 2012). It was suggested that the Lagos flood problem needs to not just adopt structural measures but also use non-structural measures with the aim of making local communities resilient to flooding (Adelekan and Asiyanbi, 2016).

In 2008, measures such as creating climate change clubs in schools to create awareness on ways to reduce individual/household greenhouse gas emissions and campaigns to increase public awareness of flooding in terms of causes and how residents could

reduce their flood risk were carried out (Adelekan and Asiyanbi, 2016). Other measures include flood warnings such as the establishment of an emergency command centre (Table 3.7), better land use management by the Ministry of Environment, adaptation levels at individual, household and community levels as well as preparedness and disaster relief efforts (Ouikotan et al., 2017). These measures have however, proven ineffective as they have not been directed to the vulnerable population and the society at large since it has been reported that the most vulnerable people to flooding, for example, the poor do not have access to constant electricity (Ajibade & McBean, 2014). It was also reported that only 29% of respondents with 1000 residents in a survey were aware of the possibility of the July 2011 floods indicating inadequate dissemination of information on flood prediction and warnings (Adelekan and Asiyanbi, 2016).
The Lagos State Government is also employing non-structural measures by managing plans in place through ensuring the use of the state's urban development framework on zoning regulations and land use planning by property developers (Jha et al., 2012; Adelekan, 2016). However, the framework has not proved effective as evident in the buildings still constructed on floodplains and along the coast (Adelekan, 2016). While the non-structural measures in the case of Lagos have not been successful in reducing flood risk, the 2010 non-structural measures developed and completed between 2010 to 2012 has proven successful in reducing flood risk in the Hubei, Hunan, Jiangxi and Yunnan provinces after information on flood warning was disseminated on time. This led to early evacuation of residents in flood-prone areas, thereby, reducing their flood risk (Sun et al., 2012).

Table 3.7: Non-structural measures by the Lagos state government

Operations	Responsible Agents
Establishment of an Emergency Command Control Centre	State Emergency Management Agency
Increasing the number of engineers and staff in the office of drainage services from 5 to 75 in the period 2007 to 2011	Ministry of Environment
Assignment of structural engineers to all local government areas to oversee the condition of drainage channels at the local level	Ministry of Environment
Decentralisation of the Building Control Agency to divisional and local government levels	Ministry of Physical Planning and Urban Development
Proposal to establish relief camps in each of the three senatorial districts to shelter displaced persons. (Only one is presently completed and in use)	State Emergency Management Agency
Improvement of primary healthcare delivery at community level	Ministry of Health

Source: Adelekan, (2016)

3.7 Summary

Flooding for Lagos has been an issue since the 1940s and has over the years, increased in frequency and severity. With the increasing population and the rapid urbanization of Lagos, vulnerable people remain at risk and will be to future flood risk. While most of the flood management measures employed in Lagos are mostly structural, there is the need to incorporate flood risk management method employed by other countries as highlighted in section 2.7.

Poor waste management, poor planning, heavy rainfall, land use changes and incapable drainage systems all contribute to the flood problem in Lagos. Understanding flood risk and flood risk management can provide a better understanding of how flood impacts people and possibly offer solutions for better managing flooding for the current and future population of Lagos.

Chapter 4 explains the methods employed in this study to assess the flood situation and management of Lagos.

CHAPTER 4 METHODS

4.1 Introduction

Two approaches were used in this study to evaluate the impacts of flooding on the residents of Lagos. The first approach was understanding the issue of flooding in other countries as well as for Lagos, Nigeria as discussed in the literature review chapters (Chapters 2 and 3). The second ensured that the four aims and objectives set for the research were achieved. They included:

1) ***To identify residents' experiences during and after flooding and understanding whether changes in flood experience has changed or influenced future flood behaviour***

   A questionnaire survey was carried out with the residents in the five chosen areas for the research differing in population size and income area type to understand the different experiences of residents; how they cope before, during and after flood events, and their understanding of factors that hinder or facilitate the delivery of flood management plans in their area.

2) ***To assess flood management measures in place and some of its issues such as drivers and barriers in the different areas chosen for the research in Lagos, Nigeria***

   In order to understand what the federal government plans are for Lagos state and their effectiveness as well as challenges to better flood management and prevention, interviews with two local flood officials was completed. One at the federal level and the other at the state level to better understand what government plans are in place for the research areas. The interviews with the flood officials will help provide comparison for what the residents experience and believe is the situation of flooding in Lagos.

3) ***To statistically analyse precipitation data over 50 years in Lagos, Nigeria for patterns such as changing seasonality of rainfall events, increase in intensity and frequency of rainfall.***

   Analysis of the precipitation data obtained from the Nigerian Meteorological Agency (NiMet) to assess the rainfall distribution of Lagos in order to determine the seasonality and any changes in the rainfall seasonality over time. The data obtained also helped to assess for changes in rainfall frequency and intensity and whether any relationship exists between the rainfall data and past flood events from trends within the data over the time period.

4) ***To use mixed-methods approach for bridging the gap between the flood situation in the five research areas in Lagos, Nigeria by assessing the perception of the flood officials in Lagos and the perception of residents in these areas of their flood experience.***

   Assessing analysed data from the questionnaire survey of residents and interviews with flood officials for similarities and/or differences in their perceptions and understanding of the causes of flooding and opportunities for flood management. This will help in identifying what can be learnt from the current approaches to flooding, the challenges and drivers as well as drawing conclusions in order to recommend approaches that could be adopted to mitigate the flood problem for both the interested stakeholders and policy makers.

4.2 Research Area and Locations

Lagos comprises sixteen Local Government Areas (LGAs). Five of these LGAs (Fig. 4.1) were selected. The areas selected differed in population size, income and housing types (Table 4.1), as well as the variation in experiences of flooding, flood vulnerability and the flood management strategies implemented in each LGA (National Population Commission, 2016). There is a lack of detailed information available for which areas of Lagos experience flooding along with the flood histories for each area (Adelekan, 2016). However, parts of Ikorodu, Surulere, Ikeja, Apapa and Lagos Island have been reported as being more vulnerable to flooding (Nkwunonwo et al., 2016).

Lagos is considered by residents to comprise of two areas: The Island (represented by Lekki and Victoria Island) and the Mainland (represented by Ikeja, Surulere and Ikorodu) (Fig. 4.1). The chosen research areas varied in the income level of their residents and would show the economic wellbeing of the residents in the separate locations which might impact flood prevention and management (Ajibade et al., 2013; Adelekan, 2016).

The Mainland (Table 4.1) contains a full cross-section of housing types ranging from high cost, generally affordable to low cost (slum areas). Almost 70% of Lagos' population are been regarded as living in slums with the number of slum communities increasing from 42 in 1981 to about 100 slum communities by 2010 (Adelekan, 2010). Lagos State's capital is Ikeja (Fig 4.1) which also contains the domestic and international airports. Surulere (Fig 4.1) consists of a mixture of middle and low-cost (slum) housing, as well as being the home to many small to medium sized businesses, while Ikorodu (Fig 4.1) possesses a larger number of low-cost housing areas compared with medium-cost housing and is mostly known as a residential area.

Most of Nigeria's financial institutions have their headquarters in Victoria Island and Lekki which are mainly large-scale businesses, along with many businesses of all sizes. The Island has also been categorised as a high-income area due to the cost of houses in the area. For example, in 2017, the average price for a four- or five-bedroom home on the Island was reportedly N196.05million (USD505,284) while the average price for a four or five bedroom home on the Mainland was valued at N75.91million (USD195,652) (RAC, 2018). Furthermore, in May 2019, the annual cost of a four-bedroom home was estimated for the five areas as follows: Victoria Island at N105million (USD291,680), Lekki at N55million (USD152,785), Ikeja at N75million (USD208,343), Surulere at N55million (USD152,785) and Ikorodu at N15million (USD41,669) (Delmendo, 2019).

Table 4.1: Characteristics of the five study areas in Lagos, Nigeria

Characteristics	Ikorodu	Ikeja	Lekki	Surulere	Victoria Island
2006 Population	527,917	317,614	117,793	502,865	283,791
Land area (km^2)	345.0	49.9	55.0	23.0	193.5
Housing Cost	Low	Middle and High	High	Low and Middle	High

Source: National Population Commission (2016); Adelekan (2010); Ajibade et al., (2013)

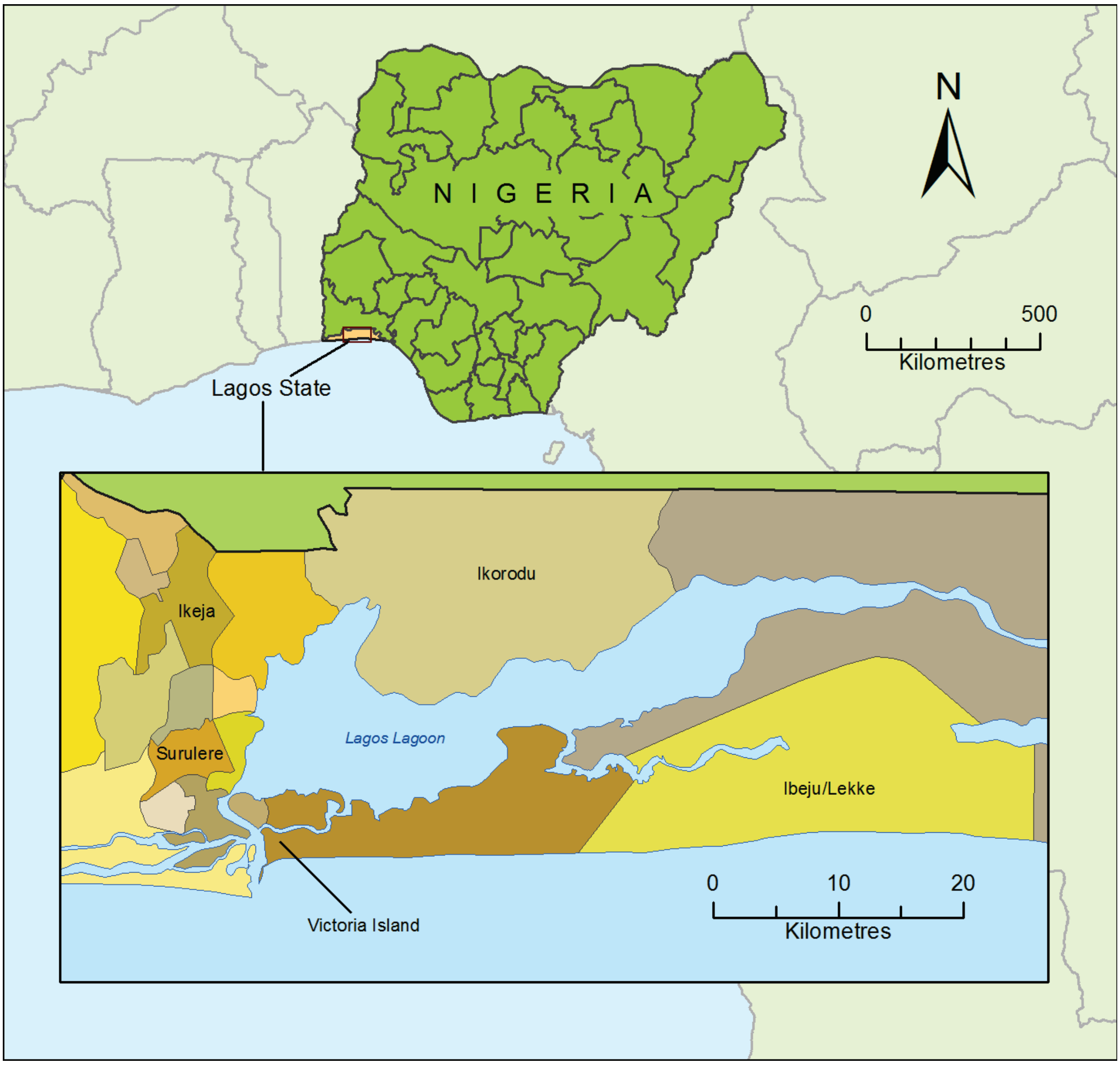


Figure 4.1: Location of areas surveyed in Lagos, Nigeria.

4.3 Data Collection and Analysis

In order for the aims of the research (section 4.1) to be achieved, a mixed methods approach was adopted which included a questionnaire survey of residents, and interviews with key flood officials to identify flood management strategies and the challenges they face . Precipitation data for Lagos was obtained from the Nigerian Meteorological Agency in order to assess patterns and trends within the data that could then be related to the perceptions of residents on flood occurrence and whether conditions are changing.

4.3.1 Mixed Methods Approach

The mixed methods approach assisted with the understanding of the physical and human aspects of the flooding in Lagos, by combining quantitative and qualitative methods.

While quantitative research method focuses on obtaining reliable and accurate numerical measurements for statistical analysis, qualitative methodology cannot be quantified. Qualitative methodology seeks to provide deeper understanding and meaning of actions in a particular context (Queiros et al., 2017). Although qualitative research method provides a holistic understanding in social contexts, it employs the use of smaller sample size which often limits generalisation to the research population and is more time consuming in terms of planning, execution and analysis (Rahman, 2017). Quantitative method on the other hand can be generalised to the research population as it usually involves a larger sample. However, a major weakness of the quantitative methodology is that it leaves out meanings of a social reality. It investigates and estimates the issues but not why or how these issues might exist (Rahman, 2017).

'Paradigm wars' are greatly debated as they influence a research's methodology (De Lisle, 2011). Therefore, in selecting mixed methods, it was useful to understand the different paradigms and their philosophical underpinning since quantitative and qualitative methodologies are different in both ontology and epistemology. The three major research paradigms were therefore explored: positivism, interpretivism and critical theory (De Lisle, 2011).

Combining both methods will therefore produce more reliability and validity in reaching a conclusion than when either method is used separately (Tanyanyiwa and Kanyepi, 2015; Guodaar et al., 2016). By using the mixed methos approach instead of just qualitative or quantitative approaches by themselves, a better understanding of the flood problem in Lagos will be arrived at (Creswell and Clark, 2011) and combines two sets of strengths while also compensating for weaknesses of both (Punch, 2009).

4.3.2 Survey of Residents

Questionnaires are the most commonly used method of survey for research (Burton, 2000; Gillham, 2008) and were used to achieve the first aim of the research. The questionnaires contained both closed and open questions like the method used by Adelekan (2010). To prevent ambiguity and bias, the questions were prepared in a very clear and easy to understand manner.

To fully understand the impacts of flooding in Lagos, it was important to survey residents with past flood experience (Nkunonwo et al., 2016; Ajibade et al., 2013). The questionnaire, attached as Appendix A, was designed in a way that ensured an understanding of the residents' experiences of flooding in each of the research areas, allowing delivery of aim which was to identify residents' experiences during and after flooding and understanding whether changes in flood experience has changed or influenced future flood behaviour. The questionnaire aimed to gather details of the individual's flood experience, responses to past flood events as well as information on how past floods have affected the individuals or changed their behaviours. Questions were also asked about what was perceived to be the causes of the floods in the area as well as responsibility for management. Flood Experience to help understand previous and past experiences of residents to flooding, Response to Flooding and Prevention to assess what is currently been done regarding management and future management plans in Lagos to help ascertain effectiveness and challenges. Additional information from individuals to identify their personal situation and how this might be putting them or preventing them from being at risk to potential flooding in each area, an approach similar to that adopted by Diakakis et al., (2018).

Questionnaires were administered in two ways: individuals completed the form themselves or had the questions read to them face to face and their responses transcribed. The face-to-face survey especially helped respondents who were either elderly or unable to understand the questions. Although face to face surveys on the other hand, may take a longer time to complete, they ensured they were completed at the convenience of the respondent as well ensured the perspectives of a vulnerable part of the population to flood impacts were included in the study.

4.3.2.1 Sampling Strategy

It was important that the areas chosen for the research could provide a better understanding of its flood context (Bhattacharjee and Behera, 2018). For that reason, the research locations were selected due to their past flood history and impacts experienced from flooding

(Nkwunonwo et al., 2016) as this ensured their representation in the survey (Daramola et al., 2016; Tongco, 2007). In each of the areas (Ikeja, Ikorodu, Lekki, Surulere and Victoria Island), an opportunistic sample was taken for the distribution of the questionnaires in the study areas by population (Table 4.2) as this method ensured information gathered from a population is representative of the population (Tambo, 2016). Data were collected over a four week period from 7th May 2017 to 4th June 2017.

A total of 600 questionnaires were distributed to residents by approaching them on the streets and asking if they would be interested in the study in the five areas, an approach also used by Kamal et al.,(2018). The sample consisted of 150 questionnaires distributed in Ikorodu and Surulere with the highest population and 100 each in Lekki, Victoria Island and Ikeja. This number of questionnaires provided a strong likelihood for a reasonable response rate large enough to ensure any relationship between variables can be detected (Davies, 2007). Face-to-face surveys were conducted with informed consent (Tambo, 2016) by providing support when requested for by the residents. The surveys were conducted in the local language of Lagos: Yoruba and also in the popular common *Pidgin English* used across Nigeria. Of the 600 questionnaires distributed (Table 4.2), there were 284 responses from 161 men (approximately 57%) and 123 women (approximately 43%) spread over the five research areas (Table 4.3).

Table 4.2: Population and area of the LGAs, with questionnaire response rates

LGA	Population (2006 census)	Area (km^2)	Number of questionnaires distributed	Number of responses	Response rate (%)
Ikorodu	527,917	345.0	150	59	39.3
Ikeja	317,614	49.9	100	65	65.0
Lekki	117,793	55.0	100	51	51.0
Surulere	502,865	23.0	150	56	37.3
Victoria Island	283,791	193.5	100	53	53.0

Source: (National Population Commission, 2016; Adelekan, 2010)

Table 4.3: Number of male and female respondents in each of the survey areas of Lagos.

Gender/Areas	Ikeja	Ikorodu	Lekki	Surulere	Victoria Island	Total
Male	39	33	27	30	32	161
Female	26	26	24	21	26	123

4.3.3 Questionnaire Data Analysis

After coding the responses, a descriptive analysis of residents' flood experiences was undertaken for the five research areas (Fig 4.1) in order to identify any similarities or differences. The coded data were inputted into Statistical Package for Social Sciences (SPSS) version 22 and the responses to each question for the whole sample and for each individual area was completed. Cross tabulations of frequency for all questions were first completed to show residents' experience of flooding, their response to flooding and prevention and coping measures.

4.3.4 Interviews with Flood Officials

Flood management in Lagos, Nigeria has always been primarily undertaken by the Lagos State Government (public agents) (Fig. 4.2). However, private agents including residents, real estate developers and communities have recently started to become proactive in taking action (Adelekan, 2016). Lagos has only recently started collaborating locally and with its neighbouring countries to mitigate flood impacts and improve flood management, however, results has not yet been evident as flood risk continues to rise significantly in the state. It has been suggested this stems from the state's inability to learn from previous flood experiences as well as the lack of flood warnings and education of residents on what they need to do in the event of a flood (Adelekan, 2016).

The interviews employed involved exploring and understanding questions, ideas, opinions and phenomena around the issue of flooding (Davies, 2007). The initial research plan was to select two flood officials from each of the five chosen areas to interview: one at an official level to compare and contrast what the current and future measures for flood management are and one at a field level to understand what the current situation of flooding in Lagos is. However, during the process of data collection, it was identified that no flood officials had offices in the local government area offices. The flood officials and management responsibilities came under the remit of the Ministry of Environment under the Emergency Flood Abatement unit (Fig 4.2) as the National Emergency Management Agency (NEMA) and under the Drainage department

(Fig 4.2) as the State Emergency Management Agency (SEMA). There was some difficulty locating the right people for this survey, however, after referrals during the visit to the Ministry of Environment, this was completed.

The interviews (Appendix B) were undertaken with a total of two flood officials. One in the National Environment Management Agency (NEMA) in charge of disaster management at the national level and at the State Emergency Management Agency in the Ministry of Environment on the state level. The National Emergency Management Agency (NEMA) office in Lagos was visited to identify the appropriate people with the necessary information on Lagos and a date was set for the interview. The researcher visited the State Emergency Management Agency in the Ministry of Environment and was advised to instead go to the Office of Drainage Services under Public Works Corporation as they were the department in charge of flood management in Lagos and a date was also set for this interview.

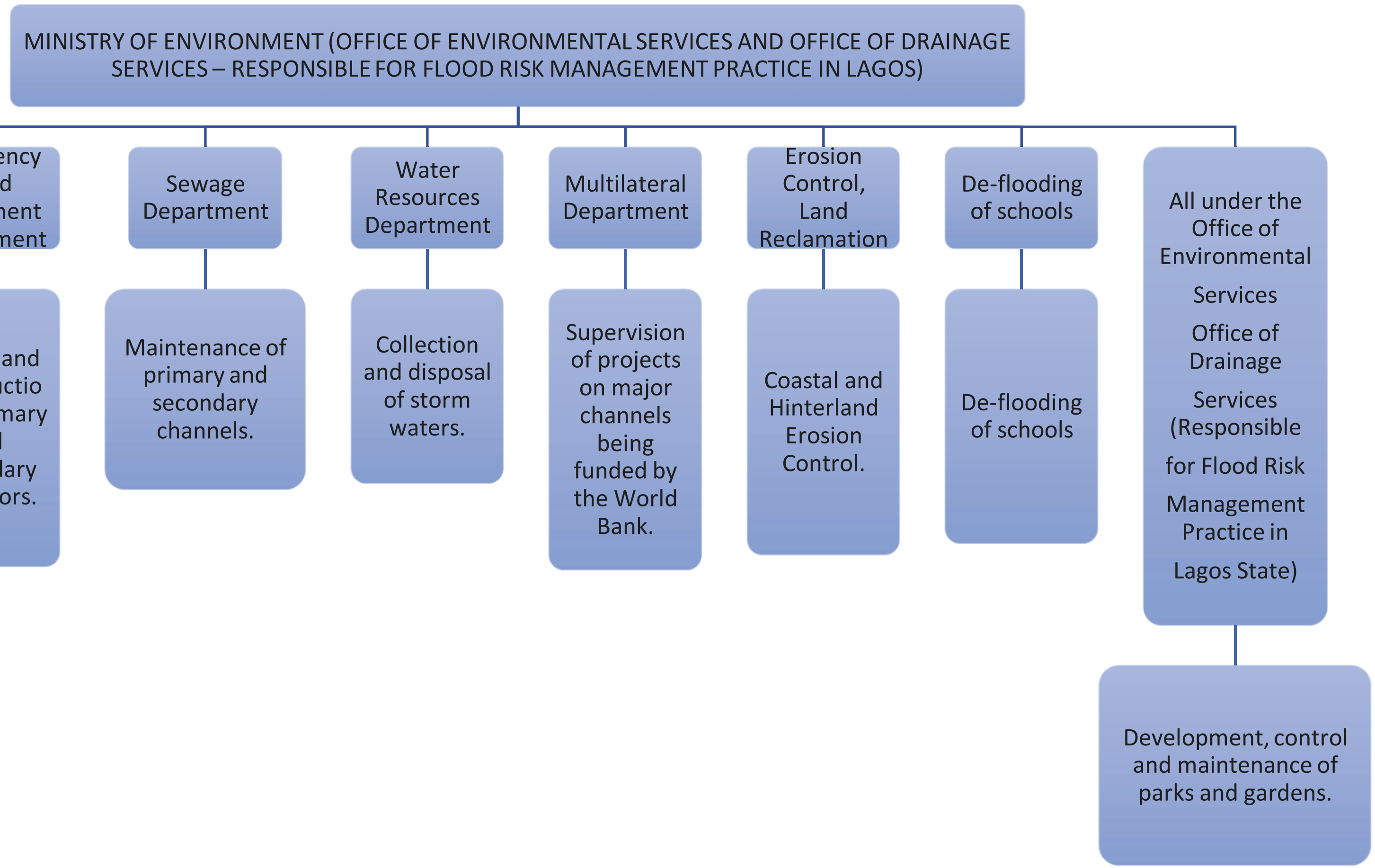


Figure 4.2: Institutional Structure for Flood Management in Lagos, Nigeria

Adapted from Oshodi, 2013

These interviews were done to ascertain the effectiveness or factors limiting the effectiveness of flood management in Lagos, Nigeria by obtaining the flood officials' perspective on what is currently been done, what has been done since the floods, and if not, what challenges they could be facing as well as future measures and plans to protect from flooding. This helped support the data collected from residents through the questionnaire survey in order to understand the different experiences of residents; how they cope before, during and after flood events, and their understanding of factors that hinder or facilitate the delivery of flood management plans in their area (Dawson, 2009) as was done by Adelekan (2010). It has been reported that a common setback with carrying out interview survey is locating the appropriate people with the required information for a research project (Burton, 2000). This was the case for this part of the study; locating the appropriate officials to interview and obtaining their consent to take part in the interview was a limitation as it slowed down this part of the data collection process and as a result, only two officials took part in the interview survey.

4.3.5 Interview Data Analysis

The interviews with the two flood officials were completed by audiotaping in English language as well as by note-taking. The audio was then transcribed for analysis which involved coding by breaking the information into groups and understanding each group as suggested by (Creswell, 2003; Davies, 2007), this was done by listening thoroughly to each response and coding or transcribing after the responses had been given by each flood official. Thematic analysis was used to analyse the data through the use of Nvivo 12, a Qualitative Data Analysis Software (QDAS) (Razak et al., 2019). Thematic analysis is a most advantageous in organising and presenting the knowledge and experience of experts in any field as it aids identifying, analysing and reporting of themes within the data (Salleh et al., 2017). It usually consists of the following steps: data familiarisation, generation of codes, theme search, theme revision, theme definition and producing the report (Braun and Clarke, 2006). This method of analysis offers flexibility, so the data is presented in various ways from the obvious to more in-depth meanings that exist in the data (Braun and Clarke, 2012). For example, its simplicity and flexibility mean there isn't a structured or rigid approach in the analysis. This allows for continuous examination so that even less obvious themes which were not identified at the start of theme definition can be revised and included (Braun and Clarke, 2006). On the other hand, some weaknesses in using thematic analysis are that the analysis can become weak and descriptive as it focuses on what was said rather than an in-depth look at nuances of the data, the assumption of a collective meaning also mean readers must assume data grouped together have the same meaning for all the participants and its flexibility could also mean difficulty identifying or determining key themes (Javadi and Zarea, 2016).

The interview questions (Appendix B) examined flood related issues for Lagos as a whole but also specific for the five research areas (Fig 4.1). The flood officials were asked about how significant of an issue flooding was in Lagos in order to compare their perspective with what the residents believed. They were also queried on causes of flooding in Lagos and the areas, groups most affected by flooding, whether or not the flood situation was changing for the better or worse and reasons for their answers. It was also important to understand what might make flooding easier or more difficult to manage in the five research areas, what flood management plans were currently in place and their effectiveness, what the future flood prevention and management plans were, the implementation timeline of these plans and challenges that might make achieving these plans a difficulty. Certain discussions around coping mechanisms and resilience came up spontaneously. The sample size for this survey was limited due to the difficulty in finding the right people and their willingness to take part in the survey (Schlef et al., 2018).

4.3.6 Positionality of the Researcher

This research combined quantitative and qualitative research methods and while quantitative research can provide more robust and generalized findings, qualitative research aims to provide insight into experiences of participants in the research (Bourke, 2014). Identifying the positionality as a researcher is an important aspect of qualitative research involving reflection or self-assessing on the part of the researcher, including how their background and own experiences has informed the research subject and the research process (Holmes, 2020). According to Malterud (2001), this reflection begins by the researcher identifying their pre-research beliefs from both a personal and professional viewpoint on the situation of the issue and what will be investigated as well as a rationale for exploring this subject and its relevance to the researcher's academic interests.

The selection of Lagos as the area of study was essential to the researcher as it is a State that has experienced more frequent flooding over the last two decades as well as significant urbanisation and population growth (Adelekan, 2016). Professionally, this area was examined during the researcher's Masters dissertation submitted in January 2014 which focused on three areas in Lagos: Apapa, Ikorodu and Victoria Island. However, the research at the time only explored residents' perspective from a questionnaire survey distributed to 300 residents and 196 completed questionnaires received back. Overall, the respondents believed heavy rainfall (48%) and failed drainages (39%) to be the two main causes of the last flooding they had experienced. Although the government had provided access to sandbags and deepened drainage systems in the past, the residents believed that the government still needed to do more in terms of reducing their flood risk by providing better flood protection measures. From a personal viewpoint, Lagos is the researcher's hometown, having grown up and lived in the State for over 20 years. The researcher also had first-hand experience of flooding and had read and seen accounts of other residents in areas of Lagos who had suffered even more severe impacts than some in other areas of Lagos through literature and media review.

Both the personal and professional experiences of the researcher therefore sparked interest into trying to understand why the issue of flooding has continued to overwhelm Lagos. For this research process, it was important to not only explore residents' experiences but also to examine the perspective of flood officials in Lagos as well as the hydrometeorological context, since historically, the researcher had found that residents believed rainfall to be the main cause of flooding and that the government had provided inadequate flood protection measures. Holmes (2020) however, suggested that it is important to note that a researcher's positionality is subjective and never fixed as it can evolve over time.

4.3.7 Process and Lived Experience of Conducting the Survey and the Role of Survey Volunteer

The five areas investigated for this research (Ikeja, Ikorodu, Lekki, Victoria Island, Surulere) had previous experience of flooding (Nkwunonwo, 2015) and so choosing these areas ensured both current and past flood situations of these areas could be examined with the residents and flood officials. The researcher designed the residents' questionnaire to capture their' perspective through the inclusion of both open and closed questions about flood experience, flood management and their personal experience. Interview questions with flood officials were designed to explore the situation of flood management in Lagos: what it is, how effective is it, factors that hindered or favoured flood management not just in Lagos but in the different research areas as well as future flood management plans for the state.

The researcher completed two data collection trips to Lagos, Nigeria after completing risk assessment for each trip and obtaining ethics approval for the ethics committee. The first trip in May 2017 lasted for a month; it involved distributing all 600 of the questionnaires in the five research areas by the researcher and a research volunteer who knew some of these areas better than the researcher. In the first week, the researcher and volunteer categorised the areas into days of week, with each day seeing a different area being targeted for questionnaire distribution. Different streets in the area were targeted and residents were approached on an opportunistic basis. The researcher was introduced together with the research study and the resident was asked whether they would be interested in taking part in the questionnaire survey. The names of the streets and house number were noted confidentially in order to keep a record of where the questionnaire had been dropped off to aid the collection process. For those that agreed to take part, consent forms were completed by the participants before disseminating the questionnaire. 36 (12.7%) of the respondents needed help understanding the questions and writing their answers as they did not speak English fluently but rather their native language of Yoruba and some wanted to converse in the common 'Pidgin English' (Table 4.4) spoken in Lagos and throughout Nigeria. The researcher and volunteer were both fluent in Pidgin however only the volunteer was fluent in Yoruba and so for these residents who needed help, both the researcher and volunteer were present. For the residents who needed the information in Pidgin English, the researcher asked the questions and the answers were recorded by the volunteer. Where the information was required in Yoruba, the volunteer asked the questions, obtained the answers and translated the answers in English to be recorded by the researcher. The researcher arranged to collect the rest of the questionnaires fourteen days later in order to provide the residents as much time as possible to answer the questions.

Table 4.4: Research Participants who needed help with the Questionnaires

Area	Pidgin English	Yoruba Language
Ikeja	3 (1.0%)	2 (0.7%)
Ikorodu	12 (4.2%)	3 (1.0%)
Lekki	6 (2.1%)	1 (0.4%)
Surulere	4 (1.4%)	1 (0.4%)
Victoria Island	2 (0.7%)	2 (0.7%)

Purposive sampling was selected for the qualitative research since the research areas had been chosen and this was to be done by visiting the local government areas and interviewing two flood officials in each of the areas; one would provide an official perspective while the other would provide a field-based perspective. The researcher visited the local government offices of Lekki and Victoria Island on Monday and the Ikorodu office on Tuesday while the volunteer visited the Surulere office on Monday and the Ikeja office on Tuesday of the second week in order to locate flood officials for the areas to arrange interviews. However, they were both advised in all five research areas that no flood officials had offices in the local government area offices. This made the research process of locating the flood officials for each area challenging. However, on Wednesday of the second week, the researcher visited the Ministry of Environment following a recommendation from the local government areas and inquired about the right officials to speak to about the research and after waiting for almost the whole day, was directed instead to the National Emergency Management Agency (NEMA) in Lagos. The National Emergency Management Agency (NEMA) offices were visited the next day and an appointment was set up for Monday of the following week with an official who the researcher was advised would be the best official to speak to about the flood issues in Lagos.

At this point the initial sampling approach which was purposive now changed and the researcher adopted a snowball sampling approach. On Monday of the third week, the first interview was completed . A consent form was completed and signed by the official who was happy to participate in the survey. The researcher was also provided with contact based in the Lagos State Ministry of Environment by the NEMA official as the next official who would be ideal to participate in the survey. Attempts to contact the official was initially unsuccessful. On visiting the office, the researcher was informed that the official was on annual leave and would not return until the following month. The rest of the third week and was spent collecting the completed questionnaires from the research areas by the volunteer while the researcher visited the Nigerian Meteorological Agency (NiMet) office in Lagos in order to obtain hydrometeorological data for Lagos, however, the researcher was sent to two extra offices in different locations and was advised that the data were unavailable despite earlier research indicating that it was.

The final week was spent visiting the offices of the Lagos State Ministry of Environment and the Nigerian Meteorological (NiMet) Agency but none of these efforts yielded any useful results for the research. Throughout the survey process, the research supervisor was updated daily of the research progress and challenges. Afterwards, the researcher returned to Northampton and over the next year, was in constant communication with the volunteer in a bid to obtain the hydrometeorological data while the researcher continued to send emails found on the website about obtaining the data.

For the second trip to Lagos, Nigeria in September 2018 which lasted for two weeks, the researcher aimed to interview more flood officials as well as obtain the hydrometeorological data. The previous contact obtained through the National Emergency Management Agency (NEMA) flood official still did not get back to the researcher. The first week was spent visiting the Lagos State Ministry of Environment and the researcher was advised to book an appointment and return the following week. The rest of the week was then spent visiting the Nigerian Meteorological (NiMet) Agency office in Lagos to obtain rainfall and river flow data. After multiple visits, the researcher was given the contact details of the person to request the data from. One of the emails was responded to in October 2018 and the researcher was advised that the data was available for a sum of approximately N95,760 Nigerian Naira, this was paid for with grant received from the University's Chancellors Fund scholarship and the data received in November 2018.

The second week of the September 2018 trip concluded the data collection survey. The researcher attended the booked appointment but after introducing the research study, was advised instead to go to the Office of Drainage services. After multiple visits, the director referred the researcher to an official who could best participate in the survey, interview appointment was booked and completed. The researcher then inquired about flood officials responsible for field work in these areas but was advised they were none situated for each area but rather engineers who visited these areas with knowledge of the area before and after the rainy season to sensitize the residents in different areas (discussed in Chapter 5, section 5.3.4). When asked if interviews could be arranged with them, the researcher was advised this was not an option as they were busy.

4.3.8 Reflections on Pros/Cons of the Sampling Approach

Non-probability methods were employed for the surveys as they have been suggested to provide more detailed responses when compared to probability sampling methods (Oliver, 2004). Opportunistic sampling was used for the questionnaire survey with the residents while a purposive sampling approach which later became adapted to a snowball approach was used for the survey with the flood officials.

Opportunistic sampling employed the use of participants who were both willing and available to take part in the survey. In the survey with the residents, this method helped save time as it was a faster way of locating participants and ensured that residents with the information required where involved in the sample. Language was a limiting factor with some residents only speaking their native language of Yoruba, which meant more time was spent in the research area than had been planned. For example, while most of the questionnaires were dropped off to be collected after completion by the respondents in the five research areas, the interviews in Yoruba (9) and Pidgin English (27) each lasted for 2 hours.

Purposive sampling which was the approach initially planned for the research by visiting the local government offices of the research areas and speaking with the flood officials would have ensured participants who due to their experience would provide significant data on the survey. However, locating participants was a limitation towards using this method as the researcher had to visit offices on different occasions where officials were unavailable to take part in the survey.

It has been suggested that locating the appropriate participants is a limitation found with using non-probability methods (Oliver, 2004). The snowball approach was used to identify the flood officials willing to take part in the survey. Several referrals finally proved tangible as the right office as well as the appropriate participant was identified for the survey. However, this was time-consuming (only completed after two data collection trips to Lagos in May 2017 which lasted for a month and the 2 weeks trip of September 2018) as well as expensive as these trips included international flight and local daily transportation costs in Lagos.

4.3.9 River Flow Data

One of the initial aims of the research (section 1.4) planned to analyse river flow data since the research focused on the fluvial and pluvial causes of flooding. This data would have helped to demonstrate the relationship between rainfall and locally generated runoff, as well as river flow from outside the immediate Lagos catchment. (Ogbiye et al., 2018). The researcher was informed after visiting the Nigerian Meteorological (NiMet) Agency and the Ministry of Environment that data for the major rivers flowing through Lagos; Yewa, Ogun, Osun, Owo and Aye (Fig 4.3) are measured and collated by the Nigeria Hydrological Services Agency (NIHSA). The data, however, was not forthcoming despite efforts and frequent requests in person, through the phone and via emails.

Figure 4.3: Major Rivers flowing through Lagos

Source: Oteri and Ayeni (2016)

4.3.10 Precipitation Data

Over time, the global earth's climate has changed leading to increased severity and frequency of extreme weather events, for example, there has been an observed change to the pattern, severity and duration of precipitation which is a common cause of flooding (Olanrewaju et al., 2017). It has also been reported that there are significant flood frequency implications associated with varying rainfall characteristics such as its seasonality, pattern and duration (McEwen, 1993). Therefore, understanding the rainfall characteristics, its pattern, variability and changes or trends where they exist for Lagos, Nigeria was tantamount to this research study (Mumo et al., 2019). Rainfall data was provided by the Nigerian Meteorological (NiMet) Agency for two locations in Lagos: the Ikeja weather station at the Murtala Muhammed International Airport (on the mainland) and the second location was in Victoria Island (on the Island) (Table 4.5). Rainfall data of 35 years was gathered from the weather stations in Ikeja and Victoria Island from daily rainfall measurements taken with a manual rain gauge. NiMet complies with the World Meteorological Organisation's (WMO's) guidelines, this is evident in the WMO Regional Training Centre funded by the WMO (NiMet, 2013). This data will help understand rainfall characteristics and also ascertain whether relationships such as trends or patterns exists between seasonality of daily rainfall and periods of flooding.

Table 4.5: Characteristics of the Research Climate Stations in Lagos, Nigeria

Station Number	Station Name	Latitude	Longitude	Elevation (m)	Data Record
65201	Ikeja	6.4ºN	3.2ºE	12.0	1981-2015
65203	Victoria Island	6.3ºN	3.2ºE	4.3	1981-2015

4.3.11 Precipitation Data Analysis

The data collected from the Nigerian Meteorological Agency (NiMet) will be used to show the current situation of flooding in Lagos, Nigeria such as rainfall characteristics using descriptive statistics analysed on Minitab, identifying differences or similarities where they exist through results such as coefficient of variation to determine deviations in rainfall amounts from 1981 to 2015 for the Victoria Island as well as the Ikeja stations (Olanrewaju et al., 2017). The descriptive statistics will also show the distribution of the data (Oguntunde et al., 2011), which could help determine seasonality of rainfall from the rainfall data and whether or not any changes or trends have been observed over the time period (McEwen, 1993). Yaya and Fashae (2015) believed that identifying past changes in yearly precipitation was key in understanding the seasonality of rainfall. However, it was also suggested that whether or not these changes are identified, flood characteristics such as surface runoff amounts, permeation and evapotranspiration are affected to a large extent by changes in how much rain falls seasonally (Yaya and Fashae, 2015).

Globally, rainfall is disparate and different regions have reported different rainfall patterns. Understanding rainfall variability for both sites for the time series from 1981 to 2015 was also important in order to determine how they impact on the areas as well as the climate's variability for our research timescale (Mumo et al., 2019). For each year, the zero rainfall days were isolated to identify how many days of precipitation occurred annually, this was further categorised into rainfall days for each month as well as rainfall amounts and identifying similarities and differences of both sites.

The occurrence of a flood event depends on the amount of precipitation as well as the rainfall intensity (Gericke and du Pleissis 2011), as a result, rainfall intensity for annual and monthly data for 35 years from 1981-2015 was calculated in order to highlight the rainy season and months when flood impacts from intense rainfall may have been more severe compared to years and months with lesser rainfall intensity (Afangideh et al., 2013; Olanrewaju et al., 2017).

A trend analysis was then carried out in order to observe whether there were any changes to the rainfall data from both sites through the use of regression analysis. However, the rainy season was first observed for increasing or decreasing rain days (Omogbai, 2010). Trend analysis for the entire research time period of 1981 to 2015 for the rainy season and annual rainfall was analysed for the Ikeja and the Victoria Island stations using linear regression models (Mumo et al., 2019) and time series plots to determine long term trends in the rainfall data for each of the stations (Olanrewaju et al., 2017). The regression analysis also identifies whether one variable is dependent on the other, thereby explaining any relationship between the rainfall data and years of flood events (Ogbiye et al., 2018). The Mann-Whitney test which is a non-parametric test was used to check for homogeneity of the Ikeja and Victoria Island sites without assumptions about the distribution of the data (Mann and Whitney, 1947).

CHAPTER 5 RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents and explores the results from the data collected and analysed in order to achieve research aims and objectives (section 1.4). In section 5.2, the flood experience and perspective of residents were explored to better understand the flood situation according to the respondents. This will help fulfil objective 1 which is to understand the different experiences of residents; how they cope before, during and after flood events, and their understanding of factors that hinder or facilitate the delivery of flood management plans in their area. In section 5.3, flood management in Lagos was explored from the responses of flood officials and examined alongside section 5.2 to identify similarities and/or differences with the situation of flooding and flood management in Lagos. Section 4.4 presents analysis of precipitation data collected from the Nigerian Meteorological (NiMet) Agency for two stations (Ikeja and Victoria Island) from 1981 to 2015. This will help fulfil objective 3 which is to assess the rainfall distribution of Lagos for seasonality and any changes in the rainfall seasonality over time, assess for changes in rainfall frequency and intensity and whether any relationship exists between the rainfall data and past flood events from trends within the data over the time period. This chapter concludes with a summary of results from data collected for this study in section 5.5.

5.2 Residents' Perspective

The five study areas (Ikeja, Ikorodu, Lekki, Surulere and Victoria Island) contain a mixture of residential and business properties (Table 5.1).

Table 5.1: Proportion of residential and business properties in each of the study areas.

Research Areas	Residential (%)	Businesses (%)
Ikeja	70	30
Ikorodu	90	10
Lekki	80	20
Surulere	40	60
Victoria Island	50	50

Source: (National Flood Official, 2017)

Although the five research areas varied in size and population, they were selected due to their having susceptibility to flooding (Nkwunonwo et al., 2016). The study areas (Fig 4.1 – section 4.2) also differed in terms of their income levels based on property values (RAC, 2018; Delmendo, 2019). The Island (Lekki and Victoria Island) is regarded as being a sought-after area with higher house prices compared to the Mainland (Ikeja, Ikorodu and Surulere) which comprises of a mixture of high, middle and low value properties. This was important in order to evaluate similarities and/or differences in flood experience of residents as their areas might make their flood experiences different (Ajibade et al, 2013; Adelekan, 2016). 600 questionnaires were distributed in the five chosen research areas on an opportunistic basis by population of the areas (Table 5.2). 100 questionnaires were distributed in Ikeja, Lekki and Victoria Island while 150 questionnaires were distributed in both Ikorodu and Surulere. 284 questionnaires were received back, with a total response rate of 47%, comprising 161 males (57%) and 123 females (43%) across all five areas. Ikeja at 65% had the highest response rate as residents in the area were more willing to participate in the questionnaire survey during fieldwork when compared to the lowest response rates seen in Ikorodu at 39% and Surulere at 37%.

Table 5.2: Population and research areas, with questionnaire response rates

Research Areas	Population (2006 census)	Area (km^2)	Number of Responses	Response Rate (%)
Ikeja	317,614	49.9	65	65.0
Ikorodu	527,917	345.0	59	39.3
Lekki	117,793	55.0	51	51.0
Surulere	502,865	23.0	56	37.3
Victoria Island	283,791	193.5	53	53.0

Source: (National Population Commission, 2016; Adelekan, 2010)

5.2.1 Experience of Flooding

Since the 1940s, flooding has become a greater concern due to the number of people affected as well as the increasing frequency and severity of the flooding. Of the almost 300 respondents, about 79% had experienced flooding whilst living in Lagos, with almost 60% having been flooded in their current property. This high proportion of residents who have experienced flooding is not exclusive to Lagos, Daramola et al., (2016) reported a response rate of 80% with residents in Anambra, Bauchi, Cross River, Kogi and Sokoto in Nigeria. Lagos has also been identified by Nkwunonwo et al., (2015) as being the most flood susceptible state in Nigeria due to urban expansion as well as its coastal location. Across the five areas there was little variation in the proportion of residents who had experienced flooding in their current property (Table 5.3). Residents of Ikeja were less likely to have been flooded in their current property (54%) while those in Lekki were most likely (65%).

Table 5.3: Proportion of residents who have experienced flooding in their current property

Research Area	Number of Residents	Percentage of Residents
Ikeja	35	53.8
Ikorodu	36	61.0
Lekki	33	64.7
Surulere	33	58.9
Victoria Island	32	60.4

Although residents of Ikeja were least likely to have been flooded in their current property, the proportion still accounts for more than half of the respondents in that area. This is not only particular to Ikeja, since, from the results (Table 5.3), more than half of the respondents in the other four research areas have been flooded in their current property (Nkwunonwo et al., 2015). The lower proportion of respondents in Ikeja having been flooded could be partially attributed to the area having better maintained drainage systems, including those designed specifically for disposing storm water. The better standard of maintenance within this area can be attributed to this area being the location of both the domestic and international airports, the home of the State Government, the affluence of the area as well as residents being more aware of behaviours that may increase the flood risk (National Flood Official, 2017). However, this is not the case for the entirety of Ikeja, for example, the Government Reservation Area (GRA) is a high-income area and home to both past and current top government officials yet is prone to flooding due to the lack of adequate drainage channels (Nigerian Tribune, 2017).

Despite drainage systems in Ikeja being well maintained, they still need upgrading and expanding as they were designed to cope with a smaller volume of run-off. Over time with urban expansion, their ability to cope with the increasing runoff being generated has been increasingly degraded (National Flood Official, 2017).

Lekki is a highly desirable area to live in Lagos due to its modern development and proximity to coast, but it has the highest proportion of respondents who have experienced flooding in their current property. This high vulnerability is due to much of this area having been reclaimed from the sea, and due to its low altitude above sea level combined with very low slope gradients runoff generated by heavy rainfall is very slow to drain away (Adepelumi and Olorunfemi, 2000). Although most of the development has been planned, the intense competition for space has led to residents building on floodplains and without adequate drainages, this combined with the low relief has made this area more vulnerable to flooding. Victoria Island is in a similar situation to Lekki. Although Victoria Island is an area characterised by offices and high value residential properties, shops line many of the street. These small shops are often responsible for some of the indiscriminate disposal of waste that can end up blocking drainage channels. Both Ikorodu and Surulere however, contain a mixture of mid- and low-value housing, though there is a slightly greater proportion of unplanned housing (slums) in these areas. The vulnerability of the residents to flooding living in unplanned housing as in Cape Town is increased due to the quality of the housing which can be easily damaged by flood waters (Dalu et al., 2018). Respondents also gave responses for how often they are flooded in Lagos (Fig. 5.1) where very often represents flood experienced more than once in a year as reported to be the case for Lagos since the year 2000 (Nkwunonwo et al., 2016). A female respondent in Ikeja added, "*we used to be flooded once a year, now it is more than once in a year. I would say it is now often.*" A male respondent in Lekki also mentioned, *"we experience flooding very often here."* Another male respondent in Ikorodu added, *"we get flooded yearly and it is so bad."*

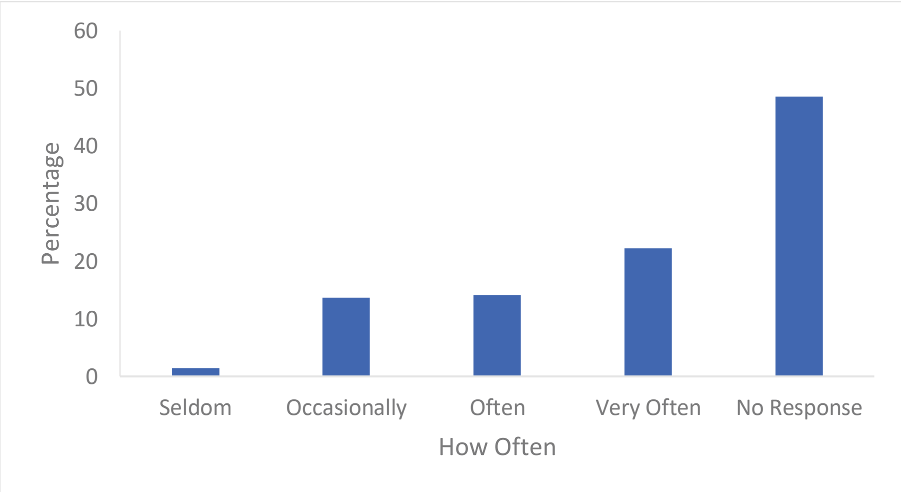


Figure 5.1: Respondents' perception of frequency of having been flooded in Lagos

Of the 161 responses from men (approximately 57% of total sample population), 77% had been flooded while living in Lagos. However, women do appear to have been more seriously affected. Out of a total of 123 women who responded (approximately 43% of the total population sample) (Section 4.3.2.1 – Table 4.3), 81% had been flooded while living in Lagos. Of the 284 respondents, 71% of men and 45% of women had been flooded while living in their current home (Fig 5.2). Chanthy and Samchan (2014) reported that women experience flooding and flood impacts more when compared to men due to living at areas that are prone to flooding. More women in Ikeja, a high and middle-income area, were flooded in their current home (Fig 5.3) as well as while living in Lagos (Fig 5.4).

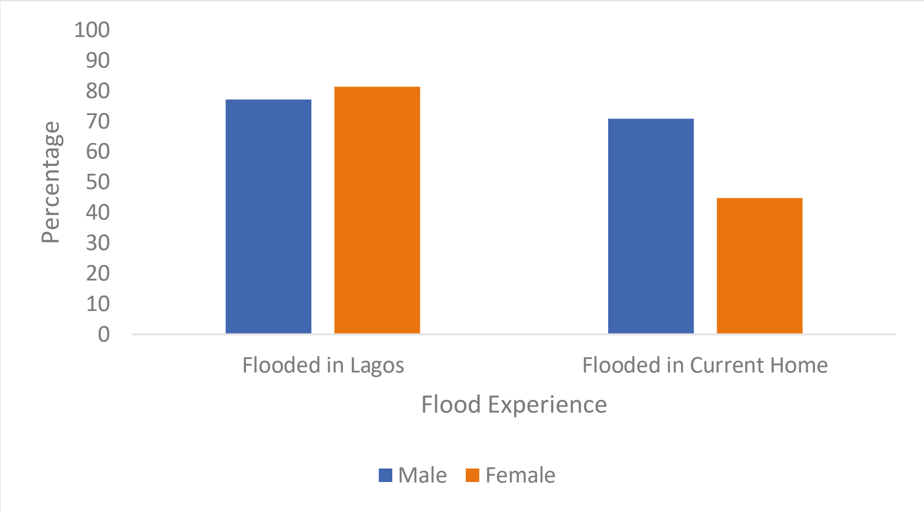


Figure 5.2: Gender Differentiated Experience of Flooding

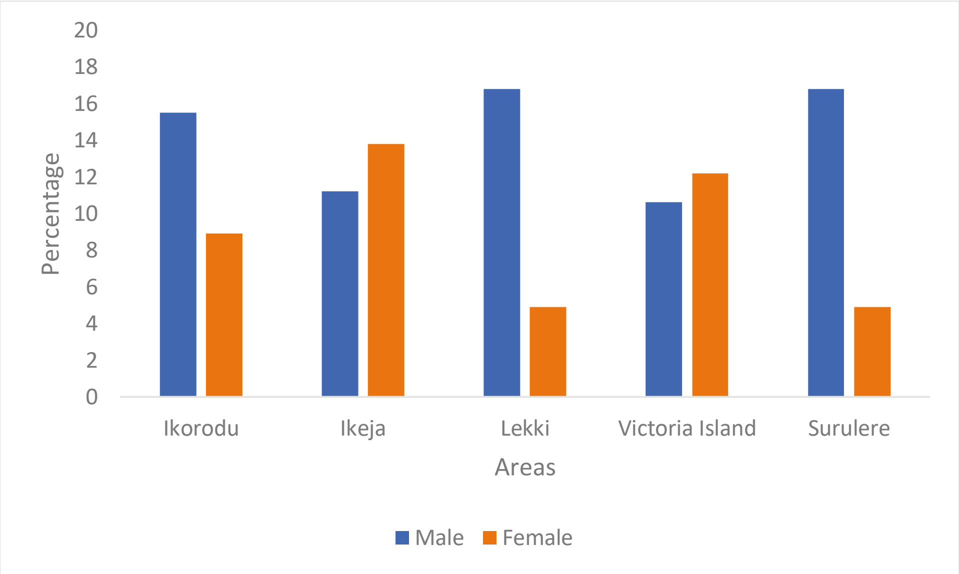


Figure 5.3: Flood Experience in Current Home by Gender and Areas

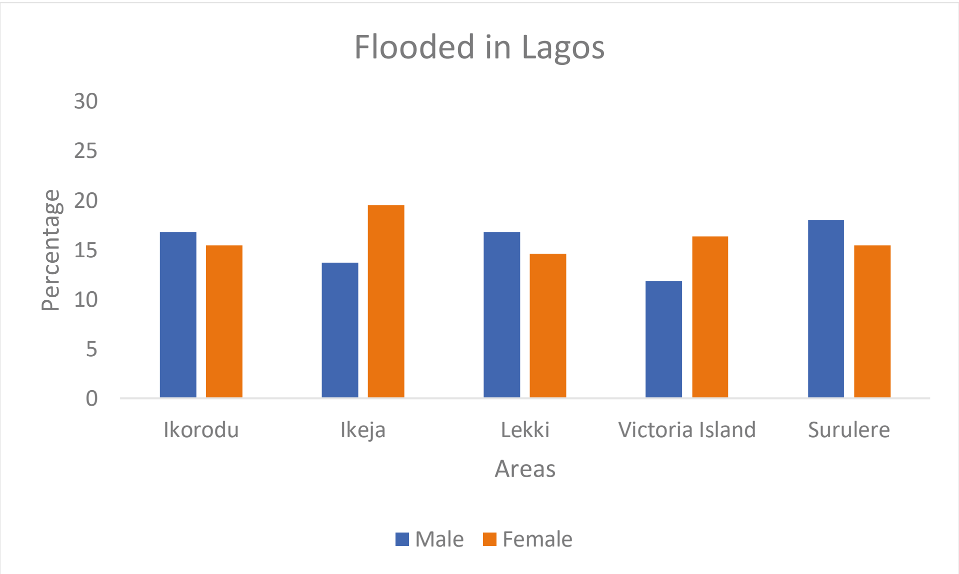


Figure 5.4: Flood Experience while living in Lagos by Gender and Areas

5.2.2 Perception of the Flood Situation

Flooding in Lagos usually occurs during the rainy season, although there are several factors that increase the likelihood of flooding occurring in a particular area. The respondents reported they experienced flooding between May and October (Fig 5.3), which matches the rainy season. None of the respondents mentioned having experienced flooding in February and December.

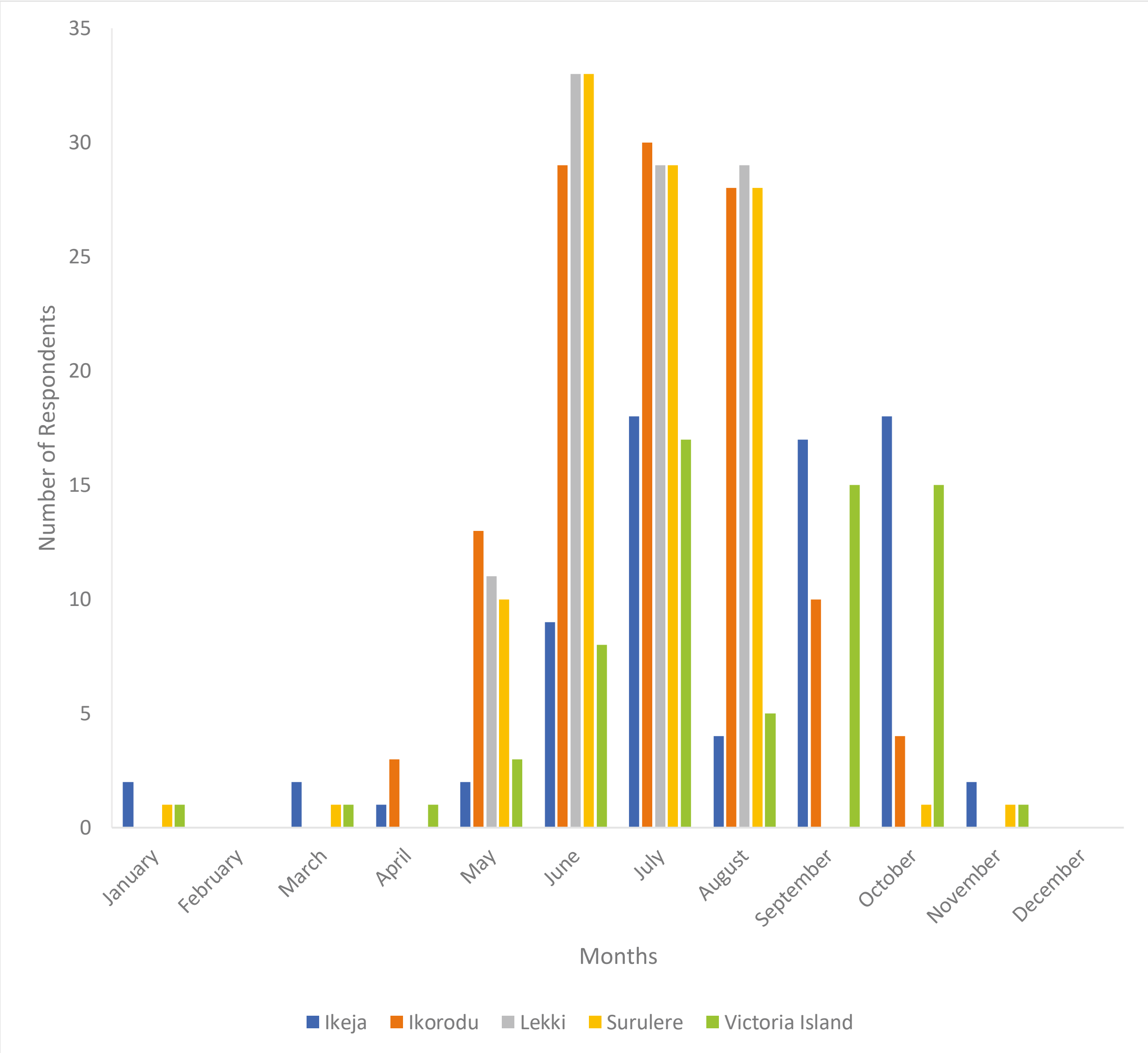


Figure 5.5: Times when residents have experienced flooding

The highest daily precipitation values occur in the month of June (Tables 5.4a & 5.4b) which is also the wettest month (Fig 5.6a & 5.6b) at both Ikeja and Victoria Island However, whilst flooding does occur in June, a greater proportion of respondents in Ikeja and Victoria Island reported July as being the most likely month for flooding (Fig 5.5).

Table 5.4a: Daily descriptive statistics per month for Victoria Island rainfall (mm)

Months	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
January	0.6	0.0	78.0	4.8	820.0
February	1.1	0.0	169.7	6.8	649.0
March	1.6	0.0	64.8	6.2	385.6
April	4.9	0.0	155.5	14.1	288.3
May	7.6	0.0	126.1	16.8	220.6
June	14.3	0.0	237.7	27.2	189.8
July	6.6	0.0	278.4	19.2	289.6
August	3.4	0.0	137.1	11.4	340.9
September	7.3	0.0	280.0	18.1	248.3
October	5.9	0.0	171.0	16.0	271.1
November	1.4	0.0	82.0	6.7	465.7
December	0.4	0.0	54.2	3.2	928.2

This fits with the rainy season which normally occurs between March/April and September/October (Israel, 2017).

Table 5.4b: Daily descriptive statistics per month for Ikeja rainfall (mm)

Months	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
January	0.4	0.0	45.8	3.2	762.1
February	1.1	0.0	64.5	5.7	505.7
March	2.3	0.0	69.5	8.1	357.3
April	4.2	0.0	152.8	11.8	284.0
May	6.2	0.0	105.1	13.7	221.9
June	9.5	0.0	237.3	20.7	217.1
July	6.3	0.0	233.0	18.2	287.8
August	2.8	0.0	118.8	9.2	328.4
September	6.5	0.0	119.5	13.8	211.7
October	5.1	0.0	108.4	11.3	219.1
November	2.6	0.0	67.8	8.2	318.8
December	0.6	0.0	85.0	4.6	727.0

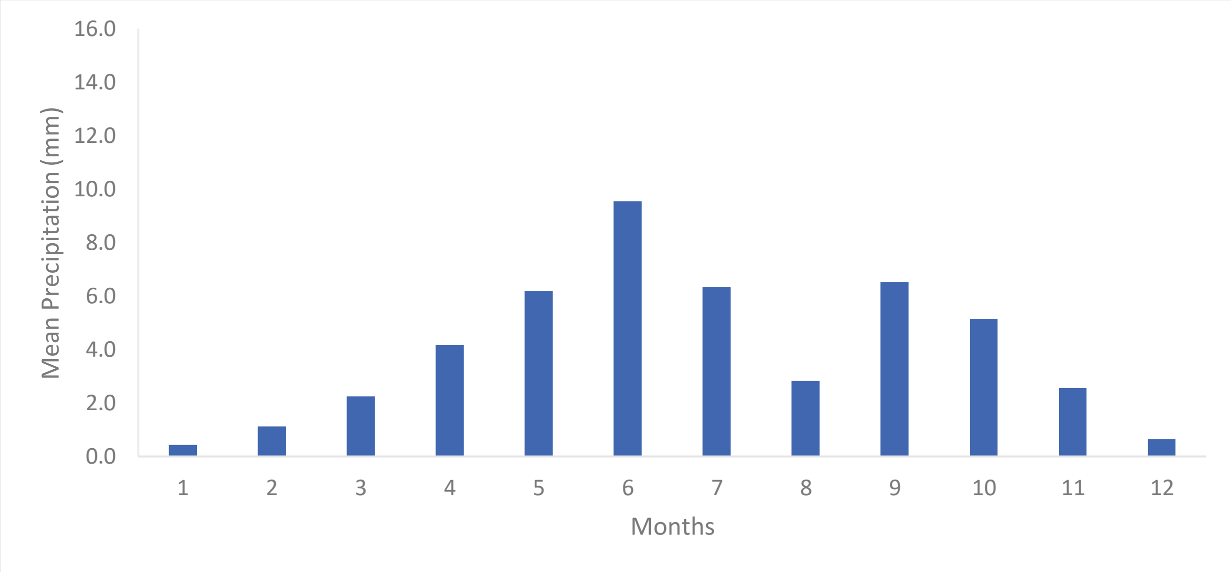


Figure 5.6a: Daily mean rainfall per month at Ikeja (1981-2015)

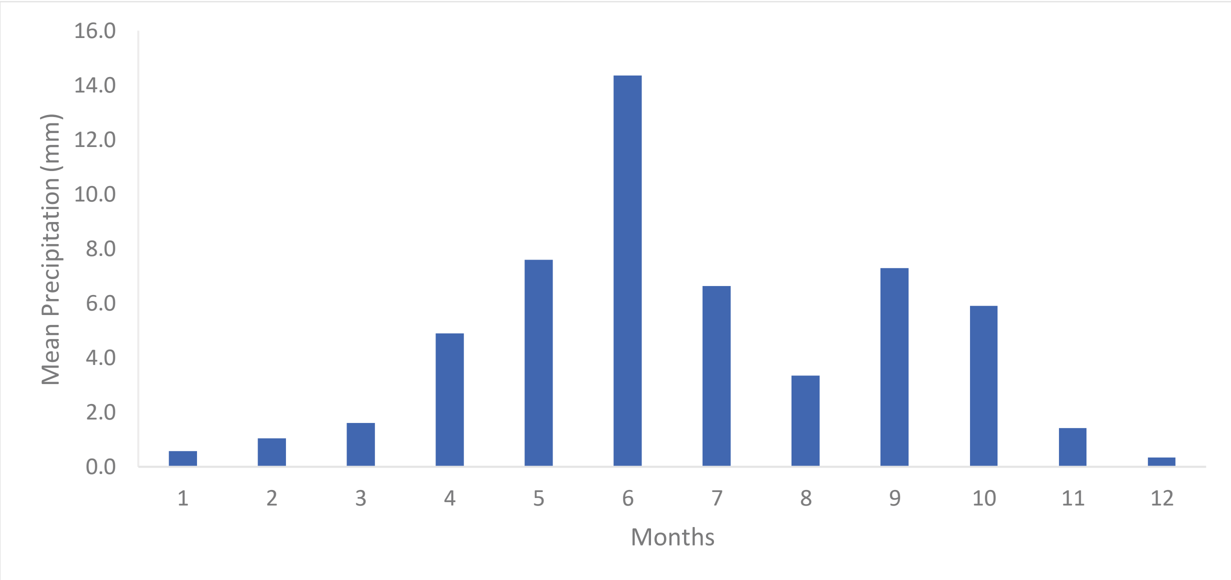


Figure 5.6b: Daily mean rainfall per month at Victoria Island (1981-2015)

The majority of residents (over 60%) (Table 5.5) attributed the cause of flooding to episodes of heavy rainfall. This brings with it the issue of seasonality and therefore a usually clearly defined time during the year when the risk of flooding will be at its greatest. Although rainfall was the main cause of flooding according to respondents, direct human activity also played a role. In Pakistan, heavy rainfall has been the main cause of various flood events. However, deforestation has led to increased runoff, this coupled with heavy rainfall, has caused flash flooding (Mahmood et al., 2016). Poorly designed and maintained drainage systems have been linked to the flash flooding in Kuala Lumpur (Mohtar et al., 2020). Heavy rainfall and blocked drainages were also regarded as the main causes of flooding in Lagos (Adelekan and Asiyanbi, 2016) with one of the respondents in Ikeja stating that, "*Heavy Rainfall always causes drains to overflow*." Another in Victoria Island stated, "*Flood is a normal thing in*

Lagos, once it is the rainy season it must flood every year."

Table 5.5: Perception of causes of flooding as a percentage of respondents

Causes	Areas				
	Ikeja	Ikorodu	Lekki	Victoria Island	Surulere
Heavy Rainfall	56.9	64.4	64.7	62.3	60.7
Flooding from River/Lagoon	26.2	15.3	13.7	28.3	12.5
Failure of Storm Drains	26.2	39.0	45.1	30.2	39.3
Waste Disposal	6.2	10.2	23.5	9.4	19.6
Lack of Appropriate Drainage	12.3	6.8	9.8	17.0	7.1
Other	16.9	10.2	23.5	22.6	19.6

It could be argued that other causes identified such as failure of the storm drains to cope with the volume of runoff or flooding from the river or lagoon are indeed associated with the heavy rainfall. However, residents were very clear in terms of what they perceived to be the main cause, for example the failure of the storm drains to cope with the volume of runoff was seen as a separate issue. Over 45% of the respondents in Lekki felt that the failure of storm drains created challenges for flood management in this particular location. The low elevation and its location by the coast, combined with the fact that much of this area has been reclaimed from the Lekki Peninsula, in order to create more land for the purposes of development as well as to relieve congestion in neighbouring areas such as Ikoyi and Victoria Island (Adepelumi and Olorunfemi, 2000), combine to make this area more vulnerable to flooding. One of the respondents in Lekki stated, "*we don't have good drainage here so every year when rain falls, everywhere floods*." Lee et al., (2016) suggested that ineffective drainage systems will lead to flooding in the event of extreme precipitation. The case study of Accra, Ghana showed that inadequate drainages ranked as the third main cause of flooding at 33% (Asiedu, 2020). Land reclamation is a common practice in many coastal countries such as China, Japan, United Kingdom, the Netherlands and Singapore to provide more space for development and living (Wang et al., 2014). Due to Lagos' increasing demand for space and its high population, land reclamation has provided housing for about 500,000 people in areas such as Lekki, Victoria Garden City (VGC), Ajah, Ogudu and Maroko. However, areas like these are characterised by flooding and drainage issues from lack of post-construction maintenance and management, this was believed to be due to insufficient management budgets (Aina et al., 2004). Since coastal wetlands are important players as flood defence and drainage, changing their original topography impacts their runoff regulation abilities, this means that residents who live in these areas have been put at risk from flooding by the fact that effective surface drainage is already a challenge to begin with. After land reclamation projects in China which dates back to the 1950s, extreme flood events have been recorded. In 1994, parts of southern China experienced severe flooding, Hangzhou experienced flooding four times between 1996 and 2000. More recently in October 2013, Zhejiang Province also became severely flooded (Wang et al., 2014).

The lack of increasing the stormwater carrying capacity of the drainages, their lack of maintenance and upgrade to manage with increased surface runoff due to urbanization, across the city poses an additional challenge to the effective management of runoff. Ikorodu is already densely congested, with the lack of available space above the level of flood waters forcing many new developments onto open areas on the floodplain. Due to the expansion into low lying areas, where drainage is less effective, a greater proportion of respondents from Ikorodu attributed the cause of flooding to heavy rainfall. The failure of storm drains to cope with the volume of runoff was considered by residents from all five areas as the second most important cause of flooding (Table 5.5).

Lack of drainage was seen as an important contributor to flooding in most areas, although the problem of blocked storm drains due to inappropriate disposal of waste was perceived to be a greater issue in Lekki and Surulere. The fact that these two areas are at opposite ends of the property value spectrum yet have similar perceptions of the impact of incorrect waste disposal as a flood cause emphasises the need for better waste disposal and collection methods. The issue of poor waste management and collection has previously been identified as a causal factor in flood initiation (Olajuyigbe et al., 2012), with 7% of residents in the area of Mile 12, Lagos agreeing that flooding was often caused by waste blocking drainage channels. The blocking of drainage systems by inappropriate waste disposal and lack of collection is an issue that increases the flood risk (Nwigwe and Emberga, 2014), though not one restricted to just Lagos or Nigeria alone. Due to insufficient waste management in the informal settlements in Mumbai, India, residents reportedly dump their waste indiscriminately by the roadside which gets swept into drainage systems after rainfall events leading blockages (Chandrasena et al., 2017). Waste does however play a more complicated role within some communities in Lagos. In the Badia community, waste is actively collected by residents and used for three purposes: income generation for the garbage collectors and unauthorised developers who use it to fill parts of the canal prior to selling the "reclaimed" land for development, a cheaper alternative to sand filling when constructing the foundations for a house, and as a material for flood control by filling bags to be used as defences in the same way as sandbags (Ajibade and

McBean, 2014).

5.2.3 Impacts of Flooding

Flooding has the potential to have wide-ranging impacts within a community causing significant disruption to day-to-day life, communication and to both the local and national economies (Douglas, 2017). The impact on Lagos residents varied with over 35% of respondents having experienced property damage due to flooding (Table 5.6). Damage to property can cause serious financial hardship to residents in the aftermath of the flood due to inadequate or more often lack of insurance cover. Historically, coastal countries have suffered significant economic damage from flooding and despite this, there is a setback in residents' willingness to purchase flood insurance (Shao et al., 2017). 55% of Veneto's topography consists of floodplains and as a result has experienced significant financial losses due to flooding, with an estimated cost of 1 billion Euros after just the October-November 2010 flood. Despite this, residents were reportedly reluctant to purchase insurance (Roder et al., 2019). Shao et al. (2017) noted that 50% of residents of the United States Gulf Coast did not have any flood insurance; in part influenced by low income, renting their property rather than owning it and trust in government (Shao et al., 2017). Lack of insurance cover tends to disproportionately affect those in the lower income brackets, making their recovery in the aftermath of the flood even more challenging. While flood insurance plays an important role in developed countries (Shao et al., 2017; Roder et al., 2019), this is not the case for cities in West Africa. In Dakar and Cotonou, flood risk is not covered by the insurance companies under multi-risk cover packages. Only the rich and businesses benefit from flood risk cover offered by insurance companies in Accra, and despite the 2003 Insurance Act in Nigeria which made hazard insurance compulsory for all public buildings, this has not been the case. This failure of the insurance industry prompted the State of Lagos to enact a law in 2010 for insuring public buildings against hazards, however, enforcement has been lacking (Ouikotan et al., 2017).

Disruption to day-to-day life, including travelling around Lagos was the second highest impact reported (Table 5.6). In addition to the disruption caused by the depth and volume of water, floods also damage public road surfaces by creating potholes that make safe movement around the affected area difficult. Whilst it is not unusual for residents to attempt to travel around the area in their vehicles, the majority, especially those in the low-income areas, will try and wade through the water (Rush, 2018), though it is more likely that they will remain in their homes, unable to get to work, or in some cases get back to their property. Approximately one third of respondents had lost property and/or had been forced to abandon their properties until the floodwaters subsided.

Table 5.6: Impacts of flooding experienced by residents

	Number	Percentage
Damage to Property	109	38.4
Disruption	97	34.2
Loss of Property	95	33.5
Displacement	89	31.3
Hospitalisation	32	11.3
Loss of life	16	5.6

The lack of pre-flood preparedness meant that flooding has had a more direct impact on the residents as this is one of the key factors required to help minimise the impact of flooding, alongside the learning of lessons from previous flood events, mitigation, emergency response and recovery (Nkwunonwo et al., 2015). However, it has been suggested that worrying about flooding does not usually mean preparedness in order to achieve flood mitigation (Adelekan and Asiyanbi, 2016). Just over 10% of respondents had either been hospitalized or had an immediate member of the family hospitalized due to the flooding. Flooding in Lagos does unfortunately cause fatalities with approximately 5% of respondents having lost a family member or being aware of a death in their immediate neighborhoods. During the 2011 floods, residents in Lagos reportedly lost from one to over 15 people, work hours and properties (Adelekan and Asiyanbi, 2016). The impacts experienced by the respondents have also been ranked from the highest to the least (Fig 5.7). Flooded roads which overwhelmed and inundated telecommunication systems, disruption of economic activities and factories having to temporarily close down were impacts experienced by residents in Accra, Ghana (Douglas, 2017).

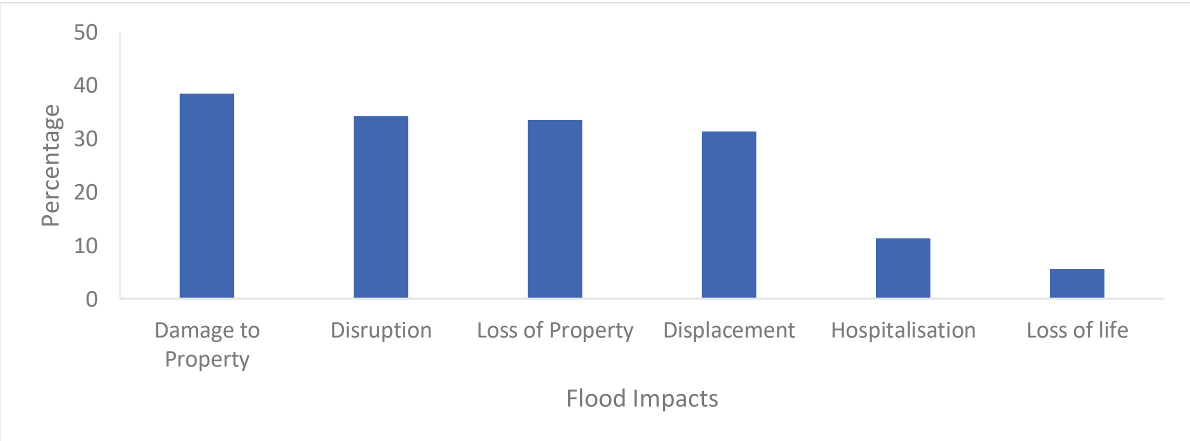


Figure 5.7: Percentage of flood impacts experienced by residents

It has been determined that men and women experience disasters differently (Nellemann et al., 2011). Of the 284 responses received, 144 (approximately 70% male and about 30% female) mentioned they and their family had been affected by flooding with particular impacts experienced mentioned (Table 5.7).

Table 5.7: Impacts of Flooding by Gender

	Displacement	Damage to Property	Disruption to Movement	Loss of Property	Hospitalization	Financial Loss	Loss of Lives
Male	26 (9.2%)	87 (30.6%)	56 (19.7%)	85 (29.9%)	26 (9.2%)	60 (21.1%)	16 (5.6%)
Female	5 (1.8%)	43 (15.1%)	11 (3.9%)	41 (14.4%)	5 (1.8%)	35 (12.3%)	0 (0.0%)

Results showed that men were mostly affected when compared to women with highest numbers recorded around damage to property, loss of property and financial loss. 5.6% flood fatalities mentioned by the male respondents when compared to 0% of the female respondents is not unique to this study as about 70% of the reported deaths were male in the evaluation of the devastating flooding experienced by the United States of America in 2005. This was attributed to more men in support and emergency roles as well as being risk-takers when compared to women (Jonkman and Vrijling, 2008). Greater financial loss may be due to the fact that men accounted for most of the sole providers (Fig 5.8) when compared to women so more money was spent coping and recovering from floods as seen in the case of Cambodia where men were suggested to be the financial decision-makers compared to the women (Chanthy and Samchan, 2014).

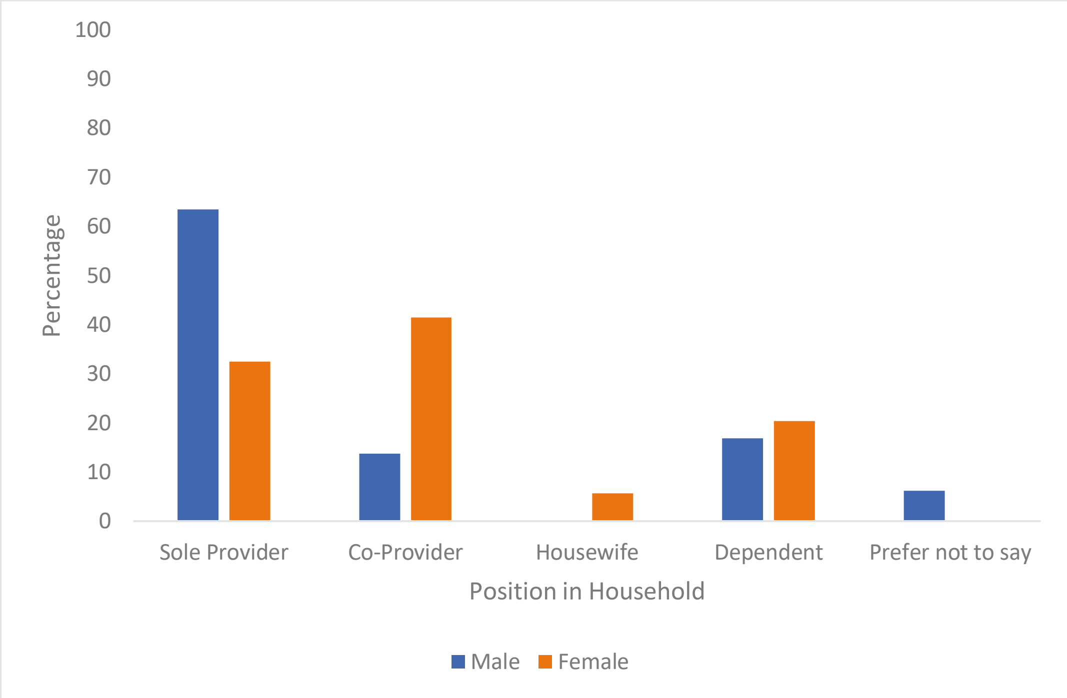


Figure 5.8: Position of respondents in their households

Ajibade et al., (2013) suggested that in developing countries where systems are inequitable due to factors such as poverty, social, political, economic and cultural status, women usually have a higher flood risk and as a result, it was also important to examine how women were affected by flooding compared to men (Table 5.8).

Of the 161 male respondents, at least 10% reported they had experienced each of the impacts mentioned when compared to the 123 female respondents. Damage to property accounted for the highest impact reported by both gender (54% male and 35% female). When examined across the five research areas (Table 5.9), for the female respondents, 13.8% respondents from Ikeja; an area comprising of high and middle-income accounted for the highest while 12.2% respondents were recorded from another high-income area, Victoria Island. However, for the male respondents, the 13% respondents from Surulere, an area characterised by a mixture of low and middle-income followed by 11.8% respondents in the high-income area of Lekki. This showed that while more men had been affected by flooding compared to women, level of income did not appear to have an effect on impacts experienced.

Table 5.8: Proportion of Gender-Differentiated Impacts across the five research areas

		Areas					
Gender	Impacts	Ikorodu	Ikeja	Lekki	Victoria Island	Surulere	Total
Male	Displacement	4 (2.5%)	11 (6.8%)	0 (0.0%)	11 (6.8%)	0 (0.0%)	26 (16.1%)
	Damage to Property	17 (10.6%)	16 (9.9%)	19 (11.8%)	14 (8.7%)	21(13.0%)	87 (54.0%)
	Disruption to Movement	12 (7.5%)	4 (2.5%)	18 (11.2%)	3 (1.9%)	19 (11.8%)	56 (34.8%)
	Loss of Property	19 (11.8%)	16 (9.9%)	17 (10.6%)	15 (9.3%)	18 (11.2%)	85 (52.8%)
	Hospitalization	6 (3.7%)	4 (2.5%)	6 (3.7%)	2 (1.3%)	8 (5.0%)	26 (16.1%)
	Financial Loss	14 (8.7%)	0 (0.0%)	23 (14.3%)	1 (0.6%)	22 (13.7%)	60 (37.3%)
	Loss of Lives	2 (1.3%)	0 (0.0%)	7 (4.3%)	0 (0.0%)	7 (4.3%)	16 (9.9%)
Female	Displacement	3 (2.4%)	1 (0.8%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	5 (4.1%)
	Damage to Property	11 (8.9%)	17 (13.8%)	0 (0.0%)	15 (12.2%)	0 (0.0%)	43 (35.0%)
	Disruption to Movement	9 (7.3%)	1 (0.8%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	11 (8.9%)
	Loss of Property	9 (7.3%)	17 (13.8%)	0 (0.0%)	15 (12.2%)	0 (0.0%)	41 (33.3%)
	Hospitalization	3 (2.4%)	1 (0.8%)	0 (0.0%)	1 (0.8%)	0 (0.0%)	5 (4.1%)
	Financial Loss	3 (2.4%)	17 (13.8%)	0 (0.0%)	15 (12.2%)	0 (0.0%)	35 (28.5%)
	Loss of Lives	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Table 5.9: Chi-Square distribution of Impacts and Location for male and female

		Male			Female		
Impacts		Value	df	Asymptotic Significance (2-sided)	Value	df	Asymptotic Significance (2-sided)
Displacement	Pearson Chi-Square	23.4	4	0.0	5.9	4	0.2
	Likelihood Ratio	30.4	4	0.0	6.7	4	0.2
	Linear by Linear Association	0.8	1	0.4	3.4	1	0.1
	N of Valid Cases	161			123		
Damage to Property	Pearson Chi-Square	10.1	4	0.0	50.4	4	0.0
	Likelihood Ratio	10.3	4	0.0	65.1	4	0.0
	Linear by Linear Association	2.1	1	0.1	8.5	1	0.0
	N of Valid Cases	161			123		
Disruption to Movement	Pearson Chi-Square	42.4	4	0.0	27.2	4	0.0
	Likelihood Ratio	45.3	4	0.0	24.0	4	0.0
	Linear by Linear Association	4.2	1	0.0	14.7	1	0.0
	N of Valid Cases	161			123		
Loss of Property	Pearson Chi-Square	4.7	4	0.3	50.8	4	0.0
	Likelihood Ratio	4.7	4	0.3	64.4	4	0.0
	Linear by Linear Association	0.2	1	0.7	5.9	1	0.0
	N of Valid Cases	161			123		
Hospitalization	Pearson Chi-Square	6.6	4	0.2	5.9	4	0.2
	Likelihood Ratio	6.9	4	0.1	6.7	4	0.2
	Linear by Linear Association	0.4	1	0.5	3.4	1	0.1
	N of Valid Cases	161			123		
Financial Loss	Pearson Chi-Square	82.7	4	0.0	60.0	4	0.0
	Likelihood Ratio	101.3	4	0.0	69.6	4	0.0
	Linear by Linear Association	6.3	1	0.0	0.8	1	0.4
	N of Valid Cases	161			123		
Loss of Lives	Pearson Chi-Square	22.1	4	0.0	-	-	
	Likelihood Ratio	25.7	4	0.0	-	-	
	Linear by Linear Association	4.4	1	0.0	-	-	
	N of Valid Cases	161			123		

Chi square (X^2) results showed while men showed a higher probability for loss of property ($p= 0.3$) compared to women ($p= 0.0$), women had a higher probability to being displaced with a significant P value ($p= 0.2$) compared to the value for men ($p= 0.0$) where correlation is significant at 0.05 (2-sided). ActionAid (2021) suggested that flooding leads to women and girls becoming displaced which forces them to move into camps where they experience difficulty assessing basic facilities. Women in Mogadishu, Somalia had to gather their resources together to employ the services of security guards to prevent them from sexual violence experienced in camps after being displaced (Andre et al., 2019).

Respondents also mentioned the different ways they had been impacted by flooding, for example, impacts to them and their family and to their neighbourhood. Impacts stated included hospitalisation, loss of lives, displacement, disruption to movement, damage to property and financial loss. In Ikeja and Victoria Island, loss of property was reported as the main impact experienced by both respondents and their family as well as in their neighbourhood (Figs 5.9 & 5.10). Damage to property was also greatest in Ikorodu with, for example, a male respondent stating that "*part of the kitchen walls collapsed and the rooms were flooded*."

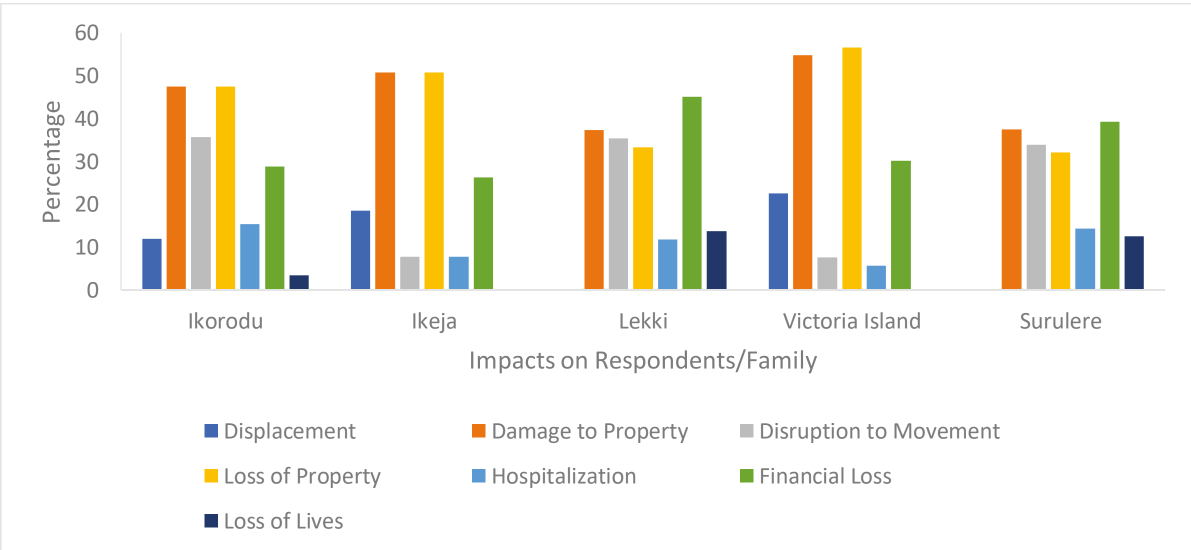


Figure 5.9: Impacts of flooding on respondents/family in each of the five areas in Lagos.

A female respondent in Ikorodu stated that during the flood experienced which caused them the greatest impact, "*no one could move on the street or you would be swept away. Cars could not move around*." In Surulere, a respondent stated, "*more people suffer from malaria after flooding*." Another respondent in Lekki stated that when they experienced flooding, "*it seriously hindered movement for some time.*" Another male respondent in Ikeja stated that their neighbourhood suffered as "*electricity supply which was not great in the first place became affected as the electricity lines/poles fell over.*"

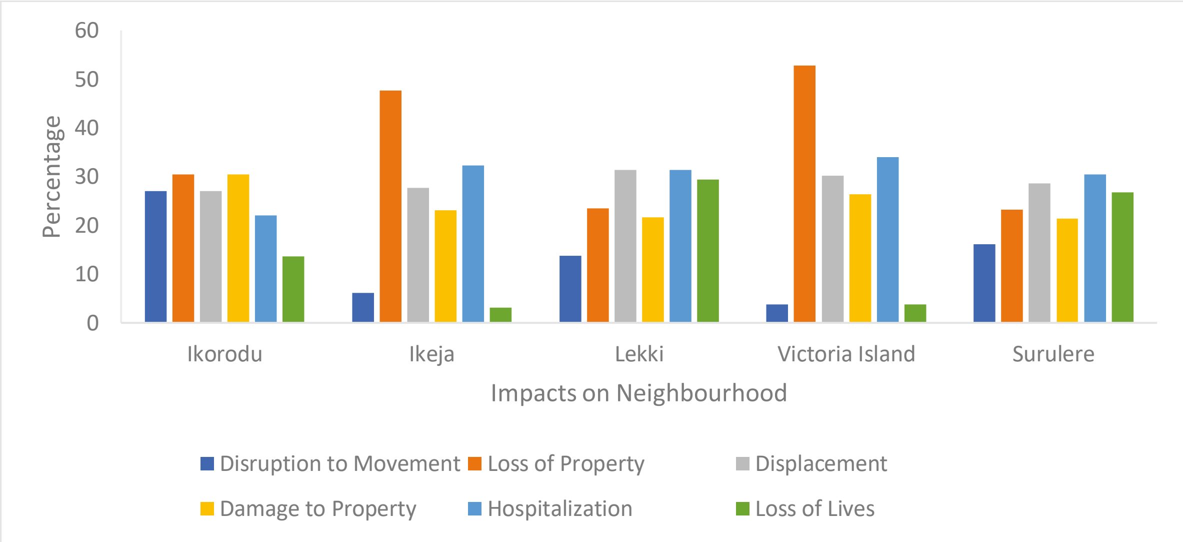


Figure 5.10: Impacts of flooding on neighbourhood in each of the five areas in Lagos

Despite the regularity of flooding, due in part to the lack of appropriate flood management infrastructure across the whole city, the government appears to be taking a reactive approach rather than being proactive. A proactive approach would include raising the public's awareness of the flood risk as well as preparing them for flooding and making and implementing plans for response to flood management. Whereas a reactive approach treats flooding as an engineering or emergency issue without the preparedness associated with the proactive approach (WMO, 2011). This could be due to a combination of the rapid growth of Lagos, and the expansion of unplanned developments within the state, plus an increase in the scale of the problem due to the lack of maintenance and expansion of the existing flood management infrastructure (Ajibade & McBean, 2014). In Accra, Ghana, rapid and unplanned urbanization has also contributed to the issue of inadequate flood management (Atanga, 2020). The Nigerian government's response is further compromised by the failure of warnings to reach residents in parts of the city due to regular and frequent power cuts which make them unable to assess news and information when televised (Ajibade & McBean, 2014), and where these are received, they are often treated with distrust due to the belief that the warnings and evacuation orders are in fact a means of removing residents by the government from slum areas. This lack of trust has been caused by this approach being used to move over 300,000 slum residents from Maroko in Victoria Island in 1990 (Adelekan, 2010). Similarly, it was reported that due to Mozambique's lack of access to electricity, disseminating and communicating flood warnings remain a challenge (Hellmuth et al., 2007).

Even though there is distrust of government action amongst certain communities in Lagos, there appears to be little concerted effort amongst residents to minimise their future flood risk. Where action is taken, it is the local community who tend to take responsibility (40%) and drive the modifications needed to reduce future flood risk and impacts (Table 5.10). This could be due to the fact that communities have a better local understanding of flood risk for their areas since communities experience direct impacts of flooding on the socio-economic and physical environment (Atanga, 2020). Residents feel let down by the government with only 16% of residents believing that there has been a government response to earlier flooding. Whilst it is widely felt that the government has not taken action, residents believe that responsibility for flood protection and reduction of the flood risk is that of the government. Individual action by the respondents and/or their families was about 5%. The lack of individual responsibility for reducing flood risks is an attitude found in other parts of the globe. In Cape Town, it was reported that individual involvement in managing their flood risk was lacking, however, it was suggested that this could be due to residents lacking the financial resources to protect themselves from the impacts of flooding (Olorunfemi, 2011).

Table 5.10: Proportion of responsible parties taking actions to minimise future flood impacts

Responsibilities	Number	Percentage
Individual/Family	15	5.3
Landlord	7	2.5
Local community	113	39.8
Government	46	16.2

Where individuals have taken action, it tends to come from a restricted list of relatively low cost, but potentially effective activities. The use of sandbags to keep water out of properties and the raising of the entrance of the property were the most common practices (Fig 5.11).

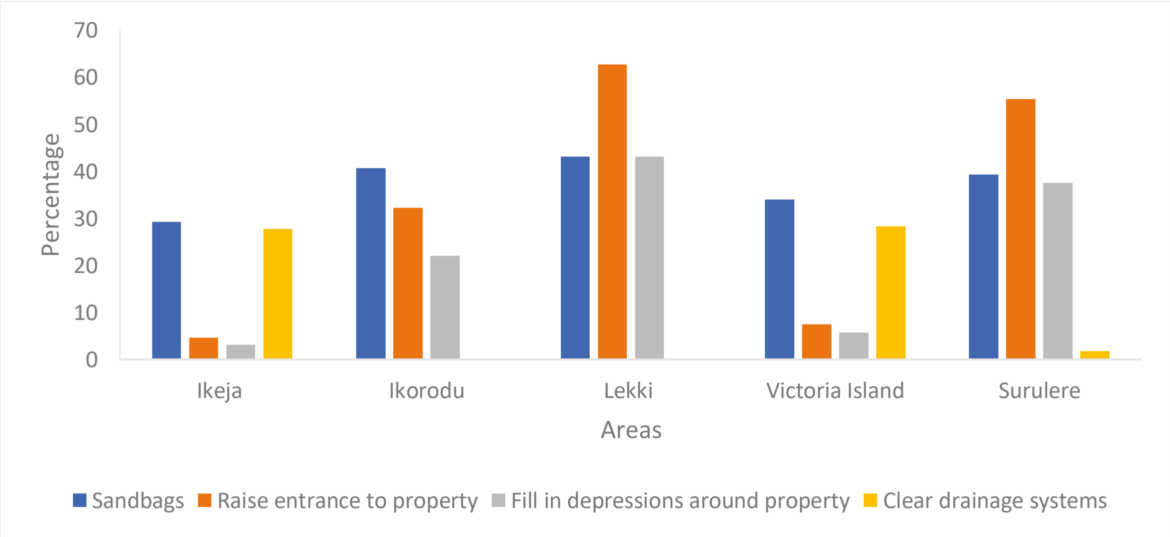


Figure 5.11: Actions taken to minimise flood risk and impacts

The blockage of drainage systems with waste is potentially an easy issue to resolve yet is the least popular of the actions. This particular action tends to be more likely to be undertaken by the local community rather than individuals. Unfortunately, the domestic and commercial waste removed from the drainage systems is usually dumped by the side of the channel. The failure to remove the waste from the locality often leads to the material being washed back into the drainage systems the next time it rains. Blocked drainages in Lagos have been attributed to be from an inadequate system for proper waste collection and disposal (Olukanni et al., 2014). Previous governments from 2007-2015 attempted to foster a sense of community pride through the introduction and promoting of an "Environmental Sanitation Day" where it was expected that all residents spent time clearing channels in their immediate neighbourhood (Olukanni et al., 2014). To clear time for this activity, businesses were required to close and travel was restricted for a three-hour period. Subsequently this compulsory activity was changed to a voluntary one as it was believed that the economy should not be shut down (State Flood Official, 2018). Following this change in status, Environmental Sanitation Day has fallen into abeyance. Waste bins are provided, although not regularly collected for disposal by the Lagos State Waste Management Authority (LAWMA) as seen in the cases of Kosofe, Alimosho and Eti-osa Local government areas where more than70% of the residents across the three areas believed LAWMA had challenges with proper waste management in the state (Onuminya and Nze, 2017). More than half respondents believed this was due to the breakdown of the waste collection trucks, while others mentioned their inability to pay the waste collection fees as another reason why the collection of their waste was not done regularly; some residents also believed LAWMA lacked sufficient machinery for waste management (Onuminya and Nze, 2017).

It was also important to understand those taking up the actions to minimise flood risk and impacts across the five locations, residents gave varied responses between the government, their neighbourhood and household/family actions. Individual activities to reduce subsequent flood risk to individual properties varied between the areas. Respondents in Lekki (63%) and Surulere (55%) mainly raised the entrance to their property, and those in Lekki and Ikorodu were less likely to clear drainage channels despite the fact that respondents in these areas saw the lack of channel clearing as the second highest cause of flooding (Lekki at 45% and Ikorodu at 39%). Respondents from all areas believed poor drainage systems were the cause for why the flood situation was getting worse. According to the respondents, since the last flood they experienced, there have also been actions taken to minimise flood risk by either or all of them and/or their family, the neighbourhood and the government (Fig 5.12).

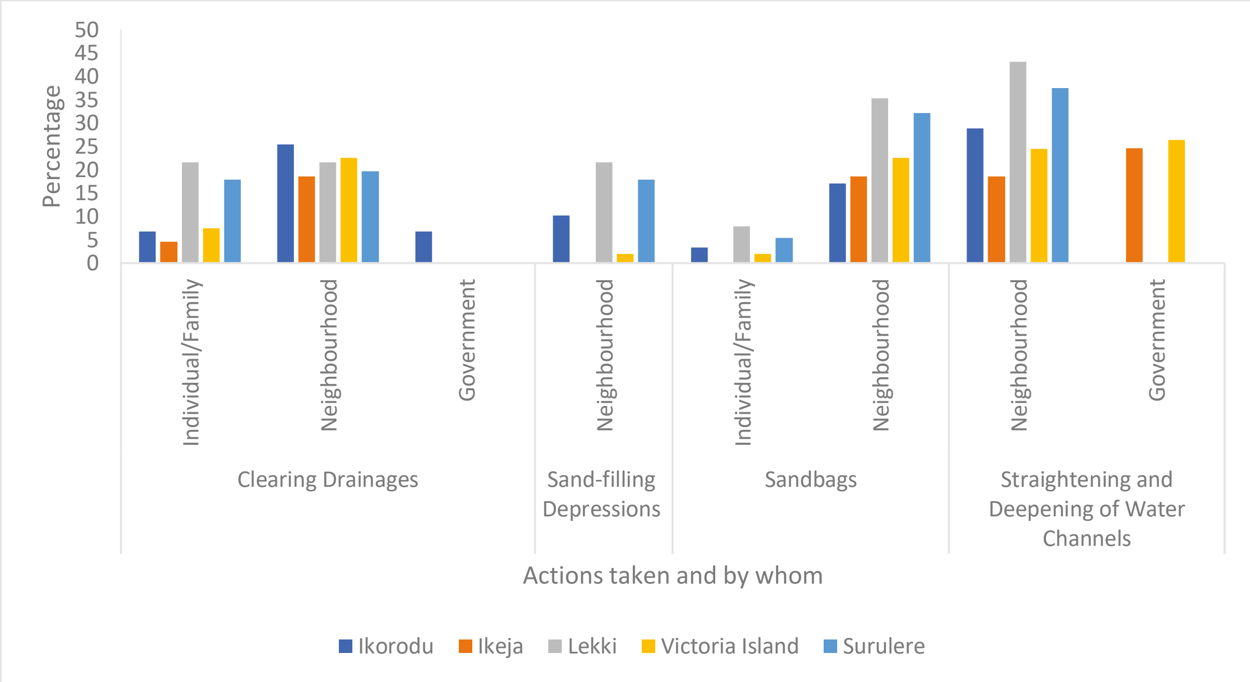


Figure 5.12: Actions taken since the last flood experienced

5.2.4 Perception of Future Flood Risk

Government's actions to minimise flood risk have only been in the form of clearing drainages; this was only done in Ikorodu as well as in straightening and deepening water channels; this action was only done in Ikeja and Victoria Island. Other actions such as sand-filling depressions and providing access to sandbags were not taken up by the government. This further shows why residents have lost faith in the government (Ajibade & McBean, 2014). Although more than 40% (Table 5.11) of the respondents across all five study areas believed that the actions taken to minimise flood risk and impact have worked towards minimising flood risk since the last flood they experienced, just over 40% of the respondents also reported there has been flooding since remedial action was taken, suggesting that what was done was not sufficient to minimise flood risk (Table 5.11).

Table 5.11: Effectiveness of the remedial actions to reduce flood risk and responses on any flood issues since then

	Ikorodu	Ikeja	Lekki	Victoria Island	Surulere	Total
Effectiveness of the remedial actions	18 (30.5%)	29 (44.6%)	22 (43.1%)	27 (50.9%)	22 (39.3%)	118 (41.5%)
Flood issues since the remedial actions	19 (32.2%)	32 (49.2%)	18 (35.3%)	28 (52.8%)	20 (35.7%)	117 (41.2%)

Previous experience of flooding usually increases the risk perception amongst the affected population (Perry and Lindell, 1990; Adelekan and Asiyanbi, 2016) however, despite almost 80% of respondents having experienced flooding while living in Lagos, only 20% of them considered the risk of flooding when selecting their current property (Table 5.12) and instead mentioned other reasons for choosing their property (Table 5.13).

Table 5.12: Consideration of flooding when selecting a property

	Areas					
Consideration of flooding	Ikeja	Ikorodu	Lekki	Victoria Island	Surulere	Total
Yes	17 (26.2%)	10 (16.9%)	6 (11.8%)	14 (26.4%)	8 (14.3%)	55 (19.4%)
No	28 (43.1%)	27 (45.8%)	35 (68.6%)	23 (43.4%)	37 (66.1%)	150 (52.8%)
Don’t Know	15 (23.1%)	14 (23.7%)	0 (0%)	12 (22.6%)	1 (1.8%)	42 (14.8%)
No Response	5 (7.7%)	8 (13.6%)	10 (19.6%)	4 (7.5%)	10 (17.9%)	37 (13.0%)

Although it has been reported that when choosing the location of a property, some consideration of environmental risk is involved, individual choices actually show different factors such as housing cost, that have been considered and that only a section of an entire population actually consider risk from natural hazards such as flood risk (Daniel et al., 2009). To assess the association between consideration of flood risk when selecting a property and the locations, the Chi square test of independence was completed. No relationship was found between location and consideration of the flood risk when selecting a property since p-value is greater than 0.05, ($X^2(4, n=55) = 7.27, p>.05$).

It has also been suggested that people consider their individual risk when selecting their properties as there is a relative awareness amongst residents about flood risk (Daniel et al., 2009). The dominant factors for the respondents were between security/privacy and availability. 55% of respondents in Lekki, 48% in Surulere and 25% of respondents in Ikorodu selected security/privacy as the main reason for choosing their property while 26% of respondents in Ikeja and in Victoria Island selected availability as their main reason for selecting their property. Residents of Mzuzu, Malawi reported affordability and feeling safe at the location as reasons for selecting their properties despite being aware of the flood risk; this security differs from flood security for their properties, meaning residents prioritise feeling safe in an area compared to flood security (Kita, 2017). Approximately 10% of participants did not choose the property in which they currently live, this was typically due to the property being inherited, though a few of the respondents were dependents (18% of respondents). Affordability were important reasons when considering properties in Ikeja and Victoria Island as these are high-income areas based on the cost of properties in these areas (RAC, 2018).

Table 5.13: Reasons for selecting current property

	Areas					
Reasons	Ikeja	Ikorodu	Lekki	Victoria Island	Surulere	Total
Availability	17 (26.2%)	8 (13.6%)	12 (23.5%)	14 (26.4%)	14 (25%)	65 (22.9%)
Security/Privacy	2 (3.1%)	15 (25.4%)	28 (54.9%)	2 (3.8%)	27 (48.2%)	74 (26.1%)
Affordability	15 (23.1%)	10 (16.9%)	1 (2.0%)	13 (24.5%)	1 (1.8%)	40 (14.1%)
Did not choose	12 (18.5%)	6 (10.2%)	0 (0%)	11 (20.8%)	0 (0%)	29 (10.2%)
Proximity to work	6 (9.2%)	5 (8.5%)	0 (0%)	4 (7.5%)	2 (3.6%)	17 (6.0%)
No response	5 (7.7%)	13 (22.0%)	10 (19.6%)	4 (7.5%)	10 (17.9%)	42 (14.8%)

Where incomes were low, such as in Ikorodu, the main driver for selecting a property in this area was whether it was in a secure or private area (25%), as it has been suggested that people are more worried about immediate risks compared to possible flood risk. (Adelekan and Asiyanbi, 2016).

According to Olorunfemi (2011), a useful part of the matrix for flood risk management is identifying the effectiveness of actions taken to reduce flood risk by assessing current flood situation. Of the respondents, in Ikeja, 31% believed that the flood situation was getting better. 2% believed it was getting worse and 31% believed there was no change to the flood situation. In Lekki, 8% believed the flood situation was getting better, 22% believed it was getting worse and 28% believed there has been no change to the flood situation (Table 5.14).

Table 5.14: Flood situation since actions taken to minimise flood risk in the five areas

	Better (%)	Worse (%)	No Change (%)
Ikorodu	25	25	17
Ikeja	31	2	31
Lekki	8	22	28
Victoria Island	8	25	30
Surulere	29	4	29

25% in Ikorodu, 25% in Victoria Island and 22% in Lekki believed the flood situation was getting worse when compared to Surulere and Ikeja. Reasons for this vary from improper planning, poor drainage systems, blocked drainage, more intense rainfall and no improvements (Fig 5.13). More residents in Lekki (28%) and in Victoria Island (30%) believed there was no change to the flood situation compared to those who believed it was either getting better or worse. This could account for why although 45% of respondents in Lekki believed the remedial actions taken to reduce their flood risk worked, 35% of them reported they had experienced flood issues since taking those actions while in Victoria Island, although 51% of the respondents believed the remedial actions had worked, 53% of the respondents reported flood issues since the remedial actions (Table 5.11).

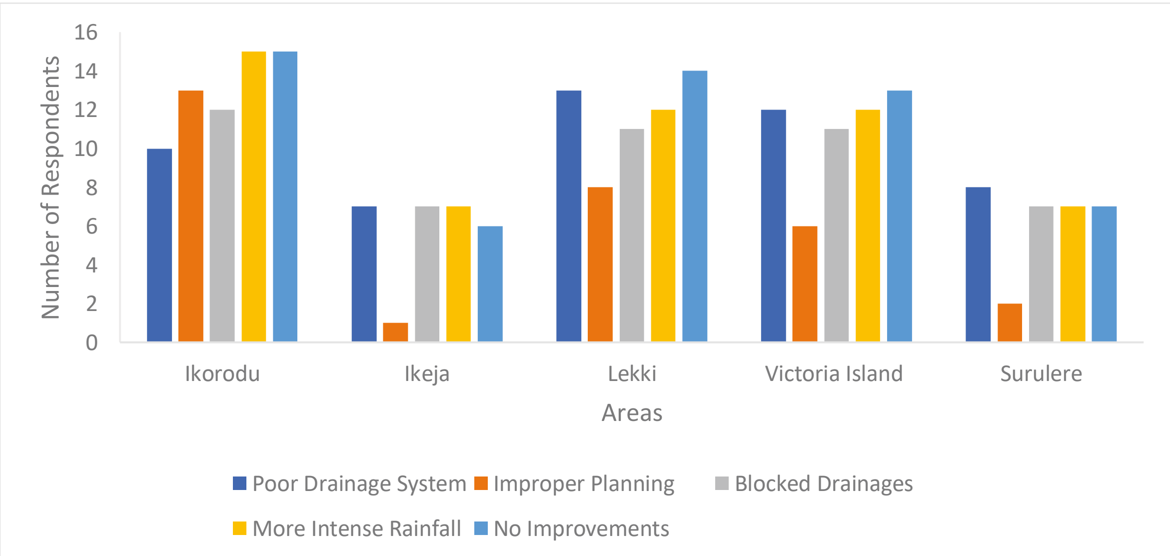


Figure 5.13: Perceived reasons for deterioration of the flood situation within the five areas in Lagos.

Respondents who believed the flood situation was getting better stated better defences and completion of drainage construction (Fig 5.14). Across the five locations, Ikorodu accounted for the lowest proportion with only two of the respondents stating better defences and ten respondents who stated completion of drainage construction. Lekki, however, represented the highest proportion with 17 respondents stating better defences and 18 respondents who believed completion of drainage construction were reasons why the flood situation had gotten better in their areas.

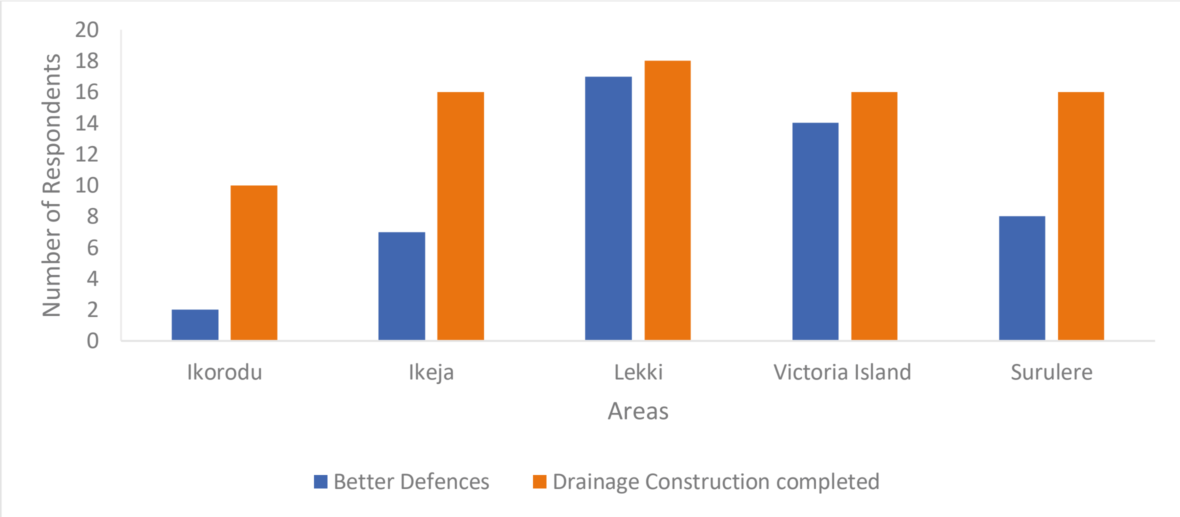


Figure 5.14: Reasons for flood situation getting better

One of the ways of achieving better flood risk management, is understanding future flood risk in order to help plan accordingly (Olorunfemi, 2011). Overall, of the approximately 79% respondents who had been flooded while living in Lagos and approximately 60% who had been flooded while living in their current property, 44% of the respondents also felt at risk to future flooding (Table 5.15). At least more than 35% of the respondents in each of the five areas felt at risk to future flooding. This is not particular to Lagos, similarly, about 30% of respondents in Attica, Greece believed that they were likely to experience future flooding (Diakakis et al., 2018). However, respondents in Veneto, Italy, did not believe future flood risk to be high (Roder et al., 2019).

Of the five study areas, the respondents (55%) at Victoria Island felt the most at risk to future flooding, this could be due to the fact that 30% of the respondents did not believe the flood situation was changing despite actions taken to minimise their flood risk. 51% of the respondents in Ikeja felt at risk to future flooding which also could be why 31% of the respondents in Ikeja (Table 5.14) did not believe there was any change to the flood situation.

Table 5.15: Residents who have been flooded and who feel at risk to future flood risk

	Ikorodu	Ikeja	Lekki	Victoria Island	Surulere	Total
Flooded while living in Lagos	46 (80%)	46 (70.8%)	45 (88.2%)	39 (73.6%)	48 (85.7%)	224 (78.9%)
Flooded in current home	36 (61%)	35 (53.8%)	33 (64.7%)	32 (60.4%)	33 (58.9%)	169 (59.5%)
Feel at risk to future flooding	24 (40.7%)	33 (50.8%)	19 (42.2%)	29 (54.7%)	20 (35.7%)	125 (44%)

In terms of why the residents felt at risk to future flooding, more people in Lekki (66.7%) and Surulere (60.7%) and across the five areas felt uncertain in terms of future flood risk, across the five locations residents also mentioned they felt at risk to future floods due to intense rainfall, 20% at Ikeja and about 23% at Victoria Island (Table 5.16). However, the rainfall data does not show that the rainfall had changed over the years (Figs 5.15a & 5.15b). It was reported that more than 50% of respondents along the Rhine anticipated increase in severe flood events in the future and over 70% of the respondents of the respondents along the Rhine expected an increase in the frequency of flooding (Becker et al., 2014).

Table 5.16: Reasons for feeling at risk to future floods

Reasons	Ikorodu (%)	Ikeja (%)	Lekki (%)	Victoria Island (%)	Surulere (%)
Uncertain	35.6	21.5	66.7	26.4	60.7
No Improvements	20.3	20.0	2.0	22.6	3.6
Blocked Drainages	13.6	4.6	3.9	7.5	14.3
No Drainages	11.9	27.7	2.0	28.3	3.6
Intense Rainfall	25.4	20.0	37.3	22.6	35.7
Need Better Flood Defences	28.8	20.0	25.5	22.6	25.0

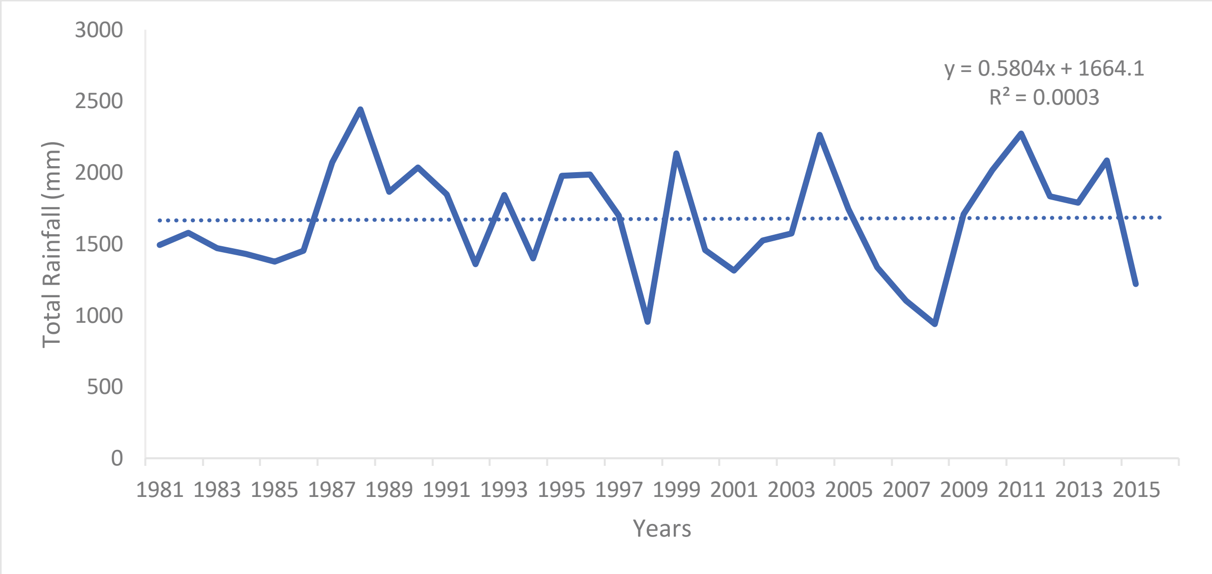


Figure 5.15a: Annual precipitation, Victoria Island (1981-2015)

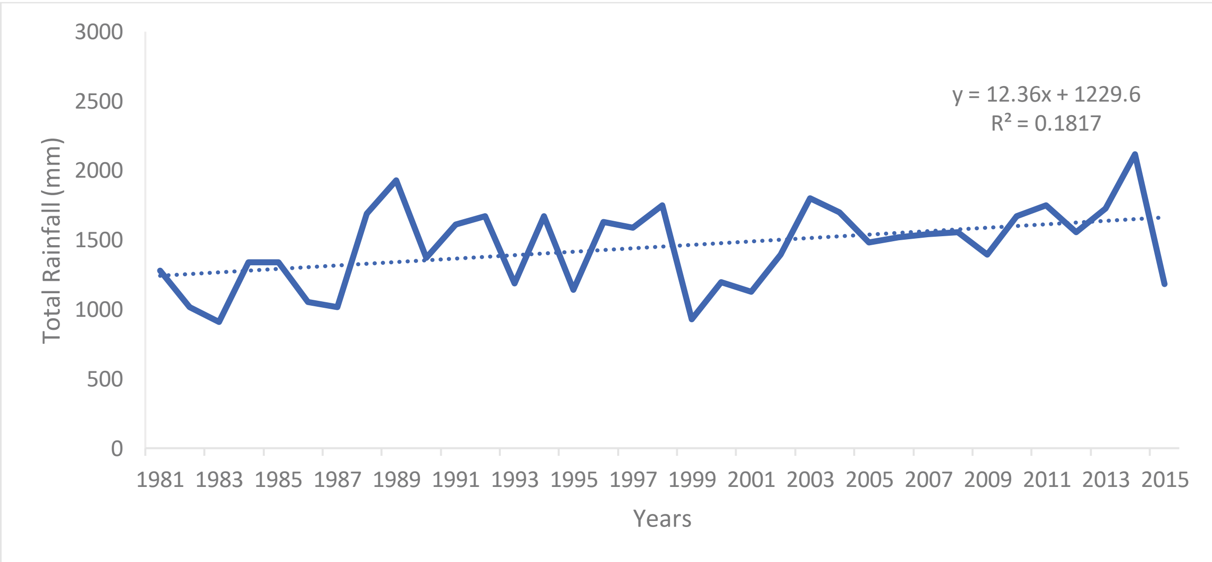


Figure 5.15b: Annual precipitation , Ikeja (1981-2015)

While more men had suffered impacts from flooding compared to women, of the respondents, over 40% felt at risk to future flooding for both genders (Table 5.17), however, men still accounted for more when compared to women. It is important to note however, that while differences such as societal roles, norms and behaviours make experience of disasters more adverse for women, compared to men, the socio-economic status of women must also be considered (Neumayer and Plumper, 2007).

Table 5.17: Gendered Differences in Future Flood Risk

	Yes	No	Do not Know	No Response	Total
Male	73 (45.3%)	33 (20.5%)	46 (28.6%)	9 (5.6%)	161 (56.7%)
Female	52 (42.3%)	34 (27.6%)	32 (26.0%)	5 (4.1%)	123 (43.3%)

Future flood risk was examined across the five research areas for male and female (Fig 5.16).

Also, chi-square was used to examine whether any relationships exist between areas and future flood risk perception for both male and female (Table 5.18).

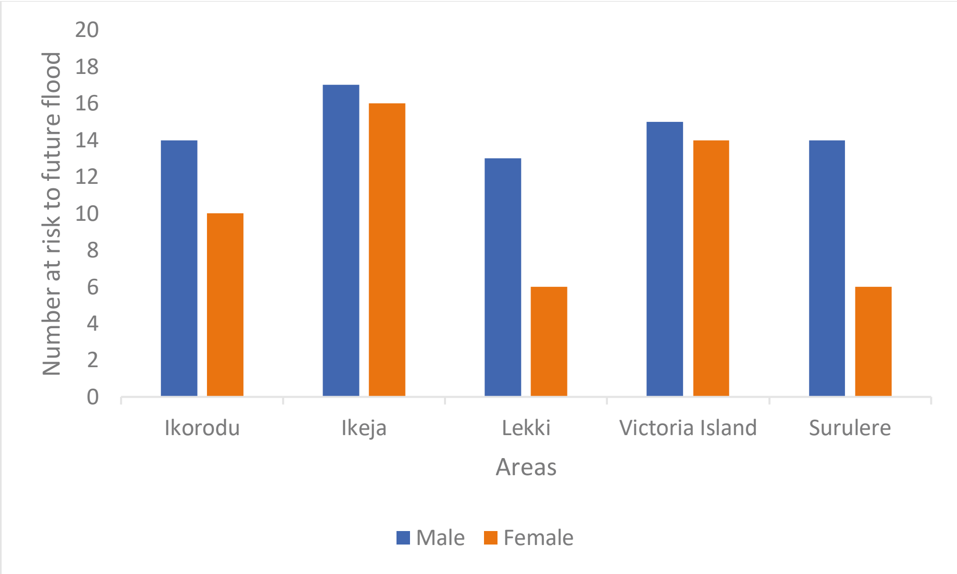


Figure 5.16: Gendered-Difference of future flood risk across research areas

Table 5.18: Chi-Square distribution of areas and future flood risk for male and female

Gender		Value	df	Asymptotic Significance (2-sided)
Male	Pearson Chi-Square	14.3	12	0.3
	Likelihood Ratio	16.3	12	0.2
	Linear by Linear Association	0.3	1	0.6
	Number of Valid Cases	161		
Female	Pearson Chi-Square	35.34	12	0.0
	Likelihood Ratio	38.6	12	0.0
	Linear by Linear Association	0.9	1	0.4
	Number of Valid Cases	123		

Higher probability was identified for men who felt at risk to future flooding in their area (p= 0.3) compared to women (p= 0.0) where correlation is significant at 0.05 (Table 5.18).

5.3 Flood Officials' Perspective

With the increasing flood issue in Lagos, there is a need for better flood management in Lagos. Since the residents believe flood protection is the responsibility of the government, it was important to evaluate flood management measures from the perspective of flood officials in Lagos (Adelekan, 2016). This was done through interviews with a national flood official and a state flood official. One in the National Environment Management Agency (NEMA) in charge of flood management at the national level and at the State Emergency Management Agency (SEMA) in the Ministry of Environment on the state level to get an overview of the flood situation in Lagos, Nigeria. This helped fulfil objective 2 of the research aims (section 4.1).

The deductive approach of thematic analysis was employed to better understand the flood officials' experiences and understanding of the flood issue in Lagos. Flood Officials have been represented as Interviewee A (National Flood Official) and Interviewee B (State Flood Official) for clarity. The following themes were therefore identified: flood issue in Lagos, perceived causes of flooding in Lagos, flood management, flood monitoring and early warning systems, post-flooding recovery and future flood prevention and drivers/challenges.

5.3.1 The Flood Issue in Lagos

This theme was selected in order to highlight how much of an issue flooding in Lagos is in order to gain the perspective of the flood officials as well as seeing how this compares to the residents' views.

The issue of flooding of Lagos has become increasingly frequent over the years (Etuonovbe, 2011; Adelekan, 2016; Nkwunonwo et al., 2016) but more severe with regards to the impacts (Adelekan, 2016). It is therefore important to understand the extent to which flooding is considered a problem throughout the research area by the flood managers. It was also useful to understand how the flood issue had affected infrastructure, residents and their businesses.

Both flood managers believed that Lagos has a significant flood problem. Interviewee A stated " *It is not only a big problem but a disturbing problem. That is how I would describe it.*" and Interviewee B believed that "*it is so much of a problem in Lagos, affecting a lot of facets: social, health and almost all facets of life*." While 48.6% respondents did not give a response on how often they had been flooded, about 22% of the respondents reported they had experienced flooding more than once a year since the year 2000 (section 5.2.1) with one respondent in Surulere stating, "*It used to be yearly but now flood happens to me more than once a year. I can't move around or go to the shop sometimes; it is really bad*."

While both Interviewees believed the government had plans to upgrade drainage systems, Interviewee A believed that flooding was especially a problem in areas where the drainage systems are not maintained, such as in the poorer areas like Ikorodu. While the Interviewee B stated that "*although all areas of Lagos have experienced flooding to some degree, Ikorodu, Lekki and Victoria Island are the areas that are most vulnerable compared to Ikeja and Surulere due to the topography of the three areas*." The topography of Lagos was examined and showed that the state is relatively flat in the centre and of the 20 local government areas, only two areas (Agege and Ifako) were not at risk to flooding and the Lagos Island area at 98% risk of flooding (Kaoje and Ishiaku, 2017). However, Agege's flood history from 2002 to 2011 and flood impact on residents of the area were examined and revealed issues with drainage systems to be the main contributor to flooding (Abolade et al., 2013).

Interviewee A suggested that while residents, business and infrastructure are affected by flooding, the flood issue is greater for residents as some own the businesses which indirectly are also impacted by flooding; damage to property and loss of property. Similarly, Interviewee B believed that the issue of flooding is one that causes interconnected impacts for the residents. For example, where infrastructure are affected by flooding, residents also are affected. Egbinola et al., (2017) suggested that the causes of flooding as well as impacts of flooding are interconnected and exacerbate the flood issue in Lagos.

5.3.2 Perceived Causes of Flooding in Lagos

This theme aimed to show what the flood officials believed were the causes of flooding in Lagos and whether any similarities or differences existed against what the respondents believed to be the causes of flooding.

Over 50% of the respondents identified heavy rainfall as the main cause of flooding (section 5.2.2, Table 5.5). However, the flood officials believed that flooding in Lagos occurred as a result of the interplay between human and natural factors, with human factors having a greater impact, the most severe impact being loss of lives.

Interviewee A stated, "*although the most common type of flooding experienced in Lagos is flash flooding as a result of heavy rainfall, man-made activities accounted for the main causes of flooding*." Interviewee A ranked the causes of flooding in terms of severity, they include houses built arbitrarily and on floodplains, attitude of residents seen in the indiscriminate dumping of waste, poor planning, poor maintenance of drainage systems and then heavy rainfall. Interviewee B stated, "*human factors play a bigger part over natural factor*." Interviewee B further reported that human factors such as unplanned development as a result of increasing population and the demand for space, poor waste management and the illegal dumping of waste by residents accounted for the frequency of flooding as they cause overwhelm of systems and infrastructures during rainfall events. Abolade et al., (2013) concluded that while the main cause of flooding was ineffective drainages (65.9%) or lack of drainages (37.7%), high precipitation (65.2%) and indiscriminate dumping of waste in drainage systems and water bodies (44.9%) contributed to the frequency of flood events in the

Agege area of Lagos.

The drainage systems have now become points of waste disposal in areas close to the markets in areas with a higher population density as the traders believed proper waste disposal to be expensive. "*For example, in Surulere and Ikeja markets, waste products ae disposed indiscriminately in the drainage system. However, throughout the research area, this behaviour of indiscriminate dumping of waste is due to lack of awareness on cause and effect of flooding.*" Interviewee A further suggested that drainage systems although available, are incapable of resilience as some were built over 30 years ago and have become obsolete without regular deepening and silting, citing a lack of maintenance culture on both the part of the residents and the government. Maintaining infrastructures is an important part of sustainable development (Abiodun et al., 2016) and the lack of maintenance culture in Nigeria has contributed to unresolved flood problem in Owerri area in Imo State, Nigeria (Oyebode, 2021).

Interviewee B explained that as a result of the quick demand for space and urban expansion, in the Victoria Island, Lekki and Ikorodu areas which are low-lying areas, there is also the issue of improper implementation of planning policies; stating, "*the government cannot turn residents who need space away. It is, however, a question of striking a balance between the need of the people and what is available. It is not that people cannot develop in wetlands; the right infrastructures just have to be there. People develop without waiting for the infrastructures to be put in place and they can hardly afford the provisions of the infrastructures themselves. They build but the government bears the brunt of substandard infrastructures*."

Interviewee A believed that the government's attitude towards addressing the causes of flooding is mostly reactive, with their attention only drawn to an issue after a devastating flood event has occurred. Interviewee B has suggested however, that the rate of physical development has outpaced planning especially as the government is focused on so many different areas of development especially with the rate of population growth.

5.3.3 Flood Management

This theme was chosen as it is the main background of the research, therefore, it will give an insight into the officials' perspectives on the management of flooding in Lagos as well as examining how it compares to responses from respondents.

Although the government is responsible for flood management in Lagos, the actions taken to minimise flood risk such as clearing drainages, sand-filling depressions, access to sandbags and straightening and deepening of water channels, were carried out mainly by the individuals/their family and the neighbourhood. According to the respondents, the government contributed to flood risk management in form of clearing drainages and straightening and deepening of water channels. However, this was not done for all five areas as approximately 7% of respondents in Ikorodu mentioned the government had cleared their drainages with one of the respondents in Ikorodu stating, "*we need help. The drainage is not working anymore, it cannot handle heavy rainfall*." While approximately 25% of respondents in Ikeja and 26% in Victoria Island mentioned the government had responded by straightening and deepening water channels in their areas in order to minimise their flood risk (Fig 4.8). Overall, the neighbourhood carried out more flood management measures (Fig 4.8).

Interviewee B believed however that the drainages systems needed upgrading, stating that, "*while drainage systems have always been in place in Lagos as a result of the issues of flooding in the early 1970s. At the time flooding was not as much of an issue as there was not as much development as there currently is*." Interviewee B further added, "*after the 1974 Flood Report was released, implementation and real purpose-built drainage systems (provisions) started in 1988. These drainages have definitely lived up to expectations, but no system lasts forever as Lagos has changed from what it was then to how it is now. Pressure on the systems have increased due to population growth and development."*

Most of the current prevention measures in place by the government appear to be non-structural. According to the Interviewee B, "*the government has put prevention measures in place. Apart from existing drainage channels, there are other operational and management measures. So many, non-structural, for example, there are yearly drainage management plan consisting of: construction where non-existing, maintenance of existing (re-construction or dredging channels) and sensitization of the public. There is an annual regular maintenance such as siltation, to eliminate the need for regular siltation. We also have the pre-rains and post-rains maintenance."* From a national perspective, the government still has a way to go. According to Interviewee A, "*There is not a lot of preventive measures given by the government in the form of warnings and information except jingles on the radio and* *advertisements*."

Interviewee B confirmed that besides the government, there were other parties contributing to and clamouring for better flood management, stating that, "*the CDAs – Community Development Associations consisting of landlords, aid in communities being strengthened by the government. CDAs make up CDCs (committees) who have oversight of CDAs acting as mild force or pressure groups first to supervise themselves and bring government's policies closer by finding ways they can help themselves more or where they can come up with standpoints for government to intervene. They are more or less pressure groups forcing the hand of the government to attend to them. One area which benefitted from this is Ikeja*." However, Interviewee B also confirmed there hasn't been much co-operation seen between these groups. It has been suggested that regular meetings between CDCs and CDAs are necessary towards creating better awareness for the residents on disasters like flooding (BNRCC, 2012).

5.3.4 Flood Monitoring and Early Warning Systems

The ability to prepare and protect from floods is an important determinant towards residents reducing their flood risk and the implementation of early warning systems is also an important element of reducing flood risk (Tarchiani et al., 2020). Therefore, exploring how the government monitors flooding and what warning systems are in place for Lagos was essential as it adds to how flood is managed in the state, hence, the selection of this theme.

According to Interviewee A, "*The national orientation agency advises people on tv and radio before the rainy season on what to do before the season, for example, not dumping waste indiscriminately to prevent flooding. The riverbanks also have warnings for residents in the areas in the form of information sheets to avoid certain areas or not go as far closer to the riverbanks at certain times*." These riverbanks are found in the island areas, monitoring and warning systems on the mainland areas look differently in the form of information and awareness. Interviewee A added that, "*Dramas are put on for residents. They have been effective as it does create the awareness and people know. The impact is just lacking as people just go back to what they have been doing before. Some believe when it is raining, that is when they should dispose of their waste in the drainages so the water carries it away but that waste goes on to block the drainage.*"

Flood monitoring was suggested to not focus on the just the hazard but also on monitoring behaviours of residents with interviewee A stating, *"enforcements need to be made as indiscriminate dumping of waste is one of the biggest issues. Government is doing its best but attitude of residents poses the biggest threat to flood risk."*

Interviewee B stated, "*The government monitors flooding in all local government areas of Lagos as part of institutional framework. There is a drainage engineer deployed for each of the local government and they know the flood history and can predict how flooding will affect the areas. These engineers help disseminate information and warnings to residents for flood preparedness and prevention. They sensitise the residents and hold regular press briefings and also provide temporary re-settlements in events of extreme flood events."*

This, however, hasn't proved effective as some residents have sentimental ties to their homes. According to Interviewee B, "*in some areas built on floodplains, for example, in Ikorodu, the government encourages residents to leave their properties in events of extreme rainy seasons, but some residents refuse to leave as they believe that's their birthplace, they believe they know the water more than the engineers and refuse to leave the area even after warnings have been issued which is a challenge. The government does its part by informing and advising but the residents also have to decide in the end."*

Furthermore, Interviewee A added that, "*Flood monitoring, warnings and prevention measures have been effective. The only limitation is the mindset of the people. Some say, I've been living here for the past 50 years. This thing (flood) comes and goes, so it is part of us. The government tries to make residents understand they should not have to suffer effects from flooding, but the residents would rather just air their wet mattresses in the sun to dry*."

The flood affected communities of Sialkot, Muzaffargarh and Rawalpindi in Pakistan revealed limitations such as lack of funds for the operation of an Emergency Warning System (EWS), lack of procedures for communicating warnings and lack of community trust in the government were responsible for the ineffective flood EWS in the areas (Rana et al., 2021). Tarchiani et al., (2020) believed that West Africa is lacking in community and impact-based flood EWS that improves on infrastructure, livelihoods, production systems and sustainable development.

5.3.5 Post-Flooding Recovery

According to Shafiai and Khalid (2016), the ability for people in a developing country to recover from the impact of a disaster such as flooding will depend on the effectiveness of the relief provisions provided by the government. As a result, it was important to explore this theme with the flood officials.

Interviewee B confirmed the government provided relief for residents affected during and after flooding. However, acknowledged that these provisions sometimes do not reach all those affected by flooding, stating that, "*mother of all challenges is resources*." Interviewee A highlighted that relief does not reach all the people affected by flooding due to mismanagement of the relief provisions. It has been suggested that the process of managing a disaster such as flooding could create opportunities for corruption in ways such as lack of accountability and lack of transparency which usually affects relief distribution from making its impact (Nordin et al., 2018).

Interviewee A believed this to be a serious problem for Lagos stating that, "*sometimes those that aren't distressed get the relief before those who need it*". Interviewee A further elaborated that, "*NEMA (National Emergency Management Agency) sends relief provisions to SEMA (State Emergency Management Agency) and even before it gets to them, some officials might take a cut. Then from SEMA it goes to the local government and before it goes out, they might not forward everything to the local communities that need them. It gets to the local community and within the local community; another cut is taken even before it gets to the grass-root. At every point there is a withdrawal and people who are not affected distribute to themselves first, leaving even less for those affected*."

Interviewee A however, believed that the federal government has started taking steps to better manage relief distribution to ensure those who really need them get them first.

5.3.6 Future Flood Prevention and Drivers/Challenges

Jonkman and Dawson (2012) believed that it is necessary to recognise the challenges and drivers (O'Donnell and Thorne, 2020) that affect future flood risk management. As a result, this theme was selected to better understand what the future flood prevention and management plans for Lagos are and what would aid as well as limit their implementation.

44% of the respondents across all the five areas believed they were at risk to future flooding (Table 5.12) due to reasons such as feeling uncertain about the future of flooding in Lagos, intense rainfall, blocked drainage, the need for better flood defences (Table 5.13). This is being addressed by the government through non-structural measures in the form of the remapping of flood prone areas to better understand vulnerability of the residents in these areas as well as how susceptible these areas are to flooding. This plan will help understand what is required for sustainable flood in these areas. Interviewee A further confirmed that, "*this process which is driven by the area's flood history is on-going and the government wants to make sure all the important stakeholders – community leaders, religious leaders, newspapers, landlords, NGOs are brought together before every rainy season to provide* *information that could be passed along further as this measure will take a grass-root effect. This way, more people will have the information*."

Better training and information for the public was also highlighted as one of the future plans in place by the government. Interviewee A stated, "*There are jingles and advertisements as well and this will educate the public even more. However, the impact is not being felt as it is hard to change people's behaviour*." Interviewee A further added that a key driver towards achieving better flood management in the future is legislation and enforcements that check behaviour; "*Lack of legislation is a big challenge, it has to be enforced and managed properly. Years ago, we used to throw plastic bottles and waste out of car and bus windows littering the environment but after the enforcements on people and buses, people became more responsible on that issue."* This, however, has its own limitation, as it creates an opportunity for corruption as highlighted by Interviewee A, "*there have been situations in the past where rather than help enforce, some officials have instead used the opportunity to enrich themselves through bribes*."

Interviewee B also acknowledged that there are future flood management plans in place which are mostly structural measures in the form of a new drainage masterplan for Lagos, construction of capable drainage systems in areas that are lacking and non-structural in the form of creating more awareness for the residents of Lagos. For example, Interviewee B added that, "*Owode-Oniru close to river Ogun used to be a forest reserve but in the quest for more space for people to live, development occurred. Previously it was primarily for agriculture and fish farming. Defence measures should have been in place, but people have gone on to build without these measures*." This suggests lax planning laws as Interviewee B also stated, "*with the high population in Lagos, there is a demand for space and we cannot turn people away as they would have nowhere to live. Developers just do not wait for us to construct proper drainages with some, erecting shoddy drainages that do not work during flooding."*

The Lagos state government has a 20–25 years drainage master plan for Lagos. Interviewee B stated that, "*its implementation and timescale will be based on the planned phase by phase implementation: priority project (2016-2021), immediate implementation (2021-2026), after that, future plans of 2026 – 2031 and 2031 – 2036. However, funding is a setback*."

Both interviewees agreed funding remains the biggest limitation. Interviewee B stated, "*there are future flood plans available but resources remain the biggest challenge towards achieving* *better flood prevention and management in Lagos.*" Interviewee A added that "*the overall challenge to implementing future flood plans remains finance.*"

5.4 Lagos Precipitation

Although changes in the climate and other climatic variables such as rainfall have been reported as the cause of the recent increase in the intensity and frequency of flood events globally (Olanrewaju et al., 2017), Adeloye and Rustum (2011) proposed that increased urbanization as well as other factors such as inadequate or lack of drainage systems and the lax planning laws which allow developments on floodplains where drainage systems are lacking; are the bigger issues causing flooding in Lagos.

This section will examine precipitation data for Lagos obtained from Nigerian Meteorological (NiMet) Agency for Ikeja and Victoria Island stations from 1981 to 2015 to assess the rainfall distribution of Lagos in order to determine the seasonality and any changes in the rainfall seasonality over time. The data will also help assess for changes in rainfall frequency and intensity and whether any relationship exists between the rainfall data and past flood events from trends within the data over the time period.

5.4.1 Lagos Precipitation Characteristics

Lagos experiences an equatorial type of climate with two seasons (rainy/wet and dry) all year round, with the rainy season starting from March/April to September/October when the season changes to dry. Flooding occurs usually in the rainy season (Israel, 2017). Similarly, the flood officials believed that flooding occurred during the rainy season and respondents' perspective showed the months when they experienced flooding were July, June, August, September, May and October in descending chronological order according to responses.

The Victoria Island and Ikeja stations when examined were also relatively close to one another (section 3.3.6 - Table 3.3). In the Ikeja station, highest total rainfall was recorded at 2117.1mm in 2014 while Victoria Island's was in 1988 at 2442.5mm (Tables 5.19 & 5.20). Annual maximum rainfall at both stations exceeded 200mm, with the highest annual maximum precipitation amounts recorded at 365mm for Ikeja in 1983 and 461mm for Victoria Island in 2000 (Tables 5.19 & 5.20). In the rainy season, the maximum rainfall amount can exceed 100mm (Braimoh and Onishi, 2007), rising to peaks of 280mm daily in September at Victoria Island and to 237mm daily at Ikeja in June (section 5.4.2 - Tables 5.4a & 5.4b)

Table 5.19: Annual descriptive statistics for Ikeja (1981-2015)

Years	Total	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
1981	1279.6	3.5	11.5	329.2	0.0	99.7
1982	1017.1	2.8	8.7	312.8	0.0	68.1
1983	909.1	2.5	9.1	364.8	0.0	105.1
1984	1339.8	3.7	11.8	321.5	0.0	119.5
1985	1339.8	3.7	11.8	321.0	0.0	119.5
1986	1052.9	2.9	7.6	265.1	0.0	55.6
1987	1015.2	2.8	8.4	303.8	0.0	58.2
1988	1688.7	4.6	14.7	317.8	0.0	147.2
1989	1927.0	5.3	16.5	311.6	0.0	136.7
1990	1368.9	3.8	10.9	289.8	0.0	80.2
1991	1610.1	4.4	16.0	363.7	0.0	169.0
1992	1671.8	4.6	12.9	282.1	0.0	133.8
1993	1188.4	3.3	10.2	312.7	0.0	85.2
1994	1671.5	4.6	12.8	278.8	0.0	107.4
1995	1141.3	3.1	10.1	323.7	0.0	85.0
1996	1629.8	4.5	10.8	242.3	0.0	85.2
1997	1589.5	4.4	11.5	265.0	0.0	80.1
1998	1749.6	4.8	17.2	358.1	0.0	237.3
1999	926.5	2.5	9.0	354.3	0.0	71.3
2000	1197.7	3.3	9.5	290.9	0.0	64.6
2001	1125.2	3.1	8.5	277.2	0.0	53.8
2002	1392.1	3.8	10.6	277.4	0.0	67.1
2003	1802.3	4.9	15.4	312.7	0.0	152.8
2004	1699.2	4.6	12.7	273.5	0.0	123.8
2005	1483.9	4.1	12.8	316.0	0.0	145.3
2006	1516.9	4.2	11.0	265.5	0.0	84.0
2007	1539.8	4.2	12.3	291.2	0.0	76.0
2008	1552.9	4.2	12.0	281.5	0.0	152.1
2009	1393.2	3.8	13.2	346.6	0.0	146.4
2010	1669.5	4.6	12.1	263.6	0.0	81.2
2011	1748.0	4.8	16.0	322.5	0.0	233.0
2012	1557.0	4.3	14.8	348.2	0.0	216.3
2013	1726.7	4.7	11.0	233.2	0.0	72.2
2014	2117.1	5.8	13.7	236.8	0.0	83.7
2015	1182.6	3.2	9.1	281.4	0.0	73.4

Table 5.20: Annual descriptive statistics for Victoria Island (1981-2015)

Years	Total	Mean	Minimum	Maximum	Standard Deviation	Coefficient of Variation
1981	1494.4	4.1	11.3	275.6	0.0	99.6
1982	1578.0	4.3	13.2	304.4	0.0	102.8
1983	1470.7	4.0	14.6	360.1	0.0	123.1
1984	1432.0	3.9	12.7	323.6	0.0	110.7
1985	1378.3	3.8	10.2	271.2	0.0	66.2
1986	1452.2	4.0	12.8	322.4	0.0	112.5
1987	2069.4	5.7	16.5	290.5	0.0	123.8
1988	2442.5	6.7	21.3	319.4	0.0	183.8
1989	1865.9	5.1	15.7	307.7	0.0	123.3
1990	2037.1	5.6	20.2	361.1	0.0	273.3
1991	1847.8	5.1	14.4	284.6	0.0	126.1
1992	1357.6	3.7	11.5	308.9	0.0	109.7
1993	1844.0	5.1	15.0	296.9	0.0	126.2
1994	1398.2	3.8	10.9	284.2	0.0	89.9
1995	1977.4	5.4	13.1	242.3	0.0	107.7
1996	1986.3	5.4	15.3	282.0	0.0	103.1
1997	1699.8	4.7	12.8	275.6	0.0	96.0
1998	953.5	2.6	10.9	416.1	0.0	133.0
1999	2136.0	5.9	17.1	292.5	0.0	155.5
2000	1458.9	4.0	18.4	461.0	0.0	280.0
2001	1314.4	3.6	12.0	333.0	0.0	114.6
2002	1523.2	4.2	13.7	328.5	0.0	130.3
2003	1575.0	4.3	15.4	356.4	0.0	150.0
2004	2262.8	6.2	21.5	348.1	0.0	237.7
2005	1746.0	4.8	17.6	368.5	0.0	169.7
2006	1337.6	3.7	12.2	333.5	0.0	125.3
2007	1103.5	3.0	13.4	443.0	0.0	190.3
2008	939.2	2.6	9.4	365.0	0.0	88.6
2009	1707.6	4.7	12.9	276.3	0.0	77.5
2010	2018.0	5.5	16.5	297.5	0.0	138.9
2011	2274.9	6.2	21.6	347.1	0.0	278.4
2012	1834.2	5.0	15.3	305.2	0.0	169.8
2013	1788.6	4.9	13.9	283.8	0.0	106.6
2014	2086.9	5.7	13.7	239.7	0.0	83.7
2015	1217.3	3.3	9.8	293.6	0.0	67.9

June accounted for the highest monthly average rainfall at over 300mm at both the Ikeja and Victoria Island stations. There was however, more than 100mm difference in the average rainfall amount for the same month with Ikeja at 334mm and Victoria Island at 502mm (Figs 5.17 & 5.18) which is unexpected given the close proximity of both stations, however, the fact that Victoria Island is located close to the coast might be a factor for the higher monthly average observed compared to that of Ikeja (Adeloye and Rustum, 2011).

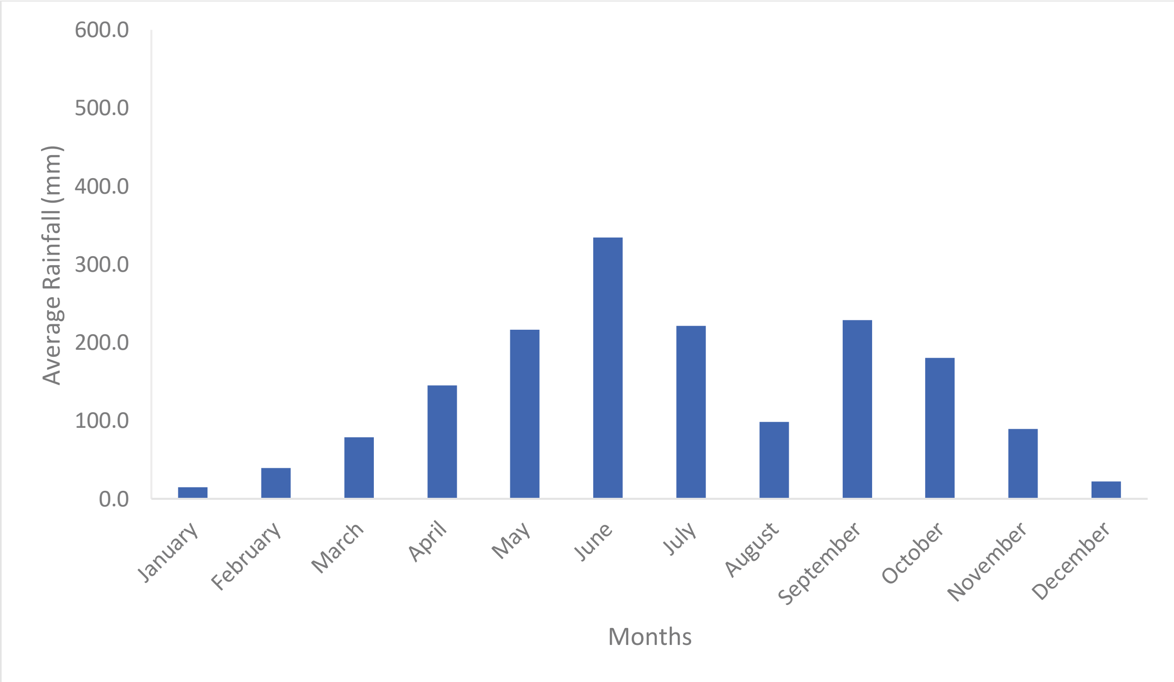


Figure 5.17: Average monthly rainfall at Ikeja (1981-2015)

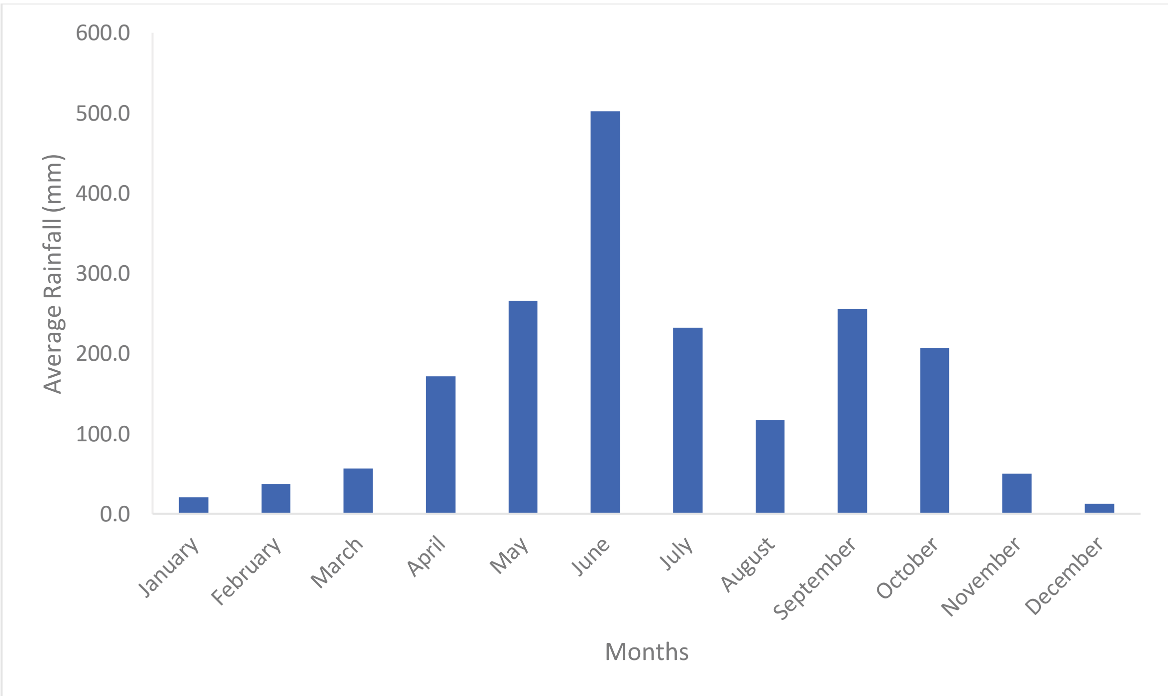


Figure 5.18: Average monthly rainfall at Victoria Island (1981-2015)

Correlation and regression were also done to examine the relationship between precipitation in Ikeja and Victoria Island with R = 0.160021 showing a weak positive correlation with P value at 0.358 (Table 5.21). The R^2 value explains only about 3% of the variation in Victoria Island's annual precipitation is explained by Ikeja's precipitation (Fig 5.19).

Table 5.21: Regression analysis for annual total rainfall of Ikeja and Victoria Island stations

Regression Equation	P-Value	Statistically Significant	Sample Correlation	R^2
Y= 1239.8 + 0.1267x	0.358	No	0	0.0256

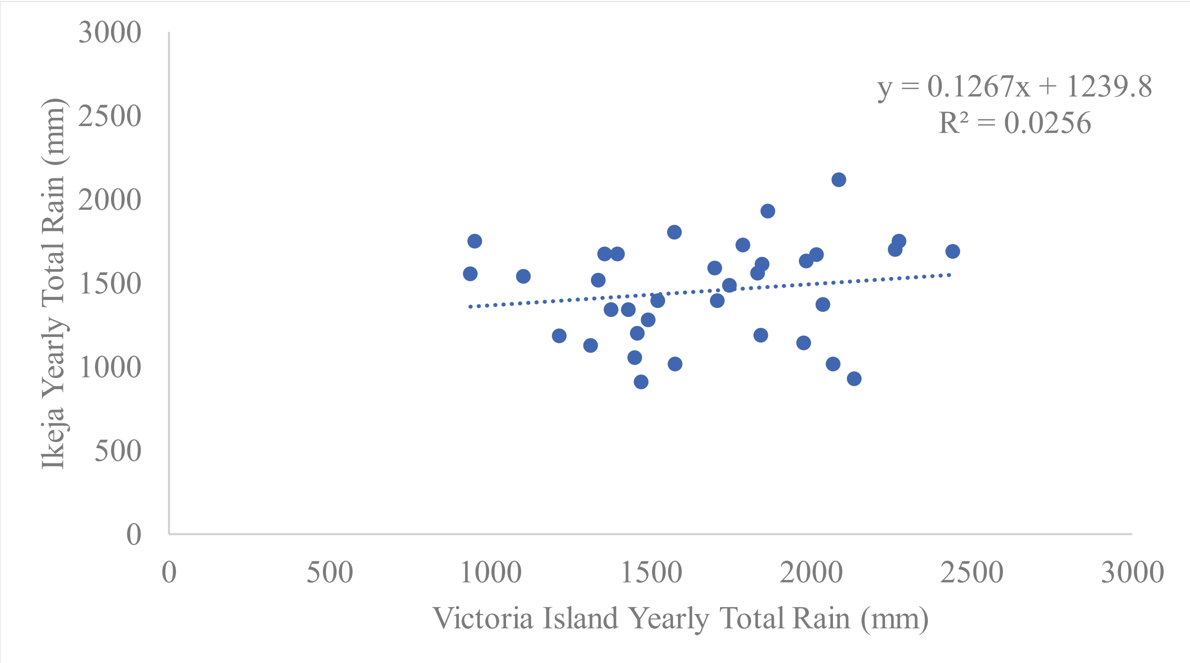


Figure 5.19: Scatterplot of yearly total rainfall for both sites (1981-2015)

5.4.2 Rainfall Variability

A probability plot was used to assess the frequency of precipitation for Ikeja and Victoria Island in order to determine the amount of rainfall expected for the daily rainfall (Shaw, 1994) at both sites. This helped determine the frequency and magnitude of extreme rainfall events (Ologunoris and Tersoo, 2006). Results showed that only for at least 10% of the time, there was zero amount of rainfall recorded and at least over 80% of the time, there was more than zero amount of rainfall recorded at both Ikeja (Fig 5.20a) and Victoria Island (Fig 5.20b) for the time series from 1985 to 2015. At Ikeja, on the extreme value was observed at 99% for the highest daily value of 237.3mm which occurred 20 September 2000. Since then, the highest daily value per month was on 10 July 2011 with a maximum amount of rainfall recorded at 233mm in Ikeja while Victoria Island's was recorded also on 10 July 2011 at 278.4mm. The well documented July 2011 floods reportedly led to 17 deaths, the displacement of more than 5000 people and a total cost of lost goods and properties valued at \$200 billion USD by the Nigerian insurance industry (Adelekan and Asiyanbi, 2016). These daily extreme values do not show increased frequency over the years, there is also no indication of increased rain days but rather that Lagos experiences isolated intense rainfall on singular days or over days. According to Olanrewaju et al., (2017), rainfall occurring over consecutive days has the capacity to cause flooding, considering the accumulative effects of precipitation amounts of the days prior to the extreme value as well as the other contributing factors to the flood problem as seen in Warri, Delta state in Nigeria.

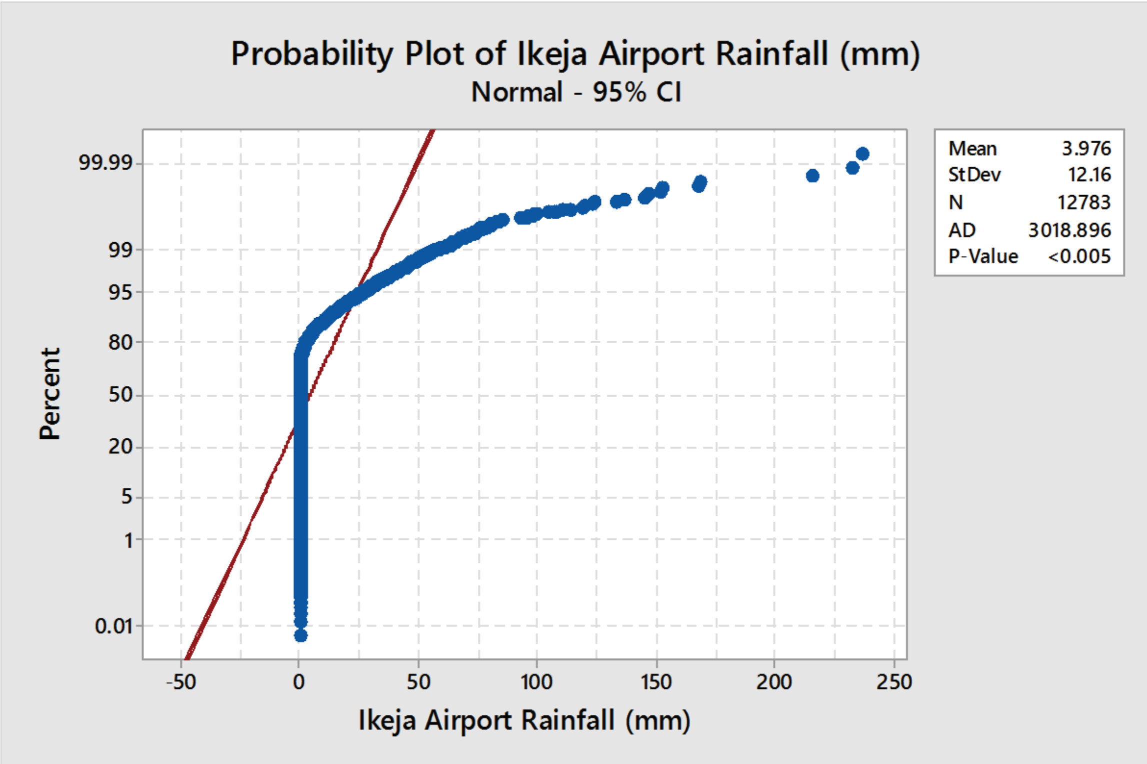


Figure 5.20a: Probability distribution of annual precipitation, Ikeja (1981-2015)

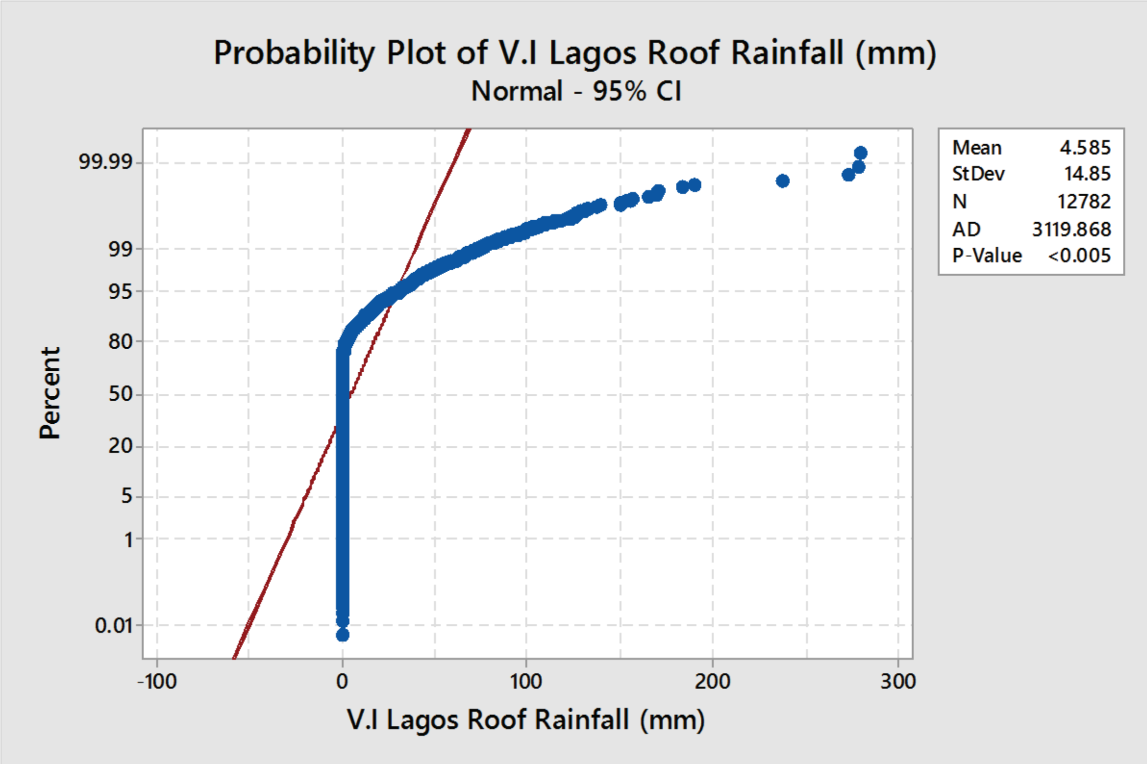


Figure 5.20b: Probability distribution of annual precipitation, Victoria Island (1981-2015)

The number of days with zero rainfall also fluctuated at the Victoria Island like the Ikeja stations across the years but were between 200 to 300 days each year, further showing that most of the rain which falls is highly concentrated and occurs in just 50 to 150 days.

It was suggested that more frequent excessive rainfall over 100mm was occurring daily in Lagos between June and September which caused severe impacts (Braimoh and Onishi, 2007). Also, rainfall total of 233.3mm was recorded after a rainfall event which lasted for 17 hours in just one day in July 2011, even though this amount is the expected total for the entire month (Adelekan, 2015) resulting in deaths, damages and displacement (IFRC, 2011). Since the highest value exceeded 300mm for average monthly total rainfall at both sites (Figs 5.14 & 5.15), monthly frequency (Figs 5.21a & 5.21b) and monthly rainfall totals (Figs 5.22a & 5.22b) of over 300mm at Ikeja were evaluated as well as those at Victoria Island.

At Victoria Island, each year had at least one month where more than 300mm of rainfall was recorded except for 1984 and 2008. However, the highest frequency was recorded in 2011 with 5 months recording more than 300mm rainfall in the rainy season (May to October).

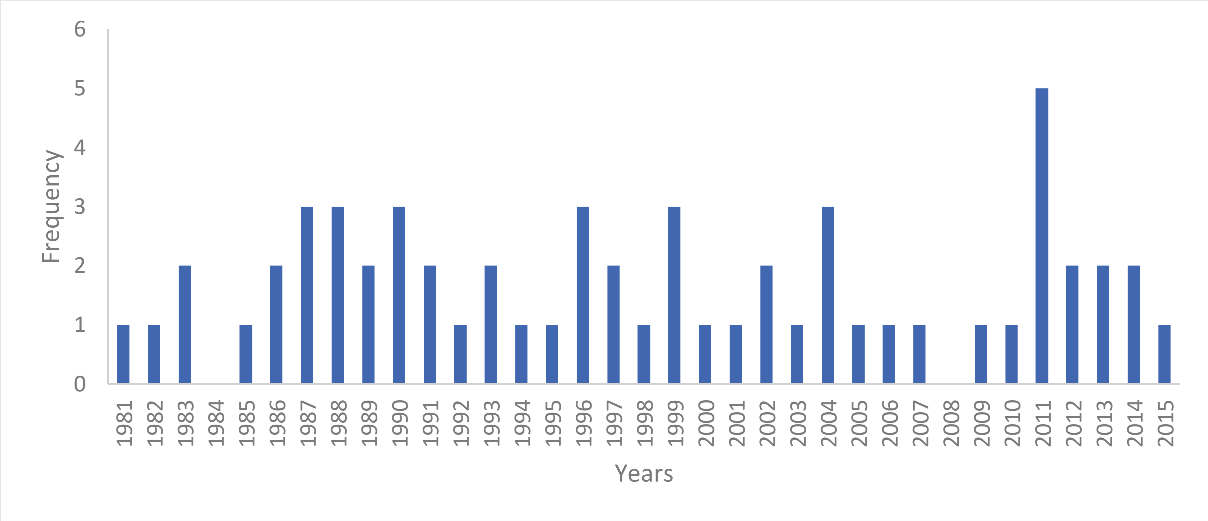


Figure 5.21a: Frequency of months exceeding 300mm rainfall at Victoria Island (1981-2015)
1988 and 2003, had the greatest frequency of months during which more than 300mm of rain fell at Ikeja station during the rainy season. Similarly, as in Victoria Island, more than half of the time period examined showed at least one month of more than 300mm of rainfall at Ikeja station.

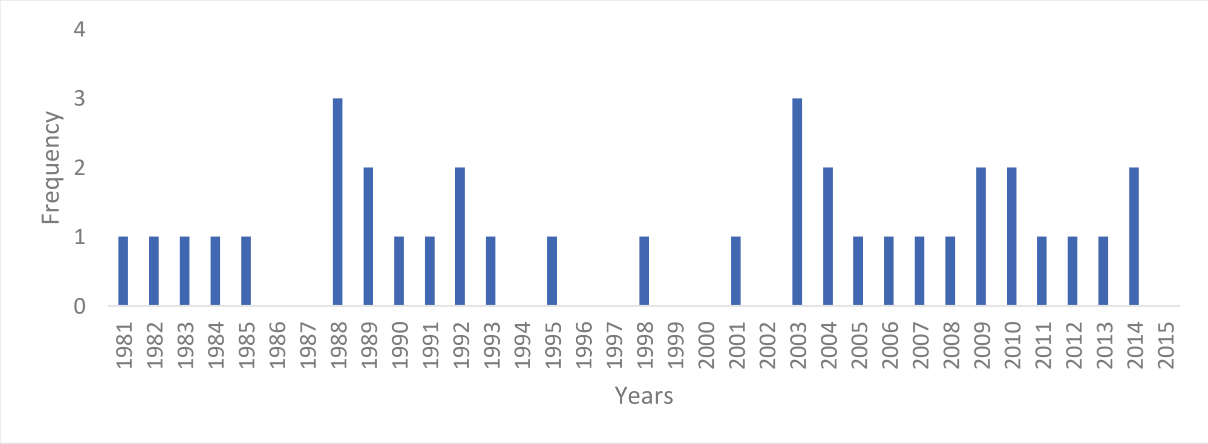


Figure 5.21b: Frequency of months exceeding 300mm rainfall at Ikeja (1981-2015)
The monthly totals of more than 300mm of rainfall in the rainy season were then examined for both Ikeja (Fig 5.22a) and Victoria Island (5.22b). Victoria Island received higher monthly rainfall totals exceeding 300mm during the rainy season compared to Ikeja. Victoria Island received over 2000mm in 2011, while Ikeja only received just under 500mm. The highest total recorded for Ikeja station was recorded in 1988 and 2003 at over 1000mm rainfall. The higher values at Victoria Island, a coastal area, may be as a result of sea breeze which has been suggested to occur frequently in the rainy season of April to October in Lagos (Olaniyan and Afiesimama, 2003).

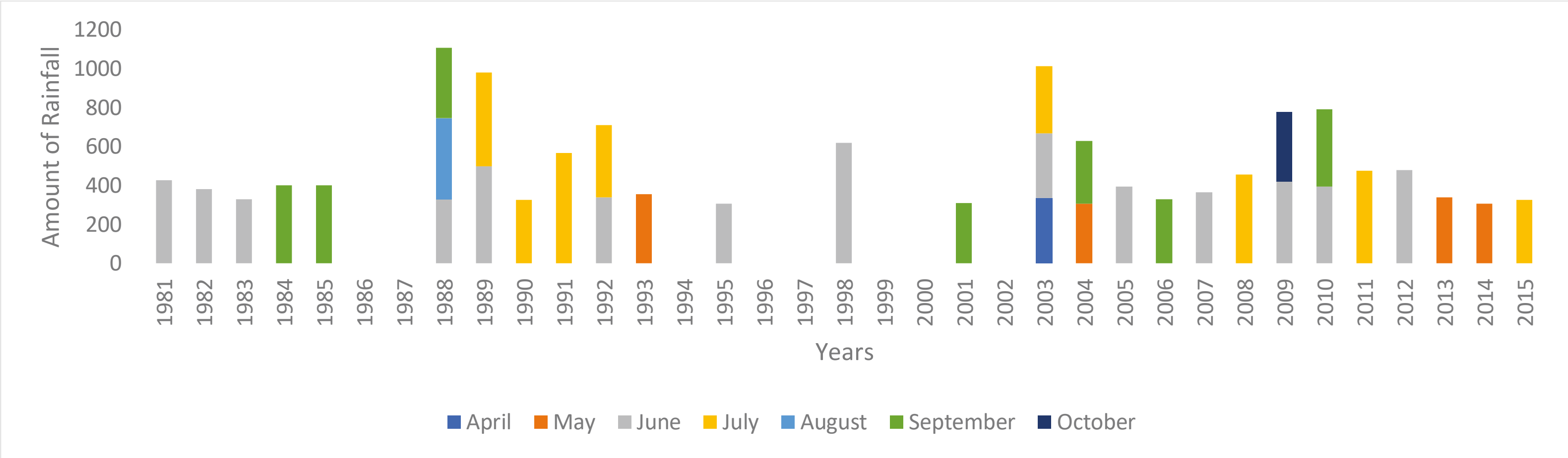


Figure 5.22a: Seasonal rainfall totals exceeding 300mm at Ikeja (1981-2015)

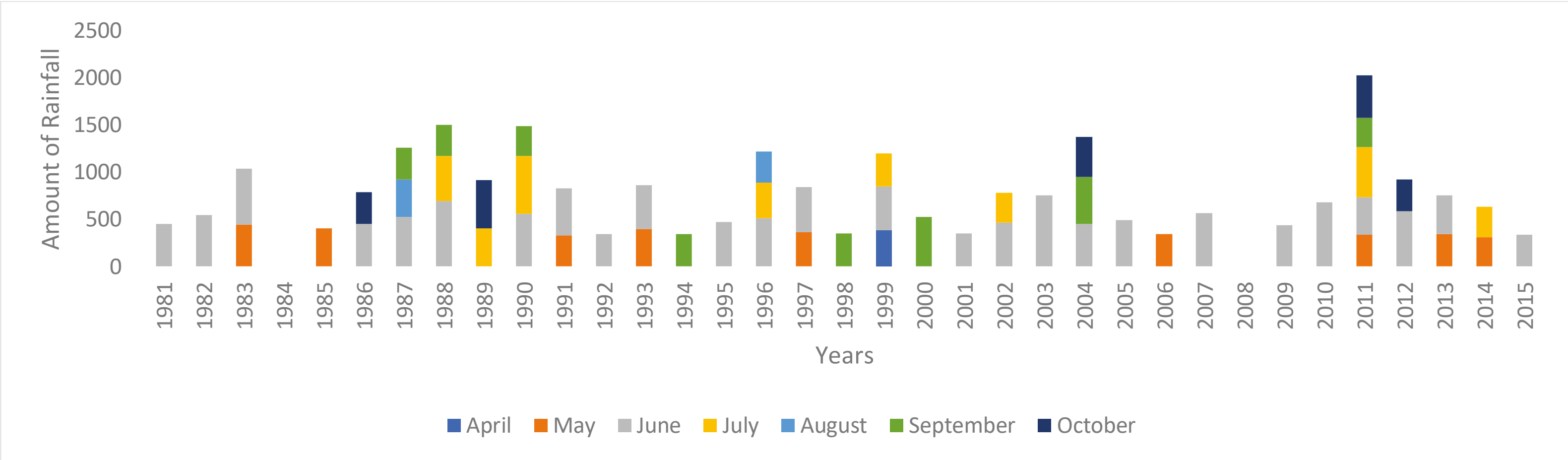


Figure 5.22b: Seasonal rainfall totals exceeding 300mm at Victoria Island (1981-2015)

5.4.3 Annual Rain Days

It was important to evaluate whether Lagos had seen more rainfall from1981 to 2015. In order to determine the onset and cessation of the rainy season, the number of rain days per month was calculated for time period from 1981 to 2015 for each of the stations (Odekunle, 2006). 1985 was observed as the year with the highest number of rain days at 122, followed by 2014 at 120 days for Victoria Island, with June having the highest number of rain days for both years (Table 5.22). Ikeja station showed 1996 as the year with the highest total number of rain days at 133, with July and August as the months with the highest number of rain days and then followed by 2014 at 118 number of rain days with May having the highest number of rain days (Table 5.23).

Although respondents in all five areas believed more intense rainfall was a reason for the deterioration of the flood situation in their areas (section 5.2.4 – Figure 5.12) and with at least 20% of respondents in all five areas feeling at risk to future flood risk due to intense rainfall, the number of rainy days over the years from 1981 to 2015 has not seemed to increase as suggested by respondents but instead remained variable (Tables 5.22 & 5.23). Ajibade and McBean (2014) concluded that while, a change in climate extremes is a key risk factor, more rain did not account for the main cause of flooding in Lagos.

Table 5.22 Number of rain days per month, Victoria Island (1981-2015).

Years/Months	January	February	March	April	May	June	July	August	September	October	November	December	Total
1981	1	1	7	12	18	20	12	15	14	9	3	1	113
1982	0	1	5	10	19	21	11	3	8	10	5	0	93
1983	0	0	3	5	19	20	6	6	11	8	6	0	84
1984	1	3	7	8	10	14	10	8	12	12	3	1	89
1985	4	2	4	8	19	20	12	17	17	16	3	0	122
1986	1	4	5	5	11	16	8	4	17	9	6	0	86
1987	1	7	6	4	12	10	15	22	20	12	2	1	112
1988	4	5	4	11	10	18	15	12	19	12	3	4	117
1989	0	0	4	7	13	19	20	14	13	17	5	0	112
1990	0	2	1	10	12	23	21	3	24	12	2	5	115
1991	2	3	8	10	13	21	18	11	19	9	0	2	116
1992	0	0	2	8	13	13	20	6	20	14	6	2	104
1993	0	5	7	8	19	19	5	9	15	9	8	1	105
1994	2	0	1	12	11	19	16	16	16	15	2	1	111
1995	1	5	9	7	14	18	18	18	17	9	2	1	119
1996	2	3	7	12	12	17	13	16	3	1	0	0	86
1997	1	0	4	11	12	19	5	6	14	1	6	1	80
1998	1	1	1	11	9	5	4	16	14	6	2	0	70
1999	2	3	6	12	10	14	16	7	11	16	8	0	105
2000	0	1	3	6	12	14	7	11	17	10	1	1	83
2001	3	1	4	11	10	15	9	4	15	8	4	2	86
2002	1	3	5	8	8	13	17	4	6	14	1	0	80
2003	3	3	1	5	10	16	4	4	11	6	6	0	69
2004	3	6	3	5	16	14	4	12	20	11	3	1	98
2005	0	2	4	5	12	15	10	6	7	8	0	0	69
2006	2	2	3	4	18	14	10	2	18	10	0	0	83
2007	0	0	0	5	7	19	8	9	5	7	0	0	60
2008	0	0	1	2	4	8	15	3	14	15	4	2	68
2009	1	3	6	9	10	18	14	5	7	15	2	2	92
2010	0	2	3	4	11	17	8	14	19	11	4	1	94
2011	0	2	1	6	14	19	17	10	15	18	5	0	107
2012	0	6	4	11	14	23	14	5	12	16	5	0	110
2013	1	2	9	9	16	20	22	2	5	11	5	2	104
2014	6	5	7	8	11	18	17	12	14	9	10	3	120
2015	1	2	6	6	10	19	7	15	13	14	5	0	98

Table 5.23 Number of rain days per month, Ikeja (1981-2015).

Years/Months	January	February	March	April	May	June	July	August	September	October	November	December	Total
1981	0	3	6	8	15	14	7	11	15	7	4	1	91
1982	2	3	4	7	11	24	13	3	7	10	6	1	91
1983	0	0	1	6	13	20	4	11	13	4	3	6	81
1984	0	0	0	7	12	11	7	9	16	12	4	1	79
1985	0	0	0	7	12	11	8	9	16	12	4	1	80
1986	2	1	6	0	15	15	11	18	16	11	8	1	104
1987	1	2	7	6	12	13	9	4	17	10	3	0	84
1988	0	8	6	5	9	9	9	20	17	8	2	0	93
1989	1	2	5	10	6	18	13	5	17	11	7	4	99
1990	0	0	6	7	12	15	17	13	7	16	1	0	94
1991	0	2	1	10	11	9	14	2	15	14	5	5	88
1992	1	2	6	10	15	19	18	9	15	9	2	2	108
1993	0	0	3	6	12	14	15	6	16	11	6	1	90
1994	0	2	6	8	14	15	8	16	13	8	7	4	101
1995	3	2	5	6	11	15	9	0	11	15	5	1	83
1996	0	6	12	9	14	17	19	19	16	17	3	1	133
1997	3	5	10	9	9	16	14	13	8	8	3	0	98
1998	0	0	7	9	0	17	10	7	16	15	6	2	89
1999	1	1	4	4	12	9	3	7	16	11	8	0	76
2000	2	0	4	11	7	12	12	20	18	11	0	0	97
2001	1	2	3	4	7	16	10	14	15	11	4	1	88
2002	1	1	2	12	9	20	13	8	20	12	7	1	106
2003	1	4	4	9	13	18	18	7	11	18	8	4	115
2004	3	3	7	9	17	9	6	11	17	15	5	1	103
2005	0	5	8	5	15	19	11	3	11	12	7	2	98
2006	3	6	5	5	14	16	13	11	19	13	6	1	112
2007	0	0	4	6	12	17	14	14	12	10	5	3	97
2008	1	0	7	7	19	19	20	12	14	12	0	2	113
2009	1	4	6	9	13	16	9	2	11	14	3	0	88
2010	0	0	1	9	15	12	18	18	20	16	1	0	110
2011	0	4	2	8	9	24	11	6	14	14	10	0	102
2012	1	5	8	9	12	19	14	6	14	13	11	2	114
2013	5	2	6	11	16	11	17	2	14	9	12	3	108
2014	6	5	7	8	11	18	17	12	14	9	9	2	118
2015	1	5	9	8	8	16	5	12	12	17	3	1	97

A Mann-Whitney test was completed on both sites in order to determine homogeneity or whether differences exist randomly in the rainfall data between both sites (Mann and Whitney, 1947). Median scores for both Victoria Island and Ikeja were 0.00 and was not significantly different as P value was > .05 for both sites. 16 out of 19 stations in London, Canada also showed non-homogeneity as there was no significant trend observed (Zhang and Burn, 2009).

5.4.4 Rain Days in the Rainy Season

The rainy season for Lagos lasts from April/May to September/October (Israel, 2017) and according to Omogbai (2010), in the south-western states of Nigeria, for example, Lagos, April and May are the first two months of the rainy season while the cessation is usually observed in September and October; qualifying as the last two months to end the rainy season. As a result, the rainy season months were evaluated (Figs 5.23a & 5.23b) and they also showed high variability of the rainy season rather than the suggested increase over the years. The rainy season for Victoria Island lasted from April to October and remained variable with no clear spike over the months in the rainy season, however, June of 1998 had lesser rainy days at just 5 days and even lesser in the following month, despite June accounting for the highest mean rainfall amount (Table 5.23) although 1998 recorded the year with the second lowest rainfall total in the time series. Furthermore, more rainfall days were recorded in August and September in 1998 with the rainy season ending in October that year.

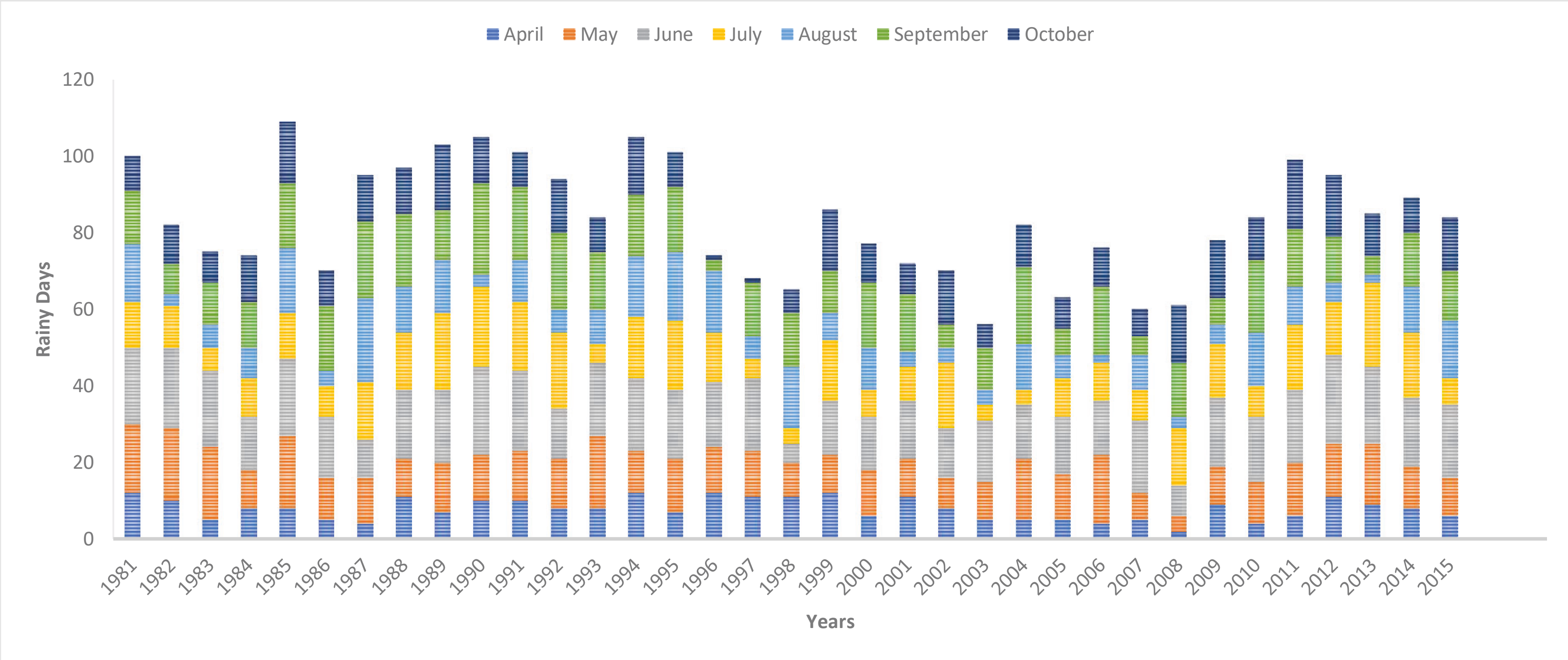


Figure 5.23a: Number of rain days per month of the wet season, Victoria Island (1981-2015)

Although for both sites, the rainy days within the rainy season remained variable. It was observed that Victoria Island's rainy days in the rainy season was more variable than that of Ikeja. In 1985, Victoria Island recorded the highest rainy days in that rainy season. However, this was not the same for Ikeja as it instead recorded year 1996 as having the highest rainy days in the rainy season. In 1986, a later start to the rainy season was observed with no rainy days recorded in April and the rainy season for that year starting in May instead. However, in May 1998, no rainy days were recorded showing how variable the rainy season is over time as again no clear spike was observed across months in the rainy season over years.

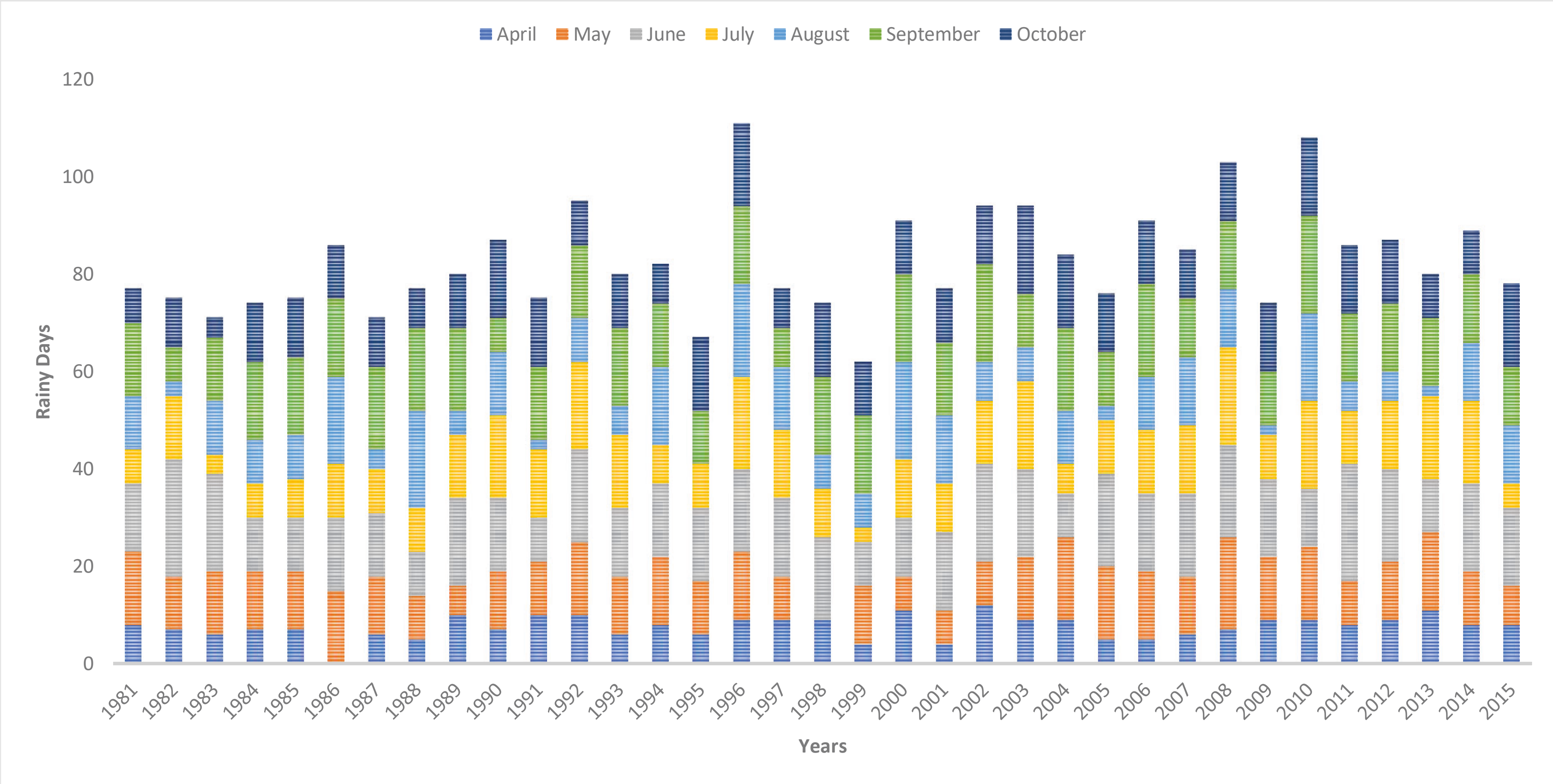


Figure 5.23b: Number of rain days per month of the wet season, Ikeja (1981-2015)

Mean rain days were calculated for both sites and the highest number of average rain days in the rainy season was in June; Victoria Island at 17days and Ikeja at 16 days. The lowest average rain days in the rainy season was recorded at 8 days for both sites (Table 5.24). The results show that although the number of rain days in the rainy season increased from April (start of the rainy season) until it peaked in June, a decline was observed in July and subsequently in August, increasing again in September, which represented the month with the second highest average rain days in the rainy season. This suggests there are two rainfall regimes (Adeloye and Rustum, 2011) and that from the start of the rainy season, the amount of rainfall is expected to increase until after June when peak rainfall amounts are reached, then a decline afterwards which increases again in September and reduces later on as the rainy season ends. Similarly, in parts of the north-eastern and central South Africa where two rainy seasons are experienced, a rise in the number of rain days was observed in between March to May which is the first part of the rainy season while from October to November, a decline in the number of rain days was observed (Nicholson et al., 2018).

Table 5.24: Mean rain days for Ikeja and Victoria Island (1981-2015).

Months/ Annual Totals	Ikeja (days)	Victoria Island (days)
April	8	8
May	12	13
June	16	17
July	12	12
August	10	9
September	14	14
October	12	11
Annual Totals	83	83

Across the time series for Victoria Island, June accounted for the month with the most rainfall days which matches June being the month with the highest total rainfall (Table 5.25).

5.4.5 Rainfall Intensity

For hydrological purposes, only precipitation hitting the ground should be considered for rainfall intensity despite its varying nature in time and space in order to be considered as 3-dimensional (Marra and Morin, 2018). The monthly and yearly rainfall intensity was calculated for the 35 years' time period of the data collected from 1981-2015 highlighting the rainy season and months when flood impacts from intense rainfall may have been more severe compared to years and months with lesser rainfall intensity (Afangideh et al., 2013; Olanrewaju et al., 2017).

Data for Victoria Island (Fig 5.24) and Ikeja (Fig 5.25) showed that over time, intensity of rainfall has not increased but instead fluctuated. However, it was observed that although the highest rainfall intensities were observed in 2005 and 1996 in Victoria Island (Fig 5.24), these years did not also account for the highest annual rainfall total (Table 5.11a), suggesting that the number of rain days played a huge part in determining the annual rainfall intensity.

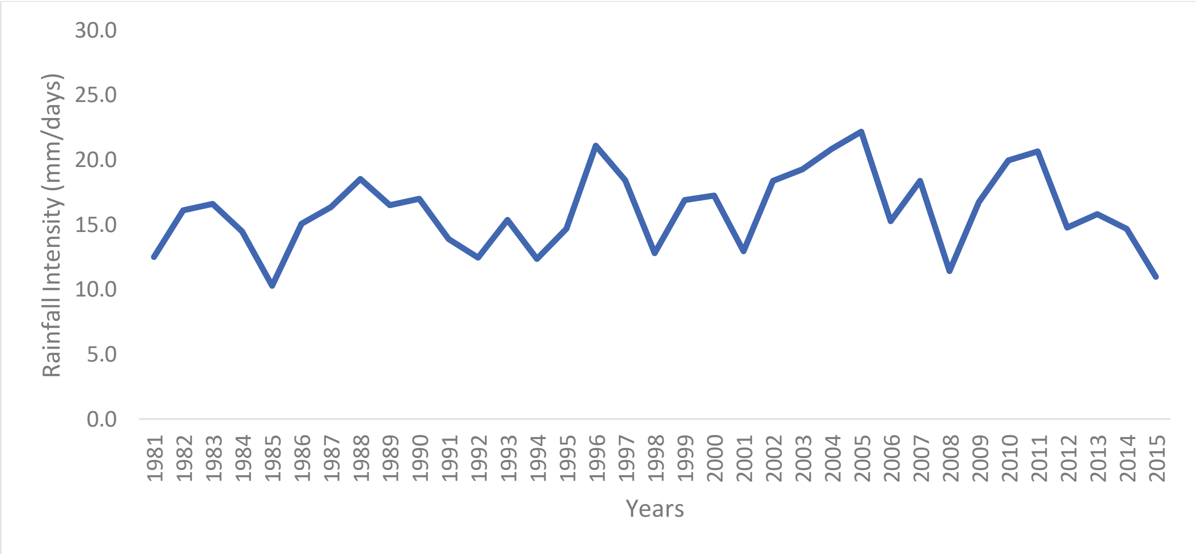


Figure 5.24: Annual rainfall intensity at Victoria Island (1981-2015)

The highest rainfall intensities for Ikeja were recorded in 1998 and then in 1989 (Fig 5.25) also did not account for the highest annual rainfall totals in Ikeja (Fig 5.14b). However, both years fell under the top 5 highest annual rainfall totals (Fig 5.14b) suggesting the high rainfall amount was a bigger factor in determining the rainfall intensity.

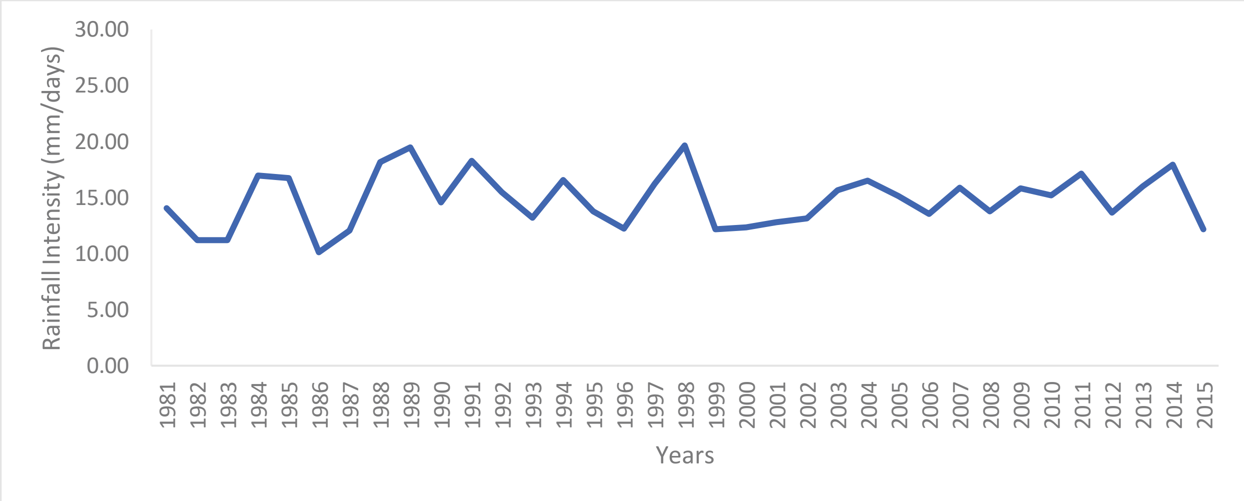


Figure 5.25: Annual rainfall intensity at Ikeja (1981-2015)

According to Gericke and du Pleissis (2011), the occurrence of a flood event depends on the amount of precipitation as well as the rainfall intensity. This matched with Victoria Island's highest rainfall intensity in 2005 as a flood occurrence was recorded in July 2005 after a heavy storm event which lasted for 5 days (Nkwunonwo et al., 2016). The fluctuations in the results from both sites over time showed that despite respondents reporting more intense rainfall as why there had been no change to their flood situation, this has not been the case and that instead other factors are responsible for the increased flood frequency experienced by the residents in Lagos as reported by the flood officials. Monthly rainfall intensity was also evaluated for both sites and June was the month with the highest rainfall intensity at both sites (Table 5.25). Similarly, June accounted for the month with highest mean monthly rainfall at both sites (Figs 5.17 & 5.18).

Table 5.25: Monthly rainfall intensity for Victoria Island and Ikeja stations

Months	Rainfall Intensity for Victoria Island (mm/days)	Rainfall Intensity for Ikeja (mm/days)
January	14.36	11.47
February	12.24	13.10
March	11.59	13.72
April	18.68	16.50
May	18.77	16.29
June	25.59	18.45
July	16.83	16.50
August	11.13	8.98
September	15.86	13.61
October	16.83	13.45
November	11.80	15.08
December	11.14	12.79

The intensity for both sites also reduced significantly in August but then increased in September and October. This might be due to the suggestion by that Lagos experiences two rainy seasons: April to July as Season 1 and October to November as Season 2 (Adeloye and Rustum, 2011).

5.4.6 Trend/Pattern of Annual and Seasonal Rainfall

The trend in annual rainfall amount was examined using regression analysis for the Victoria Island and Ikeja stations (Table 5.26). Although the rainfall is increasing at the rate of 0.59mm every year from 1981 to 2015 (Fig 5.26), the trend in Victoria Island shows no significant relationship. This is further supported by the P-value which is greater than 0.05. Similarly, Ghana's annual rainfall total for the northern zones showed no statistically significant trend (Nyatume et al., 2014).

Table 5.26: Trend/Pattern of annual rainfall using regression analysis for both sites

Variables	Regression Equation	P-Value	Statistically Significant	Sample Correlation	R^2
Victoria Island	0.585x+505.434	0.927	No	0.016	0%
Ikeja	12.36x-23448.7	0.011	Yes	0.426	18.2%

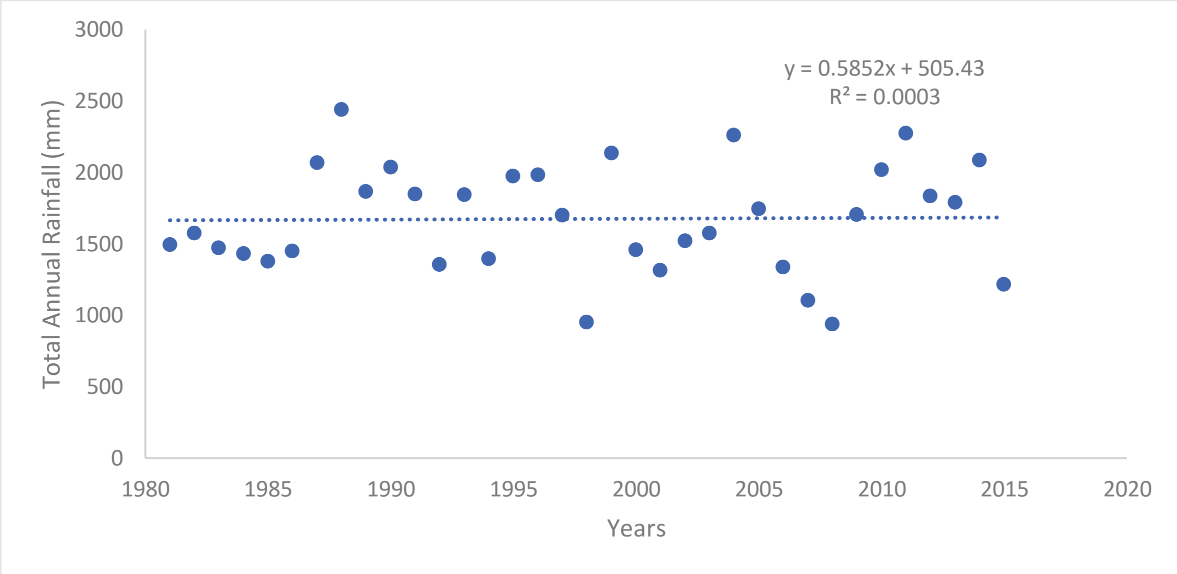
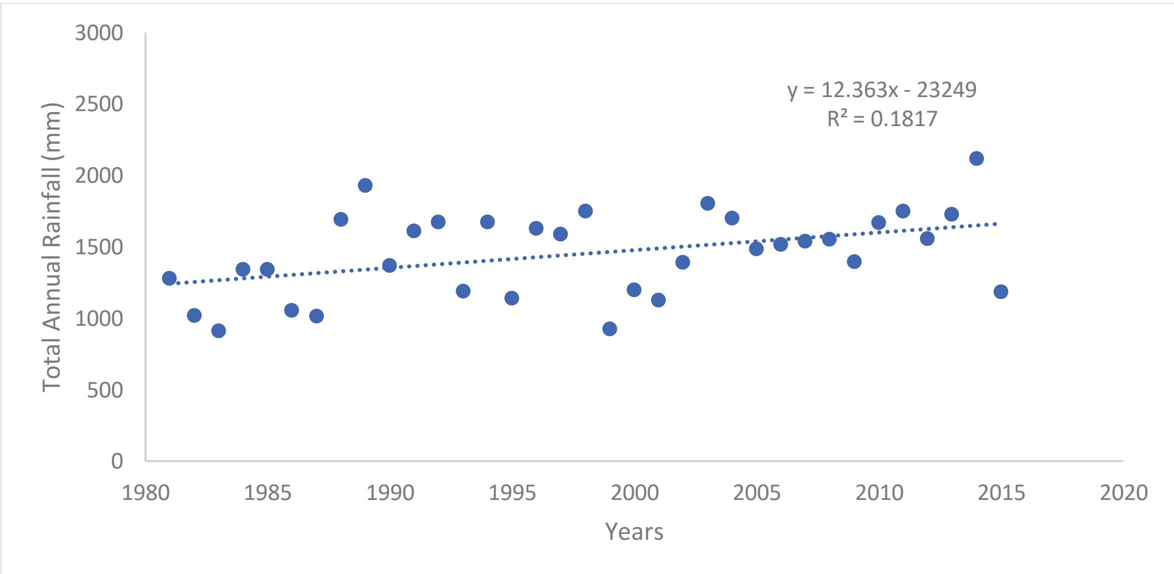


Figure 5.26 Time series plot of Victoria Island station's yearly rainfall (1981-2015)

The mainland area of Ikeja, however, showed some statistical significance of 18% with a P value <0.05 and a slight upward trend observed suggesting rainfall was increasing at about 12mm yearly from 1981 to 2015 (Fig 5.27).



Figures 5.27: Time series plot of (Mainland) Ikeja station's yearly rainfall (1981-2015)

62% of respondents in Victoria Island believed heavy rainfall was the main cause of flooding and approximately 29% of the respondents at Victoria Island also believed the flood situation had gotten worse, with 23% of them attributing this to be from more intense rainfall. However, the lack of significant relationship at Victoria Island for the 35 years does not support the perception of respondents. Also, despite rainfall events having been reported to be on the rise recently (Field et al., 2012) and as the major cause of flooding in Nigeria (Adetunji and Oyeleye, 2013), the results for Victoria

Island show this is not the case. Rather, other contributing factors such as inadequate or lack of capable drainage systems, lax planning laws and increased urban development are to blame (Adeloye and Rustum, 2011). Ikeja's results suggest a weak pattern of 18% in the data and that heavy rainfall over the years might be a contributor to flooding as suggested by the 57% of respondents in the area.

Trends in the rainy season (April to October) data for Victoria Island and Ikeja were also examined using regression analysis (Table 5.27) which showed a decline in the total precipitation in Victoria Island's rainy season at -0.7mm per year from 1981 to 2015 (Fig 5.28). The Mandera, Kongwa and Dakawa stations in Tanzania showed an increasing trend in seasonal rainfall for the period of 1983 to 2017 (Twisa and Buchroithner, 2019).

Table 5.27: Trend/Pattern of seasonal rainfall using regression analysis for both sites

Variables	Regression Equation	P-Value	Statistically Significant	Sample Correlation	R^2
Victoria Island	2919.85-0.699x	0.904	No	0.021	0%
Ikeja	7.672x-14087.3	0.084	No	0.296	8.8%

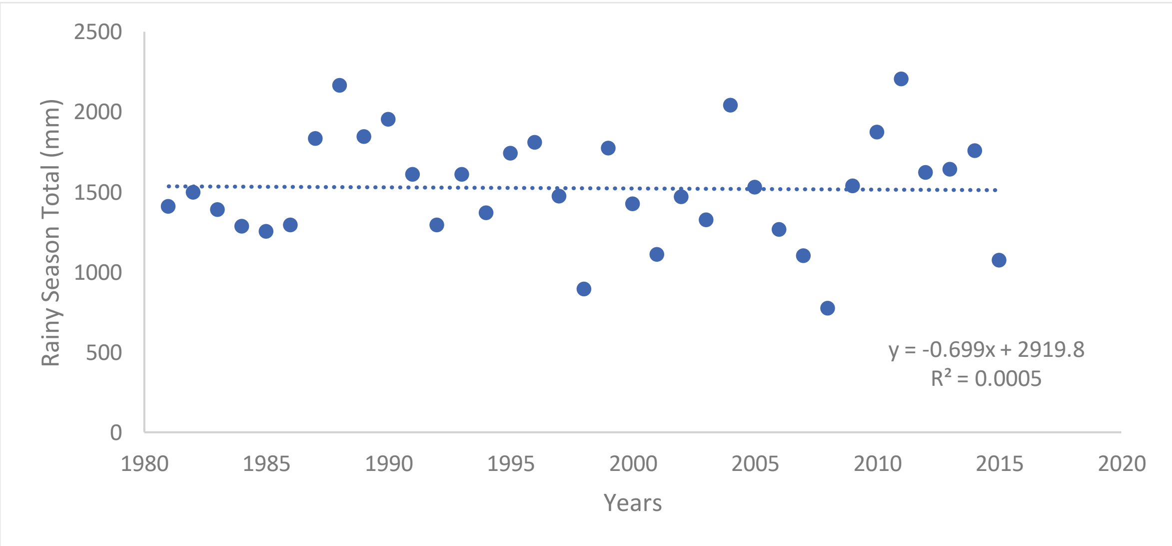


Figure 5.28: Time series plot of total rainfall in rainy season for Victoria Island (1981-2015)

The analysis for Ikeja's station showed that the rainfall in the rainy season was increasing at 8mm per year from 1981 to 2015 (Fig 5.29). A weak significance of 9% was observed, further supported by the observed P-value >0.05.

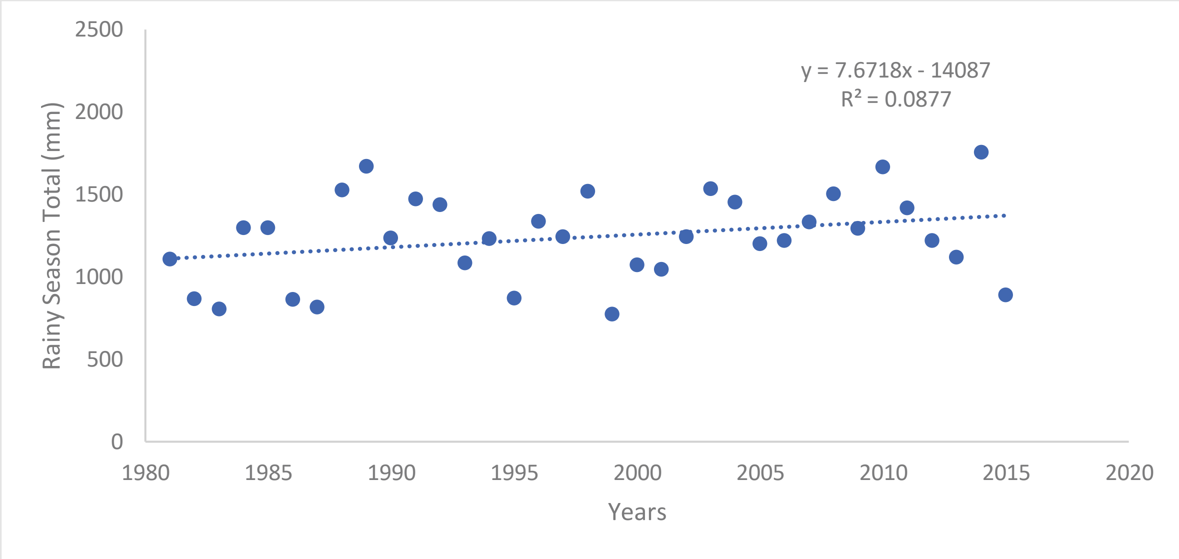


Figure 5.29: Time series plot of total rainfall in rainy season for Ikeja (1981-2015)

5.4.7 Historic Flood Chronology

Historical flood data is useful in extending hydrological records for the future as well as in filling gaps in flood knowledge (McEwen, 1987). There was some difficulty collating historical flood data for Lagos as there appeared to be a dearth of information on this. However, some historical flood data from 1968 to 2012 was obtained (Table 5.28). This difficulty highlights the issue of lack of flood data creating significant gaps in knowledge that might improve efforts for managing flooding effectively in Lagos (Nkwunonwo et al., 2016).

Data collated showed that 18 years had previous major flood events between 1968 to 2012. However, the time series for this research study was from 1981 to 2015 and so comparisons and differences were drawn where it applied on the previous major flood events collated.

Table 5.28: Major flood events and their causes in Lagos, Nigeria from 1968-2012

Dates	Cause(s)	Duration (Days)
June 1968	Heavy Storm	Unspecified
June 1969	Short Duration-High Intensity Rainfall	10
July 1970	Winds, Short Duration-High Intensity Rainfall	Unspecified
July 1971	Heavy Rainfall	5
June 1972	Heavy Rainfall	Unspecified
June 1974	Heavy Rainfall	Unspecified
July 1988	Heavy Rainfall	2
July 1990	Heavy Rainfall	2
May, June, July 1999	Unspecified	Unspecified
June, July, September 2000	Brief Torrential Rainfall	2
July 2002	Heavy Rainfall	3
June 2004	Heavy Rainfall	2
July 2005	Heavy Storm	5
August 2007	Heavy Rainfall	15
October 2008	Heavy Rainfall	Unspecified
July 2009	Heavy Rainfall	Unspecified
October 2010	Heavy Rainfall	Unspecified
July 2011	Heavy Rainfall	5
October 2011	Heavy Rainfall	9
October 2012	Heavy Rainfall	Unspecified

Adapted from: (Nkwunonwo et al., 2016; Nkwunonwo, 2016)

When compared to the amount of rainfall for the time series of this study from both sites, arranging the rainfall amounts from the highest amount to the least (Table 5.29), very few correlations could be made.

The year for both sites that matched the list of past flood events was 2011. The flood event occurred after just 2 days of heavy rain on the mainland as well as the island areas of Lagos, impacts reported included 10 deaths, significant economic losses, major disruption to movement and 10,000 people displaced (Nkwunonwo et al., 2016). The next flood event occurred in 2004 after 2 days of heavy rain resulting in significant economic losses, 1,000 people displaced, and drainage systems affected. In 2000, after 2 days of brief torrential rainfall in Victoria Island and Ikoyi, 500 people were displaced, major losses were recorded as well as a significant number of houses becoming affected (Nkwunonwo et al., 2016).

Table 5.29: Annual rainfall amounts from both sites in descending order (1981-2015)

Years	V.I Rain	Years	Ikeja Rain
1988	2443	2014	2117
2011	2275	1989	1927
2004	2263	2003	1802
1999	2136	1998	1750
2014	2087	2011	1748
1987	2069	2013	1727
1990	2037	2004	1699
2010	2018	1988	1689
1996	1986	1992	1672
1995	1977	1994	1671
1989	1866	2010	1670
1991	1848	1996	1630
1993	1844	1991	1610
2012	1834	1997	1589
2013	1789	2012	1557
2005	1746	2008	1554
2009	1708	2007	1540
1997	1700	2006	1517
1982	1578	2005	1484
2003	1575	2009	1393
2002	1523	2002	1392
1981	1494	1990	1369
1983	1471	1984	1340
2000	1459	1985	1340
1986	1452	1981	1280
1984	1432	2000	1198
1994	1398	1993	1188
1985	1378	2015	1183
1992	1358	1995	1141
2006	1338	2001	1125
2001	1314	1986	1053
2015	1217	1982	1017
2007	1104	1987	1015
1998	954	1999	926
2008	939	1983	909

5.5 Summary

The gendered differences examined how flood impacts affected men and women which revealed men were more affected by the impacts of flooding in the five research areas of Ikeja, Ikorodu, Surulere, Victoria Island and Lekki.

The precipitation data for Lagos from 1981 to 2015 for Ikeja and Victoria Island stations showed that although residents and flood officials believed increased precipitation has led to the increasing flood issue in Lagos, rainfall amounts did not show there had been more rains over the 35 years period. The rain days also did not indicate that the wet season was getting wetter from 1981-2015, although, an increase was observed in the rain days from 1984 to 1985 in Ikeja's station. High variability of the rainfall data was evident at both sites over the years. The time series plot for annual rainfall in Victoria Island showed no significant relationship using a regression analysis, the analysis for Ikeja showed a weak increasing trend in the rainfall at 18% with rainfall increasing at 12mm per year from 1981 to 2015. Time series plot for the rainy season was also completed for both sites using a regression analysis. Although results for both Ikeja and Victoria Island showed no significant relationship, Victoria Island showed a decline in the trend while there was an increasing trend of 7mm rainfall per year in the rainy season from 1981 to 2015.

Lagos' flood issue therefore lies in its management of flooding as other contributory factors have been raised by the respondents and the flood officials such as increased impervious surfaces from rapid urbanisation, failure and lack of maintenance of existing storm drains, poor planning leading to construction on flood-prone areas such as wetlands and floodplains, indiscriminate dumping of waste in the drainages and the lack of or inadequate drainage systems.

With the increasing population of Lagos and the impacts of flooding reported by the respondents which included loss of properties, displacement, damage to properties, hospitalization, disruption to movement and in severe cases; loss of lives, it is evident that Lagos requires better mitigation measures that will protect the residents from current and future flood risk. These mitigation measures are discussed in Chapter 6.

CHAPTER 6 CONCLUSION

6.1 Introduction

This chapter presents a summary of the work undertaken for this research and concludes the thesis. A summary of the research findings is discussed in section 6.2 in relation to the research aims and objectives. Section 6.3 presents reflections on lessons learned from using mixed methods research. Section 6.4 makes recommendations on flood risk reduction in Lagos based on section 6.2 and section 6.5 presents evidence-based recommendations for future work on flood risk in Nigeria. Section 6.6 discusses personal reflections on the pros and cons of the research process as well as lessons learnt for future research/practice. Section 6.7 presents limitations to the research and contribution to scientific knowledge. Finally, section 6.8 summarises and concludes the research.

6.2 Summary of Research Findings

Flooding is a common hazard associated with Lagos state, this is compounded by the high levels of flood risk and vulnerability affecting the state's low topography, high population density, large number of poor people and its location by the coast. Adaptation is even harder due to significantly low incapable infrastructures (Elias and Omojola, 2015). With this context, the goal of this research was to examine the flood situation of Lagos for its current population and what it means for its growing population in the future. The research findings in relation to the original aims and objectives of this research as outlined in section 3.2 are presented further.

Aim 1: To identify residents' experiences during and after flooding and understand whether changes in flood experience influenced future flood behaviour: The first objective dealt with residents' perception of flooding in their area. This objective is addressed in Chapter 3 through the use of a questionnaire survey with residents in the five areas with differing population sizes and income to understand the different flood experiences of the residents.

Across the different locations (Ikeja, Ikorodu, Lekki, Surulere, Victoria Island), about 80% of the respondents had experienced flooding whilst living in Lagos. Although a low proportion of the respondents considered flooding before choosing their property; Victoria Island and Ikeja at 26%, Ikorodu at 17%, Surulere 14% and Lekki at 12%, approximately almost 60% also across the five chosen research areas, had experienced flooding in their current property. Ikeja accounted for the lowest at approximately 54% while Lekki residents accounted for the highest at approximately 65% of being flooded in their current property. The proportion of respondents that had experienced flooding in their current property in Surulere, Ikorodu and Victoria Island was approximately 60% (59%, 61% and 60% respectively). With over half of the respondents having experience of being flooded, this indicates the high proportion of Lagos residents vulnerable to flooding and also supports the suggestion that Lagos is the most susceptible state in Nigeria to flooding due to urban expansion as well as its coastal location (Nkwunonwo et al., 2015).

Although more men had experienced flooding in their current homes, more women had experienced flooding while living in Lagos. When flood experience while living in Lagos was examined against location for women and men, women in Ikeja (a high and middle-income area) represented the highest proportion (19.5%). This was attributed to the fact that parts of Ikeja still remain prone to flooding (Nigerian Tribune, 2017) despite being home to the domestic and international airports. The National Flood Manager (2017) suggested that Ikeja remains flood-prone because the drainages in Ikeja are old and require upgrading from when they were first built.

The issue of urban expansion is one of the causes of flooding in Lagos and although more than half of the respondents attributed high rainfall to be the main cause of flooding, urban expansion was mentioned as a factor that seemed to exacerbate the issue of flooding. The increase of impervious surfaces in Lagos limits effective flood management for the state (Adelekan, 2016). Between 1999 to 2015, Lagos experienced its most significant period of expansion and it has also been suggested that rather than looking at what worked best for the state based on its characteristic as a low-lying and coastal state, the development was aimed instead to attract investors, tourists and businesses globally in order to achieve economic prosperity often at the expense of the poor (Hoelzel, 2018). Ikorodu which is a low-lying area is already densely congested, and due to the increasing demand for space many new properties are built on the floodplain. Lekki's position next to the coast, its low elevation and reliance on land reclamation to provide additional space, in addition to the demand for space is another example. Although these two areas are on different areas of the spectrum, with Lekki being a high-income area and Ikorodu being a low-income area, it is evident that it is essential that Lagos has effective drainage systems for managing any flood waters. This brings up another factor attributed to be a contributor to flooding in Lagos, failure and or incapable drainage systems.

The aging nature of storm drains across the state poses an additional challenge to the effective management of runoff. Just over 45% of the respondents in Lekki believed the inability of storm drains to cope with the volume of runoff raises challenges for flood management in this particular location. Approximately 39% of the respondents in Ikorodu and Surulere, 30% of the residents in Victoria Island and 26% of the respondents in Ikeja attributed failure of drainage systems as the second main cause of flooding in the state. Other factors increasing the flood risk mentioned by the respondents included improper waste disposal, river/lagoon flooding and lax planning laws.

Across the five research areas, the flood impacts experienced included: damage to property, disruption, loss of property, displacement, hospitalisation, and loss of life. This prompted the residents to take up actions to reduce future flood impacts and risk such as using sandbags, raising entrance to their properties, filling in depressions around their properties and clearing out drainage systems. It is significant to note that although improper waste disposal where some of the waste ended up in the drainage system accounted for one of the causes of flooding by the respondents, clearing out waste from the drainages accounted for the lowest action taken to reduce flood impacts. This could suggest part of the reason why just over 26% of the respondents believe that there is no change to the flood situation as the drainage systems remain blocked, approximately 16% believe the situation is getting worse and just about 20% of the respondents believe the flood situation is getting better in Lagos. Respondents mentioned actions that had been taken by their household, their communities and the government since the last flood they experienced, they include straightening and deepening of water channels, better waste disposal, clearing rubbish out of water channels, provision of access to sandbags and building of flood defences; with building of flood defences mentioned by just 3% of the respondents.

While it has been reported by Neumayer and Plumper (2007) that women and girls are reportedly more affected by flooding, results showed that overall, more men suffered flood impacts when compared to women. The highest proportions for men were recorded under damage to property (36.6%) and loss of property (29.9%) while women were recorded at 15.1% and 14.4% respectively. This could be due to more men (63.4%) being sole providers compared to women (32.5%).

Bradshaw and Fordham (2013) suggested that rather physical and biological differences, social differences were responsible for women and girls being more adversely affected by flooding. However, location did not have an effect on impacts experienced as evident in Ikeja (high and middle-income area) where women experienced the greatest impacts at 13.8% each for damage to property, loss of property and financial loss. Similarly, 14.3% of men in Lekki (high-income area) experienced the highest impact (financial loss). Relationship between impacts and gender were examined and revealed that women had a higher probability of being displaced compared to men.

Although just over 35% of the respondents reported that they had never experienced flooding, 44% reportedly believed they were at risk to future flooding stating reasons such as no drainages, blocked drainages, no improvements, uncertainty, intense rainfall and the need for better flood defences. With the high flood incidence rate, causes of flooding, flood risks and impacts and the response to flood events reported by the respondents, there is a need for better flood management. Although residents were aware of their vulnerability to flooding, the preventive measures taken have not led to alleviated flood impacts or significant reduction to future flood risk.

Aim 2: To assess flood management measures in place and some of its issues such as drivers and barriers in the different areas chosen for the research in Lagos, Nigeria: This objective was also fully outlined in Chapter 3 and it deals with the perspective of flood managers in Lagos in order to better understand how flood is managed in Lagos.

The flood managers reported that managing flooding in Lagos remains a challenge as there are current issues that worsen the flood problem, and these have to be managed first. They include houses built on floodplains, attitude of residents to flooding; there is the need for better information and public awareness that highlights cause and effect and why flooding has to be controlled especially for the future. Another issue is better waste management structure that prevents the indiscriminate dumping of waste in the drainage systems. It was suggested that enforcements such as fines might help people do better. The respondents believed that building better flood defences was key to managing flooding in Lagos and the officials suggested that the drainage systems in place aid in managing flooding, however, there is general abuse such as waste dump, oil dump and damage to the drainages by motorists. The officials also acknowledged that some of the storm water drainage systems were constructed around 1988 in response to the 1974 flood reports and thus, the drainage network requires extensive upgrading as Lagos has undergone significant urban expansion and development since then. In lieu of this, there is a 20 to 25 year drainage masterplan prepared to aid flood management in Lagos by the government which should occur in five phases. However, a major setback to its implementation is the lack of resources and funds.

The high-income areas and some of the middle-income areas (Ikeja, Lekki and Victoria Island) were highlighted as easier in terms of flood management due to awareness of flood issues and causes. However, the low-income and some of the middle-income areas (Ikorodu and Surulere) are harder to manage. This might be due to the fact that despite the flood warnings, the residents in these areas believe they understand the flood waters better and that actions such as dumping waste in the drainages will eventually get carried away by the flood waters, but this is not the case. The officials suggested that some of the residents have mentioned that as they have been experiencing flooding for over 50 years, with the belief that the issue of flooding is not one they can have any control over but rather is an act of God and will come and go. Although, there are flood incidences in these areas, there are no flood managers in any of the local government areas of Lagos state to monitor and manage flooding in the areas. However, flood engineers who have up to date flood information about flooding as well as each area's flood history and are deployed after flood prediction to educate residents and advise especially those living along floodplains about temporary re-settlements. The residents refuse the re-settlements as there is a general distrust of the government and there are significant emotional attachments to their homes and so they would rather not leave despite flood warnings.

According to the flood managers, the drivers that aid better flood management strategies are residents adopting proper sanitation and waste management measures to reduce flood impacts. The government monitors the climate situation of Lagos and predicts flooding beforehand and depending on the area's flood prone tendency, this informs the preventive measures such as provision of sandbags, deepening water channels, silting drainages, that are undertaken. The flood officials believed that the major barrier towards better flood management in Lagos was changing behaviours, however, the national flood manager highlighted that this change needs to happen on both sides; the residents and the government as there is a lack of maintenance or follow-through culture in Lagos. This is evident in the attitude of residents to flood issues who adopt better flood prevention measures sometimes and abandon them quickly after. Lax planning laws, improper waste management, inadequate drainages that are improperly maintained on the part of the government all act as challenges to effective flood management in Lagos.

Aim 3: To statistically analyse precipitation data over 50 years in Lagos, Nigeria for patterns such as changing seasonality of rainfall events, increase in intensity and frequency of rainfall: This objective presents findings from the analysis of precipitation data for Lagos. This was important to the overall aim of the study as rainfall is closely linked to flood events. Therefore, understanding the rainfall characteristics and its implications for flooding was useful. The rainfall data available was for 35 years instead of the 50 years initially planned for this research and this was obtained from the Nigerian Meteorological Agency for Lagos from Ikeja and Victoria Island stations. The results showed that the data was highly variable and there had been no change observed to rainfall seasonality from April to October, with June and July accounting for the months with higher rainfall amounts. Increased rainfall intensity and frequency was not observed for the time series for both sites as suggested by residents. There was a dearth of data on historical flood events, some information on past flood events was obtained and no significant correlations existed between flood events and rainfall amounts for both sites over the years. Victoria Island did not show any statistically significant relationship between annual rainfall and the study time series of 35 years from 1981 to 2015, furthermore no significant trend was observed for Victoria Island when the rainy season was analysed. However, Ikeja's results revealed 18% statistical significance and a slight upward trend that showed rainfall was increasing at 12mm per year from 1981 to 2015 when the annual rainfall was analysed.

Aim 4: To use mixed-methods approach for bridging the gap between the flood situation in the five research areas in Lagos, Nigeria by assessing the perception of the flood officials in Lagos and the perception of residents in these areas of their flood experience: This is presented in the summary of research findings highlighted above. The results are presented and discussed in Chapter 5.

6.3 Reflections on Lessons Learnt from using Mixed Methods

Although the researcher's previous experience had mostly focused on quantitative research methods, incorporating the use of qualitative research method also helped provide context and a depth of understanding for the study. Mixed method collects, analyses and mixes both quantitative and qualitative methods by combining the two approaches, and as a reults the research problems are better understood compared with relying on just a quantitative or qualitative approach (Creswell, 2007). Quantitative methods were used for the residents' survey as well as for analysing the hydrological data while the qualitative method was used to conduct and analyse the interviews with the flood officials.

6.3.1 Useful Approach

The lack of experience of using a mixed methods approach was initially addressed by reviewing literature from other research studies and theses that had employed the use of the mixed methods approach.

Many of the sources cited in this work used a combination of either quantitative or qualitative or the mixed methods approach. However, research into flooding and flood management (Adelekan, 2010; Amoako and Boamah, 2014; Adelekan, 2016) indicated that the use of a mixed methods for research was essential in that it can present the situation of things using statistics in quantitative methodology as well as providing the 'why' for the data results through qualitative methodology.

6.3.2 Philosophical Basis

In selecting the mixed methods approach, it was discovered that 'paradigm wars' exist and influence the methodology and method of research. It was argued by De Lisle (2011) that while some studies view paradigms as guides to be followed where appropriate, others view research paradigms as fixed. Given that quantitative and qualitative methodologies are different in both ontology and epistemology, it was useful to understand the philosophical basis of the 'paradigm wars.' The three major research paradigms were therefore explored: positivism, interpretivism and critical theory. Positivism concludes that a reality can exist independent of people and has no social context, focusing heavily on experimentation. Interpretivism opposes the positivism's belief, instead suggesting that there are various multiple realities influenced by people and society. Critical theory assumes that reality exists but has been influenced by political, religious, ethnic and cultural beliefs which then forms a social system (Rehman and Alharthi, 2016). Positivism resists the use of mixed methods, interpretivism believes that a reality can be viewed from the perspective of a research participant rather than the researcher, while critical theory criticises both positivism and interpretivism and argues instead that no reality or social issue can be studied without being affected by the researcher (Rehman and Alharthi, 2016).

It is however, not enough to conclude that mixing quantitative and qualitative methods is the best methodology for any research study. Instead, understanding the meanings of each paradigm is useful towards selecting the methodology most suited to any research study.

6.3.3 Learning and Training

As mentioned previously, the researcher had not used the mixed methods approach, so training was essential. While the university offered workshops on using quantitative and qualitative methods, there were none on this methodology.

Although most researchers will either use quantitative or qualitative, it is not enough to be resigned to this and so there should be opportunities for learning to employ the mixed methods approach. As a result, the researcher learnt how to apply the methodology for their research study. The researcher has been able to strengthen their skills in both the quantitative and qualitative methods and what it means in a mixed methods approach.

6.4 Recommendations on Flood Risk Reduction

This section examines section 6.2 and makes recommendations based on flood risk reduction in order to minimise flood impacts.

6.4.1 Better flood management and legislation: Factors such as blocked drainages from indiscriminate dumping of waste, increased impervious surfaces, lax planning laws and the lack of drainage systems contribute to the flood problem (Adeloye and Rustum, 2011). Better flood management aimed at reducing risk is therefore recommended as this is an important step towards achieving better flood management (Jha et al., 2012). Although the government is mainly responsible for flood management, there is a need for more participation on the part of the residents as reduced environmental stewardship has been observed over the years.

Better flood management, therefore, involves, better policies that prevent development on floodplains where appropriate drainage systems are lacking, planning and implementing a better waste management, building drainage systems where unavailable and rehabilitating existing drainages. There are efforts being made but the impacts have not proved effective as people continue to suffer from flooding, houses continue being built on floodplains. As the population continues to increase, there is increased flood risk to the residents of Lagos if the flood situation and management remains the same (Adelekan and Asiyanbi, 2016).

It has been suggested that bringing back the monthly environmental sanitation carried out nationally is important. However, this should be enforced in order that it may be sustainable in the state (Nwigwe and Emberga, 2014). Other measures such as better planning laws, proper waste management and improved drainage systems are required to tackle the issue of flooding. It is however, not enough to make laws and policies as they require effective enforcement and management to ensure that all sides are doing their part to better prevent and manage flooding in Lagos as the population continues to increase and this could mean more disastrous impacts in the future if nothing changes.

6.4.2 Better Public Awareness: This involves developing measures that help create more awareness about managing flood risk especially for the vulnerable areas and the vulnerable population. Examples include the development of information materials that are easily understood, developing an environmental sanitation exercise for communities. The flood managers mentioned electronic media as one of the ways flood risk information is disseminated, Ajibade & McBean (2014) have however, reported that due to the lack of constant electricity in Lagos, some households who do not have access to alternative power supply would miss this information altogether. Therefore, it is important that the information on flooding, flood risk and flood warnings are easily accessible by all residents.

6.5 Framework/Agenda for future work on flood risk in Nigeria with evidence-based recommendations for flood managers, communities and policy makers

Globally, the increased impact of flooding is a major environmental issue. With the increasing urbanisation and population, the flood risk will also be higher, making it harder for the already vulnerable to cope not just now but in the future if the flood issue in Lagos and Nigeria as a whole continues. Therefore, it is essential that flood risk is managed effectively, with plans and measures that address flood risk, not just on a national scale but also on state and local government area scales. The effectiveness of these plans will depend on the accurate assessment of flood risk through identifying and estimating the flood hazard and analysing and quantifying the impacts based on vulnerability and exposure of people, businesses and infrastructure at risk.

In some parts of the world such as the United Kingdom, United States of America, the Netherlands and China, significant progress and improvements on policies have been evidenced to alleviate their current flood risk. However, many, usually developing countries such as Nigeria, there is still work to be done towards effectively managing flood risk. The challenge for Nigeria can is caused by insufficient flood data, lack of awareness of flood risk and the poor political determination which combined to add to the literature gap around increasing flood events and recommendations for sustainable flood management (Nkwunonwo et al., 2015).

This research revealed that for Lagos, the most populous state in Nigeria, the need for better flood risk management is essential especially in light of its growing population.

The review of other research has revealed that this is also the case for the entire country of Nigeria. Adelekan (2016) concluded that effective flood management in Lagos requires both state and local governments to work together in the planning and implementation of policies that are robust, easy to understand and sustainable by through the ongoing process of research, learning and reviewing. It is not enough to make laws and policies if residents do not understand their flood risk in the first place, therefore, better awareness is just as important.

Some recommendations for the future of flood risk management in Lagos and Nigeria have therefore been included below based on lessons learnt from the flood experience and measures taken by other countries towards reducing their flood risk:

- The government of Nigeria could heed the European Union Water Framework's directive which requires all member states carry out flood risk maps (Sayers, 2003). If adopted, this legislation will be useful towards strengthening existing institutional legislation and foster increased responsibility of flood risk reduction for all the 36 states in Nigeria.
- Implementation and better enforcement of environmental and planning laws is necessary towards tackling issues such as flooding (Nkwunonwo et al., 2015). Increasing the area of impervious and impermeable surfaces through construction of buildings, roads and other urban infrastructure, development on floodplains and indiscriminate waste disposal are some of the anthropogenic activities that exacerbate the impacts of flooding.
- The United Kingdom's Environment Agency (EA) capably manages and coordinates research focused on managing the issue of flooding and its associated impacts EA, 2010). Nigeria has some national research-based groups such as the Nigeria Environmental Study/Action Team (NEST) and the Building Nigeria's Response to Climate Change (BNRCC). It is recommended that the research projects of NEST are reviewed to ensure Nigeria's flood risk and impacts are better assessed and managed.
- Countries such as the Netherlands, the United States and the United Kingdom have centralised bodies that are responsible and equipped to manage flooding with some successes highlighted by Pitt (2008). While the responsibility of Nigeria's NEMA (National Emergency Management Agency) is recognised, there remains a need for improvement. There is still a scarcity of accurate data

and inadequate resources (including funding) that detrimentally affects the effective management of flooding in Nigeria.

- There needs to be better cooperation between institutions in Nigeria to reduce the risk of flooding. For example, major financial institutions and multi-national companies could support humanitarian efforts and sponsor research studies as well as foster sustainable development that helps reduce vulnerability and builds resilience of the poorer communities. This is evident in the United Kingdom where collaboration between organisations and companies have helped addressed the challenges of flooding (Pitt, 2008; EA, 2010).
- The 1953 flood is of particular significance to the Netherlands and as a result are now regarded as having the most effective flood management due to the nation's collective determined commitment to not experience a repeat of their flood history. The residents and government work together to manage flood risk (EA, 2010). It is recommended that better cooperation between the government and people like these are adopted in Nigeria as the responsibility of flood protection should be a collective one. This can be achieved by better flood education on how the reduction of flood risk can be achieved individually and collectively.
- Nkwunonwo et al., (2015) suggested that compared to countries like the Netherlands, China, United Kingdom and the United States, there is less research into the causes, impacts and solutions to flooding in Nigeria. Furthermore, the national curriculum could be improved to include flood and flood risk awareness as well as its management. Greater public awareness of the flood risks and how to prepare for a flood should also be encouraged. Flood early warning system needs to be operational, not just a national scale but also on state and local government levels as these are essential for flood management (Nkwunonwo et al., 2015).

6.6 Personal reflections on the advantages and disadvantages of the research process and lessons for the researcher's future research/practice

6.6.1 Advantages

A major strength of using the mixed methods approach is being able to combine the strengths and weaknesses of both quantitative and qualitative research methods as discussed in section 4.3.1. Both methods complement each other and gives a more rounded picture of the research findings.

Words, pictures and narratives can be made to have a deeper meaning by the addition of statistics. Also using the mixed methods approach allowed for the exploration of grounded theory in research.

Using mixed methods also allows flexibility as there was no need to be constrained to using one type of method. Thereby, making it easier to examine a broader range of research questions.

6.6.2 Disadvantages

As with most doctoral research thesis, this study was completed by a single researcher. Therefore, applying this methodology was more difficult and time-consuming as learning and understanding of the methodology was first essential. Also, both methods had to be examined at the same time in order to draw emerging meanings from findings of both the quantitative and qualitative methods.

Discovering the paradigm wars and arguments for each paradigm as this method involved mixing the quantitative and qualitative methods was new to the researcher and so time was spent understanding how this influenced mixed methodology.

6.6.3 Lessons Learnt for Future Research/Practice

While using the mixed methods approach had its weaknesses. It was an interesting method to examine research problems and the skills and knowledge gained will be transferrable in future research studies.

The literature review around using mixed methodology revealed that for future research, there are reservations held around the quality of mixed methods research as some organizations and communities who offer grants might not be willing to approve its use in the event due to time constraints and the volume of work involved in using this methodology (Halcomb, 2018).

A useful lesson learnt was that it was important to make out time to look at the strengths and weaknesses of the quantitative and qualitative methods separately and then examining how one method's strength can complement another method's weakness. This helped create a better understanding towards using the mixed methods approach.

While some personal training was undertaken to understand using this methodology, further training and learning will be explored and done to improve on the researcher's knowledge for future research.

6.7 Limitations and Contribution to Scientific Knowledge

6.7.1 Limitations: A major limitation to achieving the initial aims and objectives of the research as outline in Chapter 1 (section 1.4) was the inability to obtain the river flow data for Lagos despite several efforts. Ideally, this information would have contributed to the research study by exploring relationships between the data and flood events as well as with the rainfall data. This presents an area for further study.

There was also a lack of well documented information on flood events as corroborated by Nkwunonwo et al., (2016). However, some information on historic flood events were located and this helped provide a basis for comparing high rainfall amounts observed and examining whether any relationships existed between the two variables.

6.7.2 Contribution to Scientific Knowledge: This study has improved on the knowledge and understanding available, as a major understanding is that flooding is mainly caused by heavy rainfall as reported by the respondents and flood managers and the implications of extreme rainfall on flooding has been well documented (Ologunorisa and Tersoo, 2006; Obot et al., 2010; Etuonovbe, 2011). The research has shown that rainfall over the last 3 decades for Lagos remained variable and showed no significant relationship to flood events.

This study has also examined three different perspectives: residents, flood managers and Lagos precipitation. The increasing urbanization, inadequate drainage systems and improper planning play a bigger part in the cause of flooding. It is interesting to note that although residents in the five research areas differ by income level, the impacts they experienced from flooding were similar. Victoria Island and Lekki, high-income areas, which are areas built on reclaimed land (Adepelumi and Olorunfemi, 2000) are also characterised by the issue of inadequate drainages and unplanned development as seen as well in Ikorodu, a low-income area and characterised as a mangrove zone (Odunuga et al., 2018). These high and low-income areas are prone to flooding; however, unplanned developments continue to be built in the areas.

6.8 Summary

The increased frequency and severity of flooding in Lagos is a major environmental concern. The aim of this study was to understand the current flood situation and flood management in Lagos, with a focus on Ikeja, Ikorodu, Lekki, Surulere and Victoria Island in order to evaluate what the current flood impacts are and what they mean for the future population if the flood management measures and practices for Lagos are not improved on.

Different factors were considered at the start of the study. It was important that residents with previous flood experience were surveyed, hence, the choice of the five areas. Also, locating the right officials who were in charge of managing flood in Lagos was essential towards achieving the study aims and finally the availability of the hydrometeorological data was essential. This was discussed in detail in Chapter 4.

This study contributed to scientific knowledge by improving on the knowledge of causes of flooding and highlighting impacts experienced as a result: the high-income areas as well as the low-income areas although on the opposite end of the financial spectrum experienced the same impacts from flooding, their areas did not have an impact.

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APPENDIX A - Questionnaire

My name is Cynthia Atufu and this questionnaire is in part fulfillment for the degree of Doctor of Philosophy. I am working on the Impacts of Flooding on the Residents of Lagos, Nigeria in accordance with the regulations of the University of Northampton. You are being asked to be in this research study. Your household was randomly selected within your neighborhood to participate in this survey that will take approximately 20 minutes to complete. Like yours, some neighborhoods within Lagos have also been chosen for this survey.

The purpose of this study is to understand the impacts of flooding, attitudes to resilience and flood management in your area. The questionnaire will gather data on information such as area you reside, number of family members, ages, experiences, behavioral adaptations, impacts, and how households cope and manage during and after flood events. Now I will ask for your verbal consent to be a respondent for this study and I will read out the questions for you to answer while I make the record. If you prefer, I can leave the questionnaire with you and come back at a convenient time to pick it up. It is voluntary and entirely your choice. If you choose to take part, you can change your mind later on and withdraw at any point of filling the questionnaire. Again, your answers will be kept completely confidential. You can skip any questions that you do not wish to answer. You may ask any questions before you provide consent.

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Section A: Flood Experience

1) Have you ever experienced flooding while living in Lagos? YES (go to Q2) NO (go to Q20)

2) Have you ever experienced flooding in your current home? YES (go to Q3) NO (go to Q20)

3) What caused the previous floods you experienced? (Tick all that apply). Please list the year the flood occurred by the cause(s)

a) Heavy Rainfall
b) River/Lagoon water overflow
c) Storm drain failure e.g gutters
d) Others, please mention

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4) How often are you flooded?

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5) What caused the most recent flooding you experienced? (Tick all that apply) Please list the year the flood occurred by their cause(s)

a) Heavy Rainfall
b) River/Lagoon water overflow
c) Storm drain failure e.g gutters
d) Others, please mention

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6) What cause of flooding have you been mostly affected by? Please list them below starting with the most frequent to the least frequent cause

7) Please tick the months when you have experienced flooding

January ☐ February☐ March☐ April☐ May☐ June☐

July☐ August☐ September☐ October☐ November☐ December☐

8) Is the flood situation changing? Please circle the response below that best describes how you feel about the question.

1 Worse	2 No Change	3 Better
☐	☐	☐

9) Please explain your reason(s) for your answer above

10) Please outline all the impact that flooding has caused to You/Your Family in a typical year experience

11) Please outline all the impacts that flooding has caused on Your Neighbourhood a typical year experience

12) Please describe the flood experience that caused you the greatest impact

Section B: Response to Flooding and Prevention

13) Was any action taken to minimize the impacts experienced during the last flood? YES (go to Q14) NO (go to Q20)

14) What actions were taken to minimize these impacts? (Tick all that apply)

a) Sandbags
b) Building Elevations at the entrance to my home
c) Building Depressions from the entrance to my home
d) Others, (please explain)

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15) Who took the actions to minimize the impacts stated in question 13? (Please tick all that apply)

a) You/Your Family
b) Your Landlord
c) The Neighbourhood
d) The Government

16) Please describe the different actions carried out also stating who carried them out from your answer above

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17) What action has been taken to reduce flooding since the last flood? (Tick all that apply)

a) Nothing
b) Straightening and deepening of water channels
c) Clearing rubbish out of water channels
d) Building Flood Defences such as levees and flood walls
e) Providing access to Sandbags
f) Installation of a Flood Warning System
g) Better Waste Disposal
h) Others, please list

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18) Please outline what was done and by whom

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19) Did they work? Have there been flood issues since then?

20) Why have you never experienced flooding?

21) Do you feel at risk from flooding in the future? Yes ☐ No ☐ Don't Know ☐

22) Please state your reason for your answer

Section C: Personal Information

23) What is your gender? Male Female

24) What is your position in your household?

a) Sole Provider
b) Co-Provider
c) Housewife
d) Dependent
e) Prefer not to say

25) Please state the number of people in your household within the age range below.

a) 0 – 6 _____
b) 7 – 16 _____
c) 17 – 35 _____
d) 36 – 50 _____
e) 51 – 65 _____
f) 66 -- 80 _____
g) Above 80 _____
h) Prefer not to say

26) What type of property do you live in? (Tick One)

Bungalow	
Ground Floor	
First Storey Building	
Second Storey Building	
Above 2nd Storey Building	

27) Why did you choose this property?

28) Did you consider flooding when selecting your property? Yes No Don't Know

29) Please tick your area

Ikorodu	
Ikeja	
Lekki	
Victoria Island	
Surulere	

APPENDIX B – Interview Questions

Please state which area you belong to ____________________

1. How much of a problem is flooding in this area?
2. Are there some areas in your district more prone to flooding than others? Can you explain why this is?
3. What are the causes of flooding in your area? Can you rank them in order of severity? Please explain why.
4. Among the causes mentioned, which is the most frequent cause of flooding in this area?
5. Which of these groups are mostly affected by flooding? Residents, Businesses or Infrastructure? In what way?
6. What is the population of your area? What proportion of businesses and residential homes make up the buildings in your area?
7. Is the flood situation changing? In what way? Why?
8. Besides the government, are there groups of people pushing for more flood defences in this area? (If yes, who are they?)
9. Have there been groups of people, community groups, businesses or organisations that have taken up roles or approached the government to improve flood prevention and management in this area? (If yes, who are they? In what way?)
10. Has there been any co-operation among these people to better achieve their individual flood management goals for the area? Who are they? What happened?
11. What makes it challenging to manage or control flooding in your area?
12. What flood defence measures does the government have in place for flood prevention?
13. Why were they put in place? When were they put in place? Have they lived up to their expectation?
14. How often are these defences maintained for upkeep?
15. Are there problems with these defences? What are they? What causes these issues/damages?
16. In which areas is it easiest to put in and maintain flood defences and why?
17. In which areas is it most challenging to put in and maintain flood defences and why?
18. Does the government have a method for monitoring floods in every area? If yes? How? If No, what are the challenges?
19. Does the government provide preventive measures such as flood warnings and information on what to do in the event of flooding?
20. If Yes, how effective have they been? If No, what are the challenges?
21. Does the government have plans to reduce the flood risk in your area for the future? What are they?
22. How will they be implemented? What is the timescale for their implementation?
23. Are there challenges and/or difficulties facing the implementation? What are they?